SCIENTIFIC ARTICLE

Assessment of the anatomical position of the vermiform appendix in a Sri Lankan cohort using contrast enhanced computed tomography imaging

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Abstract

Introduction: Proper and advanced knowledge regarding the anatomical position of the appendix is important for radiologists, surgeons, and clinicians in diagnosing pathological conditions of the appendix.

Objectives: To assess the anatomical position, length, diameter, and luminal contents of the appendix in Contrast-Enhanced Abdominal CT (CECT) scans.

Methodology: A descriptive cross-sectional study was conducted at the Department of Radiology at Teaching Hospital Peradeniya over a period of one year, from May 2022 to April 2023. A total of 275 patients were included in the study. All abdominal CECTs among the patients who fulfilled the inclusion criteria during the study period were included. Post-contrast, a 70-second delay in the portal venous phase with a slice thickness of 1.0 mm for 3D reconstructed images was used to assess the anatomical position of the appendix. The CT scans were evaluated based on the anatomical details of the appendix, which included length, the maximum values of inner and outer diameter, and the position of the base and tip of the appendix. Descriptive statistics were used to analyze the demographic profile of the study sample.

Results: The mean age of patients was 57 years, with the majority being male (54.2%). The appendix was identified in only 87% of the abdominal CECT scans. The mean length of the appendix was 6.45 cm, and the mean inner and outer diameters were 3.90 mm and 5.49 mm, respectively. The mean length from the ileocecal valve to the base of the appendix was 2.31 cm. Approximately 42% of the appendices were located in the pelvic 5 o'clock position, while the pre-ileal 1-2 o'clock and retrocecal 11 o'clock positions were identified in approximately 28% and 11%, respectively. A statistically significant association was demonstrated between gender and the mean outer diameter of the appendix ($p < 0.05$).

Conclusion: The findings of the present study provide information about anatomical details of the appendix which is useful for radiologists as well as clinicians for diagnosis and treatment planning

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Introduction

The vermiform appendix is a small but significant abdominal organ, often assessed by radiologists during abdominal CT scans in patients with various abdominal complaints. A thorough understanding of its anatomy, including common variants and unique characteristics, is critical for effectively visualizing and diagnosing conditions related to the appendix through imaging techniques [1],[2]. Accurate identification of the appendix is essential for managing diseases that involve this organ.

Typically, the vermiform appendix measures between 8-10 cm in length and has a thin wall with a diameter of about 6 mm. It is attached to the posteromedial surface of the cecum, located approximately 1-3 cm below the ileocecal valve [3],[4],[5]. Research indicates that the length and anatomical positioning of the appendix can vary significantly, influenced by demographic factors such as age, sex, and ethnicity [6].

The commonest anatomical position of the appendix is retrocecal (74%), followed by pelvic (21%). Other less common locations include para-cecal (2%), sub-cecal (1.5%), pre-ileal (1%), and post-ileal (0.5%) [7]. Understanding these variations is crucial for accurate diagnosis and management of appendiceal pathologies, especially in patients presenting with abdominal pain or suspected appendicitis.

The normal appendix can contain varying contents, including air and substances with either low or high density. A fluid-filled appendix with increased diameter (greater than 6 mm) along with features such as peri-appendiceal fat inflammation or calcified appendicoliths, may indicate underlying pathology like appendicitis. This condition can be diagnosed with a high sensitivity of 94% and specificity of 95%[8]. Multidetector computed tomography (CT) scans successfully identify the appendix in at least 80% of cases[9], although it remains unvisualized in approximately 15% of reported scans [10].

Conducting a study to assess the anatomical position, length, diameter, wall thickness, and luminal content of the vermiform appendix would be invaluable for identifying anatomical variations specific to the Sri Lankan population. By applying radiological knowledge, this research aims to enhance the identification of both normal appendices and anatomical variants. Currently, similar studies are scarce both locally and internationally, making this research a potential pilot for future multicenter study.

