

Evaluation of Normal Appendix in Adult Jordanians using Non-Enhanced Dual Source 64–Slice MDCT

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Abstract

Objective: To evaluate the frequency of visualization and size measurements of normal appendix in Jordanian adults using non-enhanced dual source 64-slice multidetector computed tomography (MDCT).

Materials and Methods: A retrospective review of 240 consecutive adult patients (150 men and 90 women, age range 18-86 years, mean age = 49.8) who underwent a non-enhanced abdominal CT for possible renal stone disease was conducted. A senior radiologist interpreted the images in the axial, coronal, and sagittal planes. The visualization, location, contents, maximum outer diameter and two wall thickness of visualized appendices were recorded.

Results: The appendix was visualized in 95% of patients. Intraluminal contents were identified in 70.6% of patients. The greatest outer diameter of the appendix ranged between 4 and 11.4 mm (mean = 6.2 mm), and the two wall thickness ranged between 1.8 and 7 mm (mean = 5.4 mm). The prevalence of appendicitis in this study was 7.8%.

Conclusions: Non enhanced MDCT is extremely useful in identification of normal appendix. The conspicuity and detection rate of normal appendix were significantly improved when additional multiplanar reformation images, particularly coronal images, were used. The wide variation in the outer diameter of normal appendix on CT may lead to significant overlap between normal and abnormal appendix, therefore, to reduce the false positive and false negative diagnoses of acute appendicitis other secondary signs should be recruited.

Keywords: Normal appendix, Multidetector computed tomography, Multiplanar reformation, Adults.

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Introduction

Visualization of normal appendix during cross sectional imaging of the abdomen and pelvis is important since its demonstration almost completely excludes the diagnosis of

appendicitis, with consequent reduction in the negative appendectomy rate (rate of normal appendix at pathological examination), and redirects radiologist to look for other causes that can mimic appendicitis. This is particularly valuable in examinations

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performed for patients with equivocal signs and symptoms of acute appendicitis. Therefore, recent efforts are directed toward improved conspicuity and detection rate of normal appendix. Recent developments in MDCT scanners have allowed rapid imaging of the abdomen and pelvis within a single breath hold with a submillimetric spatial resolution in all imaging axes. This advancement together with commercially available picture archiving and communication system (PACS) that enables rapid reconstruction and viewing of images in various planes has led to significant improvement in the evaluation of normal appendix with identification rates varied from 82% to 98.5% have been reported.^{1,2,3} However, in most of these reports, CT evaluation of normal appendix was performed with oral, rectal, and intravenous contrast material administration, with only few studies that have investigated the normal appendix by non-enhanced MDCT have been described in literature.^{4,5,6}

The aim of this study was to investigate the visualization rate and morphology of normal appendix on non-enhanced MDCT examination in patients not suspected to have appendicitis.

Materials and Methods

The study was approved by the institutional review board at our hospital.

A total of 280 consecutive adult patients who had undergone non-enhanced abdominal CT scans for suspected renal stone disease in the period between January 2013 and June 2013 were included in this retrospective study. Of these 280 patients, 40 patients (14.3%) were excluded: 22 patients (7.9%) had a previous history of appendectomy, 17 patients (6.1%) had a previous abdominal surgery but

no available history of appendectomy, and 1 patient (0.3%) had CT indication of acute appendicitis (a 34 years old male with pelvic appendix, measured 22 mm in outer diameter associated with moderate peri-appendiceal inflammatory changes). Therefore, the final study population consisted of 240 patients (150 men, 90 women; age range 18-86 years, mean age 49.8 years \pm 17.6 SD). All patients were examined with a dual source 64-slice MDCT scanner (Somatom definition, Seimens medical solutions, Germany), without oral, rectal, or intravenous contrast material administration. The stone protocol routinely used at our hospital was as follows: Scanned area, from dome of liver to symphysis pubis; tube voltage, 120-140 KVP; effective tube current time, 210-300 MAs; collimation, 0.6mm; pitch, 1 ;and gantry rotation time, 0.5s.

