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Original Article

Surgery Section

Variability in the Position of the Tip of Appendix: A Cross-sectional Analytical Study in South Indian Population

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ABSTRACT

Introduction: The fact remains that there are still some ambiguities in our understanding of the locations of the vermiform appendix. Understanding the changes in the position of the vermiform appendix is significant because, in cases of appendicitis, its varying locations may result in varying symptoms and warning indications that mirror those of other illnesses.

Aim: To determine any difference between the surgical and anatomical assessment of the position of the appendix.

Materials and Methods: A cross-sectional study was conducted in the Departments of General Surgery and Forensic Medicine, Government Medical College, Thiruvananthapuram, Trivandrum, Kerala, India, from January 2020 to July 2021. The position of the appendix in a total of 224 patients was studied, of which 115 were surgical patients and the rest (109) were autopsy cases. All consecutive patients who met the inclusion criteria undergoing appendicectomy were included in the study. A similar procedure was followed in the autopsy series, with the consent of the nearest relatives. The mean and standard deviation were used to summarise continuous data, whereas absolute numbers and percentages were used to summarise categorical data. The prevalence of the position of the appendix was reported as a percentage.

Results: The mean ± standard deviation (SD) age for the whole study group was 37.47 ± 19.30 years, and there were 149 (66.52%) males. The most common position of the appendix in the surgical arm was retrocaecal (n=58, 50.43%), and the most common position in the autopsy arm was pelvic (n=36, 33.0%). Overall, the most common position of the appendix was retrocaecal (n=86, 38.39%). Apart from a very mild correlation between age and length of the appendix, with a Pearson's correlation coefficient of -0.2808, there was no correlation between the dimensions of the appendix and anthropometric parameters.

Conclusion: The most common position of the appendix is found to be retrocaecal, followed by pelvic and subcaecal. Also, considering the various factors that may influence the position of the appendix, it is difficult to state one position as the most common one.

Keywords: Appendicitis, Appendicectomy, Autopsy, Retrocaecal

INTRODUCTION

Appendicectomy is among the most commonly performed emergency procedures worldwide [1]. The history of appendicectomy began in December 1735 when Claudius Amayand operated on an 11-year-old boy, who presented with a long-standing hernia and fecal fistula [2]. Interestingly, the hernia was approached through a scrotal incision, which revealed an appendix that was perforated with a pin, giving rise to the fecal fistula [3]. In fact, many prominent figures in surgery like Dupuytren failed to recognise appendicitis as a major cause of Right Iliac Fossa (RIF) pathology, instead considering typhlitis as a better explanation for RIF pathology [4]. In June 1886, Reginald Heber Fitz presented his paper titled "Perforating inflammation of the appendix with special reference to its early diagnosis and treatment" in the first meeting of the Association of American physicians, which subsequently revolutionised the outlook towards the management of acute appendicitis [2]. In this paper, he emphasised the need for early surgical removal of the appendix, and in fact, the term 'appendicitis' was used for the first time. Even though their incidence has been gradually dropping as non-operative treatment of uncomplicated appendicitis has gained increasing acceptance, appendectomies remain one of the most frequently performed procedures in general surgery [1]. It is often the first major procedure for someone entering into the art of surgery.

The appendix is a blind-ending tube that joins the posteromedial wall of the cecum where the three taeniae coli coalesce. A thorough knowledge of surgical anatomy is key to success in any surgical dissection. Unlike any other organ in the human body, the position of the appendix is found to be extremely variable [5]. As truly stated by Maingot, the vermiform appendix is the only organ in the human body that does not have a fixed anatomy [5]. If the published literature is perused, there is considerable variation in the position of the appendix. The length usually varies from 6 cm to 9 cm [6,7]. The mesoappendix is a small triangular mesentery running between the terminal ileum and appendix. The appendicular artery, which is a branch of the inferior division of the ileocolic trunk, runs through the mesoappendix [8]. McBurney's point is traditionally considered as a surface marking for eliciting tenderness in suspected acute appendicitis [9]. The base of the appendix is usually located at this point, but the rest of the appendix can be in different positions around the cecum.

