

Original article

Normal appendiceal diameter on computed tomography and its influencing factors in the pediatric population

Thanwarat Koonthong^{}, Teerasak Phewplung*^{}*Department of Radiology, Faculty of Medicine, Chulalongkorn University and King Chulalongkorn Memorial Hospital, Bangkok, Thailand*

Abstract

Background: Appendicitis is the most common indication for emergency abdominal surgery in children. Computed tomography (CT) plays a crucial role in evaluating pediatric patients with suspected appendicitis. However, the literature describing the normal appendiceal diameter in the pediatric Asian population remains limited.

Objectives: This study aimed to establish reference values for normal appendiceal diameter and to identify variables influencing its diameter in pediatric patients aged 18 years or younger who underwent abdominal CT.

Methods: The study was reviewed and approved by the Institutional Review Board. We conducted a retrospective study of 358 children (≤ 18 years of age) who underwent abdominal CT scans between January 1, 2018, and December 31, 2022, for indications unrelated to appendicitis. Demographic data, including calculated body mass index and body surface area (BSA), were recorded. Radiologic data on the appendices included the maximal outer diameter and single-wall thickness. The data were classified into five age-based strata, and the mean appendiceal diameters were calculated. Associations between appendiceal diameter and age, and between appendiceal diameter and BSA, were assessed using linear regression models.

Results: The mean appendiceal diameter was 5.0 ± 1.1 mm. Stratified analysis by age revealed the following mean appendiceal diameters: 4.2 mm (0–1 years), 4.4 mm (1–5 years), 4.9 mm (5–10 years), 5.5 mm (10–15 years), and 5.8 mm (15–18 years). Age and BSA demonstrated significant predictive variability for appendiceal diameter ($P < 0.001$), explaining 35.2% and 33.1% of the variance, respectively. The regression equations were: appendiceal diameter (mm) = $4.0 + 0.1 \times \text{age (years)}$ and appendiceal diameter (mm) = $3.7 + 0.1 \times \text{BSA (m}^2\text{)}$.

Conclusion: A uniform diameter cutoff for appendiceal diameter should not be applied across the pediatric population because the appendix grows during childhood. This study demonstrated positive correlations between the appendiceal diameter and age and between the appendiceal diameter and BSA.

Keywords: Appendicitis, appendix, computed tomography (CT), normal children.

Appendicitis is a common pediatric surgical emergency and one of the most common indications for surgical exploration in pediatric patients.⁽¹⁾ Imaging is a critical tool for the evaluation of pediatric patients with suspected appendicitis.⁽²⁾ Ultrasound (US) is the

preferred imaging method for the initial assessment of children with potential acute appendicitis because it is non-invasive and cost-effective.⁽³⁾ However, in cases with high clinical suspicion or when US findings are inconclusive, computed tomography (CT) is frequently used for a definitive diagnosis or to rule out appendicitis.^(2, 4, 5) Recent studies have reported the potential of magnetic resonance imaging as an alternative imaging modality for the evaluation of acute appendicitis in pediatric patients.⁽⁶⁾ Despite diagnostic technique advances, the preoperative diagnosis of appendicitis in children continues to present challenges

***Correspondence to:** Teerasak Phewplung, Department of Radiology, Faculty of Medicine, Chulalongkorn University and King Chulalongkorn Memorial Hospital, Bangkok 10330, Thailand
E-mail: Teerasak.P@chula.ac.th

Received: May 15, 2025

Revised: December 10, 2025

Accepted: January 10, 2026

due to nonspecific clinical symptoms. The rate of negative appendectomy, which is a surgical intervention performed in the absence of acute appendicitis, has been reported to be 3.0–13.0%.^(7–11)

Appendiceal diameter is a critical parameter in the diagnostic assessment of acute appendicitis. Many studies have reported established imaging-based cutoff values for appendiceal diameter.^(2, 6, 12–16) Acknowledging that the optimal cutoff diameter for a normal appendix in children may vary with age and body size is important. However, the traditionally recognized diameter limit for diagnosing appendicitis in Caucasian children is 6.0 mm when using either a US or CT scan.^(17, 18)

While many studies have investigated the mean diameter of the normal appendix, the literature on the appendiceal diameter in Asian pediatric populations remains relatively limited. To date, definitive cutoff diameters for Thai and Asian populations have not been established. This study aims to comprehensively evaluate the appendiceal diameter in normal pediatric appendices and to identify the influencing variables in a cohort of pediatric patients aged 1 day to 18 years who underwent CT scans at King Chulalongkorn Memorial Hospital, Thai Red Cross Society.

