Anatomical variations of caecal appendix on tomography, a retrospective study

Variaciones anatómicas del apéndice cecal en tomografía, un estudio retrospectivo

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ABSTRACT

Introduction: the most common surgical cause of abdominal pain is appendicitis; its diagnosis is affected by anatomical variations of the vermiform appendix, because this is the most variable abdominal organ in terms of position and organ relations.

Objective: to determine the characteristics of the normal appendix in computed tomography scans, including length, diameter, wall thickness, and the location of the base and the appendicular tip.

Methods: abdominal computed tomography scans with UroCT scan protocol images were studied to measure length, width, and diameter of the appendix, and to identify the locations of its base and tip. The appendicular tip location was categorized as anterior or posterior and subdivided into: pelvic, retrocaecal/retrocolic, postileal, paracolic, subcaecal, subhepatic or midline. The appendicular base location was defined in three planes in relation to the ileocaecal valve: anterior-posterior, medial-lateral, or superior-inferior.

Results: were included the abdominal tomography images of 83 patients in which general characteristics of the appendix were determined: a mean length of 78 mm (SD = ±23.41) and a mean diameter of 6.55 mm (SD =± 1.77) were observed. The bases were more frequently located inferior posterior, lateral and medial, to the ileocaecal valve, and the tips were more frequently located in the pelvic cavity, followed by the retrocaecal and paracaecal location.

Conclusions: the locations of the base of the appendix were correlated with overall reports. There was no correlation between the tip location and the length of the appendix, this means that, even if the appendix is long, it is not associated with a tip location further from the ileocaecal valve.

Keywords: Appendix; Cecum; Lower Gastrointestinal Tract; Anatomic Variation; Tomography.

ACCESO ABIERTO

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RESUMEN

Introducción: la causa de dolor abdominal mayormente relacionada a cirugía es la apendicitis; su diagnóstico se ve afectado por las variaciones anatómicas del apéndice vermiforme, debido a que es el órgano abdominal con mayores variaciones en cuanto a su posición y relación con otros órganos.

Objetivo: determinar las características del apéndice cecal normal en tomografías computarizadas, incluidas la longitud, el diámetro, el grosor de la pared, y la ubicación de la base y de la punta apendicular.

Métodos: se estudiaron tomografías computarizadas abdominales con imágenes del protocolo de exploración UroCT para identificar la localización de la base y la punta, y medir longitud, ancho y diámetro del apéndice cecal. La ubicación de la punta se categorizó como anterior o posterior y se subdividió en: pélvica, retrocecal/retrocólica, postileal, paracólica, subcecal, subhepática o línea media. La localización de la base apendicular se definió en tres planos en relación con la válvula ileocecal: antero-posterior, medial-lateral o superior-inferior.

Resultados: fueron incluidas tomografías abdominales de 83 pacientes en las que se determinaron las características generales del apéndice cecal: se observó una longitud media de 78 mm (DE = 23,41) y diámetro medio de 6,55 mm (DE= 1,77). Las bases tuvieron con mayor frecuencia una localización inferior posterior, lateral y medial a la válvula ileocecal, las puntas estuvieron más frecuentemente localizadas en la cavidad pélvica, seguidas de localizaciones retrocecal y paracecal.

Conclusión: la localización de la base del apéndice se correlaciona con lo descrito en estudios previos. No existe correlación entre la ubicación de la punta y la longitud del apéndice, esto significa que, incluso si el apéndice es largo, no se asocia con una ubicación de la punta más alejada de la válvula ileocecal.

Palabras Clave: Apéndice; Ciego; Tracto Gastrointestinal Inferior; Variación Anatómica; Tomografía.

INTRODUCTION

The most common cause of acute abdominal pain requiring surgery is appendicitis. Its maximum incidence is during the second and third decades of life, but it can occur at any age, with a 6,7 to 8,6% lifetime risk (1,2). The vermiform appendix is a blind-ending, tubular structure arising from the posteromedial aspect of the caecum, with a length averaging between 8 to 10 cm (3).