The position of the appendix and the development of the cecum are closely connected. The fetal intestine returns to the abdominal cavity after the 10th week of intrauterine life, causing the cecum to gradually descend into the RIF with a counterclockwise twisting motion around its longitudinal axis [10]. Concurrently, the anterolateral wall of the cecum stretches and grows faster than the other parts, causing the appendix to shift from its original position at the apex of the cecum to an anteromedial position. During this process of caecal descent, the appendix can bend behind the cecum, and if peritoneal lining development is occurring at the same time, the appendix will remain fixed in this retrocaecal posture [11]. However, if the appendix remains free and directed downward during the caecum's descent, the appendix will remain permanently as an organ with free mobility.

Retrocaecal is described as the most common position in most anatomical and surgical textbooks [12]. This position is of special interest to treating surgeons because of the associated difficulty in diagnosis and surgical management [13]. Classical signs of appendicitis

are often found to be absent in a true retrocaecal appendix because of its retrocaecal position [14]. Dissecting an inflamed appendix that is in a retrocaecal position can be very difficult, whether in an open or laparoscopic approach. The majority of textbooks on anatomy employ illustrations to describe various positions of the appendix. The retrocaecal position is not well defined as it can be different in a mobile cecum and a fixed cecum. In a patient with a fixed cecum, the retrocaecal position will be retroperitoneal, while in a mobile cecum, it will be intraperitoneal [15]. So, in a case when the cecum is well mobile, determining between a subcaecal and retrocaecal position can be difficult. The aim of the present study was to determine the most common position of the appendix. Additionally, the authors attempted to compare the position of the appendix by autopsy and by surgical description and thus determine the factors that may influence determining the position of the appendix.

MATERIALS AND METHODS

A cross-sectional study was conducted simultaneously at the Departments of General Surgery and Forensic Medicine, Government Medical College, Thiruvananthapuram, Trivandrum, Kerala, India, from January 2020 to July 2021. The study was carried out in accordance with the regulations of the Helsinki Declaration, after obtaining clearance from the Human Ethics Committee (HEC. No.09/2019/MCT). The authors studied the position of the appendix in a total of 224 patients, of which 115 were surgical patients and the remaining 109 were autopsy cases. Consecutive patients undergoing appendicectomy were included in the study after obtaining their informed consent. A similar procedure was followed in the autopsy series, with the consent of the nearest relatives.

Inclusion criteria:

- For operated cases: Patients aged above 14 years who were operated for acute appendicitis during the study period.
- For autopsy cases: Cases brought for autopsy aged above 14 during the study period.

Exclusion criteria:

- For operated cases: Patients for whom the appendix was partially or completely sloughed off, patients with appendicular mass where position determination was difficult, and patients with a previous history of abdominal surgeries were excluded from the study.
- For autopsy cases: Any evidence of previous abdominal surgeries and any evidence of abdominal trauma were excluded from the study.

Study Procedure

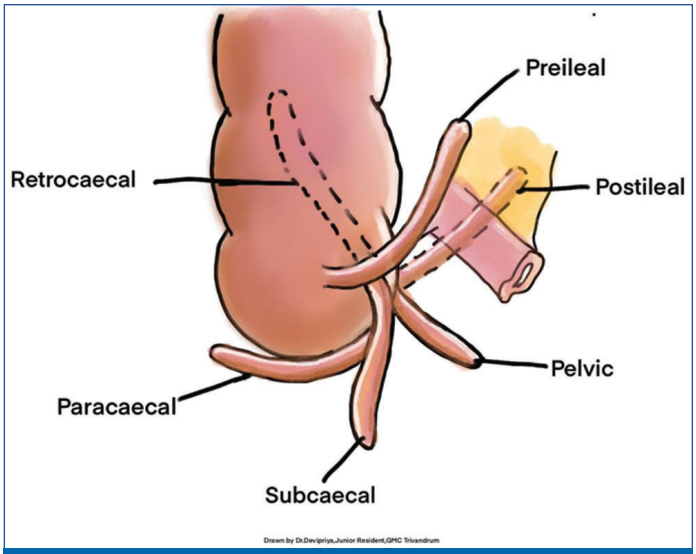
Intraoperatively and during autopsy, the authors documented the position of the tip of the appendix. The following positions were distinguished [Table/Fig-1]:

- **Retrocaecal:** appendix located behind and above the caecum or ascending colon
- **Paracaecal:** appendix located lateral to the caecum and ascending colon
- **Subcaecal:** appendix located inferior to the caecum
- **Pelvic:** 'Pointing' to the pelvis with an inferiorly oriented appendix
- **Pre-ileal and post ileal:** appendix located anteriorly and superiorly or posteriorly and superiorly to the ileum.