Materials and methods

Study population and design

This retrospective study was performed in the Department of Diagnostic Radiology at King Chulalongkorn Memorial Hospital, Bangkok, Thailand. A comprehensive search of the institutional Picture Archiving and Communication System (PACS) was conducted to identify CT scans of pediatric patients younger than 18 years who underwent abdominal CT imaging with or without contrast media from January 1, 2018 to December 31, 2022. The inclusion criteria included patients without a clinical suspicion of acute appendicitis. Patient charts were reviewed, and the following exclusion criteria were applied: a diagnosis of appendicitis, including spontaneously resolved cases, documented histories, or imaging findings that were suggestive of pathologic processes that could potentially alter appendiceal diameter (e.g., appendiceal tumor, ileocecal region diseases such as lymphoid hyperplasia, tuberculosis, inflammatory bowel disease, active colitis, cystic fibrosis, and hematologic

malignancies). Patients with a history of appendiceal surgery, those with missing essential data, those who underwent CT scans at outside institutions, examinations lacking images or reconstructed images in the axial or coronal planes, and patients whose appendix could not be visualized by the researchers were excluded. The study population was stratified into five age groups: 0–1 year, >1–5 years, >5–10 years, >10–15 years, and >15–18 years.

This study was reviewed and approved by the institutional review board (IRB no. 0057/66), and informed consent was waived because of the study's retrospective nature.

Data collection

Demographic data were retrospectively extracted from the hospital information system, including the clinical indication of CT, sex, age, height, and weight. Body surface area (BSA) was calculated from the available data using the Mosteller formula.

Imaging data were analyzed retrospectively utilizing PACS workstations (Synapse, Fujifilm Medical Systems) with Synapse software. Imaging assessment and measurements were evaluated by a radiologist (TP) with 10 years of experience in collaboration with a diagnostic radiology resident. The CT images were initially measured by the diagnostic radiology resident, followed by a final evaluation by the pediatric radiologist to ensure measurement precision.

In each instance, the appendix was identified, and the maximal outer diameter (from serosa to serosa) and single-wall thickness at the site of greatest transverse dimension were measured across the axial, sagittal, or coronal images and recorded as the largest measurement rather than an average value, as shown in **Figure 1**. All measurements were obtained using an electronic caliper on the PACS and recorded to the nearest 0.1 mm. The mean and range of the maximal outer diameter and single-wall thickness of the appendix were subsequently calculated.

The density of the appendix content was measured and classified as air, low-density material (<80 Hounsfield Units (HU)), high-density material (>80 HU), and air combined with other materials.

The location of the tip of the appendix was classified as pelvic, retrocolic/retrocaecal, paracolic, subcecal, post-ileal, or pre-ileal.