The primary objective of this study was to determine the common anatomical positions of the base and tip of the vermiform appendix among patients undergoing contrast-enhanced abdominal CT scans at Teaching Hospital Peradeniya (THP). Additionally, the study assessed the length and diameter of radiologically normal appendices, the nature of luminal contents, and variations in length and diameter concerning patient gender and age.

Methodology

This descriptive cross-sectional study was conducted in the Department of Radiology at Teaching Hospital Peradeniya over a one-year period, from May 2022 to April 2023. Ethical clearance was obtained from the Ethical Review Committee of the Faculty of Medicine, University of Peradeniya, and administrative approval was granted by the director of Teaching Hospital Peradeniya. The study population comprised patients undergoing abdominal contrast-enhanced computed tomography (CECT) scans at the Department of Radiology during the study period. All included abdominal CECT scans were originally performed for various diagnostic indications unrelated to this study, and the images were retrospectively reviewed to evaluate the appendix.

Patients aged 16 years and older were included in the study, whereas those presenting with acute appendicitis, appendicular abscess, or appendicular mass were excluded. Additionally, individuals who had previously undergone appendicectomy or had a history of abdominal surgery, as well as CTs with poor image quality, were also excluded from the study.

The sample size calculation was performed using the Lwanga and Lemeshow formula, based on a prevalence of appendicitis identified through multidetector CT scans of 0.8 [9], a 95% confidence level, and an absolute precision of 5%. According to the sample size calculation, a minimum of 246 participants was required. To account for potential sampling errors, a total of 275 patients were ultimately enrolled in the study.

Patients' demographic details, including age, gender, and relevant clinical history, were collected through an interviewer-administered questionnaire to assess the inclusion and exclusion criteria. Patients who fulfilled the inclusion criteria were recruited for the study after obtaining informed written consent. Low-osmolar iodinated contrast (300 mg I/ml) was administered as intravenous contrast, with the dose calculated according to body weight (1 mg/kg). Axial images were acquired using a Siemens® 16-slice multiplanar CT machine in the post-contrast portal venous phase with a 70-second delay, at a slice thickness of 1.0 mm. Reformatted sagittal and coronal images were obtained using the multiplanar reconstruction method.

All studies were reported by a consultant radiologist, and the findings were documented. The CT scans were evaluated based on anatomical details of the appendix, which included the length, maximum inner and outer diameters, position of the base and tip, and density of the intraluminal contents. The anatomical orientation of the tip of the appendix was recorded using a 'clock-face' analogy, where the position was determined relative to the base of the appendix. The base was considered as the centre, and the direction of the tip was assigned accordingly. The Hounsfield (HU) value of the luminal contents was obtained by averaging the HU value at the most dilated part of the cross-section of the appendix in the axial image.

All data were entered and analyzed using SPSS (version 26). Descriptive statistics were employed to analyze the demographic profile of the study sample, and the results were presented using graphs and tables where necessary. The mean value with standard deviation was used as the measure of central tendency and dispersion to calculate representative values for the length and diameter of the normal appendix. Separate mean values with standard deviations were calculated for males and females to obtain representative values for each group. An unpaired t-test was utilized to examine the possible relationships between gender and the length of the appendix, as well as between gender and its diameter. Pearson's correlation coefficient was applied to assess the potential relationships between age and the length of the appendix, and between age and its diameter. For luminal contents, the results were expressed as percentages. A statistically significant p-value was defined as ($P< 0.05$).

Results

Demographic correlation

The total study sample was 275, of whom 144 (52.5%) were male and 131 (47.5%) were female. The mean age of the study population was 57.4 years. In terms of age distribution, 44% of participants were under 40 years old, 41% were between 40 and 60 years old, 11% were aged 60 to 80 years, and only 1% were over 80 years (Figure 1). Appendix was identified in 87% of abdominal CECTs, whereas it could not be visualized in 13% of CECTs.

