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Effect of Vermiform Appendix Anatomical Variations on Laparoscopic Surgical Outcomes in Appendicitis: Systematic Review

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ABSTRACT

The most common surgical cause of abdominal pain is appendicitis, and its diagnosis is affected by anatomical variations of the vermiform appendix. The appendix may be in different positions, but the base of the appendix is attached to the cecum. Based on positional variations, the appendix is classified as retrocecal, pelvic, anterior, or subhepatic. This study aims to evaluate the effect of anatomical variations in appendix position on laparoscopic surgical outcomes. This study uses a systematic review method following the PRISMA 2020 guidelines. Literature searches were conducted through the Scopus and Google Scholar databases for the 2016–2026 period using the PICOS framework. The selection process identified two articles that met the inclusion criteria. Both articles reported similar findings regarding anatomical variations of the appendix and surgical outcomes. The most common finding associated with each anatomical variation of the appendix during surgery was appendiceal rupture, with a higher risk observed in the subhepatic appendix position. In addition, the subhepatic appendix position requires a longer operative time compared to other appendix positions. Meanwhile, the pelvic appendix position has a higher rate of postoperative intestinal obstruction compared to other appendix positions. In conclusion, variations in the anatomical position of the appendix have differing levels of impact on surgical and postoperative outcomes, particularly in the subhepatic and pelvic positions. This is reflected in the most common complications, such as appendiceal rupture, prolonged operative time, and an increased risk of postoperative intestinal obstruction.

INTRODUCTION

Appendix is a diverticulum of the cecum and marks the beginning of the colon at the confluence of the taeniae coli. It has a wormlike structure and arises during embryological development from the posteromedial wall of the cecum, about 2 cm below the ileocecal valve. The appendix contains lymph follicles, and lymphoid tissue first emerges in the appendix about 2 weeks after birth. Its epithelial lining has a surface coat of immunoglobulins, which may be involved in the control of lymphatic surveillance (Vieira et al., 2019). The appendix develops from the midgut loop together with the cecum, ascending colon, and the proximal two-thirds of the transverse colon. The vermiform appendix is characterized by anatomical variations and congenital abnormalities, including variations of the mesoappendix; such variations may be associated with acute appendicitis (De León Benedetti & De León Martínez, 2021). Four positions of the vermiform appendix have been described: anterior (the tip of the appendix lies anterior to the cecum, in the greater pelvis), retrocecal (the tip of the appendix lies posterior to the cecum, in the right iliac fossa), pelvic (the tip of the appendix lies in the lesser pelvis), and subhepatic (the tip of the appendix lies posterior to the cecum and reaches the subhepatic area) (Induchoodan et al., 2023).

Acute appendicitis is considered the most frequent cause of abdominal pain requiring emergency surgery, with a mortality risk of 6%–7% from its onset (Uttinger et al., 2024). Appendectomy is one of the most frequent emergency surgical procedures, with lifetime risks of approximately 12% for men and 25% for women. It is among the most commonly performed emergency procedures worldwide, with an estimated 17.7 million new cases globally in 2019 (Aziz et al., 2021). Consequently, emergency appendectomy, particularly in the form of laparoscopic appendectomy, has been advocated as the state of the art due to the high morbidity and mortality rates associated with complicated appendicitis (GBD Collaborators, 2024).

Laparoscopic surgery, sometimes referred to as minimally invasive surgery, has transformed the field of surgery by offering less invasive alternatives to conventional open procedures (Harriott & Sadava, 2024). This technique uses a laparoscope—a small video camera inserted through a small incision in the patient's skin—that captures high-quality, magnified images of organs within the abdominal cavity, enabling surgeons to perform precise maneuvers using a monitor. Studies have shown that laparoscopic appendectomy is safe and suitable for various anatomical positions of the inflamed appendix, with benefits including shorter hospital stays and reduced postoperative pain compared to open surgery (Ruiz et al., 2024). However, the existing literature provides limited information on the effect of anatomical variations on surgical outcomes and complications following laparoscopic appendectomy (Iqbal et al., 2024). Moreover, there is little information on best surgical practices in cases involving anatomical variations of the appendix during laparoscopy (Castro et al., 2019).

