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Evaluation of Normal Appendix by Computed Tomography: A Retrospective Cross-sectional Study

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Abstract

Introduction: The appendix is a blind-ended tubular gut structure which arises from caecum with considerable variation in position and morphology. Acute appendicitis remains one of the most common causes of acute abdomen that requires emergency radiological investigation. The objective of this study was to evaluate normal appendix by computed tomography (CT) of abdomen in patients with non-appendicular symptoms.

Methods: This was a retrospective cross-sectional study based on record review of patients undergoing CT abdomen attending Rapti Academy of Health Sciences (RAHS) without suspicion of acute appendicitis from October 2024 to March 2025. Axial including reformatted coronal and sagittal images were evaluated for appendix visualization, its diameter, wall thickness, intra-luminal contents and tip position. Data collection was done after receiving ethical approval from the Institutional Review Committee of RAHS. Data analysis was performed using Statistical Package for the Social Sciences version 27.

Results: Among 216 patients (109 males, 107 females; mean age of 46.8 years), appendix visualization rate was 96.8% (98.1% in female and 95.4% in male). The mean appendix diameter was 6.13±1.03 mm (range: 3.6-10.0 mm) with no significant sex difference. Mean wall thickness was 2.55 ± 0.53 mm. Air was the predominant intra-luminal content (50.7%), followed by collapsed lumen (35.9%). The most common appendix tip position was retro-caecal (49.3%), followed by pelvic (22.0%).

Conclusions: There was higher appendix visualization rate in our study using CT. As normal appendix can measure >6 mm in CT, ultrasound size criteria for appendicitis is not applicable in CT.

Keywords: computed tomography; diameter; normal appendix; position; wall thickness

Introduction

The appendix is a blind-ended, tubular gut structure which arises from the caecum, with considerable anatomical variation in position and morphology.[1] Acute appendicitis remains one of the most common causes of acute abdomen that requires emergency surgical intervention, making accurate radiological assessment crucial for patient management.[2,3]

Ultrasonography has traditionally been the first-line imaging modality for suspected appendicitis; however, computed tomography (CT) has emerged as superior due to its operator independence and better visualization capabilities.[4] Factors such as obesity, surrounding gas-filled bowel loops, and variable appendix positions can limit ultrasound visualization, which CT can overcome more effectively.[5,6] Appendix visualization has improved significantly with the advent of multi-detector computed tomography (MDCT).

The diagnostic criteria for appendicitis on ultrasound traditionally include an outer-to-outer diameter > 6 mm. Recent CT studies have reported normal appendix

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diameters can range from 6-11 mm, thus questioning the applicability of ultrasound criteria to CT imaging.[7] Study by Orschelin and Trout has emphasized that CT diagnosis of appendicitis should be based more on secondary signs rather relying solely on the size criteria.[8]

Detecting a normal appendix presents greater challenges than identifying an inflamed one. There is higher visualization rate of normal appendix in CT (69-98%) compared to ultrasound (46-82%).[5,9] The imaging is important in diagnosis of appendicitis and also to rule out appendicitis as some literatures showed reduced negative appendectomy rates from 20% before cross-sectional imaging to 4% with ultrasound and CT.[10,11] Rhee JT et al. reported an even lower rate of negative appendectomies, as low as 3% when CT scan was used.[12] The latter study justifying the use of CT in evaluating suspected appendicitis.

Despite the clinical significance, there have been limited research articles in this topic. So, we aim to study the morphology of normal appendix in CT abdomen of patients without suspicion of acute appendicitis attending Rapti Academy of Health Sciences (RAHS), Lumbini Province, Nepal.

Methods

Study Design and Setting

This was a retrospective cross-sectional study based on record review which was conducted at Rapti Academy of Health Sciences (RAHS), Ghorahi, Dang, Nepal, a tertiary care center in the Lumbini Province.

Study Population and Sampling

The study included the record sheets of patients, collected from the Medical record department of RAHS who underwent CT abdomen at RAHS from October 2024 to March 2025 for non-appendicular symptoms. Census sampling was employed, resulting in total of 216 participants.