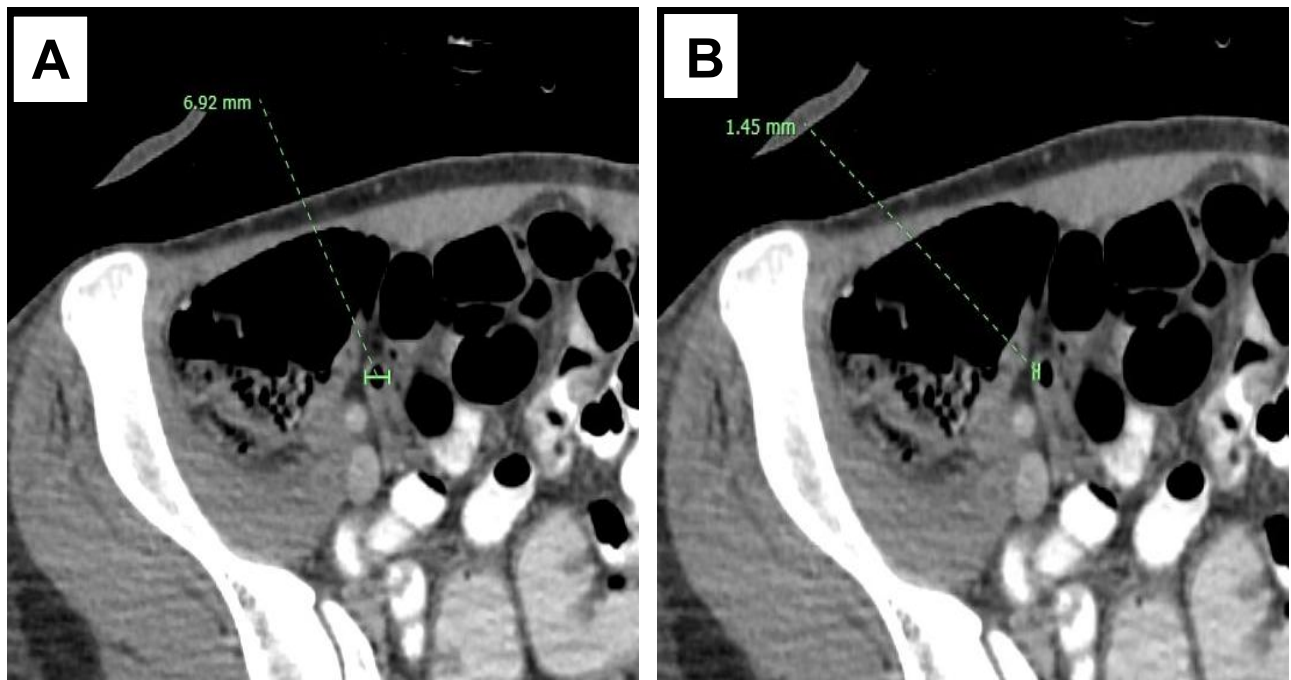


Figure 1. Examples of measurements. (A) The cropped axial CT image shows the measurement of the maximal outer diameter, and (B) single wall thickness of the appendix. Appendiceal content at the location of measurement contains air.

Statistical analysis

Descriptive statistical analyses were conducted for exclusion criteria and patient demographics. Continuous variables, including maximal appendiceal diameter, single-wall thickness of the appendix, age, height, weight, and BSA, were summarized as the mean $\pm$ standard deviation. Categorical variables were tabulated as frequencies and percentages. The relationships between the appendiceal diameter and age, and between the appendiceal diameter and BSA, were examined using simple linear regression analysis. Comparison of appendiceal diameter between cases with and without intraluminal content was performed using the Mann–Whitney U test. Correlation of the appendiceal wall thickness with age and BSA was assessed using Spearman’s rank correlation coefficient (ρ). Comparison of the mean appendiceal wall thickness between large-diameter (>6 mm) and non-large-diameter (≤ 6 mm) groups was performed using the two-sample t -test. Comparison of the proportion of appendices with intraluminal content between the diameter groups was performed using the chi-square (χ^2) test. A P -value < 0.05 was deemed statistically significant. All statistical analyses were performed using STATA version 18 for Windows.

Results

Of the 936 patients, 578 were excluded from the study for several reasons, including clinical suspicion or a confirmed diagnosis of acute appendicitis. These imaging findings may have altered the appendiceal diameter, a history of appendectomy, unavailability of essential data, or the reviewers’ inability to visualize the appendix. Ultimately, 358 patients were included in the final analysis. **Figure 2** presents a flowchart of the study groups and details the exclusion reasons.

The mean age of the 358 patients included in the analysis was 8.6 ± 5.8 years, with an age range of 0 to 18 years and a median age of 8.8 years. Of these, 60.9% (218/358) were male, and 39.1% (140/358) were female. The mean BSA of the study population was 1.0 ± 0.5 m², ranging from 0.2 to 2.3 m². Patients were categorized into five age groups: 0–1 year (20 patients), >1 –5 years (130 patients), >5 –10 years (44 patients), >10 –15 years (96 patients), and >15 –18 years (68 patients). **Table 1** provides the patient cohort demographic data.