Therefore, the objective of this study is to systematically review and analyze the effect of anatomical variations of the vermiform appendix on laparoscopic surgical outcomes in patients with appendicitis. This includes evaluating intraoperative findings, operative time, and postoperative outcomes such as complications and length of hospital stay. The benefits of this study are both theoretical and practical. Theoretically, this research contributes to the development of medical knowledge, particularly in the fields of surgical anatomy and minimally invasive surgery, by providing a comprehensive synthesis of existing evidence regarding appendiceal variations and their clinical impact. Practically, the findings of this study are expected to assist surgeons in improving preoperative assessment and surgical planning, thereby reducing the risk of complications and enhancing patient outcomes. Additionally, this study may serve as a reference for future research in developing standardized surgical approaches for different anatomical variations of the appendix.

METHOD

The method used in writing this article is a systematic review, which is a literature-based study that critically examines knowledge, ideas, or findings published in high-quality health journals. The information is organized and analyzed theoretically and methodologically for a specific topic. The strategy used in searching for articles involved selecting research articles relevant to the topic from the Scopus and Google Scholar databases. The literature search was limited to a 10-year range (2016–2026) using the keywords: "appendicitis," "vermiform appendix," "appendix anatomical variation," and "surgical outcomes appendectomy."

The literature obtained consisted of full-text articles, and a screening/elimination process was conducted using the PRISMA 2020 guidelines and the PICOS framework.

The population in this study consisted of patients with appendicitis who underwent laparoscopic appendectomy. The intervention examined was the anatomical position of the vermiform appendix. Differences in the anatomical position of the vermiform appendix were compared in relation to the outcomes of laparoscopic surgery, including intraoperative and postoperative complications, duration of surgery, and length of postoperative hospital stay.

The PRISMA method used in this article is adapted according to the figure below.

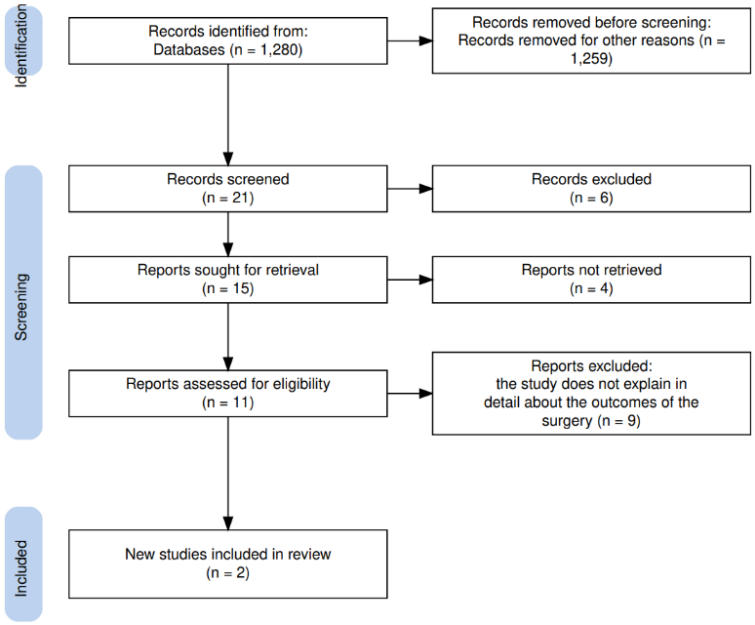

Figure 1. PRISMA 2020 Guidelines

Source: Adapted from PRISMA 2020 Statement (Page et al., 2021), processed by the authors

Based on the PRISMA 2020 guidelines shown in the figure, 1,280 studies were identified and then screened according to the inclusion criteria and relevance for analysis. After the elimination process, 2 articles met the specified criteria and were included in the study.