Inclusion and Exclusion Criteria

Patients with no clinical suspicion of appendicitis undergoing CT abdomen were included in the study, while patients with clinical history of appendicitis, incidental findings of inflamed or perforated appendix on CT, right iliac fossa pathologies affecting appendix caliber, or past history of appendectomy were excluded from the study.

Data Collection

CT abdomen reports were collected from the Radiology Department of RAHS. Clinical history and relevant information were obtained from the record sheets of patients from Medical record department and CT requisition forms. Data were recorded using structured proforma and entered into Excel spreadsheets.

CT Protocol and Image Analysis

Both non-enhanced and contrast-enhanced CT (CECT) abdomen scans were obtained using 128 slice helical Multi-detector Computed Tomography (Neu Viz 128, Neusoft Medical Systems, China). Axial along with coronal and sagittal reformatted images were evaluated for: appendix visualization, maximum outer-to-outer wall diameter, wall thickness measurement, intra-luminal content/s assessment, and position of appendix tip. Appendix was searched by tracing caecum in right iliac fossa region, and labeled as visualized or not. When the appendix was visualized, its maximum outer-to-outer wall transverse diameter, wall thickness measurement, intra-luminal content were noted. The intra-luminal content were identified as air, collapsed, fluid or lith. Localization of appendiceal tip was noted for their positions as retro-caecal, pelvic, sub-caecal, para-colic, post-ilieal, midline, pre-ileal or sub-hepatic. Retro-caecal position was labeled with appendiceal tip lying behind the caecum or the ascending colon; pelvic position if appendiceal tip extending into the pelvis region; sub-caecal position if appendiceal tip noted just below the caecum; para-colic position with appendiceal tip was seen on either lateral or medial to the caecum/ascending colon; post-ileal or pre-ileal position if appendix tip was noted posterior or anterior to ileum; midline position with appendiceal tip extending medially towards the midline while sub-hepatic position if the appendix tip was lying inferior to the liver.

Statistical Analysis

Descriptive statistics were performed using SPSS version 27, where categorical variables were expressed as frequencies and percentages, while continuous variables were presented as means ± standard deviations. For demographic analysis, age groups were created using 10-year intervals.

Ethical Considerations

The study was conducted after the approval of this study was obtained from the Institutional Review Committee (IRC) of RAHS (ref no: 2498 dated 6th June 2025). We guaranteed the confidentiality of all the cases. As this was a retrospective study using existing medical records, informed consent was waived by the ethics committee, however written permission letter was obtained from hospital administration of RAHS for conducting this study.

Results

Participant Characteristics

The study included 216 patients with a mean age of 46.8 years (range: 4-96 years). The sex distribution was nearly equal with 109 males (50.5%) and 107 females (49.5%). The largest age group was 31-40 years (20.4%), followed by 21-30 years (15.7%) and 51-60 years (15.7%) (Table 1).

Table 1: Characteristics of participants (n = 216)

Characteristics	Number	Percentage (%)
Sex		
Male	109	50.5
Female	107	49.5
Age group (years)		
<10	3	1.4
11-20	15	6.9
21-30	34	15.7
31-40	44	20.4
41-50	29	13.4
51-60	34	15.7
61-70	25	11.6
71-80	28	13.0
81-90	3	1.4
91-100	1	0.5

Appendix Visualization

The overall appendix visualization rate was 96.8% (209/216 patients). Females showed slightly higher visualization rates (98.1%, 105/107) compared to males (95.4%, 104/109). Appendix was not visualized only in 7 patients (3.2%), with 5 males and 2 females (Table 2).

Table 2: Visualization of appendix according to sex (n = 216)

Appendix Visualization	Female	Male	Total	Percentage (%)
Not visualized	2	5	7	3.2
Visualized	105	104	209	96.8
Total	107	109	216	100.0

Appendix Diameter

The mean appendix diameter was 6.13±1.03 mm (range: 3.6-10.0 mm). No significant difference was observed between sexes (females: 6.07 ± 0.98 mm vs males: 6.18 ± 1.07 mm) (Table 3 and figure 1).