The appendix is the most variable abdominal organ in terms of position and organ relations (4), its location has always been a controversial topic and some suggest it can be related to demographic characteristics such as age, gender and race (5). There is not a consensus in the literature in relation to the different appendiceal positions in the abdominal cavity, thus many classifications have been proposed.

The tip of the appendix is free, which leads to distinct locations within the abdominal cavity (5). The base of appendix is connected to the cecum, but its head can be placed in different situations (6).

Some of the anatomical variations of the appendix can lead to different symptoms when appendicitis

develops, resulting in delays in the diagnosis, and subsequently, in the treatment (7). For this reason, it is essential to know what possible locations it might have and what the most common ones in our population are. The aim of this study was to determine the characteristics of the normal appendix in CT (Computed Tomography) scans, including length, diameter, wall thickness, and location of the base and the appendicular tip.

METHODS

Design

A retrospective study was conducted in the Department of Diagnostic Imaging in Medihelp Services Clinic, Cartagena, Colombia. Abdominal CT and UroCT scans performed during a period of twenty-four months were reviewed to evaluate the length, diameter and wall thickness and location of the base and the tip of the appendix. The study was approved by institutional ethics committee.

Were included all the abdominal CT scans with UroCT scan protocol indicated to study ureteral disease, with and without contrast, that showed an appendix that could be analyzed. The scans were obtained with a multi-detector Somaton Perspective 128 CT Scanner® (SIEMENS, Germany). The images were reviewed by a radiologist with extensive experience in abdominal CT scans, who performed measurements of the dimensions of the caecal appendixes and reviewed the location of the appendix in relation to the ileocaecal valve (Figure 1). There was not access to the surgical records of the patients, therefore it was not possible to calculate the rate of appendectomy. The scans from patients that did not show an appendix after revision by the radiologist were excluded.

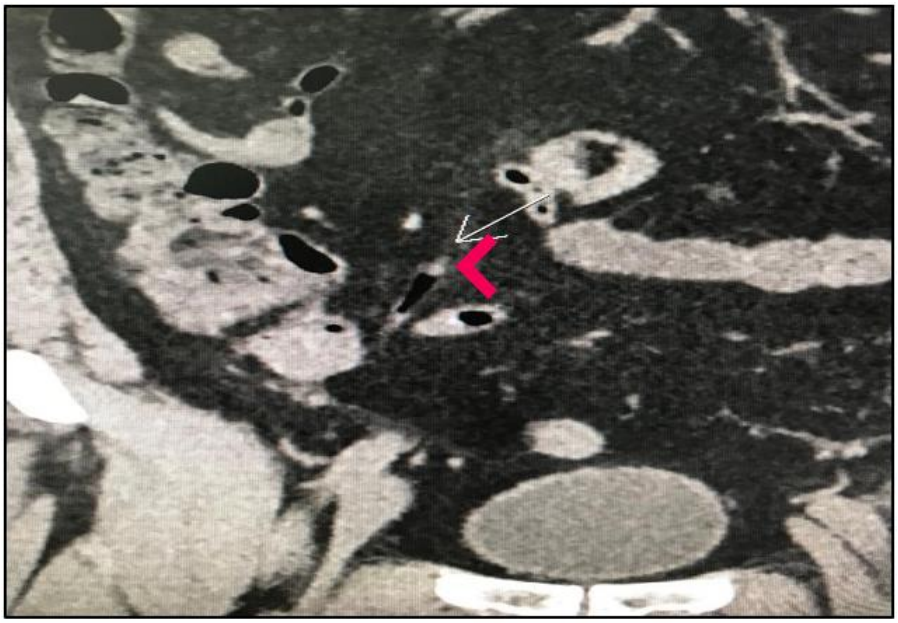

Figure 1. Localization of the appendix in a reconstruction of a coronal CT scan. Red and white arrows identify the caecal appendix with thin walls.

The measurements were done using the Syngovia for Computed Tomography software®, (Siemens, Germany), which allowed the visualization and measurement of the appendix in its length from the base to the tip. Along with the measurement of the maximal outer diameter, and the maximal wall thickness in the axial and coronal scan (Figure 2. A-B). The length was measured in the axial and vascular visualization which was determined from the base to the tip of the appendix (Figure 3).