RESULTS AND DISCUSSION

Table 1. Population and Method

No	Author	Title Journal	Population	Method
1	Atif Iqbal , et all	Evaluation of Laparoscopic Appendectomy in Response to Anatomical Variation of Appendix	91 patiens	cross-sectional study
2	Belén Aneiros Castro, et all	Impact Of The Appendiceal Position On The Diagnosis And Treatment Of Pediatric Appendicitis	1.736 patiens	Cohort study (retrospective)

Source: Compiled and analyzed by the authors based on Iqbal et al. (2024) and Castro et al. (2019)

Table 2. Variation of Appendix and Intra Operative Finding

`No	Author	Variation of appendix		Intra Operative Finding		
		Variation	N	Appendiceal Rupture	Appendiceal bleeding	Operative time (minutes)
1	Atif Iqbal , et all	Anterior	54	7%	2.1%	55.7
		Pelvic	10	11%	3%	56.9
		Retrocecal	19	13.6%	2.9%	64.8
		Sub-hepatic	8	17.1%	1.9%	79.2
2	Belén Aneiros Castro, et all	Anterior	1.366	8%	2.4%	55.6
		Pelvic	66	9%	3%	56.8
		Retrocecal	248	11.6%	2.8%	63.2
		Sub-hepatic	56	14.2%	1.7%	75.6

Source: Compiled and analyzed by the authors based on Iqbal et al. (2024) and Castro et al. (2019)

Table 3. Variation of Appendix and Post Operative Finding

No	Author	Variation of appendix		Post Operative Finding	
		Variation	N	Hospital stay (days)	Bowel Obstruction
1	Atif Iqbal , et all	Anterior	54	2.7	2.1%
		Pelvic	10	3.5	7.7%
		Retrocecal	19	2.8	0
		Sub-hepatic	8	3.1	0
2	Belén Aneiros Castro, et all	Anterior	1.366	4.9	1.4%
		Pelvic	66	6.5	9%
		Retrocecal	248	4.5	0
		Sub-hepatic	56	6.1	0

Source: Compiled and analyzed by the authors based on Iqbal et al. (2024) and Castro et al. (2019)

Based on the two studies analyzed, all patients were diagnosed with appendicitis and underwent laparoscopic appendectomy. The reported anatomical variations of the appendix included anterior, pelvic, retrocecal, and sub-hepatic positions, with differences in the number of cases as well as intraoperative and postoperative outcomes. This pattern is consistent with previous cadaveric and radiological studies demonstrating that the anterior position is the most common, while subhepatic and pelvic positions are less frequent but clinically more challenging (Arif et al., 2024).

The study conducted by Atif Iqbal et al. involved 91 patients using a cross-sectional study design. The most common appendiceal position was anterior with 54 cases, followed by retrocecal (19 cases), pelvic (10 cases), and sub-hepatic (8 cases) (Iqbal et al., 2024). The highest rate of appendiceal rupture was found in the sub-hepatic position (17.1%), followed by

retrocecal (13.6%), pelvic (11%), and anterior (7%). This finding aligns with previous reports suggesting that the subhepatic appendix position frequently leads to delayed diagnosis and higher rates of perforation due to its atypical location mimicking hepatobiliary pathology (Sun et al., 2022). Intraoperative findings showed that the incidence of appendiceal bleeding was relatively low across all anatomical variations, with the highest rate observed in the pelvic position (3%) and retrocecal position (2.9%), while the sub-hepatic position had the lowest rate at 1.9%. The average operative time varied according to appendiceal position, with the longest duration observed in the sub-hepatic position (79.2 minutes), followed by retrocecal (64.8 minutes), pelvic (56.9 minutes), and anterior (55.7 minutes). Prolonged operative time in the subhepatic position has been attributed to the need for additional port placement, cecal mobilization, and careful dissection due to anatomical complexity (Ng et al., 2025). The length of hospital stay ranged from 2.7 to 3.5 days, with the longest hospitalization observed in the pelvic position (3.5 days). Postoperative bowel obstruction was reported in the anterior (2.1%) and pelvic (7.7%) positions, whereas no cases were found in the retrocecal and sub-hepatic positions. The elevated rate of bowel obstruction in the pelvic position is consistent with the proximity of the inflamed appendix to the pelvic viscera and peritoneal surfaces, which increases the risk of adhesion formation (Håkanson et al., 2020).