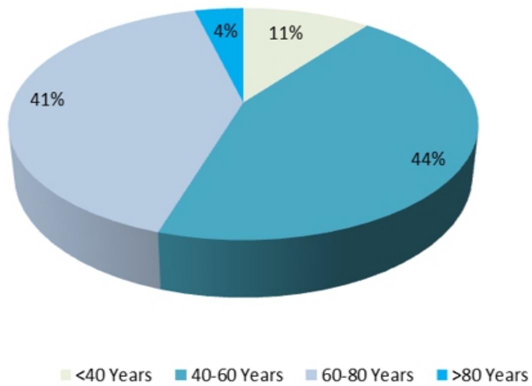

Figure 1: Age distribution of the study sample

Anatomy of the appendix

The mean length of the appendices was 6.45 cm (SD = 1.60). The mean inner diameter measured 3.9 mm, while the mean outer diameter was 5.49 mm (see Table 2).

Position of the appendix

The position of the base and tip of the appendix was observed. The base of the appendix was found below the ileocecal valve in all patients, with a mean distance of 2.31 ± 0.851 cm from the ileocecal valve to the base of the appendix. The clock-face analogy used in this study refers to the position of the tip with respect to the base of the appendix. For instance, a 5 o'clock position indicates that the tip lies in the pelvic direction when the base is considered as the centre point. According to that, the most common position of the tip of the appendix was in the pelvis at the 5 o'clock position (41.8%, n = 100). The second most common position was preileal at the 1-2 o'clock position (27.6%, n = 66). The paracecal position was the least common position of the tip of the appendix identified in our study (1.7%, n = 4) (see Table 1).

To ensure the evaluation of anatomically normal appendices, all cases with suspected or confirmed appendiceal pathology (such as acute appendicitis, appendicular abscess, or mass) and previous abdominal surgery cases were excluded during sample collection. Therefore, pathological presentations were not assessed or discussed in this study.

Table 1: Frequencies and percentages of different positions of the tip of the appendix.

Position of the tip of the appendix	Frequency (%) (N=275)
Retrocecal 11 o'clock	25(10.5)
Para-caecal	4(1.7)
Sub caecal 6 o'clock	39(16.3)
Pelvic 5 o'clock	100(41.8)
Post -ileal 1-2 o'clock	5(2.1)
Pre -ileal 1-2 o'clock	66(27.6)

Luminal contents of the appendix

Luminal contents were categorized into five groups based on the Hounsfield value (Hu) of the contents. Most appendices contained low-density material (61.1%), while 4.2% of the appendices contained fat, which was the least common type. High-density material was found in 5.4% of the cases, and fluid was present in 11.7% of the cases (Figure 2).

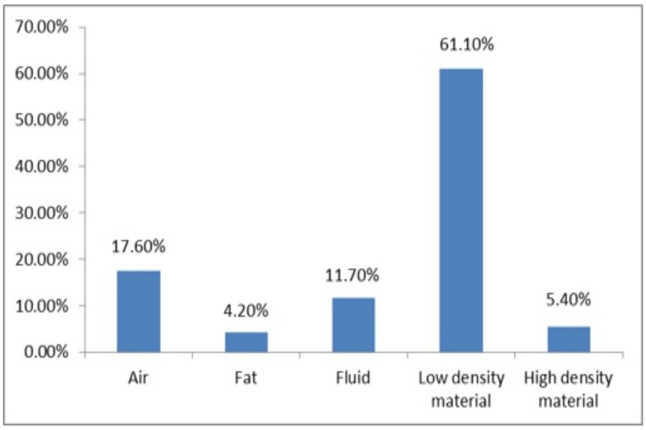

Figure 2: Distribution of luminal contents

Association between length of the appendix with demographic factors.

The Kruskal-Wallis H Test was used to assess the association between age and gender with the length of the appendix. The p-value was > 0.05, indicating that there was no statistically significant association between the length of the appendix and age or gender (Table 2).

Table 2: Correlation between the length of the appendix with demographic factors

Demographic factors	Length (cm) (Mean ±SD)	p Value
Age		
<40 Years	6.35±1.62	0.150
40-60 Years	6.66±1.40	
60-80 Years	6.37±1.73	
>80 Years	5.41±1.97	
Gender		
Male	6.55 ±1.49	0.297
Female	6.34±1.72	

Association between inner diameter of the appendix with demographic factors

The p-value for the inner diameter of the appendix with age and gender was > 0.05, leading to the conclusion that there was no statistically significant association between the inner diameter of the appendix and age or gender (Table 3).