The location of the appendicular tip was categorized as anterior or posterior and subdivided into: pelvic, retrocaecal/retrocolic, postileal, paracolic,

subcaecal, subhepatic or midline (Figure 4), according to the description of Ghorbani (6). The appendicular base location in relation to the ileocaecal valve was also determined, and defined in three planes: anterior-posterior, medial-lateral, or superior-inferior. Both categories were established in accordance to previous reports (5,8–10).

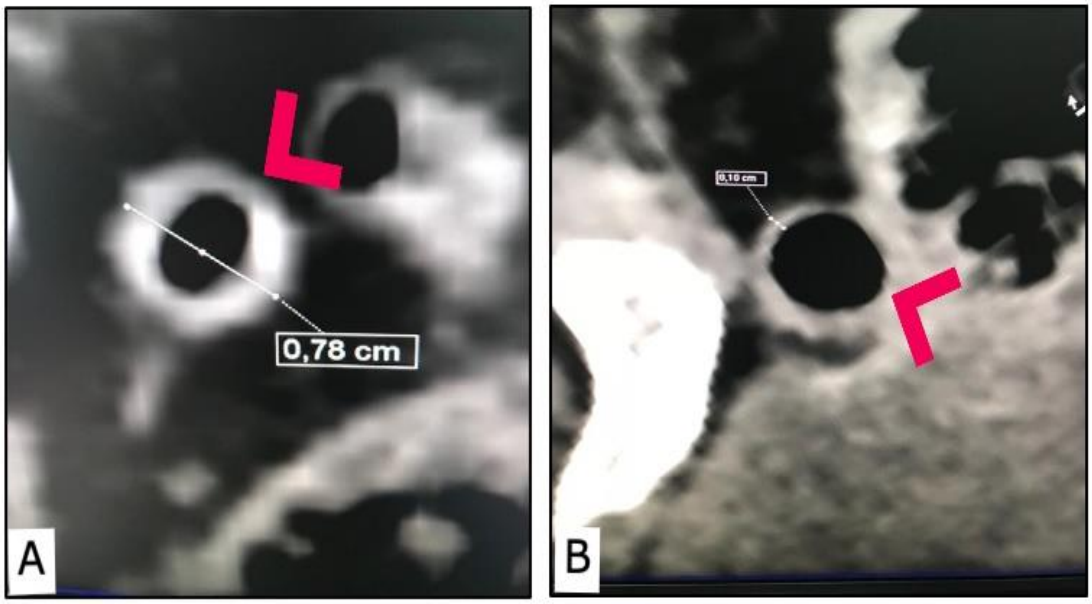

Figure 2. Measurement of diameter and the wall thickness of the appendix. A: amplification of a coronal CT where the white line represents the transverse diameter of the caecal appendix**.** (red arrow) **B:** amplification of coronal CT to measure the wall thickness of the caecal appendix (red arrow) represented by the white line.