All examinations were reviewed and interpreted at a work station (Syngo Multi Modalities MMWP, Seimens, Germany), in axial and coronal planes, and whenever needed in sagittal plane with slice thickness of 1mm and 5mm. All examinations were interpreted by experienced radiologist, who was aware of the history of renal colic, but blinded to patient surgical history including appendectomy.

The appendix was interpreted as visualized or not visualized. The maximum outer diameter for all visualized appendices and the maximal two wall thickness of all appendices with recognized intra-luminal contents were measured. For patients with collapsed appendix or with iso-dense luminal contents, that could not be recognized from appendix wall, the maximum outer diameter was measured only. All measurements were obtained on workstation by using electronic calipers. The presence and type of intra-luminal contents were indicated. The appendix tip was localized and the appendix was

accordingly classified into: paracolic (tip adjacent to ascending colon), retrocolic (tip behind the caecum), pelvic (tip extending to the pelvis), midline (tip extending to midline) and retroileal (tip behind the ileum). The ileo-cecal valve was interpreted as visible or not visible, and location of the base of the appendix was described in relation to ileo-cecal valve as; same level, anterior, posterior, medial, lateral, and superior or inferior relative to the ileo-cecal valve. Pericecal fat was described as adequate if the caecum is completely surrounded by fat or inadequate if it is not completely surrounded by fat. Presence of peri-appendiceal fat stranding or free pelvic or abdominal fluid was also described.

Results

Appendectomy was documented in 22 out of 280 patients included in the study population; a prevalence of 7.8%. Upon using axial, coronal and sagittal images during evaluation the appendix was visualized in 228

(95%) of 240 patients included in the final study group. For combined axial and coronal images, it was detected in 223 patients (93%), and for the axial images alone it was visualized in 203 patients (84.6%). Intraluminal contents of the appendix were identified in 70.6% (161/228) of patients (Table 1). While in 29.4% (67/228) of patients intraluminal content was not identified, either due to collapsed appendix lumen or due to isodense luminal contents (Figure 1). The tip of the appendix was located in paracolic position in 87 patients (38.2%), pelvic position in 62 patients (27.2%), retrocaecal position in 49 patients (21.5%), midline position in 27 patients (11.8%), and in retro-ileal position in 2 patients (0.9%) (Figure 2). The ileocaecal valve was identified in 235 (97.9%) of 240 patients with visualized appendices. The level of the appendix base in relation to the ileocaecal valve was as follows; caudal in 96%, and cephalic in 4%. Posterior in 91%, medial in 8%, lateral in 1%, and anterior in 0%.

Table 1. Distribution of intraluminal contents of the appendix in 161 patients

Number	Type of content	Number of patients	Percentage
1	Air only	124	77%
2	Fluid only	8	5%
3	Hyperdense material (calcification)	12	7.5%
4	Mixed air, fluid, and high density material	17	10.5%

The pericaecal fat was described as adequate in 233 patients (97%), and inadequate in 7 patients (3%) (Figure 3). Periappendiceal fat stranding was identified in 3 patients with visualized appendix, in two of them, significant ascitis was demonstrated, and the outer appendiceal diameter measured less

than 6 mm in each of these patients, therefore, the diagnosis of appendicitis was not suggested in any of them and stranding was attributed to the ascites. In the third patient, however, the outer diameter of the appendix measured 22 mm and was diagnosed as acute appendicitis and therefore, excluded from the

study. Of the 228 visualized appendices the greatest outer diameter measured between 4 and 11.4 mm with a mean diameter of 6.2 mm \pm 1.48 SD. The outer appendicular diameter measured greater than or equal to 7 mm in

