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Original Article

Observational assessment of anatomical variations of the appendix and their surgical relevance in complicated appendicitis cases. A cross-sectional study.

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Abstract

Background
Anatomical variations in the position of the appendix may influence the clinical presentation, diagnosis, and surgical outcomes of complicated appendicitis. Accurate knowledge of these variations is crucial for timely intervention and improved patient outcomes.

Objectives
To assess the anatomical variations of the vermiform appendix and analyze their association with surgical findings and complications in patients with complicated appendicitis.

Methods
This observational study was conducted on 100 patients diagnosed intraoperatively with complicated appendicitis at a tertiary care hospital. Patient demographics, type of complication, appendix position, intraoperative difficulties, and histopathological findings were recorded. Data were presented using descriptive statistics and tabulated.

Results
The mean age of patients was 28.6 ± 10.4 years; 64% were male. Perforated appendix (39%) and appendicular abscess (27%) were the most frequent complications. Retrocecal position was the most common anatomical variant (48%), followed by pelvic (24%) and subcecal (12%). Atypical appendix positions (post-ileal and pre-ileal) were associated with delayed diagnosis, increased operative time (mean: 68.2 ± 12.7 minutes), and higher conversion rates to open surgery (39.3%). Histopathology confirmed transmural inflammation in 86% and gangrenous changes in 14% of cases.

Conclusion
Anatomical variations in appendix position significantly influence the severity and type of complications in appendicitis. Retrocecal and pelvic positions were most common and often associated with perforation and abscess formation, respectively. Awareness of these variations is essential for prompt diagnosis and optimal surgical management in complicated cases.

Recommendations
Preoperative imaging and intraoperative vigilance are recommended to anticipate anatomical variation and reduce surgical morbidity and delay.

Keywords: *Appendix, anatomical variation, complicated appendicitis, retrocecal, pelvic, perforation, abscess, intraoperative findings, surgical relevance.*
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Introduction

Acute appendicitis remains one of the most common surgical emergencies worldwide, with clinical presentations ranging from classical to highly atypical. The diversity in presentation is largely influenced by variations in the length and anatomical location of the vermiform appendix, which differ across populations and age groups [1]. Such variability often masks typical clinical features, leading to diagnostic uncertainty and a higher likelihood of complications such as perforation or abscess formation.

Several studies have highlighted the spectrum of appendix positions, including retrocecal, pelvic, subcecal, pre-ileal, and post-ileal orientations, each associated with distinct clinical manifestations [2]. Recognizing these positional differences is especially critical in emergency settings, where prompt diagnosis can significantly reduce morbidity. Radiological tools, particularly ultrasonography and computed tomography (CT), have proven valuable in identifying unusual appendix positions. CT is especially useful for delineating location and length in patients with non-classical symptoms [3]. From a surgical perspective, awareness of these variations is equally important, as atypical positions may complicate intraoperative identification and increase the risk of procedural difficulties. Rare anatomical anomalies, such as situs viscerum inversus, further challenge both diagnosis and surgical planning, requiring heightened clinical vigilance [4]. In children, especially those under five years, the task is even more complex due to vague symptomatology and limited communication, underscoring the need for detailed anatomical knowledge [5].

This study aims to assess the anatomical variations of the appendix and their surgical relevance in patients with complicated appendicitis.

Methodology

Study Design

This was a hospital-based observational cross-sectional study conducted over one year from March 2024 to April 2025. All consecutive patients who met the eligibility criteria and were diagnosed intraoperatively with complicated appendicitis were included in the study. Data were collected at a single point of surgical intervention without longitudinal follow-up.

Study Setting

The study was carried out in the Department of General Surgery, GMERS Medical College and Hospital, Himmatnagar, Gujarat, India. This tertiary care teaching hospital serves a large catchment area comprising both urban and rural populations of the Sabarkantha district. The institution is equipped with advanced diagnostic facilities, a high-volume emergency unit, and specialized surgical services, making it a referral center for acute abdominal emergencies, including complicated appendicitis.

Study Size

The study included 100 consecutive patients diagnosed intraoperatively with complicated appendicitis over one year (March 2024 – April 2025). The sample size was not calculated statistically, as this was an exploratory observational study. Rather, all eligible cases within the defined study period were included to provide a representative overview of anatomical variations and surgical outcomes in complicated appendicitis.

Study Population

The study included 100 patients who were diagnosed intraoperatively with complicated appendicitis, defined as appendicitis with perforation, gangrene, abscess formation, localized peritonitis, or appendicular mass.

Inclusion Criteria

Patients of all age groups and both sexes.
Patients diagnosed intraoperatively with complicated appendicitis.
Patients who underwent surgical intervention (open or laparoscopic appendectomy).

Exclusion Criteria

Patients with simple (uncomplicated) appendicitis.
Patients managed conservatively without surgical intervention.
Patients with incomplete operative or histopathological records.