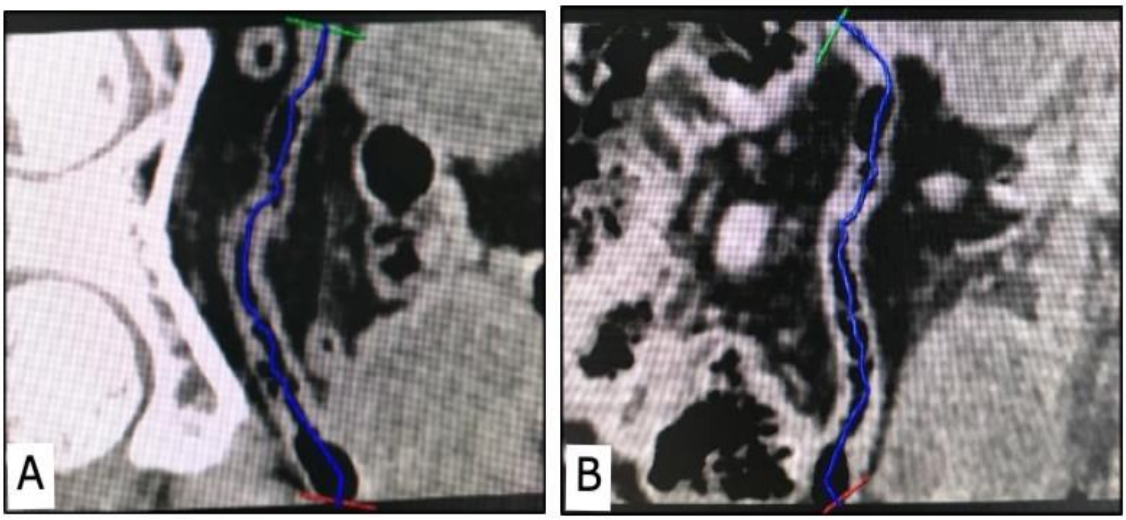

Figure 3. Measurement of the length of the appendix. The two images show a representation of a longitudinal reconstruction of the appendix to measure its length. The blue line represents the interior of the appendix from the base (red line) to the tip (green line).

Statistical Analysis

For the statistical analyses the frequency for each appendiceal tip location and each appendiceal base location were calculated for every location mentioned before. The mean, median and range were calculated for length, diameter, and wall thickness of all the appendix studied. The relations between the appendix localization and length were calculated

using the Pearson R correlation, and the relations between gender and the location of the appendix were also calculated. Statistical analyses were performed using GraphPad Prism® v8.00 software (Graph-Pad Software Inc, San Diego, CA); A p value < 0.05 was considered statistically significant.

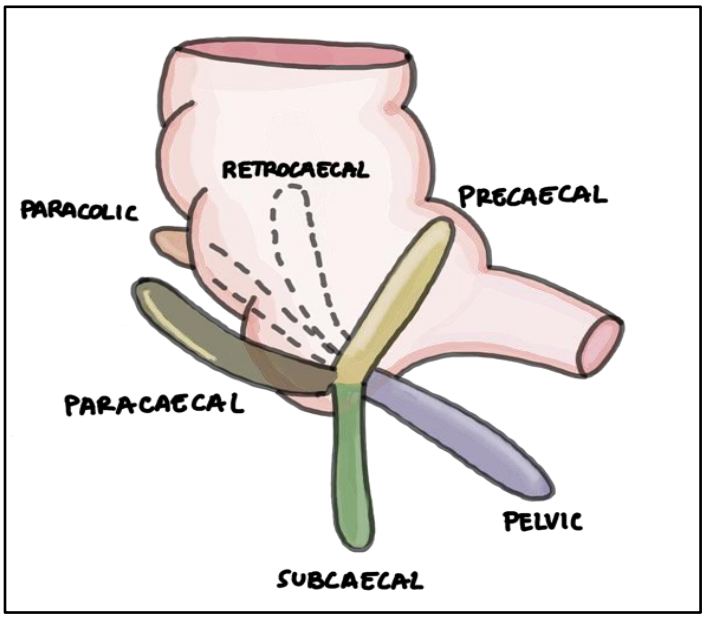

Figure 4. Locations of the tip of the appendix in relation to the ileocaecal valve. The different locations are represented in different colors and intermittent lines indicate posterior placement. (Image designed by the authors).

RESULTS

Were included the abdominal CT scans with UroCT scan protocol of 83 patients with a median age of 49 (SD= ±14,08), 39 (46,4%) of which were women. The general measures of the appendixes were evaluated, a mean length of 78 mm (SD = ±23,41) was observed, the mean diameter was of 6,55 mm (SD= ±1,77) being higher than 6 mm in 50 (59%) of the cases, and the wall thickness mean was of 1,83 mm (SD= ±0,58), (Table 1). There was not a significant difference in the appendixes length between male and women (p = 0.189, t test).

