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ANATOMICAL VARIATIONS OF THE APPENDIX AND THEIR IMPACT ON DIAGNOSTIC IMAGING AND SURGICAL APPROACH

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ABSTRACT

Background: This study aimed to determine the frequency of different anatomical positions of the appendix and evaluate their impact on imaging accuracy, operative difficulty, and postoperative outcomes.

Methods: A cross-sectional study was conducted at the Department of Surgery, Bannu Medical College, Bannu, from January 2024 to January 2025. Seventy-two patients undergoing appendectomy for suspected acute appendicitis were enrolled through consecutive sampling. Demographic data, clinical presentation, imaging findings, and intraoperative observations regarding appendix position and length were recorded. Operative time, conversion rates, and postoperative complications were documented. Statistical analysis was performed using SPSS version 26, with $p<0.05$ considered significant.

Results: The mean age of patients was 26.8 ± 8.4 years, with a slight male predominance (55.6%). Retrocecal position was the most frequent anatomical variant (41.7%), followed by pelvic (25%) and subcecal (13.9%). Ultrasound correctly identified appendix position in 80.6% of cases, with lower sensitivity for retrocecal appendices ($p=0.02$). Mean operative time was significantly longer for retrocecal appendices ($p=0.04$), but complication rates and hospital stay showed no statistically significant difference.

Conclusion: Anatomical variation of the appendix, particularly the retrocecal type, affects preoperative imaging accuracy and increases operative time but does not significantly influence postoperative morbidity. Awareness of these variations and appropriate imaging can enhance diagnostic accuracy and optimize surgical planning.

Keywords: Appendix, Anatomical Variation, Retrocecal Appendix, Diagnostic Imaging, Appendectomy, Operative Time, Surgical Approach

INTRODUCTION

Acute appendicitis remains one of the most common surgical emergencies worldwide, with a lifetime risk of 7–8% and a peak incidence in young adults. Despite advances in diagnostic imaging and minimally invasive surgery, anatomical variations of the appendix continue to present diagnostic and therapeutic challenges. The vermiform appendix is a highly variable organ, with reported positions including retrocecal, pelvic, subcecal, pre-ileal, post-ileal, and, rarely, ectopic locations such as subhepatic or left-sided in cases of malrotation [1-3].

The position of the appendix directly influences the clinical presentation of appendicitis. Retrocecal appendices may present with atypical pain distribution, sometimes leading to delayed diagnosis, while pelvic appendices may mimic gynecological pathology. Accurate preoperative localization is therefore crucial to reduce negative appendectomy rates and avoid unnecessary delay in intervention. Ultrasonography is often the first-line imaging modality but may be limited by body habitus or overlying bowel gas, especially for retrocecal positions. Computed tomography (CT) has higher sensitivity and specificity but may not always be available in low-resource settings [4-6].

From a surgical perspective, atypical locations can prolong operative time, necessitate extended dissection, and, in some cases, require conversion from laparoscopic to open approach. Recognition of these variations is thus essential for both surgeons and radiologists to plan an appropriate and safe operative strategy [7-9].

This study was designed to determine the distribution of anatomical positions of the appendix in a regional population, assess their impact on imaging accuracy, and analyze their influence on operative time and postoperative outcomes. Findings from this study may help improve preoperative planning, minimize diagnostic errors, and contribute to better patient care.

METHODOLOGY

This study was designed as a descriptive cross-sectional analysis and was conducted in the Department of Surgery at Bannu Medical College, Bannu, over a period of one year, from January 2024 to January 2025. The study was aimed at identifying the various anatomical positions of the appendix, assessing their impact on diagnostic imaging accuracy, and evaluating their influence on intraoperative decision-making and surgical outcomes.

A total of 72 patients who underwent appendectomy during the study period were included. The sample size was calculated using OpenEpi sample size calculator, considering a 95% confidence interval, an expected proportion of retrocecal appendix of 40%, and a 10% margin of error. A non-probability consecutive sampling technique was employed to recruit all eligible patients until the required sample size was achieved.