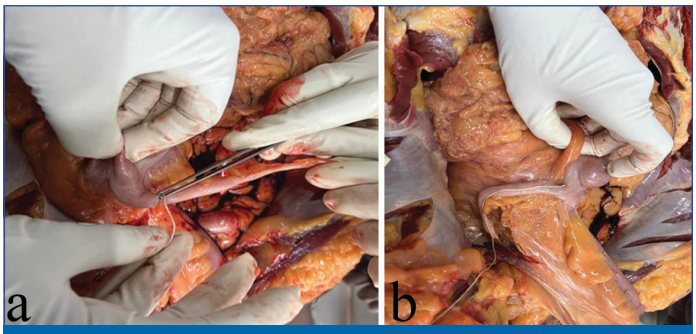
Basic demographic data were collected from all patients. In the autopsy specimens, in addition to the position of the appendix, the authors routinely collected data on the dimensions of the appendix. A cotton thread was used to measure the length of the appendix from base to tip, and the circumference was measured and later straightened against the ruler [Table/Fig-2a,b].

STATISTICAL ANALYSIS

Continuous data were summarised using mean and standard deviation, while categorical data were presented as absolute numbers and percentages. The position of the appendix was reported as a percentage. A proportion test was conducted to compare the various positions of the appendix in the surgical and autopsy series. Pearson's correlation test was used to examine the correlation between the patients' anthropometric data, age, and the dimensions of the appendix. All data analysis was performed using R statistical software version 4.2.3.



[Table/Fig-1]: Schematic representation of different positions of appendix.



[Table/Fig-2]: Measurement of a) length and b) circumference of appendix during autopsy.

RESULTS

The mean±SD age for the entire study group was 37.47±19.30 years. There were 149 (66.52%) males and 75 (33.48%) females in the entire series. The mean±SD height was 1.66±0.19 meters, while the mean±SD weight was 61.41±12.13 kg. The mean age in the autopsy series was 48.83±18.32 years, and in the surgery group, it was 26.70±13.06 years. Out of the 109 autopsy cases, 71 (65.14%) were males, whereas in the surgical series, 78 (67.83%) were males. The autopsy specimens had a mean length of 9.10±2.98 cm and a mean circumference of 2.32±0.94 cm. The most common position in the surgery series was retrocaecal, followed by pelvic, whereas in the autopsy series, the pelvic position was the most common, followed by retrocaecal [Table/Fig-3]. A proportion test showed a statistically significant difference in the most common position of the appendix between these two groups, with a z-value of 3.7417 (p-value=0.0018). There was a very mild correlation between age and length of the appendix, with a Pearson's correlation coefficient of -0.2808. Although the p-value was below 0.05, the very weak coefficient ruled out any correlation [Table/Fig-4].

DISCUSSION

In the worldwide literature, there is a plethora of research on the usual positions of the vermiform appendix. The largest series reviewed included 3000, 10000, and 4680 appendices, as well as a meta-analysis of 114080 appendices [6,10,11,16]. Most standard textbooks in surgery consider the retrocaecal position as the

Position of appendix	Autopsy group n (%)	Surgery group n (%)	Overall n (%)
Paracaecal	5 (4.6)	6 (5.22)	11 (4.91)
Pre-ileal	11 (10.1)	16 (13.91)	27 (12.05)
Pelvic	36 (33.0)	28 (24.35)	64 (28.57)
Post ileal	5 (4.6)	2 (1.74)	7 (3.13)
Retrocaecal	28 (25.7)	58 (50.43)	86 (38.39)
Subcaecal	24 (22.0)	5 (4.35)	29 (12.95)
n	109	115	N=224

[Table/Fig-3]: Distribution of position of appendix among surgical and autopsy groups.