Table 1. General measures of the appendixes: length, diameter and wall thickness (n=83)

	Length (mm)	Diameter (mm)	Wall thickness (mm)
Mean (±SD)	78,43 (±23,41)	6,55 (±1,77)	1,83 (±0,58)
Median	78,3	6,3	0,5
Range	29,5-132,4	3-14	0,5-3,3

The specific locations of the tip and the bases of the appendixes were evaluated. In most percentage of the patients the appendixes bases were located inferior posterior lateral to the ileocaecal valve, and inferior posterior medial to the ileocaecal valve. The tip of the appendix location was more evenly distributed, with the most in pelvic location, in 20 (24%) patients they were in retrocaecal location, in 11 (13,2%) patients the tips were in the body midline, in 10 (12%) patients the tips had a paracaecal location, meanwhile it was in the pelvic cavity in 2 (2,4%) patients (Figure 5).

There was not a statistically significant difference in the length of appendix between the different locations of the tip (p = 0.42, ANOVA test).

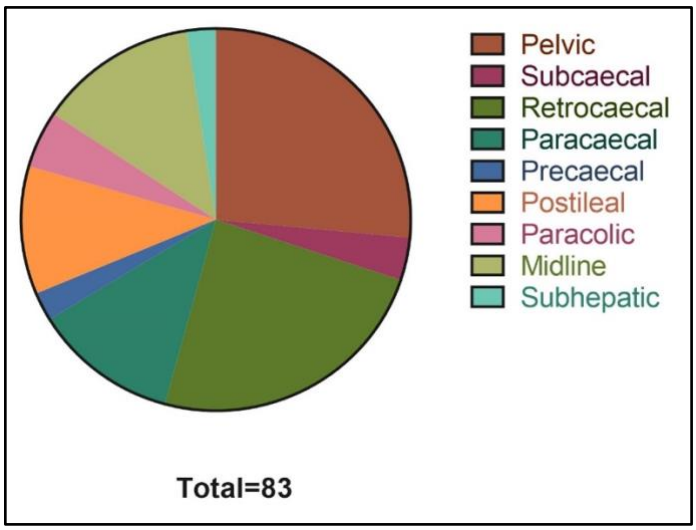

Figure 5. Distribution of the localization of the appendix in relation to the ileocaecal valve.