Table 3: Diameter of appendix in various age groups and sex

Parameter	Maximum (mm)	Minimum (mm)	Mean	SD
Overall Diameter	10.0	3.6	6.13	1.03
Diameter by Sex				
Male	10.0	3.6	6.18	1.07
Female	9.2	3.8	6.07	0.98

Appendix wall thickness

The mean appendix wall thickness was 2.55±0.53 mm (range: 1.6-4.6 mm) among 209 patients with measurable wall thickness and more than 3 mm was seen in 14.4% of the patients.

Intra-luminal Content

Air was the most common intra-luminal content (50.7%, n=106), followed by collapsed lumen (35.9%, n=75), fluid (11.0%, n=23), and air with appendicolith (2.4%, n=5) (Table 4).

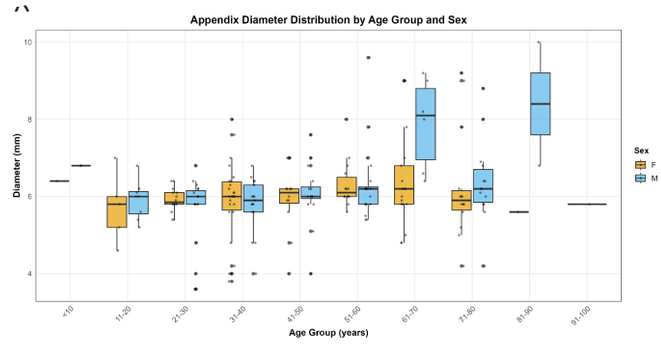

Figure 1: Box plots showing appendix diameter distribution across age groups and sex, demonstrating relatively consistent diameters.

Table 4: Intra-luminal content of visualized appendix (n = 209)

Content	Total	Male	Female	Total %	Male %	Female %
Air	106	55	51	50.7	52.9	48.6
Collapsed	75	33	42	35.9	31.7	40.0
Fluid	23	14	9	11.0	13.5	8.6
Air and Lith	5	2	3	2.4	1.9	2.9

Appendix tip position

Among the 209 visualized appendices, the most common position of tip of appendix was retro-caecal (49.3%, n=103), followed by pelvic (22.0%, n=46), and sub-caecal (8.1%, n=17). Other positions included para-colic (6.2%), post-ileal (5.7%), midline (3.8%), pre-ileal (3.3%), and sub-hepatic (1.4%) (Table 5).

Table 5: Location of appendix tip (n = 209)

Position	Total	Male	Female	Total %	Male %	Female %
Retro-caecal	103	51	52	49.3	49.0	49.5
Pelvic	46	25	21	22.0	24.0	20.0
Sub-caecal	17	11	6	8.1	10.6	5.7
Para-colic	13	7	6	6.2	6.7	5.7
Post-ileal	12	5	7	5.7	4.8	6.7
Midline	8	2	6	3.8	1.9	5.7
Pre-ileal	7	2	5	3.3	1.9	4.8
Sub-hepatic	3	1	2	1.4	1.0	1.9

Discussion

Nowadays, ultrasound and less frequently computed tomography are widely used for the diagnosis of clinically suspected cases of acute appendicitis, although some studies argue these imaging methods don't significantly

help. Instead, they might delay treatment, potentially leading to higher perforation rates.[13,14] However, some studies showed reduced negative appendectomy rates from 20% before use of cross-sectional imaging to 4% with ultrasound and CT in evaluating cases of suspected appendicitis.[10–12] So judicious application of the imaging modality in evaluating suspected cases of appendicitis is warranted.

This study has tried to provide comprehensive morphological data on normal appendix characteristics using CT in a Nepalese population of Lumbini Province.

Appendix Visualization

The appendix visualization rate of 96.8% (209 out of 216) observed in our study is at the higher end of the reported range (69-98%) in international literatures[5,9] and more than the studies by Ansari et al. (86%), Sulwal et al. (90%), Jan et al. (93%) and Johnson et al. (94%).[15–18] The higher rate of appendix visualization in our study could be attributed to the use of higher slice MDCT equipment and use of contrast in CT for image acquisition. The patients with non-visualized appendix (3.2%) had minimal peri-caecal fat and ileo-caecal junction/valve couldn't be identified, which could be the possible cause for the non-visualization.