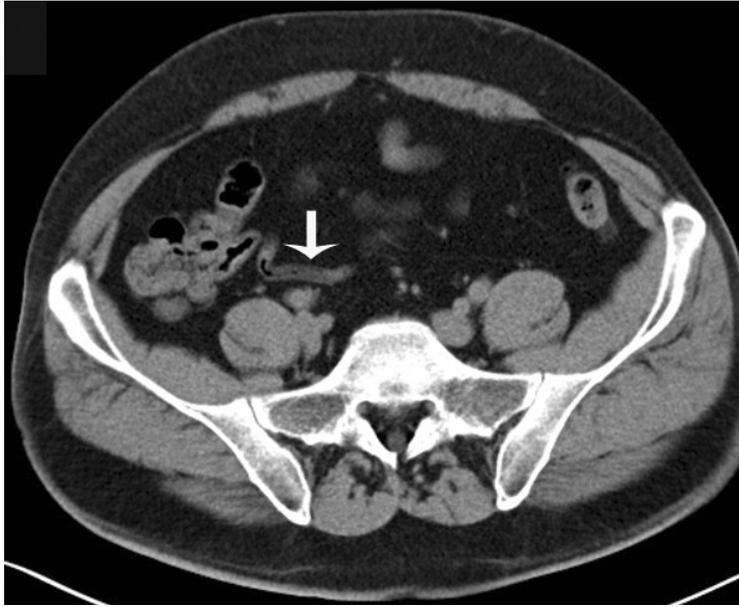
52% (119/228) of patients, and greater than or equal to 10 mm in 0.13% (3/228) of patients. Intraluminal air was visualized in all 3 patients with outer appendicular diameter greater than or equal to 10mm (Figure 4).



**Figure 1. Non enhanced CT shows an appendix with isodense luminal content
a. axial**



Figure 1.b. coronal



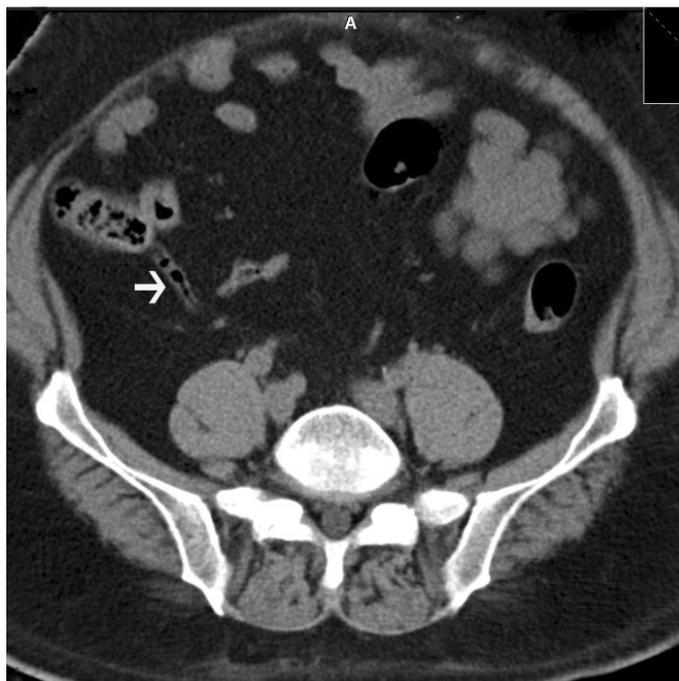
**Figure 2. Non enhanced CT shows various positions of the appendix
a. midline appendix**



Figure 2.b. retrocecal appendix



Figure 2.c. pelvic appendix



**Figure 3. Non enhanced CT shows
a. adequate pericecal fat surrounding the appendix**



Figure 3.b. inadequate pericecal fat

Of 161 patients with recognized intraluminal contents the maximum two wall thickness of the appendix ranged between 1.8 and 7mm, with a mean of 5.4 mm \pm 1.99 SD. In all patients with a maximum diameter greater than or equal to 7mm, the two wall thickness was measured less than or equal to 6mm.

Discussion

The objective of the current study is centered on performance of MDCT examination technique with MPR images in evaluating normal appendix in patients not suspected to have appendicitis, without the need for oral, rectal or intravenous contrast material administration, since the literature record is deficient regarding this issue, and in most of previous studies addressing this subject, contrast material administration was used during assessment of normal appendix.^{1,7,8,9,10} In fact all CT examinations in this study were performed primarily for assessment of patients with suspected urinary stone disease, since unenhanced CT examination of the abdomen and pelvis is

routinely used at our hospital for evaluation of these patients.