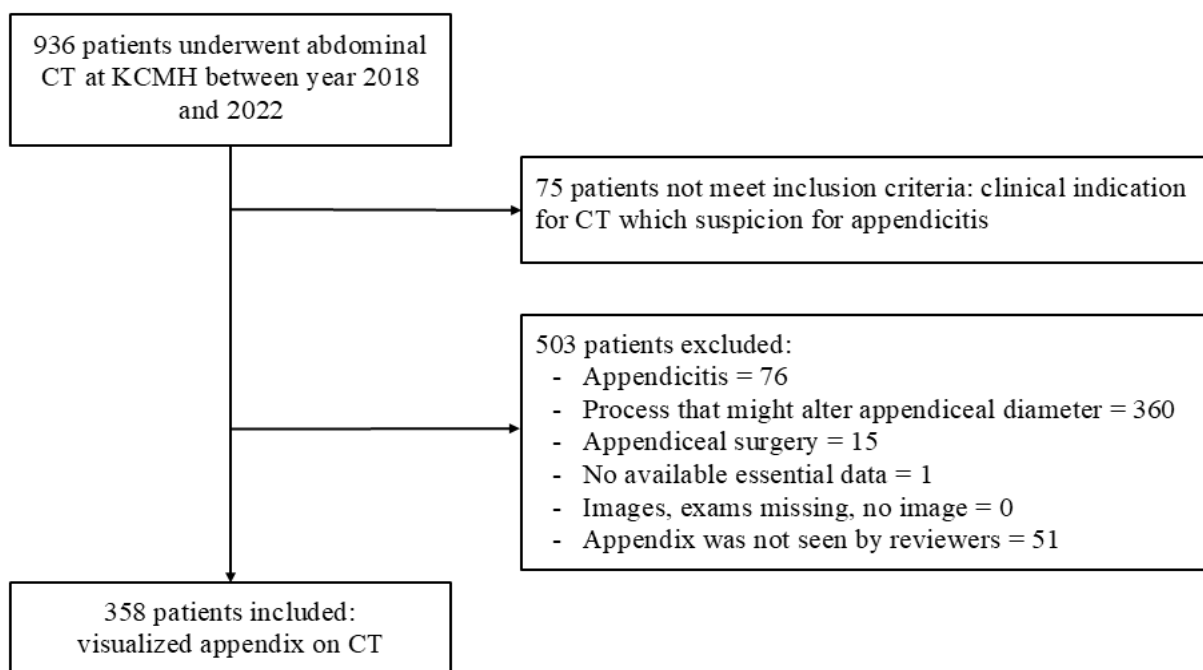


Figure 2. Flow chart represents the selection of the study population.

Table 1. Demographic data

	Male (n = 218)	Female (n = 140)
Age (years)	8.5 ± 5.8	8.8 ± 5.7
Weight (kg)	31.8 ± 24.7	29.7 ± 18.6
Height (cm)	121.0 ± 36.2	122.2 ± 32.8
BSA (m ²)	1.0 ± 0.5	1.0 ± 0.4

BSA, body surface area

The mean maximal outer diameter of the appendix was 5.0 ± 1.1 mm, with a range of 2.2–9.9 mm. The mean single-wall thickness of the appendix was 1.4 ± 0.5 mm, with a range of 0.6–3.7 mm. The mean appendiceal diameter, stratified by age group, was 4.2 mm for ages 0–1 year, 4.4 mm for ages >1–5 years, 4.9 mm for ages >5–10 years, 5.5 mm for ages >10–15 years, and 5.8 mm for ages >15–18 years, as shown in **Figure 3**.

The location of the appendix tip relative to the cecum was variable, with the most common location being subcecal, which was observed in 124 of the 358 appendices (34.6%). Other locations included post-ileal in 108 cases (30.2%), pelvic in 75 cases (21.0%), retrocolic/retrocecal in 37 cases (10.3%), pre-ileal in 9 cases (2.5%), and paracolic in 5 cases (1.4%).

Regarding the intraluminal content, normal appendices contained air in 242 out of 358 cases (67.6%), no intraluminal content in 60 cases (16.8%), low-density material in 34 cases (9.5%), air combined with other material in 16 cases (4.5%), and high-density material in six cases (1.7%).

There was a significant positive correlation between the appendiceal diameter and age. The coefficient of determination (r^2) was 0.35, indicating that age accounted for 35.2% of the variability in

appendiceal diameter. The linear regression equation for predicting appendiceal diameter based on age was: predicted appendix diameter (mm) = $4.0 + 0.1 \times \text{age (years)}$ (adjusted $r^2 = 0.352$, $P < 0.001$), as shown in **Figure 4A**. Similarly, a significant positive correlation was observed between the appendiceal diameter and BSA. The coefficient of determination (r^2) was 0.331, meaning that BSA explained 33.1% of the variability in appendiceal diameter. The linear regression equation for predicting the appendiceal diameter based on BSA was: predicted appendix diameter (mm) = $3.7 + 0.1 \times \text{BSA (m}^2\text{)}$ (adjusted $r^2 = 0.331$, $P < 0.001$), as shown in **Figure 4B**.