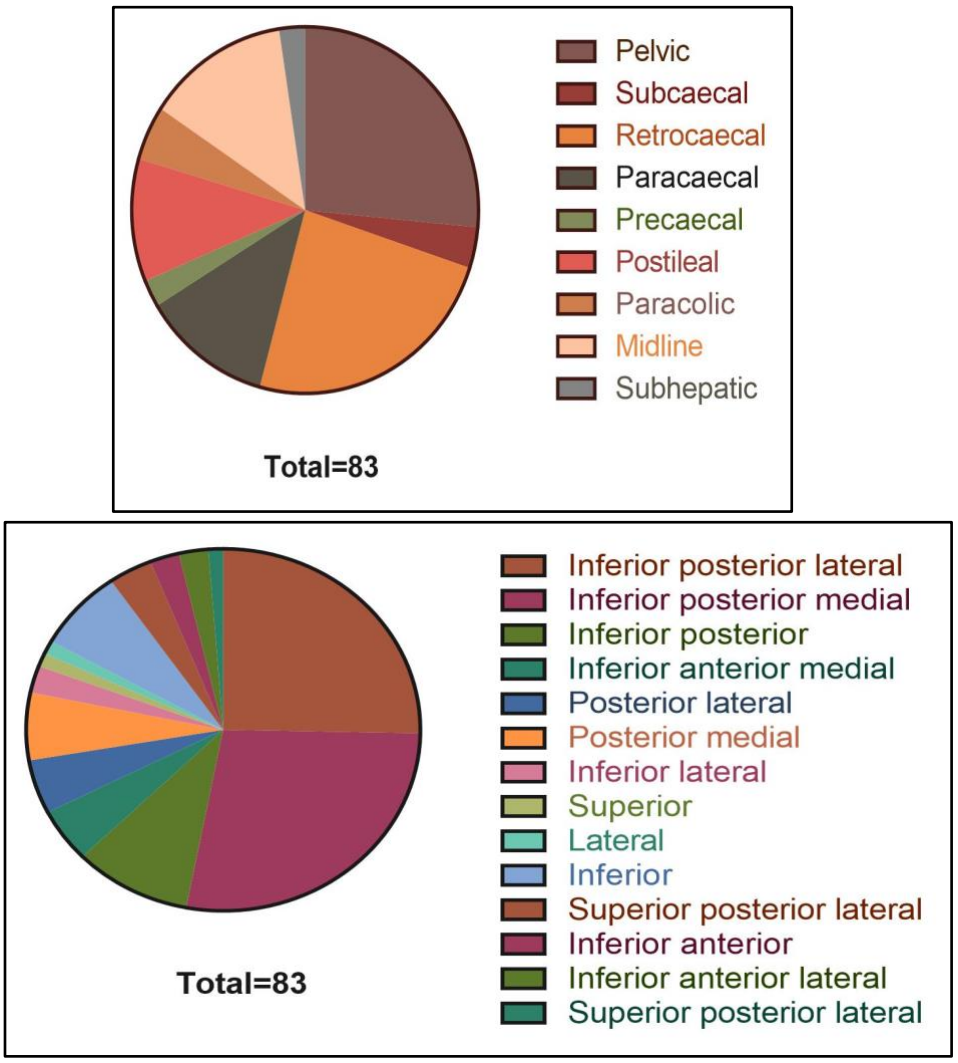

Figure 6. Distribution of the appendix tip and base locations. Top: Locations of the tips, bottom: locations of the bases.

Using the Pearson R correlation, the comparison between the variables of location and length was calculated; the relation between the tip location of the appendix and its length resulted in 0,1 with the Pearson R correlation, a value close to zero which demonstrates a small positive correlation (Figure 7).

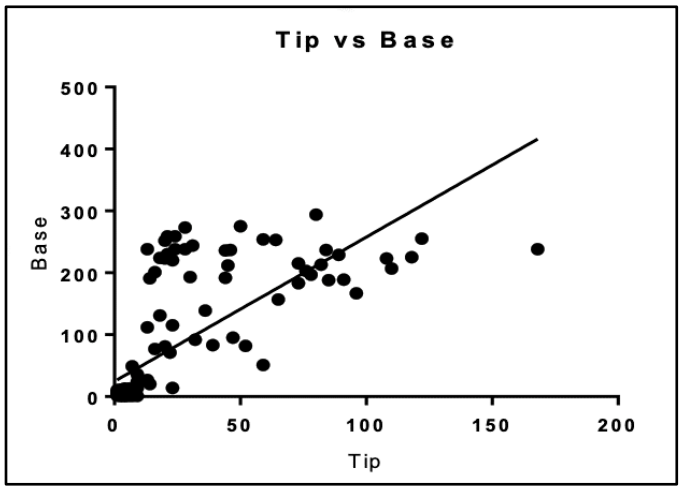

Figure 7. Correlation between the tip location of the appendix and its length. A Pearson correlation between the tip location of the appendix and its length was calculated with a result of 0,1 that is close to zero demonstrating a small positive correlation.

DISCUSSION

Appendicitis classic clinical presentation with nausea, vomit and pain in the lower right quadrant is not always the case which is why imaging techniques nowadays are fundamental during its diagnosis process. It has been proven that the use of diagnostic images can minimize the delay to treatment, reducing morbidity and also increases the diagnostic accuracy lowering the negative appendectomy rate (11). The first line imaging technique used for the diagnosis of appendicitis is ultrasonography where the appendix appears as a tubular structure, however, when it comes to visualizing the appendix, the diagnostic value diminishes once the diameter increases (> 6 mm), there is lack of compressibility or there is presence of intraluminal fluid (12).

Therefore, to obtain good images of the appendix the best diagnostic image is the tomography with the purpose of obtaining frequency and prevalence, even when there is presence of inflammation or fluid (3). Computed tomography is also used in nonspecific abdominal pain, so given this statement, the objective of this study was the visualization of the appendix and its correlations in space and location to the contents of the abdominal and pelvic cavity to determine the causes of pain (13). Computed tomography criteria for the diagnosis of appendicitis are based on its diameter size (more than 6 mm), wall thickness (more than 2 mm), periappendiceal fat stranding, appendiceal wall enhancement, and the presence of an appendicolith, which are the internationally recognized criteria for the diagnosis (13,14). The sensitivity and specificity of abdominal computed tomography and pelvic computed tomography without contrast material are 83% and 98%, respectively, being high for this pathology (12).