In this study normal appendix was identified in 84.5% of patients using thin cut axial images alone. This result was comparable with previously reported rates using similar CT examination technique. In two separate studies performed by lane et al.¹¹ and Binjaminov et al.¹² normal appendix was visualized in 77% and 79% of patients, respectively using non enhanced helical CT examination technique. This study results showed that the visualization rate of normal appendix was increased to 93% and 95%, when additional coronal or coronal and sagittal reformation images were used during evaluation, respectively. In other way additional MPR images (including coronal and sagittal images) enabled us to accurately evaluate normal appendix in 25 (10.5%) of 240 patients in whom axial images alone were unhelpful or inadequate. In fact 22 (88%) of these 25 patients were adequately evaluated by additional coronal images alone, and further evaluation by sagittal reformation images were needed in 3 patients (12%) only. In addition,

the anatomical relationship between caecum, ileo-cecal valve, and appendix base was accurately assessed and the location of the appendix tip within the pelvi-abdominal cavity was accurately determined in all visualized appendices in this study, when added coronal and sagittal images were used. These results were in agreement with those of Kim et al.³ who concluded that most of normal appendices can be identified by axial and coronal reformation images using 64-slice MDCT, even if oral contrast material is not administered, and with those of Jan et al.⁷ who reported that the visualization rate of normal appendix by MDCT has increased to 93% when additional coronal reformation images were used. Interestingly, the appendix was identified in all patients with inadequate pericaecal fat (7/240), and in all patients with ascitis (3/240) included in this study. These findings also agreed with those of Jan et al.⁷, who found that degree of intra-abdominal fat did not significantly influence the visualization rate of normal appendix using MDCT with MPR images. These results indicate that axial and other MPR images especially coronal reformation images are complementary for proper assessment of normal appendix, and may provide improved identification and accurate localization of normal appendix within pelvi-abdominal cavity without the need for contrast material administration, even in patients with paucity of pericecal fat and possibly in patients with ascitis.

Beside identification and accurate localization, MDCT with MPR images enabled accurate assessment of the outer diameter of all visualized appendices, and the two wall thickness of all appendices with recognized luminal contents in this study. Similar to what has generally been described in literature^{7,8,10,13}, results of quantitative

assessment of outer appendicular diameter in this study showed a wide range of sizes varied from 4 mm to 11.4 mm (mean =6.2 mm), with outer diameter greater than or equal to 7 mm which is the diameter assumed to be abnormal according to literature in 52% of patients.^{1,12,14,15} Intraluminal content especially intraluminal air was identified in the vast majority of these patients. In fact intraluminal content was identified in 93% (109/117) of patients with appendiceal diameter greater than or equal to 7 mm and in 100% (6/6) of patients with appendiceal diameter greater than or equal to 10 mm in this study. These findings are quite similar to those described in a recent study carried out by Webb et al.¹³ which showed a wide range of normal appendix diameter, with appendiceal diameter greater than or equal to 6-7 mm in 45% of patients, with visualized intraluminal contents in 93.4% of patients with outer diameter greater than 6-7 mm, and in 100% of patients with outer diameter greater than or equal to 10 mm. In an earlier study carried out by Huwart et al.¹, the mean outer diameter of normal appendix was 6.7 mm (range; 5-11mm) with outer diameter greater than 6-7 mm in 70% of cases which is higher than the reported rates, however, intraluminal air was identified in 87% (41/47) of their patients. These results indicate that the wide variation in the outer diameter of normal appendix can at least partially be attributed to appendix morphology, so that normal appendices with recognized intraluminal contents especially intraluminal air are associated with increased outer diameter compared with those with indiscernible luminal contents. Therefore, in all patients with outer diameter greater than or equal to 7 mm, other CT criteria of appendicitis like increased two wall thickness (more than 6 mm) and peri-appendicular inflammatory

changes should be recruited, so that false prevented.
positive diagnosis of appendicitis can be



Figure 4: Non enhanced CT shows the appendix filled distally with air, with an outer appendicular diameter of 11.4 mm
a. axial