Table 3: Association between demographic factors and the inner diameter of the appendix.

Demographic factors	Inner Diameter (mm) (Mean ±SD)	p Value
Age		
<40 Years	3.85 ±0.77	0.815
40-60 Years	3.94 ±0.69	
60-80 Years	3.89 ±0.88	
>80 Years	3.77 ±0.71	
Gender		
Male	3.94 ±0.78	0.450
Female	3.86±0.78	

Association between outer diameter of the appendix with demographic factors

Although there was no association between age and the outer diameter of the appendix ($p > 0.05$), a statistically significant association was observed between gender and the outer diameter of the appendix ($p < 0.05$). The mean outer diameter of the appendix in males was greater than that in females, with values of 5.61 mm and 5.36 mm, respectively (Table 4).

Table 4: Association between demographic factors and the outer diameter of the appendix

Demographic factors	Outer Diameter (mm) (Mean ±SD)	p Value
Age		
<40 Years	5.44 ±0.81	0.772
40-60 Years	5.50±0.72	
60-80 Years	5.52±0.93	
>80 Years	5.33±0.95	
Gender		
Male	5.61 ±0.81	**0.020**
Female	5.36±0.83	

Discussion

In our study, the appendix was identified in 87% of CECT abdominal scans, which is similar to some studies [11] slightly higher than in some studies [12],[13],[14] and slightly lower than in others [15],[16]. The study by Narayan V et al. reported 100% visualization of the appendix in 120 patients who had undergone CECT abdomen; however, unlike our study, oral and rectal contrast were administered to all patients [25]. The use of only intravenous contrast may have contributed to the non-visualization of 13% of cases in our study. According to Willekens et al., the accuracy of appendix visualization is 82%, which is slightly lower than our findings [12]. Another study conducted on multidetector computed tomography identified the normal appendix in 92% of patients [16]. Visualization of the appendix is lower in non-contrast CT studies, as reported by Benjaminov O et al. [14]. This study indicated that the interobserver agreement for visualization of the normal appendix ranged from 69% to 75%. These findings are likely due to the poor visualization of structures in non-contrast CT, especially smaller structures like the appendix. Poor visualization or non-visualization of the appendix can also be influenced by other factors in the abdomen, such as ascites or inadequate pericecal fat [16].

The most common position of the tip of the appendix in our population was the pelvic 5 o'clock position (41.8%). This finding is consistent with the study conducted by Willekens et al., in which the most common location of the tip of the appendix was in the pelvis in 66% of cases [12]. The study conducted by Ahmed et al. using laparoscopic findings also shows that the most common position of the appendix is the pelvic (51%) [5]. According to Narayan V et al., the most common location of the tip was retrocecal (37%), with the pelvic location identified in 32% of cases [15].

Another descriptive study was conducted in India in 2018 with the aim of studying the variation in the anatomical features, length, and external diameter of the appendix and its association with age and sex in the Indian population, which was similar to ours. Out of the 418 cases included in this study, the majority (55.5%, n=111) demonstrated an appendix situated in the retrocecal position. The pelvic position was observed in 47 cases (23.5%). In addition to these two positions, retroileal (9.0%, n=18), subcecal (6.5%, n=13), paracecal (5.0%, n=10), and subhepatic positions were also identified (0.5%, n=1). The methodology of this study was quite different from ours, as it was conducted on patients who were clinically diagnosed with acute appendicitis. Diagnosed patients underwent thorough clinical examinations, laboratory investigations, and ultrasound scans (USS) of the abdomen, and the appendiceal specimens were sent for histopathological examination after surgery [18]. The inclusion of inflamed appendices in this study, as opposed to the normal appendices evaluated with CECT in our study, could explain the discrepancy in results regarding the position of the appendix in the two studies.