Inclusion Criteria

- Patients of either gender aged 15–50 years.
- All patients diagnosed with acute appendicitis based on clinical findings and imaging who underwent surgery (open or laparoscopic).
- Patients providing informed consent for participation and data use for research purposes.

Exclusion Criteria

- Patients with previous right lower quadrant surgery or adhesiolysis.
- Patients with generalized peritonitis requiring immediate laparotomy for causes other than appendicitis.
- Patients with incomplete records or missing intraoperative data.

After obtaining ethical approval from the Institutional Review Board, eligible patients were enrolled preoperatively. Demographic details, body mass index (BMI), and ASA (American Society of Anesthesiologists) physical status were recorded. Clinical presentation, including duration of symptoms, was documented. Preoperative ultrasonography findings regarding appendix visualization, diameter, and position were collected, and CT scan results were recorded when available.

Intraoperatively, the exact anatomical position of the appendix (retrocecal, pelvic, subcecal, pre-ileal, post-ileal, or paracaecal) was carefully identified and documented by the operating surgeon. The length of the appendix was measured from base to tip using a sterile ruler. Operative time was recorded from skin incision to closure, and the need for conversion from laparoscopic to open procedure was noted.

Postoperatively, patients were followed until discharge. Complications such as wound infection, intra-abdominal abscess, or prolonged ileus were documented. The duration of hospital stay was recorded in days.

The primary outcome was the frequency and distribution of various anatomical positions of the appendix. Secondary outcomes included the accuracy of imaging modalities in predicting appendix position, operative time differences across anatomical types, conversion rates, and postoperative complications.

All measurements were standardized. Imaging interpretation was performed by a single senior radiologist to minimize inter-observer variation. Operative data were confirmed by the attending consultant surgeon. The study proforma was pre-tested on five patients before data collection to ensure clarity and feasibility.

All data were entered and analyzed using SPSS version 26. Quantitative variables, such as age, BMI, appendix length, operative time, and hospital stay, were presented as mean ± standard deviation. Qualitative variables, such as gender, appendix position, imaging accuracy, and complications, were presented as frequencies and percentages. Chi-square test or Fisher's exact test was applied for categorical variables, while independent sample t-test or ANOVA was used for continuous variables where appropriate. A p-value <0.05 was considered statistically significant.

RESULTS

In this study, 72 patients undergoing appendectomy were analyzed. The mean age was 26.8 ± 8.4 years, with most patients falling in the 20–30-year age group. Males slightly outnumbered females (55.6% vs. 44.4%). The mean BMI was 23.5 ± 2.9 kg/m², and the majority were classified as ASA I–II, indicating a relatively low preoperative risk. No significant difference was observed in baseline demographics between patients with retrocecal and non-retrocecal appendices ($p>0.05$).

Table 1: Demographic Profile of Patients (n=72)

Variable	Frequency (%) / Mean ± SD	p-value
Age (years)	26.8 ± 8.4	0.62
Gender	Male: 40 (55.6%)Female: 32 (44.4%)	0.47
BMI (kg/m²)	23.5 ± 2.9	0.58
ASA Class	I: 50 (69.4%)II: 18 (25%)III: 4 (5.6%)	0.39

The majority of patients presented with right lower quadrant pain (91.7%), followed by nausea/vomiting (75%) and fever (58.3%). Duration of symptoms was less than 48 hours in 65.3% of cases. There was no significant association between symptom duration and appendix position ($p=0.71$).