The appendiceal diameter was significantly greater in cases with intraluminal content than in those without intraluminal content ($P = 0.028$). In addition, appendiceal wall thickness revealed significant positive correlations with age and BSA (Spearman's $\rho = 0.44$, $P < 0.001$ for both). The mean appendiceal single-wall thickness was significantly greater in the large-diameter group (>6 mm) than in the non-large group (≤ 6 mm) (1.9 mm vs. 1.4 mm, $P < 0.001$). The presence of intraluminal content was observed in 82.2% of appendices with a diameter ≤ 6 mm and 89.1% of those with a diameter > 6 mm, with no significant difference between groups ($P = 0.207$).

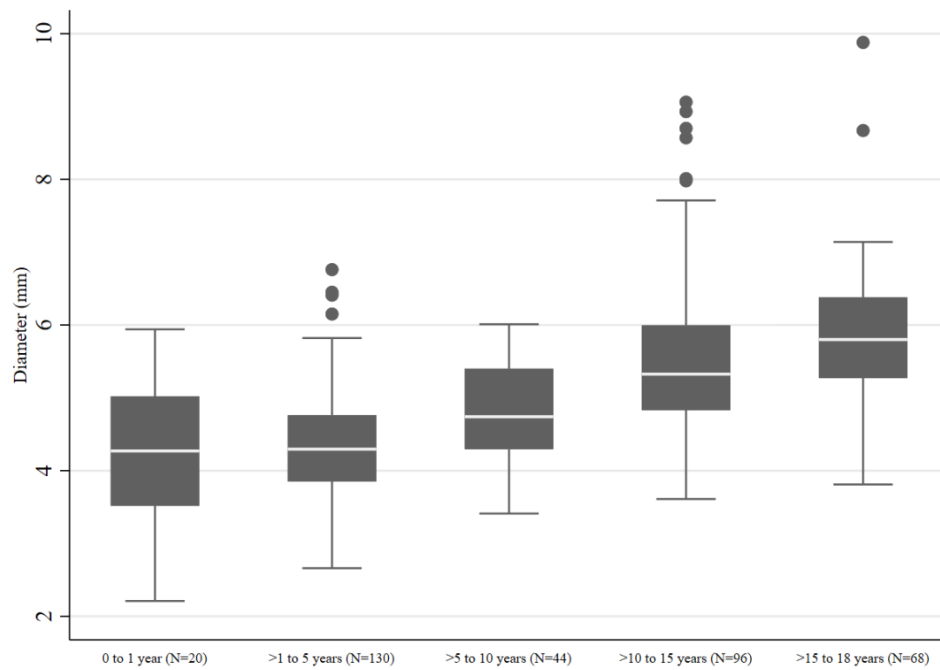


Figure 3. Boxplot displaying the distribution of appendiceal diameter according to patient age group.

