ORIGINAL RESEARCH ARTICLE

Analysis of Morphology of Normal Appendix using Contrast Enhanced CT Abdomen

Varun Narayan[1], Sajin George Joseph[2]

[1]Assistant Professor, Department of Radiodiagnosis, [2]Senior Resident, Department of Radiodiagnosis, Amala Institute of Medical Sciences, Thrissur, Kerala, India

Corresponding author: Dr.Sajin George Joseph, Senior Resident, Department of Radiodiagnosis, Amala Institute of Medical Sciences, Amala Nagar, Thrissur, Kerala, India

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ABSTRACT

Introduction: Appendix is identified as blind ending tubular structure arising from caecum and has variable intraluminal contents and position. Acute appendicitis is one of the common indications for emergency imaging studies.

Material and Methods: Contrast enhanced computed tomography images of abdomen from 120 patients without suspicion of acute appendicitis and without any pathology localized within right iliac fossa were examined retrospectively. The images were reviewed in axial,coronal and sagittal reformations for tracing appendix upto its tip; assessing intraluminal contents, maximum transverse diameter and single wall thickness of appendix. The relationship between appendicular diameter, intraluminal content and position with different age groups and gender were also determined.

Results: The mean diameter of the appendix was 6.87±1.73mm. Most common location of the tip of appendix was retrocecal position. Most of the appendices were opacified by enteric contrast. Mean single wall thickness of appendix was 1.99±0.9mm.

Conclusion: The understanding of variation in the diameter, wall thickness and position of the normal appendix will assist in enhancing the precision of diagnosis of appendix related pathologies, particularly appendicitis. Severe caution must be exercised in making a diagnosis of acute appendicitis solely considering diameter of appendix in the absence of other signs.

Keywords: Normal Appendix, CECT, Diameter, Luminal Contents, Location, Wall Thickness, Appendicitis

INTRODUCTION

Imaging has been widely used over the past two to three decades for evaluation and diagnosis of acute appendicitis which is the most common acute abdominal pathology in adults and children requiring surgery.[1] Computed tomography (CT) is fast becoming the favored imaging modality for suspected acute appendicitis, especially in adults owing to its high sensitivity and specificity.[2] Accuracy wise CT has the upper hand than ultrasound (US) as CT is less operator dependent.[3] Also patient factors like obesity, overlying gas-filled bowel loops and differences in positions of appendix may pose serious challenges in visualizing normal as well as abnormal appendix with ultrasound.[4,5] Patients undergoing laparoscopic appendicectomy also benefit from CT preoperatively.[6]

Another factor favoring CT is that normal appendix is more commonly visualized at CT thereby excluding the diagnosis of appendicitis for all practical purposes.[7,8] The reported diameter of a normal appendix at CT is an extrapolation from US results[5,9-11],with use of a 6mm short-axis diameter as the upper limit of normal.[7,8,12,13] However normal appendiceal diameter ranging from 6-11 mm in CT have been shown by recent studies.[14] Using same diameter cut-off for ultrasound and CT for the diagnosis of appendicitis has been questioned by Orschelin and Trout.[15]

The purpose of this study was to determine the variability in CT characteristics of a normal appendix namely diameter, wall thickness, position and intraluminal contents.

MATERIAL AND METHODS

The study was conducted in the Department of Radiodiagnosis, Amala institute of medical sciences, Thrissur, Kerala.

The hospital picture archiving and communication system (PACS) was interrogated to identify all patients who underwent contrast enhanced CT examination of the abdomen with positive oral and rectal contrast, for various purposes retrospectively over the period starting from January 1 to May 31, 2019. Out of various indications, patients with pain in the right lower quadrant or a clinical suspicion of appendicitis and patients with history of appendicectomy were excluded.

The study included 120 patients, out of which 69 were males and 51 were females. Age of subjects ranged from 15 to 81

years.

Image Analysis

The obtained axial images from picture archiving and communication system (PACS) were transferred to the work station (GE medical systems Milwaukee, USA) where the image analysis was performed by two experienced practicing radiologists.

Images were analyzed in axial, multiplanar reconstructions (MPR) and post processed maximum intensity projection (MIP) images. The appendix was visualized along its complete length and maximal outer diameter of the appendix was measured in a plane perpendicular to its axis using electronic calipers (Figure 1). Single wall thickness of the appendix was measured in walls in the same plane (Figure 2). All measurements were done to the nearest 0.1 mm. In cases where the appendiceal lumen were collapsed (unopacified) the wall thickness was calculated as half of maximum diameter.

The density of the contents of the appendix was measured on axial images. We described it as opacified (hyperdense with >80HU), hypodense material (<80 HU), air, partially opacified (Figure 3) and collapsed (unopacified).