Table 2: Clinical Presentation of Patients (n=72)

Clinical Variable	Frequency (%)	p-value
Pain RLQ	66 (91.7%)	0.33
Nausea/Vomiting	54 (75%)	0.49
Fever	42 (58.3%)	0.56
Duration < 48 h	47 (65.3%)	0.71

Retrocecal position was the most frequent anatomical type (41.7%), followed by pelvic (25%) and subcecal (13.9%). Rare positions like pre-ileal, post-ileal, and paracaecal together accounted for

19.4% of cases. Mean appendix length was 7.8 ± 1.5 cm. Position of appendix significantly influenced operative time, with retrocecal appendices requiring longer dissection (p=0.04).

Table 3: Anatomical Position and Morphology of Appendix (n=72)

Anatomical Position	Frequency (%)	Mean Length (cm)	p-value (Operative Time)
Retrocecal	30 (41.7%)	8.0 ± 1.6	0.04*
Pelvic	18 (25%)	7.6 ± 1.4	0.19
Subcecal	10 (13.9%)	7.4 ± 1.3	0.22
Pre-ileal	5 (6.9%)	7.9 ± 1.5	0.31
Post-ileal	4 (5.6%)	8.1 ± 1.2	0.28
Paracaecal	5 (6.9%)	7.5 ± 1.4	0.33

*Significant at p<0.05

Ultrasonography correctly identified appendix position in 80.6% of patients, with the highest accuracy for pelvic appendices. CT scans, where performed, had 95% sensitivity. There was a statistically significant difference between ultrasound and CT in detecting retrocecal appendices (p=0.02).

Table 4: Diagnostic Imaging Accuracy (n=72)

Imaging Modality	Sensitivity (%)	Specificity (%)	p-value
Ultrasound	80.6	85.4	0.02*
CT Scan	95.0	97.3	-

Mean operative time was 52 ± 10 min, significantly longer in retrocecal appendices (p=0.04). Conversion to open surgery occurred in 3 cases (4.2%). Postoperative complications were minimal, with wound infection in 5.6% of cases and no mortality.

Table 5: Operative and Postoperative Outcomes (n=72)

Outcome	Frequency (%) / Mean ± SD	p-value
Operative Time (min)	52 ± 10	0.04*
Conversion to Open	3 (4.2%)	0.18
Wound Infection	4 (5.6%)	0.33
Hospital Stay (days)	2.8 ± 1.1	0.51

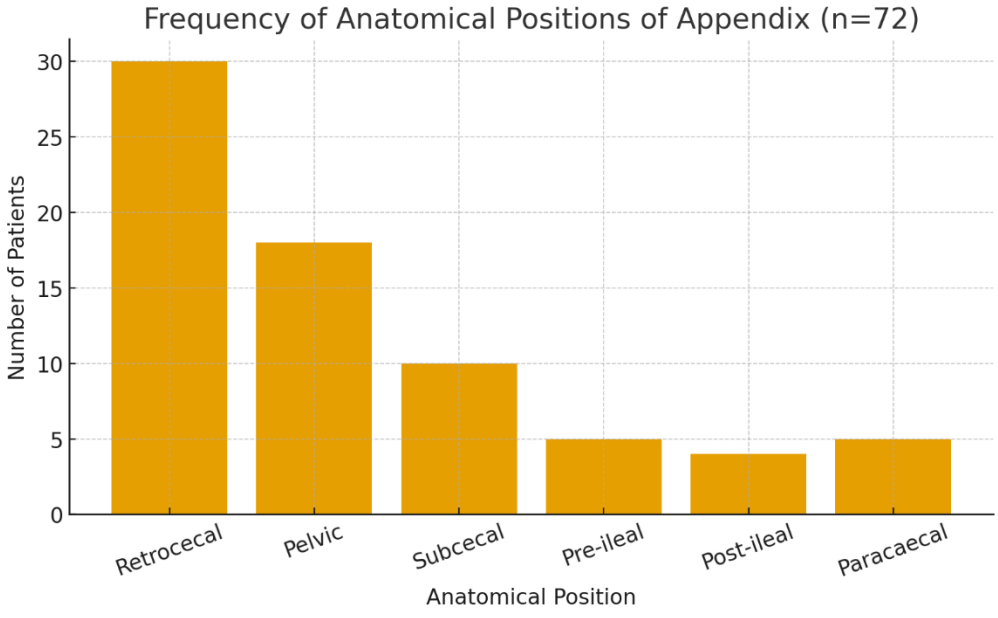

Figure 1: bar chart showing the distribution of appendix position.