Parameters	Length		Circumference	
	R score	p-value	R score	p-value
Age	-0.2808	0.00224	0.0711	0.38084
Height	0.129	0.31186	-0.168	0.12711
Weight	-0.0413	0.67888	0.0167	0.88103

[Table/Fig-4]: Correlation tests between age, height and weight of autopsy group with length and circumference of the appendix.
R score: Pearson's Correlation Coefficient

most common position for the appendix. However, in Bailey and Love's textbook of surgery, which is widely used for undergraduate teaching, the retrocaecal position is reported as the most prevalent (74% of the time), which is difficult to accept [17].

Most of the larger studies in the literature are based on intraoperative findings during open appendicectomy or from cadaveric studies. Among these, Sir Cecil PG Wakeley's research on 10,000 cadavers stands out as the most illustrious work [10]. In his paper published in 1933, Wakeley challenged the popular teaching of that time by renowned anatomist Frederic Treves. Treves and many other widely used textbooks of the era believed that the "Splenic" or post ileal location of the appendix was the most typical. However, Wakeley's investigation refuted this notion, demonstrating that the retrocaecal position of the appendix was the most frequent (65.28%), while the splenic position was quite rare (0.40) [10]. Since then, many textbooks have cited the findings of this study, and it is now widely believed that the appendix is typically located in the retrocaecal position. In the present study, there was a statistically significant difference in the position of the appendix between the surgical and autopsy groups (p-value<0.0018). The retrocaecal position was the most common in the surgical series, whereas the pelvic position was found to be the most common in the autopsy series.

The authors hypothesize that the difference in the most common position may be due to the following reasons. In the present study institution, most emergency appendectomies are performed via an open approach, preferably through Lanz incisions. This approach makes it very difficult to determine the exact position of the appendix. Often, the operating surgeon may feel that they are delivering the appendix from a retrocaecal position even when it is not the case. Periappendiceal infection and inflammation can make the appendix more adherent to the retrocaecal position. Another notable observation is that the subcaecal position is relatively low in the surgical series (4.35%), whereas it is higher (22%) in the autopsy series. This difference may not represent a true anatomical difference due to the reasons mentioned above. A subcaecal appendix may shift to a more retrocaecal location when inflammation and adhesions increase. It is possible to mistake a subcaecal position for a retrocaecal position during an open dissection, which may explain the increased incidence of retrocaecal appendix in the surgical series.

From the previous data examined, it can be inferred that the combined incidence of subcaecal and retrocaecal positions in the autopsy arm is comparable to the incidence of retrocaecal position in the surgical arm. The authors believe that radiographic evaluation in individuals without any known appendicular pathology will be the most accurate technique to establish the most typical position of the appendix, considering all the variables that could affect it. Ultrasound (USG), Magnetic Resonance Imaging (MRI), and Computed Tomography (CT) have frequently been used in radiological studies to localise the appendix. However, ultrasound examination has its drawbacks, as it can be challenging to

visualise a normal appendix in an obese person, especially when it is retrocaecally placed. The accuracy of CT and MRI for locating the appendix is comparable. Interestingly, none of the radiological studies identified the retrocaecal location as the most common one [18-20]. Various studies from the literature show contradicting findings regarding the position of the appendix, as summarised in [Table/Fig-5] [5,7,10-12,16,18-23].

On the other hand, the strength of the present study lies in its focus on the actual prevalence of retrocaecal appendix position in surgical and autopsy cases, compared to the expectations based on standard anatomical teachings. The authors have taken steps to ensure the ethical conduct of the study by collecting data from both surgical and autopsy cases and obtaining informed consent. The use of statistical analysis to compare the position of the appendix between the two groups adds rigor to the study. The inclusion of demographic data such as age, height, and weight allows for an exploration of potential correlations with the position and dimensions of the appendix. The finding of a statistically significant difference in the most common position of the appendix between the surgical and autopsy groups adds to the existing knowledge on the subject. Overall, the present study provides valuable insights into the actual prevalence of retrocaecal appendix position and factors that may influence its determination.

