Multi-Detector Computed Tomography Evaluation of Normal Appendix

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ABSTRACT

Background

Appendix is a blind-ended tubular structure arising from caecum, with variable intraluminal contents and position. Acute appendicitis is one of the common indications for emergency radiological investigation.

Objective

To assess visualization rate, size and position of normal appendix by Computed Tomography (CT).

Method

This cross-sectional observational study was done in 198 individuals undergoing abdominal CT without suspicion of acute appendicitis and without any pathology localized within right iliac fossa. Axial and coronal reformatted images of non-enhanced and contrast enhanced CT of abdomen were evaluated for visualization of appendix. Visualized appendices arising from caecum were traced and tip localized. Contents within the appendicular lumen were also evaluated and maximum transverse diameter of appendix measured. The relationship between appendicular diameter, intraluminal content and position with different age groups & gender were also derived.

Result

Visualization rates of appendix were 90% (93% male and 87% female) in non-enhanced CT and 97% (99.8% male and 95.4% female) in enhanced CT. The mean diameter of the appendix was 6.2 ± 1.16 mm. Most common location of the tip of appendix was pelvic position, followed by retrocaecal position. Most of the appendices showed intraluminal air.

Conclusion

Multi-Detector Computed Tomography is superior over ultrasonography (USG) in detection of appendix. Modifications of CT protocol reduce limitations of CT over ultrasound in evaluation of appendix. Ultrasound size criteria for appendicitis (>6 mm) is not applicable in CT as normal appendix can measure >6 mm in CT.

KEY WORDS

Diameter, location, normal appendix, multi-detector computed tomography

INTRODUCTION

The appendix is a blind-ended, tubular structure arising from the caecum.[1] Acute appendicitis is the common cause of acute abdominal pain which has widely been diagnosed with ultrasound.[2,3] However, CT is superior to USG for evaluation of appendix as it is less operator dependent.[4] On the other hand, obesity, overlying loops of gas-filled bowel and variable positions of appendix may lead to difficulty in visualizing appendix with ultrasound.[5,6] With the use of multi detector CT (MDCT) the visualization of appendix at CT is even better.

Appendicitis is usually said when the diameter of the appendix is more than 6 mm on USG. However, various recent studies have showed normal appendices ranging from 6-11 mm in CT.[7] Orschelin and Trout questioned the use of same diameter cut-off for ultrasound and CT for the diagnosis of appendicitis.[8] Thus, the diagnosis of appendicitis in CT should be based on the appearance of secondary signs, rather than the size criteria alone.

Visualization of normal appendix in any imaging modality excludes appendicitis. However, detection of normal appendix is not as easy as detecting inflamed appendix. Visualization of normal appendix in CT (69-98%) is again superior to ultrasound (46-82%).[5,9]

The purpose of this study is to detect visualization rate of normal appendix in CT, including difference between the visualization rate between the contrast-enhanced and non-enhanced CT. This study also aims to find out the various intraluminal contents of appendix and positions of appendix.

METHODS

This was a prospective study conducted in 198 individuals with no clinical suspicion of acute appendicitis undergoing abdominal CT in Dhulikhel Hospital from the period of September 2015 to February 2016. CT scans were obtained with Seimens Somatom Perspective 128 slice CT. Both male and female individuals of variable age groups were included in the study.

All the studies were carried out in non-enhanced and contrast-enhanced (IV) CT of abdomen. All the individuals with history of appendectomy, with incidental findings of inflamed or perforated appendix were not included in the study. Individuals with other right iliac fossa pathologies that can affect the caliber of appendix were also excluded in the study.

The axial images were assessed focusing in the right iliac fossa. If needed coronal reformatted images were also used for equivocal findings in axial images. Non-enhanced CT was evaluated prior to the enhanced CT. Appendix was searched by tracing caecum, and interpreted as whether visualized or not. If appendix was not visualized in non-enhanced CT, then the enhanced CT of the same patient was evaluated for visualization of appendix. When the appendix was visualized, its intraluminal content and maximum transverse diameter were noted. Intraluminal content were categorized as collapsed, air, fluid, contrast or lith.

Then the tip of the appendix was localized for noting their positions as whether retrocaecal, paracaecal, retrocaecal, pelvic or in midline. Retrocaecal position noted with tip of appendix lying behind the caecum or the ascending colon; Paracaecal position noted if the tip of appendix was seen on either lateral or medial to the caecum/ascending colon; Subcaecal position noted if the tip of appendix was seen just below the caecum; pelvic position noted if appendicular tip was extending into the pelvis; and midline position noted when the tip of appendix was directed medially towards the midline.

Data obtained were compiled and analyzed using standard statistical analysis – Microsoft Excel and SPSS 21. Frequencies of visualization of appendix (in enhanced and non-enhanced CT) and location of its tip when visualized were determined with SPSS. The mean diameter along with the standard deviation of the appendices was also determined with SPSS. The mean diameters in different gender were also determined.