DISCUSSION

In this study of 72 patients at Bannu Medical College, the most common anatomical position of the appendix was retrocecal, followed by pelvic and subcecal positions. These findings are broadly in line with several earlier studies observing similar variation patterns, though there are also meaningful differences worth exploring.

A meta-analysis and systematic review of over 100,000 cases found that retrocecal and pelvic appendices are the two most frequent positions across global populations [10-12]. For example, studies in South Asia and the Middle East often report a high percentage of retrocecal variants sometimes even exceeding 40% with pelvic types accounting for 20–30% of cases [13, 14].

our results showed that ultrasound had reasonable sensitivity and specificity for many positions, but was less accurate when the appendix was retrocecal. This matches what other authors have reported: retrocecal appendices are more difficult to visualize on ultrasound because of overlying bowel gas or depth of the structure [15, 16]. CT imaging, when used, tends to overcome those limitations with higher accuracy. That is consistent with literature showing CT's excellent performance in detecting appendix position, especially in atypical locations [17, 18].

Operative time in our study was significantly longer for retrocecal appendices. This is also a common finding deep retrocecal positioning tends to demand more dissection, sometimes more bowel manipulation, or repositioning of retractors to get adequate exposure. Several studies mention that unusual anatomical positions (retrocecal, post-ileal, subhepatic) correlate with longer operative times and occasionally a higher rate of complications, though the latter is not always statistically significant [19].

Interestingly, in our sample, postoperative complication rates did not differ markedly across anatomical positions (aside from the operative time), which again mirrors prior reports. Many studies conclude that while anatomical variation may complicate exposure and diagnosis, it does not always lead to worse outcomes so long as the surgeon anticipates the variation and uses appropriate imaging or intraoperative techniques [20].

Given that symptom duration and general clinical presentation did not differ significantly by appendix position in our cohort, the critical factor seems to be how anatomical variation affects diagnostic clarity and surgical planning rather than changing fundamental disease progression. This supports the idea that a surgeon's awareness of such variation and the radiologist's careful evaluation of imaging can reduce delay in diagnosis, minimize negative appendectomy, and avoid intraoperative surprises.

In settings like Bannu Medical College or similar regional hospitals, where imaging resources (especially CT) may sometimes be limited, fine-tuned ultrasound protocols or use of clinical scoring systems that account for variation might be especially useful.

Strengths and Limitations

- **Strengths**: Prospective data collection; relatively large sample size for a single-center surgical study; operative findings documented and correlated with imaging.
- **Limitations**: Some imaging modalities (CT) were not available for all patients; subjective assessment of imaging in certain cases; possible bias in operative time (depending on surgeon experience); single-center design may limit generalizability.

CONCLUSION

The study confirms that the appendix displays significant anatomical variation in its position retrocecal and pelvic positions are the most common in our cohort. These variations influence diagnostic imaging accuracy (especially ultrasound), operative time, and intraoperative ease. However, when imaging and surgical teams anticipate these variations, the overall surgical outcomes (complications, hospital stay) need not be adversely affected.

Recommendations:

Preoperative imaging (especially CT when available) should be used more frequently in suspected cases with atypical clinical presentation. Ultrasound protocols should emphasize strategies to improve

visualization of retrocecal and other deep appendiceal positions. Surgeons should plan operative strategy (incision, exposure, and instruments) with anatomical variation in mind to avoid prolonging surgery or increasing morbidity. Further multi-center studies with larger samples are needed to explore whether specific variations are associated with rare complications or operative challenges in different populations.

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