In our study, the mean length of the appendix was 6.45 cm, which is less than the range described in international literature, which is 8-12 cm [3], [4], [8]. A Brazilian cadaveric study reported the mean length of the appendix to be 11.4 cm [4], which is significantly greater than the findings of our study. The body habitus of the individuals may contribute to this discrepancy.

A retrospective study evaluating 186 patients undergoing CT with no suspicion of acute appendicitis demonstrated a statistically significant correlation between gender and appendiceal length, with men having longer appendices than women [12]. These findings are consistent with those of our study as well.

An Iranian cadaveric study shows a significant difference in diameter ($p = 0.002$) between females and males [19], supporting the statistically significant association between gender and outer diameter detected in our study.

No significant association was identified between age and gender with the mean length of the appendix in our study.

The mean outer diameter of the appendix in males and females in our study was 5.61 ± 0.81 cm and 5.36 ± 0.83 cm, respectively, which is consistent with the findings of the study conducted by Jan et al. [16].

According to Jan et al, luminal contents of the appendix were unrecognizable in 35 (39%) of 91 patients, because the lumen collapsed, or the contents had the same attenuation as the wall. In contrast to our study, the major substance in the lumen in the visualizing cases of this study was air (48%, n=44) Contrast medium (4%, n=4), and high-density material (9%, n=8) was also detected. Ten of the 44 air-filled appendices also had some high-density material in the lumen. Therefore, high-density material was present in 18 (20%) of 91 patients in Jan et al. [16].

High-density material was detected only in 5.4% of cases in our study.

In a retrospective review of 186 patients undergoing abdominal CT without suspicion of acute appendicitis, it was shown that normal appendices contained air and low-density material in 44.7% (42 of 94), low-density material in 22.3% (21 of 94), were completely air-filled in 17% (16 of 94), contained air and high-density material in 13.8% (13 of 94), and contained high-density material in 2.2% (2 of 94) [12]. In our study, combinations like these were not demonstrated, as we obtained the average HU value at the most dilated part of the appendix and predicted the density of material based on that HU value.

It is important to note that our study exclusively included radiologically normal appendices, and cases with suspected appendiceal pathology were systematically excluded. Therefore, although variations in anatomical positioning can influence clinical symptoms, these implications were not explored in our study. Future research involving pathological cases could assess how these anatomical variations correlate with clinical presentations, especially during episodes of acute appendicitis.

Limitations and recommondations

One of the limitations of this study was the smaller sample size, which may account for some discrepancies in the findings compared to international literature. To standardize the conclusions for the Sri Lankan population, a study involving a larger sample size is recommended.

A primary limitation of using CT to detect pathologies in the appendix is radiation exposure. Several modifications to the CT protocol have been attempted to reduce this exposure, including low-dose CT, non-contrast CT, and focused CT of the appendix/right iliac fossa. Therefore, with the increased CT visualization rate of the appendix and the reduced radiation exposure resulting from these modifications, CT may be used more freely in the evaluation of suspected appendicitis in the near future.

Conclusion

In this study, we found that the appendix was visualized in 87% of abdominal CECT scans, consistent with previous literature but slightly variable compared to other studies. The mean length of the appendices was determined to be 6.45 cm, which is less than the international average but may reflect demographic factors unique to the population studied. The most common position of the tip of the appendix was noted to be the pelvic 5 o'clock position, aligning with findings from other studies.

Notably, our research revealed no significant associations between the length or inner diameter of the appendix and demographic factors such as age or gender. However, a statistically significant correlation was observed between gender and the outer diameter of the appendix, with males exhibiting a larger mean diameter compared to females.

The findings regarding luminal contents also suggest variability, with low-density material being the most common type identified in our study compared to other studies which reported air or high-density material as prevalent.

While our results provide valuable insights into the anatomical features and visualization characteristics of the appendix within the Sri Lankan population, the study is limited by its relatively small sample size and potential biases inherent in using CT imaging. Future research with a larger cohort will be essential to validate these findings and establish a more comprehensive understanding of appendiceal anatomy and pathology.

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