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Research Article

Ultrasound-Determined Appendix Position and Anatomical Variation as Predictors of Operative Difficulty and Anesthetic Duration in Laparoscopic Appendectomy

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ABSTRACT

Background: Appendicitis is one of the most frequently encountered surgical emergencies and laparoscopy is a well-established surgical approach for appendicitis. The procedure is basically easy to perform, but the position of the appendix and the grade of local inflammation may affect the intra-operative visualization, dissection and operative difficulty, as well as the total anesthetic exposure. Ultrasonography, performed before the surgery, may be helpful in giving anatomical information that can help anticipate these challenges.

Objective: To determine the association of ultrasound-determined appendix position and anatomical variation with operative difficulty and anesthetic duration in patients undergoing laparoscopic appendectomy.

Methodology: This prospective observational study was conducted at Mercy Teaching Hospital, Peshawar, from January 2026 to June 2026. Fifty-seven patients with acute appendicitis were included who underwent laparoscopic appendectomy. The position of the appendix and inflammatory findings were determined by ultrasonography before surgery. The position of the appendix was classified as retrocecal, pelvic, subcecal, pre-ileal, or post-ileal. Intraoperative findings, operative difficulty, operative duration and total anesthetic duration were recorded. Comparative tests were used for the statistical analysis and multivariable logistic regression, $p<0.05$ was considered statistically significant.

Results: The appendix was visualized preoperatively in 52 (91.2%) patients. Retrocecal position was the most common, occurring in 20 (35.1%) cases, followed by pelvic position in 16 (28.1%). Operative difficulty was classified as difficult in 11 (19.3%) patients. Difficult procedures were most frequent among patients with a post-ileal appendix, 4/5 (80.0%), followed by retrocecal position, 5/20 (25.0%), with a significant association between appendix position and operative difficulty ($p=0.006$). Post-ileal appendices were also associated with the longest mean operative duration (78.6 ± 18.2 minutes) and anesthetic duration (103.8 ± 21.6 minutes). Periappendiceal fluid and sonographic evidence of perforation were also significantly associated with increased operative difficulty.

Conclusion: Ultrasound-determined appendix position and associated inflammatory changes may help predict the technical difficulty and anesthetic duration of laparoscopic appendectomy. Post-ileal and retrocecal positions were associated with more challenging procedures and longer operative and anesthetic times. Detailed preoperative ultrasonographic assessment may therefore improve perioperative planning.

Keywords: Acute Appendicitis, Appendix Position, Ultrasonography, Laparoscopic Appendectomy, Operative Difficulty, Anesthetic Duration.

INTRODUCTION

Acute appendicitis is still one of the most common reasons for emergency abdominal surgery globally. The surgery known as laparoscopic appendectomy has proved to be the more preferred surgery in many centers due to the increased visualization of the abdominal cavity, smaller incisions, less postoperative pain, quicker recovery time, and early return to normal function. Although useful, the laparoscopic appendectomy can be technically challenging in some patients. The duration and nature of the surgery can significantly differ depending on differences in appendix anatomy, severity of the inflammation, adhesions and perforation (1-3).

The vermiform appendix exhibits significant anatomical variability when compared to the cecum and distal ileum. Retrocecal, pelvic, subcecal, pre-ileal and post-ileal are common locations. The differences in anatomy may influence the presentation of appendicitis and the ability to find and move the appendix during appendectomy. The appendix may be partially buried behind the cecum (retrocecal) or behind loops of small bowel (post-ileal). These sites may need greater manipulation, adhesiolysis, or mobilization and thus require a longer procedure (4-6).

The use of ultrasonography in the diagnostic evaluation of suspected appendicitis is commonplace, especially due to its non-invasive and inexpensive nature, as well as the fact that it is widely available and doesn't involve the use of ionizing radiation. Besides showing an enlarged, non-compressible appendix, ultrasonography can detect appendicoliths, periappendiceal inflammatory changes, localized fluid collections, perforation, and the location of the appendix. These findings may be utilized for information that goes beyond diagnosis, with the possibility of offering some information regarding the complexity of the planned laparoscopy procedure (7-9).

Operative difficulty not only has significant implications for surgeons, but also anesthesiologists. Technically challenging appendectomy can lengthen the surgery and thus exposure to general anesthesia. The longer anesthesia lasts, the more it can affect intra-operative medication doses, fluid intake, mechanical ventilation, recovery and post-operative monitoring. Therefore, correct estimation of cases that require a longer time for surgery could help the surgical team and the anesthesia team to plan and allocate resources for the perioperative period (10-13).