In the appendix, the normal diameter is 6 mm, and any value over this number is considered as a possible inflammation, nevertheless this has to be correlated to the clinical presentation of the patient (11,13). In this study, considering the lack of further information available on the patients it was not possible to discern if those with a diameter above 6 mm had an associated inflammatory process in their appendix, so this can be described as an interesting finding considering that it is reported that one third of patients have an atypical presentation (15).

According to some reports (3), the results in this study fulfilled criteria for radiologic appendicitis, nonetheless recent studies report that the maximum normal diameter of the appendix can reach up to 10-13 mm, which explains our findings (8,10).

On the other hand, there are recent reports that consider that distension in the appendix is better measured with wall thickness (10). The wall thickness mean value in this study was in the normal range, the upper limit being 6 mm if luminal content if visualized, which was not evaluated in this study (10).

In regards to localization of the appendix, a similar study to this one was also performed in Colombia, in which the most prominent location was retrocaecal followed by the pelvic position (16), contrary to our results with more frequency of pelvic location. In this study the location of the base of the appendix was mostly inferior and posterior to the ileocaecal valve which correlated to general findings in other studies (17). This finding is very important to the surgical team in the moment of surgical removal and to the imaging experts in the way of interpretation.

The most relevant information is the location of the tip of the appendix, as it is related to length and prevalence of symptoms in an acute process, as in appendicitis. A study in Brussels that took into account the location of the appendix found that the most common location of the tip was pelvic (18) and it agrees with the results of this study where the majority where observed in this location.

Contrary to other reports in which other locations are not so frequent (16,19), an interesting finding in this study was that the locations were more evenly distributed. However, has been described that given normal growth and different interventional abdominal procedures, sometimes the appendix can change position (5).

The locations of the base of the appendix were mostly in inferior posterior lateral and inferior posterior medial to the ileocaecal valve, which correlates with overall reports (10).

According to the results obtained, there was no correlation between the tip location and the length of the appendix. This means that, even if the appendix is long, it is not associated with a tip location further from the ileocaecal valve which was the initial hypothesis.

There are some limitations to this study including the lack of previous history of the patients limiting the capacity of analysis. Moreover, these were patients in the hospital setting so they were not healthy and that could affect the results of the study, nevertheless patients with any confirmed appendiceal pathology were excluded. Also, the vast experience of the radiologist reduce the possibility of measurement error and visualization error.

In conclusion, most appendixes are located in the pelvis as is reported in previous studies (6), but, the locations were more evenly distributed and there was no correlation between the tip location and the length of the appendix. Nonetheless, more studies of a larger magnitude need to be made to recognize the distribution of this in Colombia and determine the difference with other countries for the better management of pathology of the appendix. Considering the prevalence of the specific locations of the appendix is relevant in clinical and in surgical context for the better diagnosis of the patients.

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CONFLICTS OF INTEREST: None to declare.

AUTHORS CONTRIBUTIONS: JDLM: study design, data analysis and interpretation, critical appraisal, approval of final version, responsible of veracity and integrity of the article. LDLB: data analysis and interpretation, manuscript writing, critical appraisal, approval of final version, responsible of veracity and integrity of the article.

REFERENCES

1. Snyder MJ, Guthrie M, Cagle S. Acute appendicitis:

Efficient diagnosis and management. Am Fam Physician. 2018; 98(1): 25–33.

2. Cabrera-Rivera PA, Posso-Valencia HJ, Dennis-Verano RJ. Clinical and cost benefits of a standardization model in the management of acute appendicitis. Rev Colomb Cir. 2021; 36(2): 283–300.