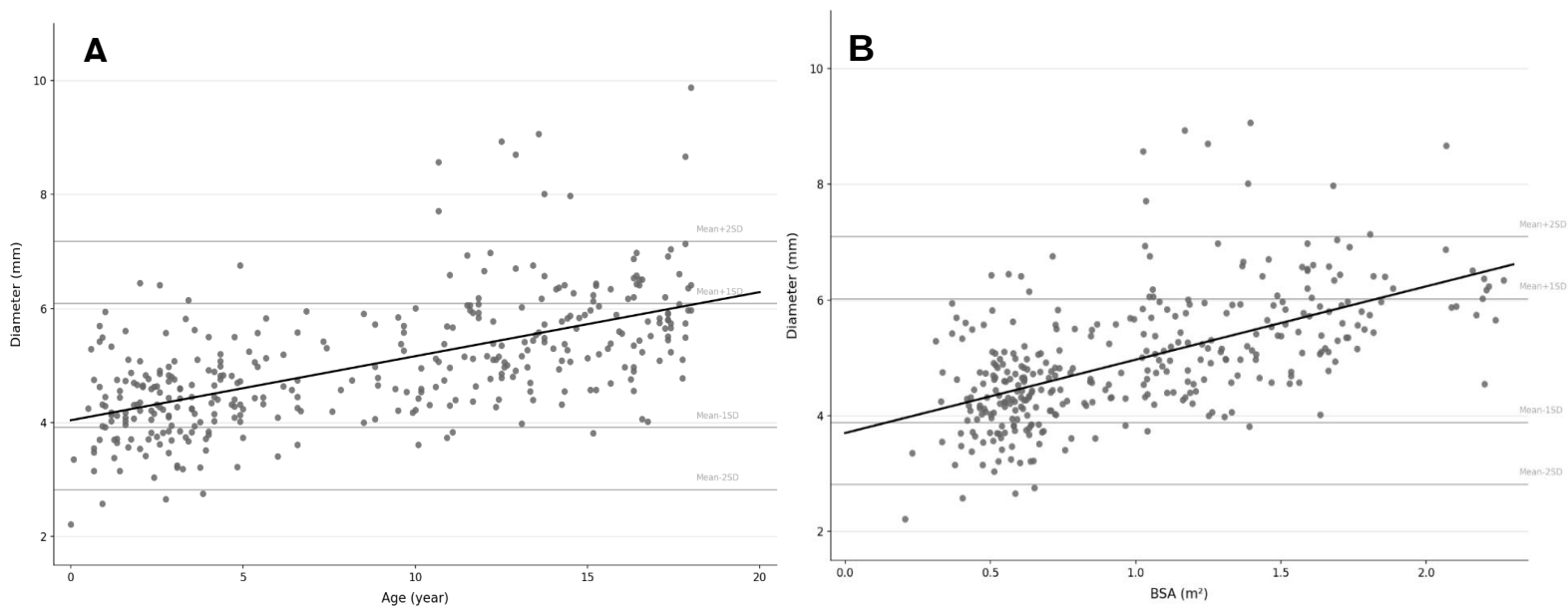


Figure 4. (A) Scatterplots between appendiceal diameter and age, (B) scatterplots between appendiceal diameter and BSA. BSA, body surface area.

Discussion

The appendiceal diameter is an important parameter for diagnosing acute appendicitis in children.⁽¹²⁾ Therefore, radiological data on the normal appendix diameter are valuable for enhancing diagnostic accuracy. While previous studies have measured appendix size using different imaging techniques, there is limited data on normal appendix diameter in the Asian pediatric population. This study aimed to determine the normal appendix diameter in Thai children using CT scans, and our findings may contribute to establishing a reference standard for assessing the normal appendix on CT in this demographic.

Previous CT-based studies have frequently regarded a diagnostic threshold of >6 mm for abnormally enlarged or distended appendices.^(17, 18) Trout AT, *et al.* reported mean appendiceal diameters of 5.6 ± 1.4 mm and 5.7 ± 1.5 mm, as measured by two reviewers, in children aged 0–18 years.⁽¹²⁾ Furthermore, Orscheln ES, *et al.* described a mean diameter in the same age group of 5.3 ± 1.0 mm.⁽¹⁵⁾ These results are similar to previous studies that used US data. Wiersma F, *et al.* reported a mean diameter of 3.9 ± 0.8 mm in children aged 2–15 years⁽¹⁹⁾; Ozel A, *et al.* found a mean diameter of 4.2 ± 0.9 mm in children aged 2–16 years⁽²⁰⁾; and Queiroz MR, *et al.* observed a mean diameter of 4.1 ± 0.9 mm in children aged 0–15 years.⁽²¹⁾ These results are consistent with the study by Fukuta A, *et al.*, which examined excised normal appendices and found a median diameter of 5.0 mm.⁽²²⁾

Our study revealed a mean appendiceal diameter of 5.0 ± 1.1 mm in children aged 0–18 years. These findings are consistent with the few similar studies previously published on CT examinations. Given the minimum appendiceal diameter of 2.2 mm and a maximum of 9.9 mm, 55 patients (15.5%) had an appendiceal diameter >6.0 mm.

Previous studies on the correlation between appendiceal diameter and age have yielded inconsistent findings. While some studies have found no correlation between these two variables^(19–21), others have reported a significant positive correlation.^(6, 12) In a 2014 study, Trout AT, *et al.* used CT scans to measure the appendiceal diameter of 420 patients with normal appendices. They observed a gradual increase in appendiceal diameter until the age of 6.5 years, followed by a plateau.