Although ultrasound is commonly employed for diagnosing acute appendicitis, relatively less attention has been given to its role in predicting operative complexity and anesthetic duration according to appendix position and anatomical variation. The present study was therefore conducted to assess the relationship between preoperative ultrasound-determined appendix position and operative difficulty in patients undergoing laparoscopic appendectomy and to determine whether these anatomical variations were associated with prolonged operative and anesthetic duration.

METHODOLOGY

This prospective observational study was conducted at Mercy Teaching Hospital, Peshawar, from January 2026 to June 2026. A total of 57 patients who were diagnosed with acute appendicitis and subsequently underwent laparoscopic appendectomy were included. Patients were enrolled through consecutive sampling after fulfillment of the predefined eligibility criteria. The study was designed to evaluate whether the preoperative ultrasound-determined position and anatomical variation of the appendix could predict operative difficulty and anesthetic duration during laparoscopic appendectomy. Ethical approval was obtained from the institutional ethical review committee before initiation of the study, and written informed consent was obtained from all participants or their legal guardians where applicable.

The patients who fulfilled following criteria were included: 1) clinical features suggestive of acute appendicititis, 2) ultrasonographic evaluation before surgery, and 3) laparoscopy appendectomy surgery. Those who underwent a primary open appendectomy, previous right hemicolectomy or other abdominal surgery that had caused severe distortion of right lower abdominal anatomy, surgery for generalized peritonitis that had to be performed open, or had incomplete ultrasound or anesthesia records were excluded from the study. Data were collected using a standard data collection form, which included basic demographic and clinical data: age, sex, body mass index, duration of symptoms, history of previous abdominal surgery, and American Society of Anesthesiologists (ASA) physical status classification.

All patients enrolled had an abdominal ultrasound examination performed before the

procedure by a well-trained radiologist with a high-frequency linear transducer and, when necessary, a curvilinear transducer. Ultrasonography was used with a graded compression technique for identification of appendix and to find its anatomical position. The position of the appendix was divided into retrocecal, pelvic, subcecal, pre-ileal and post-ileal based on its relationship with the cecum and terminal ileum. Other ultrasound parameters noted were the diameter of the appendix, compressibility, wall thickening, periappendiceal fat inflammation, periappendiceal fluid, free peritoneal fluid, appendicolith, localized collection and signs of perforation. Later the position of the appendix was compared with the ultrasonographic position which was identified during laparoscopy.

All appendectomies were done laparoscopically under general anesthesia with a standard institutional anesthetic and surgical technique. The pneumoperitoneum was created and standard laparoscopic ports were placed following induction and endotracheal intubation. Intraoperative findings included intraoperatively documented appendix position, severity of inflammation, presence of appendix gangrene/perforation, adhesions, need for adhesiolysis, need for an additional port, conversion to open surgery. The operative difficulty was evaluated by the identification of the appendix, its mobilization, adhesions, anatomical accessibility and other surgical procedures needed, and was classified as easy, moderate, or difficult. The total time of the surgery was calculated from the time the skin was opened until the skin was closed, and anesthetic times were calculated from the induction of anesthesia to the completion of the transfer from the operating room and extubation.

Data were input and analyzed with IBM SPSS Statistics. Continuous data like age, body mass index, operative duration and anesthetic duration were presented as mean ± SD or median (IQR) based on the distribution of the data. Categorical variables were displayed as frequencies and percentages. Chi-square test or Fisher's exact test was used to evaluate the correlation between ultrasound measurement of appendix position and operative difficulty. Operative and anesthetic durations were compared between the groups of the appendix position by one-way analysis of variance (ANOVA) and the Kruskal-Wallis test (if the data were not normally distributed). Univariate and multivariate logistic regression analyses were performed to determine independent risks for difficult laparoscopic appendectomy, and the adjusted odds ratio and confidence intervals are presented. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 57 patients who received laparoscopic appendectomy were included in the analysis. The mean age of the participants was 29.8 ± 11.6 years, with an age range of 16–58 years. Most patients, 25 (43.9%), were aged 21–30 years, followed by 14 (24.6%) aged 31–40 years. There were 32 male (56.1%) and 25 female (43.9%) participants. The mean body mass index was 24.7 ± 3.5 kg/m². Most patients were classified as ASA-I, 39 (68.4%), while 18 (31.6%) were ASA-II. Preoperative diagnosis of complicated appendicitis was made in 14 of the patients (24.6%).