There are several potential directions for future research in the field based on the findings of the current study. First, larger studies with more diverse patient populations could be conducted to confirm the

Study reference	N	Country	Type	ReC	SuC	Pe	PaC	Pol	Prl	Others
Mwachaka P et al., [21]	48	Kenya	Anatomic	27.1%	4.2%	25%	2.1%	18.8%	18.8%	Subhepatic- 4.2%
Ghorbani A et al., [22]	200	Iran	Autopsy	7%	19%	55.1%	-	12.5%	1.5%	Ectopic-4.2%
de Souza SC et al., [5]	377	Brazil	Autopsy	43.5%	24.4%	9.3%	5.8%	14.3%	2.4%	Other positions-0.27%
Khatun S et al., [7]	264	Nepal	Surgical	35.98%	11.36%	25.37%	-	23.1%	4.16%	-
Ahmed I et al., [23]	303	UK	Laparoscopy	20.1%	-	51.2%	3.6%	22.1%	3%	High lying- 4.3%
O'Connor CE and Reed WP [12]	129	USA	Surgical	28%	13%	19%	13%	7%	5%	Subileal-15%
Wakeley CPG [10]	10000	UK	Anatomic	65.28%	2.26%	31.01%	-	0.4%	1%	Ectopic-0.05%
Gladstone RJ and Wakeley CPG [11]	3000	UK	Combined	69.2%	1.86%	27.5%	-	0.5%	0.9%	Ectopic-0.033%
Kacprzyk A et al., [16]	114080	Poland	Meta-analysis	32.1%	13.2%	28.5%	7.5%	5.4%	9.7%	Anterocecal-4%, hepatic-2.4%, other-3%
Altunkas A et al., [18]	1245	Turkey	Radiologic	18%	23%	32%	3%	18%	6%	-
Willekens I et al., [19]	186	Belgium	Radiologic	19.5%	-	66%	8.5%	-	-	Other positions-6%
Lee SL et al., [20]	1157	Korea	Radiologic	10.9%	42.8%	16.2%	3%	9%	1.7%	Subileal-12.9%

[Table/Fig-5]: Distribution of position of appendix as quoted by various authors [5,7,10-12,16,18-23].
ReC: Retrocaecal; SuC: Subcaecal; Pe: Pelvic; PaC: Paracaecal; Pol: Post ileal; Prl: Pre-ileal

findings of the present study and better understand the prevalence and characteristics of retrocaecal appendix position. This could include studies in different geographical regions, as well as studies with a wider range of demographic factors. Second, research could focus on identifying factors that may influence the position of the appendix, such as genetics, diet, and environmental exposures. This could help explain the variations in appendix position and aid in the diagnosis and treatment of appendicitis. Finally, further research could examine the impact of different surgical approaches on the success of appendicectomy in cases of retrocaecal appendix position. This could inform the development of guidelines for the optimal management of this condition. Overall, there is a need for ongoing research in this field to advance our understanding of the anatomy and surgical management of appendicitis.

Limitation(s)

First, the sample size of 224 patients may not be large enough to accurately represent the general population and therefore may not be sufficient to detect more subtle correlations. Second, the study was conducted at a single institution, which may limit the generalisability of the findings to other populations and settings. Third, the exclusion of patients with a history of previous abdominal surgeries may not accurately reflect the true prevalence of retrocaecal appendix position in the general population. Fourth, the use of both surgical and autopsy cases may introduce bias, as the position of the appendix may be affected by the disease process or other factors present in the patient. Another important factor is the lack of a proper definition for the positions of the appendix, which can make the results ambiguous. An open dissection through a small RIF incision makes it very difficult to determine the exact position of the appendix unless it is anteriorly located, and subsequently, there could be considerable overlap between subcaecal, paracaecal, and retrocaecal positions. The authors also did not stratify the patients based on the type of incision used. Additionally, the authors did not collect radiographic data on the position of the appendix.

CONCLUSION(S)

The most common positions of the appendix were retrocaecal, pelvic, and subcaecal. There was a statistically significant difference in the most common position of the appendix between the surgical and autopsy groups. The findings of the present study suggest that the actual prevalence of retrocaecal appendix position may be lower than expected based on standard anatomical teachings. Inflammatory adhesions may change the actual position of the appendix, and the surgical approach to appendicitis may alter the determination of the position of the appendix. However, the authors are not convinced whether the retrocaecal position predisposes to appendicitis or vice versa. The best approach to solve this conundrum, given all the variables that could affect the location of the appendix, will be a large-scale radiological study in individuals without any appendicular pathology.

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