The location of the tip of the appendix was described as paracolic- adjacent and along the ascending colon; retrocolic/ retrocaecal- behind the colon or caecum (Figure 4); pelvic- extending to the pelvis; midline-extending to the midline.

The mean and range of maximal diameter and single wall thickness of appendices were calculated from the data.

RESULTS

The appendix was visualized in all the 120 patients included. The mean maximal diameter was 6.87mm± 1.73mm(SD). The minimum caliber of appendix that we encountered was 3.6 mm with a maximum of 13mm. The mean maximal diameter in males was 7±1.89 (SD) mm and in females 6.7±1.46(SD) mm. The mean single wall thickness of the normal appendix was 1.99 mm±0.9mm(SD) (range 0.5 to 5.3mm).

The most common location of the appendiceal tip was retrocolic or retrocaecal in 44 of 120 (37%) appendices.

Position	Male (%)	Female(%)
Midline	7(10.1)	3(5.9)
Paracolic	14(20.3)	14(27.5)
Pelvic	18(26.1)	20(39.2)
Retrocecal/Retrocolic	30 (43.5)	14(27.5)
Grand Total	69	51

Table-1: Location of appendix

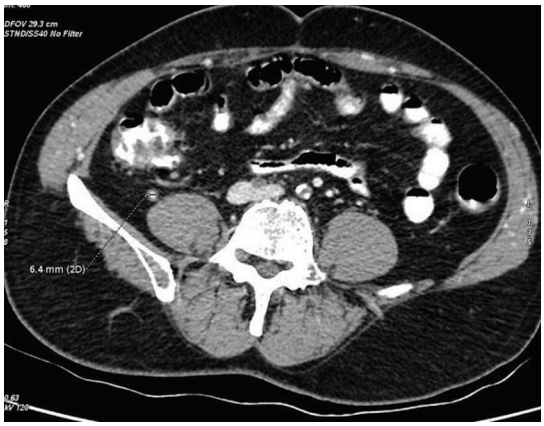

Figure-1: Measurement of appendicular maximal outer diameter in axial MPR image in the plane perpendicular to appendicular lumen.

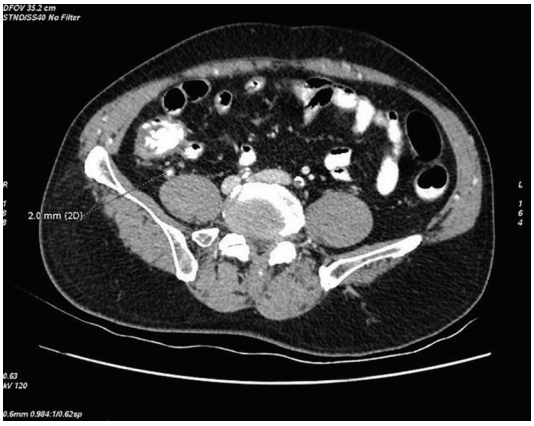

Figure-2: Measurement of appendicular single wall thickness in axial MPR image in the plane perpendicular to appendicular lumen.

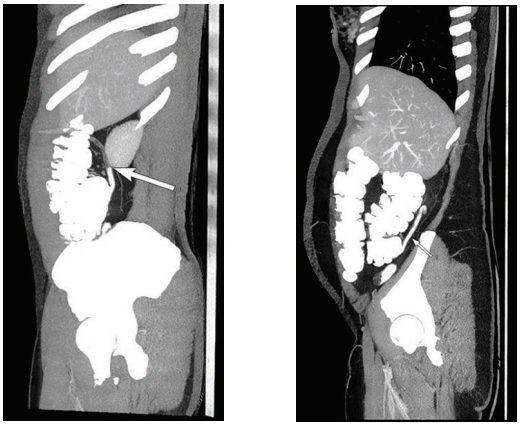

Figure-3: Sagittal MIP reformatted image showing partially opacified appendix (white arrow) with proximal part opacified by oral contrast and distal part having hypodense material; **Figure-4:** Sagittal MIP reformatted image showing retrocolic appendix(white arrow) which is completely opacified by oral contrast.

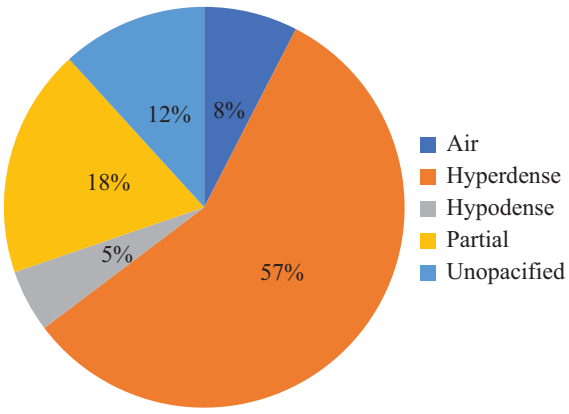

Figure-5: Pie chart showing distribution of appendix based on intraluminal contents.