Data Collection Procedure

After obtaining informed consent, detailed demographic data (age, gender), clinical presentation, type of complication, and intraoperative findings were recorded. Particular emphasis was placed on the anatomical position of the appendix, which was noted intraoperatively by the operating surgeon. The positions were classified as retrocecal, pelvic, subcecal, pre-ileal, or post-ileal.

The intraoperative surgical approach, operative time, need for conversion to open surgery, and any difficulties encountered were documented. Resected specimens were

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subjected to histopathological examination to confirm the diagnosis and assess for transmural inflammation or gangrenous changes.

Bias

To minimize selection bias, all consecutive patients fulfilling the inclusion criteria during the study period were enrolled without exclusions. Intraoperative documentation of appendix position was made independently by the operating surgeon, and histopathological confirmation was performed by blinded pathologists to reduce observer bias. Data entry was cross-checked by two investigators to avoid transcription errors.

Data Analysis

The collected data were tabulated and analyzed using descriptive statistics. Frequencies and percentages were calculated for categorical variables, and means with standard deviations were calculated for continuous variables. The results were presented in tables to illustrate key findings.

Ethical Considerations

Ethical clearance was obtained from the Institutional Ethics Committee of GMERS Medical College, Himmatnagar, before initiation of the study. Informed written consent was obtained from all participants (or their legally authorized representatives in the case of minors) before enrollment, ensuring confidentiality and adherence to ethical principles throughout the study.

Results

Participant Flow

A total of 112 patients were initially evaluated for suspected complicated appendicitis during the study period. Of these, 7 patients were excluded due to conservative management without surgery, and 5 patients had incomplete operative or histopathological records. The remaining 100 patients were confirmed intraoperatively as cases of complicated appendicitis and were included in the final analysis.

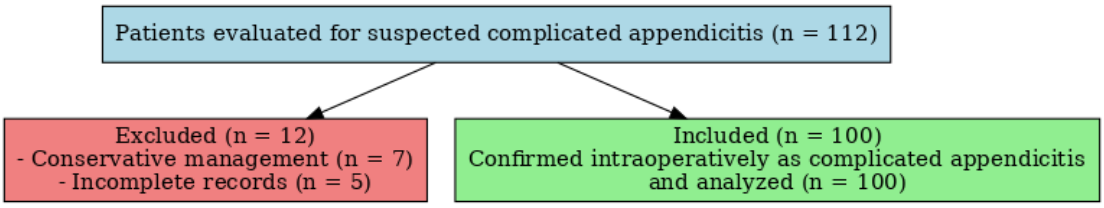

Figure 1. Participant Flow Diagram

A total of 100 patients with complicated appendicitis were included in the study. The mean age of the participants was 28.6 ± 10.4 years, with a male predominance (64%) compared to females (36%) (Table 1).

Table 1: Demographic Profile of the Study Population (n = 100)

Parameter	Value
Mean Age (years)	28.6 ± 10.4
Male	64 (64%)
Female	36 (36%)

The most common complication observed intraoperatively was a perforated appendix, present in 39% of cases, followed by appendicular abscess in 27%, gangrenous appendix in 18%, appendicular mass in 10%, and localized peritonitis in 6% of patients (Table 2).

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Table 2: Types of Complications in Complicated Appendicitis

Type of Complication	Number of Cases	Percentage (%)
Perforated appendix	39	39%
Appendicular abscess	27	27%
Gangrenous appendix	18	18%
Appendicular mass	10	10%
Localized peritonitis	6	6%

Anatomical variations in the position of the appendix were documented in all cases. The most frequent position was retrocecal (48%), followed by pelvic (24%), subcecal (12%), post-ileal (9%), and pre-ileal (7%) (Table 3).

Table 3: Anatomical Variations in Appendix Position

Position of the Appendix	Number of Cases	Percentage (%)
Retrocecal	48	48%
Pelvic	24	24%
Subcecal	12	12%
Post-ileal	9	9%
Pre-ileal	7	7%

Retrocecal and post-ileal appendices were more frequently associated with perforation and gangrene, whereas pelvic appendices were commonly linked with abscess formation. Intraoperatively, atypical positions (subcecal, post-ileal, pre-ileal) were associated with increased surgical difficulty. These cases required longer operative times, averaging 68.2 ± 12.7 minutes, and had a higher rate of conversion to open surgery (39.3%) compared to typical positions. Histopathological examination revealed transmural inflammation in 86% of specimens and gangrenous or necrotic changes in 14% (Table 4).

Table 4: Intraoperative Observations and Histopathological Findings

Observation	Value
Mean operative time (atypical positions)	68.2 ± 12.7 minutes
Conversion to open surgery (atypical positions)	11/28 cases (39.3%)
Transmural inflammation (histopathology)	86 cases (86%)
Gangrenous/necrotic changes (histopathology)	14 cases (14%)

Discussion

This observational study evaluated the anatomical variations of the appendix and their surgical relevance in complicated appendicitis. The findings emphasize the critical impact of appendix position on clinical presentation, operative complexity, and patient outcomes.