The second study conducted by Belén Aneiros Castro et al. used a retrospective cohort study design with a total of 1,736 patients. The most frequently observed appendiceal position was anterior (1,366 cases), followed by retrocecal (248 cases), pelvic (66 cases), and sub-hepatic (56 cases) (Castro et al., 2019). The highest rate of appendiceal rupture was also observed in the sub-hepatic position (14.2%), followed by retrocecal (11.6%), pelvic (9%), and anterior (8%). These perforation rates are consistent with findings from CT-based studies showing that subhepatic appendicitis frequently presents atypically, leading to diagnostic delays that increase the risk of rupture (Singhal et al., 2024). The incidence of intraoperative appendiceal bleeding was relatively similar across all anatomical positions, ranging from 1.7% to 3%, with the highest rate observed in the pelvic position (3%). The longest mean operative time was again observed in the sub-hepatic position (75.6 minutes), followed by retrocecal (63.2 minutes), pelvic (56.8 minutes), and anterior (55.6 minutes). Research has shown that preoperative CT imaging can play a crucial role in predicting operative complexity and duration, particularly for appendiceal anatomical variations (Tanır & Ekinci, 2024). The length of hospital stay ranged from 4.5 to 6.5 days, with the longest duration observed in the pelvic position (6.5 days). Postoperative bowel obstruction was reported in the anterior (1.4%) and pelvic (9%) positions, while no cases were reported in the retrocecal or sub-hepatic positions. The risk of postoperative small bowel obstruction has been linked to perforated appendicitis and intra-abdominal abscess formation, both of which are more prevalent in complicated anatomical presentations (Sghaier et al., 2023).

Overall, both studies demonstrated a consistent pattern in which the sub-hepatic position tended to be associated with a higher rate of appendiceal rupture and longer operative time. This is consistent with the literature indicating that subhepatic appendicitis poses significant diagnostic and therapeutic challenges, often requiring advanced laparoscopic techniques and additional trocar placement (Al-Kharabsheh et al., 2020). In contrast, the pelvic position showed a tendency toward longer hospital stays and a higher incidence of bowel obstruction compared to other appendiceal variations. The elevated bowel obstruction rate in pelvic

appendicitis has been attributed to greater proximity to the rectosigmoid and pelvic peritoneum, which promotes adhesion formation and subsequent obstruction (Harriott & Sadava, 2024).

CONCLUSION

Based on the two studies analyzed, anatomical variations in the position of the appendix influence intraoperative findings and postoperative outcomes in patients with appendicitis undergoing laparoscopic appendectomy. The most frequently observed appendiceal position was anterior, followed by retrocecal, pelvic, and sub-hepatic, a distribution consistent with previous population-based studies (Arif et al., 2024). The sub-hepatic position tended to be associated with a higher rate of appendiceal rupture and longer operative time compared with other anatomical variations, likely due to its atypical location and the technical complexity of dissection in the subhepatic region (Sun et al., 2022). Meanwhile, the pelvic position was associated with longer hospital stays and a higher incidence of postoperative bowel obstruction, which may be explained by the proximity of the inflamed appendix to pelvic structures that promote adhesion formation (Håkanson et al., 2020). Overall, variations in appendiceal position may affect the complexity of the surgical procedure and the clinical outcomes of patients. Therefore, understanding the anatomical variations of the appendix is important to assist in surgical planning, reduce the risk of complications, and improve clinical outcomes in patients with appendicitis undergoing laparoscopic appendectomy. Therefore, it is recommended that surgeons consider preoperative imaging and anatomical assessment more carefully to identify appendiceal position prior to surgery, as computed tomography has demonstrated high sensitivity and specificity in identifying appendiceal location and perforation risk (Tanır & Ekinci, 2024). The clinical symptoms of appendicitis may be significantly altered by appendiceal position, particularly in subhepatic and pelvic cases where presentations can mimic other pathologies and delay surgical intervention (Singhal et al., 2024). In addition, further large-scale and multicenter studies are needed to strengthen the evidence regarding the relationship between appendix anatomical variations and laparoscopic surgical outcomes, as well as to develop standardized surgical strategies for managing different anatomical variations. The mesoappendix position classification system proposed by Ng et al. (2025) represents a promising framework for guiding intraoperative decision-making in cases with complex appendiceal anatomy.

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