RESULTS

The numbers of individuals studied were 198, among them 110 were female and 88 were male. Age of the individuals ranged from 7 years to 85 years. (Table 1) Appendix was visualized in 192 cases (97%), including 105 female and 87 male individuals. Among those individuals in whom appendix was not visualized, five were female and one was male. Among female individuals, appendix was visualized in 95.4% and in male, in 99.8%. (Table 2) In non-enhanced CT, appendix was visualized in 178 cases (89.9%), including 96 females and 82 males.

Table 1. Characteristics of participants **(n= 198)**

Characteristics	Number	%
Sex		
Male	88	44.4
Female	110	55.6
Age group (years)		
<10	1	0.5
11-20	12	6.1
21-30	26	13.1
31-40	35	17.7
41-50	41	20.7
51-60	33	16.7
61-70	36	18.2
71-80	11	5.6
81-90	3	1.5

Table 2. Visualization of appendix according to sex (n= 198)

	Frequency		%
Appendix not visualized	6		3
	Male	1	0.5
	Female	5	2.5
Appendix visualized	192		97
	Male	87	43.9
	Female	105	53.1

Regarding positions of the appendix, in this study, most common position was pelvic (35.9%), followed by retrocaecal (22.4%), midline (17.2%), subcaecal (16.2%) and paracaecal (8.3%). The position of the appendix according to the gender was also noted. Pelvic position was the most common position in both male and female individuals.(Table 3)

Table 3. Location of appendix

	Frequency			Valid percentage		
	Total	Male	Female	Total	Male	female
Paraceacal	16	6	10	8.3	6.9	9.5
Retrocaecal	43	20	23	22.4	23.1	22
Pelvic	69	35	34	35.9	40.2	32.4
Midline	33	13	20	17.2	14.9	19
Subcaecal	31	13	18	16.2	14.9	17.1
Total	192	87	105	100	100	100

The mean diameter of appendix was 6.22 mm with standard deviation of 1.16 mm and range of 3.5-9.5 mm. (Table 4) 41% of the visualized appendix were collapsed, 44% were filled with intraluminal air, 6.8% were contrast filled and 4.2 % were fluid distended. 1.5% of the visualized appendix showed both contrast and air within. 2.1% of the visualized appendix showed lith within and all of them showed air as well in appendicular lumen. (Table 5)

Table 4. Diameter of appendix in various age group and sex

	Maximum	Minimum	Mean	SD
Diameter	9.5	3.5	6.22	1.16
Diameter according to sex				
Male	9.5	3.5	6.26	1.23
Female	9.3	3.5	6.18	1.10

Table 5. Intraluminal content of visualized appendix

	Frequency			Valid Percentage		
	Total	Male	Female	Total	Male	Female
Collapsed	79	28	51	41.1	32.2	48.6
Air	85	45	40	44.3	51.7	38.1
Fluid	8	3	5	4.2	3.5	4.7
Contrast	13	8	5	6.8	9.2	4.7
Air and Contrast	3	2	1	1.5	2.3	1
Air and Lith	4	1	3	2.1	1.1	2.9
Total	192	87	105	100	100	100

DISCUSSION

Although USG and CT are frequently used for the diagnosis of clinically suspected acute appendicitis, there are literatures mentioning no significant contribution of imaging methods to diagnose acute appendicitis, and rather they delay treatment resulting in increased perforation rates.[10,11] However, some literatures also showed negative appendectomy rate of 20% before the utilization of cross-sectional imaging decreased to 4% with the use of US and CT.[12,13] Rhee JT et al even found lesser negative appendectomy rate (3%) with the use of CT.[14]

Diagnostic criteria of acute appendicitis in imaging include size criteria of >6 mm diameter, periappendiceal inflammatory changes and demonstration of appendicoliths.[15] The size criterion is based on US, and has been proved to be inaccurate in CT. This study also shows similar findings with mean diameter of normal appendix being > 6 mm with maximum diameter ranging upto 9.5 mm. Similar findings were demonstrated by Benjaminov et al. (6.6 mm), Huwart et al. (6.7 mm) and Charoensak et al. (6.6 mm).[4,1617] Emily MW et al. and Tamburini et al. also mentioned >40% of normal appendix measures >6 mm in their studies. The findings in this study is higher than the study conducted by Ozturkmen et al. (5 mm), Bursali et al. (5.1 mm), Ya-Ting Jan et al. (5.6 mm), Torkoglu et al (5.9 mm), Victoria et al. (5-5.1 mm).[5,18-21]