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants (N=57)

Variable	**n (%) / Mean ± SD**
Age, years	29.8 ± 11.6
Age group	
≤20 years	9 (15.8)
21–30 years	25 (43.9)
31–40 years	14 (24.6)
>40 years	9 (15.8)
Sex	
Male	32 (56.1)
Female	25 (43.9)
BMI, kg/m²	24.7 ± 3.5
Duration of symptoms, hours	31.6 ± 17.9
ASA physical status	
ASA-I	39 (68.4)
ASA-II	18 (31.6)
Previous abdominal surgery	7 (12.3)

Complicated appendicitis	14 (24.6)

Preoperative ultrasonography was a successful tool for identifying the appendix in 52 (91.2%) patients. The average diameter of the appendix was 8.7 ± 1.8 mm. The most common anatomical position was retrocecal (20, 35.1%) followed by pelvic position (16, 28.1%), subcecal (9, 15.8%), pre-ileal (7, 12.3%) and post-ileal (5, 8.8%). Twelve (21.1%) patients had an appendicolith, and 34 (59.6%) and 16 (28.1%) had periappendiceal inflammatory fat changes and fluid, respectively. Eight (14.0%) had sonographic findings suggestive of perforation.

Table 2. Preoperative Ultrasound Findings and Appendix Anatomical Position (N=57)

Ultrasound variable	**n (%) / Mean ± SD**
Appendix visualized	52 (91.2)
Appendix diameter, mm	8.7 ± 1.8
Non-compressible appendix	49 (86.0)
Ultrasound-determined appendix position	
Retrocecal	20 (35.1)
Pelvic	16 (28.1)
Subcecal	9 (15.8)
Pre-ileal	7 (12.3)
Post-ileal	5 (8.8)
Appendicolith present	12 (21.1)
Periappendiceal fat inflammation	34 (59.6)
Periappendiceal fluid	16 (28.1)
Free intraperitoneal fluid	11 (19.3)
Sonographic evidence of perforation	8 (14.0)

In 47/52 cases (90.4%) the position of the appendix found intraoperatively was confirmed as noted in the ultrasound examination. The mean operative time was 55.7 ± 17.8 minutes and the mean total anesthetic time was 78.9 ± 20.6 minutes. Adhesiolysis was needed in 15 (26.3%) patients; and a second laparoscopic port was needed in 6 (10.5%). Operative difficulty was classified as easy in 29 (50.9%) cases, moderate in 17 (29.8%), and difficult in 11 (19.3%). There were 2 patients (3.5%) who converted to an open procedure.

Table 3. Intraoperative and Anesthesia-Related Characteristics (N=57)

Variable	**n (%) / Mean ± SD**
Operative duration, minutes	55.7 ± 17.8
Anesthetic duration, minutes	78.9 ± 20.6
Appendix identification time, minutes	8.6 ± 5.1
Ultrasound-operative position agreement*	47/52 (90.4)
Adhesiolysis required	15 (26.3)
Additional port required	6 (10.5)
Operative difficulty	
Easy	29 (50.9)
Moderate	17 (29.8)
Difficult	11 (19.3)
Gangrenous appendix	8 (14.0)
Perforated appendix	7 (12.3)
Conversion to open surgery	2 (3.5)
Intraoperative complication	3 (5.3)

*Calculated among patients in whom the appendix was visualized on preoperative ultrasonography.

The position of the appendix influenced the difficulty in the operation. The ones with a post-ileal appendix experienced difficult operations the most often (4/5, 80.0%) followed by the retrocecal group (5/20, 25.0%). The prevalence of difficult surgery was rare in those with pelvic, subcecal and pre-ileal appendices compared with others. The overall correlation

between the ultrasound localization of the appendix and the difficulty of surgery was statistically significant (p=0.006). The presence of appendicolith, periappendiceal fluid and sonographic findings of perforation were also significantly correlated with the higher difficulty of the operation.