Regarding our results, age and BSA were significant predictors of appendiceal diameter, accounting for 35.2% and 33.1% of the explained variability, respectively. The regression equation between appendiceal diameter and age was: appendiceal diameter (mm) = $4.0 + 0.1 \times \text{age (years)}$. The regression equation between appendiceal diameter and BSA was: appendiceal diameter (mm) = $3.7 + 0.1 \times \text{BSA (m}^2\text{)}$. Our findings indicate a significant positive correlation between the appendiceal diameter with age and BSA.

In this study, the appendiceal diameter was significantly greater in cases with intraluminal content than in those without intraluminal content. This finding suggests that intraluminal content may contribute to increased appendiceal diameter in an otherwise normal appendix. Therefore, a larger appendiceal diameter on CT should be interpreted with caution, as it may reflect physiological distension rather than early inflammatory change. We also observed a moderate positive correlation between the appendiceal single-wall thickness with age and BSA. This finding indicates that appendiceal wall thickness may vary with patient growth and body size. Consequently, relatively greater wall thickness or diameter in older or larger children may represent proportional scaling of normal tissue rather than a pathological process. In addition, the appendiceal wall thickness was significantly greater in the large-diameter group compared with the non-large-diameter group. However, the prevalence of intraluminal content did not differ significantly between appendices measuring ≤ 6 mm and those >6 mm. These findings suggest that appendiceal diameter alone may not be sufficient to distinguish normal- from abnormal-sized appendices, particularly in borderline cases. Overall, our results support the importance of interpreting appendiceal diameter in conjunction with other imaging findings, such as wall thickness, luminal content, and the patient's clinical and biometric characteristics. Considering these factors may help reduce the risk of overdiagnosing acute appendicitis when the appendiceal diameter approaches the upper limit of the normal range.

This study has several limitations that should be acknowledged. First, we did not measure the diameter of abnormal appendices. To establish an accurate diagnostic threshold for acute appendicitis, it is essential to evaluate normal and abnormal appendices. Second, the results of the study are based on the data

from a single institution's patient population. Results may vary in different populations or among individuals of different ethnicities. Third, the reported mean diameter of the normal appendix might be slightly higher than the actual average for pediatric patients, as patients with unidentified appendices were likely younger and, consequently, had smaller appendices. Finally, the accuracy of the measurements was limited by the image pixel size.

Conclusion

This study represents the first report on the normal appendiceal diameter in the Thai pediatric population using imaging. We found a mean appendiceal diameter of 5.0 ± 1.1 mm and observed a positive correlation between the appendiceal diameter with age and BSA. Our results suggest that a single-diameter cutoff may not be suitable for all pediatric patients. Notably, appendiceal diameters up to 9.9 mm were observed in otherwise healthy children, thus emphasizing that diameter alone may not reliably distinguish normal from early appendicitis. Additional factors, such as the appendiceal wall thickness, intraluminal content, and the patient's age, body size, and clinical context, should be considered for accurate interpretation. These findings provide a reference standard for normal appendiceal diameter in Thai children and may help reduce the risk of overdiagnosis of acute appendicitis in clinical practice.

Author contributions

TK and TP contributed equally to this work. TP contributed substantially to the study's concept and design. TK acquired the data and reviewed the literature. Both authors contributed to data analysis and interpretation. TK drafted the manuscript. TP edited the manuscript critically for important intellectual content. All authors approved the final version submitted for publication and take responsibility for statements made in the published article.

Acknowledgments

The authors would like to thank the Faculty of Medicine, Chulalongkorn University, for supporting the statistical analysis. The authors did not receive any specific grant for this research from any funding agency in the public, commercial, or not-for-profit sectors.

Conflicts of interest statement

The authors have each completed the International Committee of Medical Journal Editors Form for Disclosure of Conflicts of Interest. No author has any potential or actual conflict of interest to disclose related to the present article.

Data sharing statement

Statistical summaries are presented in the published article. The data sets generated or analyzed during the present study are available from the corresponding author upon reasonable request for non-commercial purposes.