In this study, the retrocecal orientation was the most common anatomical variant, accounting for 48% of the cases. This positioning often leads to atypical or subdued clinical signs, which can delay diagnosis and increase the risk of complications such as perforation and gangrene. These findings are consistent with reports describing atypical or rare positions of the appendix complicating diagnosis and management [6,8].

Pelvic appendices, found in 24% of patients, were commonly associated with appendicular abscess formation. Their proximity to pelvic organs can result in misleading clinical presentations, such as urinary symptoms or vague lower abdominal pain, which may be mistaken for genitourinary or gynecological conditions. Atypical positions such as pre-ileal and post-ileal were particularly significant in our study due to their association with delayed diagnosis, longer operative durations, and increased rates of conversion to open surgery. The presence of vascular anomalies and adhesions, as documented in rare case reports, can further complicate surgical dissection and increase the risk of intraoperative vascular injuries [7,12].

Histopathological analysis revealed transmural inflammation in 86% and gangrenous changes in 14% of cases, underscoring the advanced disease status at presentation. These findings correlate with global data on

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appendicitis burden, where delayed presentation and anatomical variation contribute to complication rates [9,10]. The timing of surgical intervention also plays a pivotal role in determining patient outcomes. Delays due to diagnostic uncertainty, often caused by anatomical variation or non-classical symptoms, can lead to increased severity at surgery [10]. Moreover, the ongoing challenge in balancing the risk of negative appendectomy versus the dangers of delayed intervention in complicated cases continues to impact surgical decision-making [11].

Overall, the study reaffirms that knowledge of anatomical and vascular variations of the appendix and mesoappendix is vital for surgeons, particularly in complex or atypical cases [12]. Preoperative imaging, timely intervention, and intraoperative awareness are essential to improving outcomes in complicated appendicitis.

Furthermore, awareness of anatomical variation is vital for surgeons, especially when using minimally invasive techniques such as laparoscopy, where visualization may be limited, and orientation distorted by inflammation or adhesions. Knowledge of likely appendix positions can facilitate efficient dissection, reduce operative time, and avoid inadvertent complications.

Generalizability

The findings of this study, though valuable, should be interpreted in the context of its single-center design. As the data were derived from patients managed at a tertiary care teaching hospital in Gujarat, the results are most directly applicable to similar clinical settings with comparable patient demographics and healthcare resources. Nevertheless, the anatomical variations of the appendix observed align with patterns reported in broader populations, suggesting that the findings may be extrapolated with caution to other regions. However, differences in genetic, dietary, and environmental factors across populations may influence the prevalence of specific appendix positions and associated complications. Larger multicenter studies would therefore be required to enhance external validity and strengthen the generalizability of our observations.

Conclusion

This study highlights the significant role of anatomical variations of the appendix in the clinical presentation, complications, and surgical outcomes of complicated appendicitis. The retrocecal position was most commonly observed and associated with higher rates of perforation and gangrene, whereas pelvic appendices were frequently linked to abscess formation. Atypical positions such as pre-ileal and post-ileal contributed to delayed diagnosis, longer operative times, and increased conversion rates to open surgery. Awareness of these variations is crucial for early diagnosis and effective surgical planning. Incorporating preoperative imaging and maintaining a high index of suspicion in atypical presentations can significantly reduce morbidity and improve patient outcomes.

Limitations

This study had several limitations. It was conducted at a single tertiary care center, which limited the generalizability of the findings to broader populations. The sample size, although adequate for observational analysis, did not capture the full spectrum of anatomical variations and their rare complications. Intraoperative identification of appendix position was based on the surgeon's observation, which introduced the potential for subjective bias. The study also excluded long-term postoperative outcomes and did not correlate imaging findings with intraoperative observations.

Recommendations

Based on the findings of this study, it is recommended that clinicians maintain a high index of suspicion for atypical presentations of appendicitis, especially in patients with vague or non-classical symptoms. Preoperative imaging modalities such as ultrasonography or contrast-enhanced CT should be routinely considered to anticipate anatomical variations of the appendix, particularly in suspected complicated cases. Surgeons should be familiar with the range of appendix positions to ensure timely and appropriate surgical intervention. Training programs should emphasize anatomical variability during surgical education. Future research should focus on correlating radiological and intraoperative findings to improve diagnostic accuracy and clinical outcomes.

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Abbreviations

CT – Computed Tomography
IEC – Institutional Ethics Committee
USG – Ultrasonography

Source of funding

The study had no funding.

Conflicts of interest

The Author declares no conflict of interest.

Data Availability

Data available on request

Author's contribution:

NKM-Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript. **BP** -Concept and design of the study, results interpretation, review of literature, and preparation of the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript.

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