Table 4. Association of Ultrasound Findings with Difficult Laparoscopic Appendectomy

Predictor	Difficult operation n/N (%)	p-value
Appendix position		0.006
Retrocecal	5/20 (25.0)	
Pelvic	1/16 (6.3)	
Subcecal	0/9 (0.0)	
Pre-ileal	1/7 (14.3)	
Post-ileal	4/5 (80.0)	
Appendicolith absent	5/45 (11.1)	0.014
Appendicolith present	6/12 (50.0)	
Periappendiceal fluid absent	3/41 (7.3)	<0.001
Periappendiceal fluid present	8/16 (50.0)	
Sonographic perforation absent	5/49 (10.2)	<0.001
Sonographic perforation present	6/8 (75.0)	

The duration of the operation and the anaesthetic procedure also varied depending on the location of the appendix. The mean operative duration was the longest for patients with a post-ileal appendix (78.6 ± 18.2 minutes), and the mean anesthetic duration was the longest for patients with a post-ileal appendix (103.8 ± 21.6 minutes). Relatively longer procedures were also seen to be associated with retrocecal appendices. On the other hand, shorter operative and anesthetic time was associated with subcecal and pelvic positions. The difference between the anatomical positions was statistically significant in regard to the duration of the operation (p=0.002) and the duration of the anaesthetic (p=0.004).

Table 5. Operative and Anesthetic Duration According To Ultrasound-Determined Appendix Position

Appendix position	n	Operative duration, min Mean ± SD	Anesthetic duration, min Mean ± SD
Retrocecal	20	61.8 ± 16.4	85.9 ± 18.9
Pelvic	16	48.4 ± 12.7	70.6 ± 15.8
Subcecal	9	43.7 ± 10.9	65.8 ± 14.1
Pre-ileal	7	54.9 ± 13.6	77.7 ± 16.5
Post-ileal	5	78.6 ± 18.2	103.8 ± 21.6
Overall p-value		0.002	0.004

Multivariable logistic regression analysis showed that post-ileal appendix position, periappendiceal fluid and sonographic signs of perforation were independent risk factors for a difficult laparoscopic procedure. There were a roughly six-fold increase in odds of operative difficulty with a post-ileal appendix compared with more accessible locations (adjusted OR 6.21, 95% CI 1.18–32.72; p=0.031). The strongest association was with sonographic evidence of perforation (adjusted OR 7.46, 95% CI 1.42–39.18; p=0.018), with periappendiceal fluid also being independently associated (adjusted OR 4.38, 95% CI 1.12–17.14; p=0.034) with difficult surgery. After adjustment for BMI, age was not independently associated with operative difficulty.After adjusting for age, BMI was not independently associated with operative difficulty. In general, the results proved that ultrasound examination of the position of the appendix before the surgery, along with inflammatory changes or anatomical changes, had a significant relationship with the complexity of the surgery and the duration of the procedure. The average operative and anesthetic times were longer for post-ileal and retrocecal appendices, and signs of perforation or periappendiceal fluid on sonography helped identify patients likely to be faced with a technically more difficult laparoscopic appendectomy.

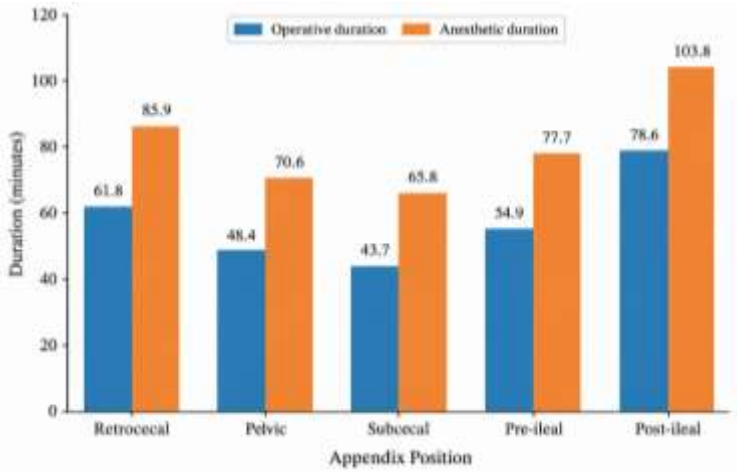

Figure 1. Operative and Anesthetic Duration According To Ultrasound-Determined Appendix Position.

This bar graph shows the mean operative duration and mean anesthetic duration across different appendix positions identified on preoperative ultrasonography. The longest operative and anesthetic durations were observed in patients with a post-ileal appendix, followed by those with a retrocecal appendix, whereas subcecal and pelvic positions were associated with comparatively shorter durations. These findings suggest that appendix position may influence the technical complexity of laparoscopic appendectomy and the overall duration of anesthesia.