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The appendiceal tip was pelvic in 38 (32%), paracolic in 28 (23%), and midline in 10 (8%) (Table 1). In females the most common location was pelvic (20 out of 51) and in males retrocecal/retrocolic (30 out of 69).

The normal appendices contained hyperdense material (opacified) in 57% (68 of 120), were partially opacified in 18%(22 of 120), completely air-filled in 8% (10 of 120), collapsed (unopacified) in 12%(14 of 120) and filled with hypodense material in 5%(6 of 120) (Figure 5).

DISCUSSION

In our study appendix was visualized in all the patients. This is partly due to the fact that we included patients who underwent CT abdomen with intravenous and enteric positive contrast. It is in accordance with previous studies where administration of rectal or oral contrast provided the highest sensitivity (>90%) for visualization of the normal appendix.[3,8,16] However rectal contrast administration may be uncomfortable for the patients. In about 18% of individuals failure of rectal contrast to reach the caecum also has been noted.[17] Oral contrast may delay treatment as it takes 45 to two hours to reach caecum[18,19,20] and may be poorly tolerated by patients with nausea and vomiting. In our study failure of appendix to be opacified by enteric contrast was seen in about 26%(32 of 120) of patients. Moteki and Horikoshi in their study found high sensitivity and specificity (>80%) for diagnosis of acute appendicitis for depth of the intraluminal appendiceal fluid greater than 2.6 mm.[21] They had found 3.4% of their normal population group showing this sign. In our study also we found only 5%(6 out of 120) patients showing appendix filled with hypodense material.

In our study the most common location of appendix tip is found to be retrocecal/retrocolic (44 of 120), second most common location was pelvic (38 out of 120). This is concordant with previous studies where they found tip of appendix most commonly located posteriorly to cecum.[2,14]

In our study, the mean maximal diameter was 6.87mm$\pm$ 1.73mm(SD) (range, 3.6 to 13mm). Other studies have shown that the mean diameter of a normal appendix is 6-8mm.[20,22,23] A transverse diameter of up to 11 mm is reported in a normal appendix with air or contrast material distension.[16,24,25] In our study, around 43%of patients had an appendiceal diameter greater than 7mm. Other studies have proposed a threshold of 10mm especially in cases where there is non visualization of luminal contents or there is no periappendiceal inflammatory signs.[20,24,25] Our results are consistent with these studies and suggest that a diameter of 6mm may not be a reliable cut off to predict appendicitis in the absence of other signs.

Mean single wall thickness in this study was 1.99 mm$\pm$0.9mm(SD). Other studies have shown mean wall thickness ranging from 1.2 to 2.22mm.[14,20,26] Our findings are in accordance with these studies. The normal appendix has a reported maximum mural thickness less than 2-3mm.[27] Previous reports showed that wall thickening beyond 3 mm may be considered a sign of inflammation and only 0.9% of normal appendices had a wall thickness of 3 mm or greater.[14] However Willikens et al in their study had found wall thickness of more than 3mm in 8% of patients.[20] In our study wall thickness of more than 3 mm was found in 13% (16 of 120).

To the authors' best knowledge this is a first study of its kind evaluating the CT characteristics of normal appendix in Indian population. The study has its limitations, the major one being use of patient history as gold standard and absence of surgicopathological correlation for a normal appendix. However the inclusion of a patient with appendicitis in our patient population is considered highly unlikely since in their clinical course appendicectomy has not been performed or the diagnosis of appendicitis not suspected for atleast a month after the CT examination. We included only patients who underwent CT abdomen with intravenous and enteric contrast administration, excluding patients having history of appendicectomy. This would explain the difference in rates of visualization between our study and other previous studies. Inclusion of patients with enteric contrast also may have masked the visualization of appendicoliths which are usually hyperdense. However some previous studies have not found significance of appendicoliths alone to diagnose appendicitis[21] and appendicoliths was found in 1.7% patients with normal appendix.[20]

CONCLUSION

Concluding we have found that diameter of normal appendix is variable and extrapolating ultrasound criteria for diagnosing appendicitis may not be an accurate approach in CT. MDCT with intravenous and enteric contrast is a formidable investigation to visualize and depict the anatomy of normal appendices. Various characteristics including wall thickness, intraluminal content should also be considered along with diameter to improve the accuracy of diagnosing pathologies related to appendix.

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