3. Monsonis B, Mandoul C, Millet I, Taourel P. Imaging of appendicitis: Tips and tricks. Eur J Radiol. 2020; 130: 109165. Available from: https://doi.org/10.1016/j.ejrad.2020.109165

4. Banerjee A, Kumar IA, Tapadar A, Pranay M. Morphological Variations in the Anatomy of Caecum and Appendix - A Cadaveric Study. Natl J Clin Anat. 2012 Jan 23; 01(01): 030–5. Available from: http://www.thieme-connect.de/DOI/DOI?10.1055/s-0039-3401654

5. Zacharzewska-Gondek A, Szczurowska A, Guziński M, Sąsiadek M, Bladowska J. A pictorial essay of the most atypical variants of the vermiform appendix position in computed tomography with their possible clinical implications. Polish J Radiol. 2019; 84: e1–8.

6. Ghorbani A, Forouzesh M, Kazemifar AM. Variation in Anatomical Position of Vermiform Appendix among Iranian Population: An Old Issue Which Has Not Lost Its Importance. Anat Res Int. 2014 Sep 10; 2014: 1–4. Available from: https://www.hindawi.com/journals/ari/2014/313575/

7. JM W, W M, JL C. Does this patient have appendicitis? JAMA. 1996; 276(19): 1589–94.

8. Johnson PT, Eng J, Moore CJ, Horton KM, Fishman EK. Multidetector-row CT of the appendix in healthy adults. Emerg Radiol. 2006; 12(6): 248–53.

9. Mwachaka P, El-busaidy H, Sinkeet S, Ogeng'o J. Variations in the Position and Length of the Vermiform Appendix in a Black Kenyan Population. ISRN Anat. 2014 Apr 30; 2014: 1–5. Available from: https://www.hindawi.com/journals/isrn/2014/871048/

10. Charoensak A, Pongpornsup S, Suthikeeree W. Wall thickness and outer diameter of the normal appendix in adults using 64 slices multidetector CT. J Med Assoc Thail. 2010; 93(12): 1437–42.

11. Baird DLH, Simillis C, Kontovounisios C, Rasheed S, Tekkis PP. Acute appendicitis. BMJ. 2017; 357: j1703.

12. Kabir SA, Kabir SI, Sun R, Jafferbhoy S, Karim A. How to diagnose an acutely inflamed appendix; a systematic review of the latest evidence. Int J Surg. 2017; 40: 155–62. Available from: http://dx.doi.org/10.1016/j.ijsu.2017.03.013

13. Demir MK, Savas Y, Furuncuoglu Y, Cevher T, Demiral S, Tabandeh B, et al. Imaging Findings of the Unusual Presentations, Associations and Clinical Mimics of Acute Appendicitis. Eurasian J Med [Internet]. 2017 Oct 25; 49(3): 198–203. Available from: https://www.eajm.org//en/imaging-findings-of-the-unusual-presentations-associations-and-clinical-mimics-of-acute-appendicitis-132995

14. Whitley S, Sookur P, McLean A, Power N. The Appendix on CT. Clin Radiol. 2009; 64(2): 190–9.

15. Pinto P, N PL, Jm P, Cunha R, Pinto P. CT Evaluation of Appendicitis and Its Complications : Am Roentgen Ray Soc. 2005; 185 (August): 406–17.

16. Giovanni E, Gómez C, Luis P, Porras F, Uribe LA, Camargo DB. Posición anatómica y longitud del apéndice vermiforme en una población de raza mestiza de la ciudad de Bucaramanga - Colombia. 2009; 55: 116–20.

17. Barlow A, Muhleman M, Gielecki J, Matusz P, Tubbs RS, Loukas M. The vermiform appendix: A review. Clin Anat . 2013 May; 842. Available from: https://onlinelibrary.wiley.com/doi/10.1002/ca.22269

18. Willekens I, Peeters E, De Maeseneer M, de Mey J. The Normal Appendix on CT: Does Size Matter? Lo AW, editor. PLoS One. 2014 May 6; 9(5): e96476. Available from: https://dx.plos.org/10.1371/journal.pone.0096476

19. Wakeley CPG. The Position of the Vermiform Appendix as Ascertained by an Analysis of 10,000 Cases. J Anat. 1933; 67(Pt 2): 277–83.