DISCUSSION

The present study evaluated whether the ultrasound-determined position and anatomical variation of the appendix could predict operative difficulty and anesthetic duration in patients undergoing laparoscopic appendectomy. The findings showed that appendix position was significantly associated with both surgical complexity and procedural duration. Among the anatomical positions identified on ultrasonography, the post-ileal appendix was associated with the greatest operative difficulty and the longest mean operative and anesthetic durations. Retrocecal appendices also demonstrated comparatively longer procedure times, whereas pelvic and subcecal appendices were generally associated with easier surgical access and shorter durations. These findings indicate that preoperative ultrasound assessment may provide clinically useful information for anticipating technical challenges before laparoscopic appendectomy.

The position of the appendix may be different in different patients, potentially affecting the visualization, mobilization, and dissection during laparoscopic surgery. An appendix that lies behind the cecum or ascending colon (retrocecal appendix) may be partially hidden behind the cecum or ascending colon, and an appendix that is located behind loops of the terminal ileum (post-ileal appendix) may be embedded in these loops, which makes identification and exposure more difficult. Overall, the most common difficult laparoscopic procedures were in the post-ileal position, and the retrocecal position was also correlated with the greater complexity of the operation. These anatomical relationships could be responsible for the longer time it takes to identify the appendix, for the need to perform more adhesiolysis in the more difficult cases, and for the sometimes-necessary further surgical maneuvers. The identification and mobilization of pelvic and subcecal appendices, however, are typically easier when done laparoscopically, thus making the procedure shorter (14, 15).

Other ultrasound inflammatory parameters were correlated with operative difficulty in addition to appendix position. Patients with technically difficult procedures had a higher rate of periappendiceal fluid, appendicolith and sonographic features suggestive of perforation. The clinical implications of these results are that complicated appendicitis may involve other changes such as edema, friability, adhesion, and the presence of pus and changes of local anatomy, which can make dissection more difficult during laparoscopy. Perforation was most strongly associated with sonographic evidence in the current analysis, and was a factor that increased operative difficulty. Thus, pre-operative ultrasonography might have a role in the diagnosis of appendicitis as well as the delineation of anatomical and inflammatory characteristics, which could alert the surgeon to a complex operation (16, 17).

Another important finding was the relationship between the position of the appendix and the length of the anesthesia. Patients with post-ileal appendices experienced the longest mean anesthetic duration followed by retrocecal appendices. This matchup closely mimicked the operative time, indicating that the longer it takes to get to the kidney, the longer the exposure to general anesthesia. Shorter procedures may not require as much anesthetic, mechanical ventilation, intraoperative monitoring, or post-operative recovery resources as longer procedures would. Under the anesthetic aspect, it is possible to identify patients who are likely to have longer surgery, which can help to plan the administration of anesthetic drugs, airway management, fluid therapy, and postoperative care. This close association between operating room and anesthetic time can thus underscore the importance of communicating pre-operative imaging information to the surgical and anesthesia staff (18-20).

The study has several limitations that should be considered when interpreting its findings. It was performed in a single centre and comprised a relatively small number of patients (57), which may reduce the external validity and accuracy of some comparisons among subgroups, especially for rare appendix localisation, like post-ileal, where few patients were studied. The use of ultrasound is also limited by operator dependence and appendix visualization may be influenced by body habitus, bowel gas, and severity of inflammation. Also, the difficulty of the operation was subjectively assessed and is somewhat subjective. Nevertheless, this study provides a clinically relevant correlation between ultrasound anatomy prior to surgery and surgical outcome. These findings suggest the need for a multicenter study with a larger number of patients, standardized operative-difficulty scoring systems and evaluation of interobserver ultrasound agreement to confirm these findings and establish a reliable predictive model for preoperatively.

CONCLUSION

Preoperative ultrasonographic assessment of appendix position and associated anatomical or inflammatory changes appears to be useful in predicting the technical difficulty of laparoscopic appendectomy**.** Post-ileal and retrocecal appendix positions were associated with greater operative difficulty and longer operative and anesthetic durations, while periappendiceal fluid and features of perforation further increased the likelihood of a challenging procedure. Incorporating detailed appendix localization into routine preoperative ultrasound reporting may assist surgeons and anesthesiologists in anticipating procedural complexity, optimizing operative planning, and improving perioperative resource preparation.

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