The diameter of appendix depends on the luminal content as well. In this study air was seen in lumen of most of the appendices which may have resulted in mean appendicular diameter more than the USG criteria for diagnosis of appendicitis. Similar finding was seen in the study conducted by Huwart et al. (87%), Charoensak et al. (54.5%) and Ya-Ting Jan et al. (48%).[16,17,19] However, in study conducted by Ozturkmen et al. most of the appendicular lumens were collapsed (54.2%).[5]

Visualization of normal appendix virtually excludes appendicitis. However, even with CT sometimes appendix is not identified. In this study also appendix was not visualized in 3%, similar to the findings of Kim et al. (1.5%), and Joo SM et al. (4-8%).[9,22] The visualization rate of appendix in this study is significantly higher than that of the study conducted by Benjaminov et al. (79%), Ozturkmen et al. (68.5%), Tamburrini et al. (82%), Huwart et al. (82%), Bursali et al. (70%), and Lane et al. (77%).[4,5,7,16,18,23] The visualization rate of appendix in this study is slightly higher than that of the study conducted by Ya-Ting Jan et al. (93%) and Johnson et al. (94%).[19,24] Most of the studies showing less visualization rate of appendix were done in non-enhanced CT, which might give impression of importance of contrast enhanced CT for more visualization of appendix. However, in our study appendix was not seen in only 14 non-enhanced CT (7.2%) which were identified in enhanced CT with iv contrast agent. This suggests no significant difference in visualization of normal appendix with or without iv contrast agent. Similar findings were

seen in study conducted by Turkoglu et al.[25] Another cause of the difference in the visualization rate of appendix could be difference in CT equipment (Single slice vs Multi detector) and observer variability.

The location of appendix is one of the causes of less visualization of appendix with USG, however, with CT the visualization is less dependent on the location of the appendix. The position of appendix was commonly seen in pelvis in our study, similar to the findings of Torkoglu et al. and Willekens et al.[20,26] The position of the appendix was most common in paracolic location in various studies conducted by Benjaminov et al., Bursali et al. and Ya-Ting Jan et al.[4,18,19] Similarly in study conducted by Charoensak et al. midline position was most common location.[17]

Garcia et al. assessed the role of intra-abdominal fat on CT visualization of normal appendix and found significant difference in visualization rate of appendix with or without adequate intra-abdominal fat.[27] Appendix visualization was significantly higher in those with adequate intra-abdominal fat.[27] One of the reasons of non-visualization of normal appendix in our study could be inadequate intra-abdominal fat, as those cases with non-visualization of normal appendix were either thin or had ascites in our study. Similar findings were seen in study conducted by Jan YT et al.[28] as well. Jan YT et al. found all the patients in unsure group had ascites or inadequate pericaecal fat or both.[28] Benjaminov et al. also stated low visualization of appendix with less intra-abdominal fat in their study.[4]

Review of literature shows many studies on imaging of appendix worldwide, however, there are few studies on imaging of appendix in Nepal. One of the recent study conducted by Ansari et al. in Kathmandu showed 86% visualization rate of normal appendix on MDCT, which is significantly low as compared to our study. Mean diameter of the appendix and intraluminal contents were similar to our study. Contradictory finding is the position of the appendix. Our study showed appendix mostly in pelvic position, however, their study found paracolic position as most common site. Also the study was done in post contrast (iv) CT, however, present study was done in both non-enhanced as well as contrast-enhanced CT. We compared the visualization rate of appendix in both non-enhanced as well as enhanced CT, which showed visualization of 90% of appendix in non-enhanced CT compared to 97% visualization rate in contrast-enhanced CT.

One of the limitations of this study include smaller sample size, which may be the cause in significant discrepancy in the findings of Ansari et al and our study regarding the position of appendix in Nepalese population. In order to standardize the findings in Nepalese population, study on larger population (large sample size) is recommended.

Another limitation of CT is radiation exposure. Several modifications in CT protocol have been tried to reduce the radiation exposure, including low dose CT, non-contrast CT (non invasive) and focused CT of appendix/ right iliac fossa. Study done by Karabulut N et al concluded no significant difference in visualization rate of normal appendix low dose and standard dose non-contrast CT.[29] Bursali A et al. also found normal appendix frequently at nonenhanced low dose CT.[30] Wijetunga R et al. also found high accuracy of focused appendiceal CT in detecting appendicitis.[31] These modifications reduce the limitations of CT over USG. Thus, with increased CT visualization rate of appendix and reduced radiation exposure with above mentioned modifications, CT can replace USG in evaluation of suspected appendicitis in near future.

CONCLUSION

MDCT is more accurate for detection of appendix as compared to USG. However, USG size criteria for diagnosis of acute appendicitis cannot be used in CT as normal appendix in CT can have diameter >6 mm. Modifications in CT protocol can be done in imaging of appendix with reduced limitations of CT over USG, without reducing its visualization rate.

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