Appendix Diameter

The mean appendix diameter in our study was 6.13±1.03 mm (range 3.6-10 mm) aligns with recent CT study reporting normal diameters between 3-10 mm.[7] Likewise, our study mean appendix diameter is also similar to the studies by Sulwal et al. (6.2±1.1 mm) and Singh et al. (6.3±1.4 mm) while slightly lower than the studies by Ansari et al. (6.5±1.1 mm) and Narayan et al. (6.8±1.7 mm).[15,16,19,20] The higher mean normal appendix diameter in our study population could be due to distension by air, as it was the most common intra-luminal content. The higher mean normal appendix diameter in above studies supports the argument that CT criteria for appendicitis should differ from ultrasound criteria, where 6 mm has traditionally been the upper limit of normal appendix diameter.

Appendix wall thickness

The mean appendix wall thickness in our study was 2.55±0.53 mm (range: 1.6-4.6 mm), similar to the findings of study done by Singh et al. (2.4±0.4 mm, range: 1.2- 4.2 mm) and by Willekens et al. (2.22±0.56 mm, ranging 1.15-3.85 mm).[19,21] The maximum thickness of appendix wall was reported to be less than 2-3 mm in the published literature.[22] Tamburrini et al.[7] reported that appendix wall thickness of more than 3 mm may be considered a sign of inflammation. The appendix wall thickness of more than 3 mm was seen in 14.4% of the patients in our study, higher than the study result by Willekens et al.(8%).[21] The higher appendix wall thickness in our study was seen in the appendix with collapsed lumen.

Appendiceal intra-luminal content

In our study among the visulized appendices, 50.7 % had intra-luminal air, while 35.9% had collapsed lumen. Our study findings were similar to the study done by Jan et al. (48% had intr-luminal air and 39% had collapsed lumen), Ansari et al. (52% had intra-luminal air while 34% had collapsed lumen) and Suwal et al. (44.3% had intra-luminal air and 41.1% had collapsed lumen).[15–17]

Appendix tip position

The most common position of appendix tip among visualized appendices in our study was retro-caecal (49.3%), a classical anatomical description and concordant with previous imaging studies[7,19,23] followed by pelvic (22.0%), similar to the positions described in a study by Narayan et al.[20], where retro-caecal position was most common accounting for 36.6% followed by pelvic position (31.6%). The proper understanding of these anatomical variations is crucial for radiologists and surgeons, as appendix tip position affects both imaging interpretation and surgical approach.

Clinical Implications

This study addresses a significant knowledge gap by providing the comprehensive data on the normal appendix in the Nepalese population of Lumbini province. Our findings have important clinical implication: the established mean normal appendix diameter of 6.13±1.03 mm, gives local baseline reference values for radiology trainees and radiologists practitioners. This reference value can significantly improve diagnostic accuracy, helping to reduce false-positive diagnoses and prevent unnecessary surgical procedures/interventions.

Study Limitations

Few key limitations should be considered while interpreting our study findings. Since this study is conducted in a single-center, the results may not be generalized to other institutions or populations. While the sample size was sufficient for preliminary data, larger, multi-center studies are needed to strengthen the findings. Additionally, this retrospective study design may have resulted in incomplete clinical information. Variations in CT protocols and contrast administration, could have influenced the measurements.

Future Research

Future studies should aim to validate the findings through multi-center research and to ensure the results are widely applicable. Prospective studies with standardized CT protocols are also needed to reduce the technical variations seen in retrospective designs to get more consistent and reliable results. Furthermore, correlating

our radiological findings with surgical outcomes in patients undergoing appendectomy would provide clinical validation. Studying appendix morphology in different ethnic populations would help broaden the scope of the research and determine the likely variations in appendix morphology based on ethnicity.

Conclusions

This study demonstrates excellent appendix visualization rates (96.8%) using CT scan. The mean normal appendix diameter of 6.13±1.03 mm supports the use of higher diameter thresholds for CT compared to ultrasound in diagnosis of appendicitis. Retro-caecal position remains the most common position of appendix tip, and air is the predominant intra-luminal content. These findings provide valuable baseline morphological data for normal appendix characteristics in the Nepalese population of Lumbini province, which may improve diagnostic accuracy and reduce unnecessary surgical interventions. The current study establishes local reference values that can aid radiologists in distinguishing normal from pathological appendix findings.

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