ORCID

Thanwarat Koonthong  <https://orcid.org/0009-0000-3440-6955>

Teerasak Phewplung  <https://orcid.org/0000-0001-9132-5799>

References

1. Becker C, Kharbanda A. Acute appendicitis in pediatric patients: an evidence-based review. *Pediatr Emerg Med Pract* 2019;16:1–20.
2. Koberlein GC, Trout AT, Rigsby CK, Iyer RS, Alazraki AL, Anupindi SA, et al. ACR Appropriateness Criteria(®) Suspected Appendicitis-Child. *J Am Coll Radiol* 2019;16:S252–S63.
3. Strouse PJ. Pediatric appendicitis: an argument for US. *Radiology* 2010;255:8–13.
4. Callahan MJ, Rodriguez DP, Taylor GA. CT of appendicitis in children. *Radiology*. 2002;224:325–32.
5. Taylor GA, Callahan MJ, Rodriguez D, Smink DS. CT for suspected appendicitis in children: an analysis of diagnostic errors. *Pediatr Radiol* 2006;36:331–7.
6. Swenson DW, Schooler GR, Stamoulis C, Lee EY. MRI of the normal appendix in children: data toward a new reference standard. *Pediatr Radiol* 2016;46:1003–10.
7. To T, Langer JC. Does access to care affect outcomes of appendicitis in children?—A population-based cohort study. *BMC Health Serv Res* 2010;10:250.
8. Rao PM, Rhea JT, Rattner DW, Venus LG, Novelline RA. Introduction of appendiceal CT: impact on negative appendectomy and appendiceal perforation rates. *Ann Surg* 1999;229:344–9.
9. Oyetunji TA, Ong'uti SK, Bolorunduro OB, Cornwell EE 3rd, Nwomeh BC. Pediatric negative appendectomy rate: trend, predictors, and differentials. *J Surg Res* 2012;173:16–20.
10. Bachur RG, Hennelly K, Callahan MJ, Chen C, Monuteaux MC. Diagnostic imaging and negative appendectomy rates in children: effects of age and gender. *Pediatrics* 2012;129:877–84.

11. Karabulut R, Sonmez K, Turkyilmaz Z, Demirogullari B, Ozen IO, Demirtola A, et al. Negative appendectomy experience in children. *Ir J Med Sci.* 2011;180:55–8.
12. Trout AT, Towbin AJ, Zhang B. Journal club: The pediatric appendix: defining normal. *AJR Am J Roentgenol.* 2014;202:936–45.
13. Sivit CJ, Siegel MJ, Applegate KE, Newman KD. When appendicitis is suspected in children. *Radiographics* 2001;21:247–62.
14. Ozturkmen Akay H, Akpınar E, Akgul Ozmen C, Ergun O, Haliloglu M. Visualization of the normal appendix in children by non-contrast MDCT. *Acta Chir Belg* 2007;107:531–4.
15. Orscheln ES, Trout AT. Appendiceal diameter: CT versus sonographic measurements. *Pediatr Radiol* 2016;46:316–21.
16. Trout AT, Zhang B, Towbin AJ. Measurement error in CT assessment of appendix diameter. *Pediatr Radiol* 2016;46:1831–6.
17. Lowe LH, Penney MW, Scheker LE, Perez R Jr, Stein SM, Heller RM, et al. Appendicolith revealed on CT in children with suspected appendicitis: how specific is it in the diagnosis of appendicitis? *AJR Am J Roentgenol* 2000;175:981–4.
18. Krishnamoorthi R, Ramarajan N, Wang NE, Newman B, Rubesova E, Mueller CM, et al. Effectiveness of a staged US and CT protocol for the diagnosis of pediatric appendicitis: reducing radiation exposure in the age of ALARA. *Radiology* 2011;259:231–9.
19. Wiersma F, Srámek A, Holscher HC. US features of the normal appendix and surrounding area in children. *Radiology* 2005;235:1018–22.
20. Ozel A, Orhan UP, Akdana B, Disli C, Erturk SM, Basak M, et al. Sonographic appearance of the normal appendix in children. *J Clin Ultrasound* 2011;39:183–6.
21. Queiroz MRG, Francisco Neto MJ, Rahal Junior A, Jabour VA, Andrade GNL, Silva PSDD, et al. Ultrasonographic evaluation of cecal appendix diameter in pediatric population. *Einstein (Sao Paulo)* 2022;20:eAO6935.
22. Fukuta A, Kakiuchi T, Sadashima E, Inoue T, Muramori K. Reference growth curves for normal appendiceal diameter in childhood. *Sci Rep* 2020;10:12206.