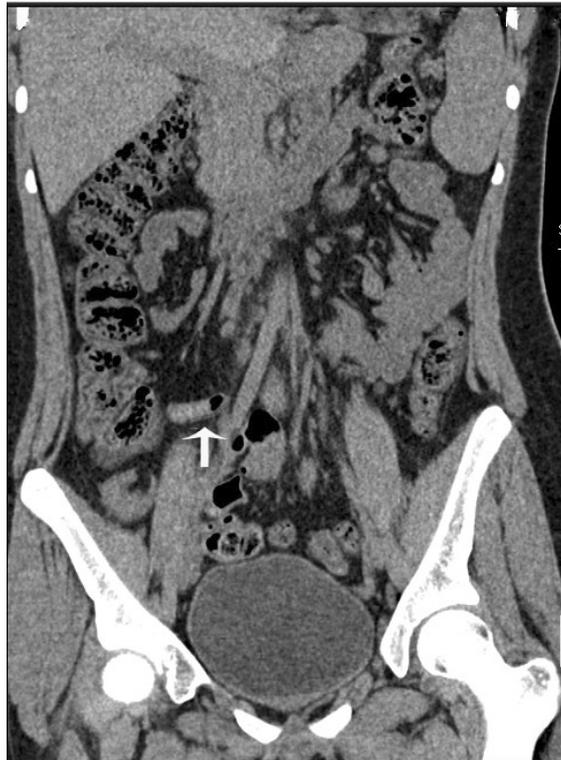


Figure 4.b. coronal

Fortunately, two wall thickness can easily be assessed in patients with identified luminal contents. In the current study, the two wall thickness of the appendix was assessed in all patients with recognized luminal contents, and interestingly, it measured less than or equal to 6mm in all patients with outer appendicular diameter greater than or equal to 7mm, indicating normal appendix. However, in patients with outer diameter greater than or equal to 7mm and ambiguous morphology (indiscernible appendix wall due to collapsed or isodense appearance of the appendix), additional contrast enhanced CT or ultrasound examination of the appendix is indicated for visualization and measurement of the appendix wall, so that false positive diagnosis of appendicitis can be avoided. This is particularly important in the absence of periappendicular inflammatory changes, since the absence of periappendicular inflammatory changes on non

enhanced CT will not exclude the presence of acute appendicitis.¹⁶

Conclusions

This study concluded that non-enhanced MDCT is accurate and efficient imaging modality in detection and evaluation of normal appendix, and confirmed that the addition of coronal reformation images can significantly improve identification and evaluation of normal appendix, if appendix is not seen or confidently evaluated on axial images alone. Based on appendix measurements, the results of this study showed that while the maximum outer diameter of the normal appendix was frequently greater than or equal to 6mm, it is very rarely gone beyond 6mm in appendices with isodense morphology, and two wall thicknesses very rarely gone beyond 6mm in normal appendices with recognized intraluminal contents.

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تقييم الزائدة الدودية الطبيعية عند الأردنيين البالغين باستخدام الطبقي المحوي

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الملخص

الهدف: لتقييم معدل رؤية الزائدة الدودية وقياس حجمها الطبيعي عند البالغين الأردنيين باستخدام التصوير الطبقي متعدد المقاطع دون استخدام صبغات التباين في المرضى الذين لا يشبه في أن لديهم التهاباً في الزائدة الدودية.

النتائج: تم إعادة تحليل الصور المأخوذة لمنطقة البطن والحوض لعينة مكونة من 240 من المرضى البالغين (150 رجلاً و90 امرأة، تتراوح أعمارهم 18-86 سنة، معدل عمر 49.8) الذين تم تصويرهم دون استخدام صبغات التباين بواسطة جهاز الطبقي متعدد المقاطع، حيث تم مراجعة وتقييم الصور في مختلف المحاور، وتم تسجيل نسبة رؤية الزائدة الدودية وتحديد موقعها، وقياس الحد الأقصى لقطرها الخارجي وسماكة جدارها.

الاستنتاجات: النتائج أنه تم رؤية الزائدة الدودية في 95% من الحالات، وقد تم تحديد محتويات داخل اللمعة في 70.6% من تلك الحالات، أن القطر الخارجي للزائدة الدودية تراوح بين 4 و11.4 مم (بمعدل 6.2 مم)، وأن ثخانة جدارها تراوحت بين 1.8 و7 ملم (بمعدل 5.4 ملم). لقد بلغت نسبة استئصال الزائدة الدودية في هذه الدراسة 7.8%.

الخلاصة:

إن التصوير الطبقي المحوري دون استخدام صبغات التباين مفيد جدا في تحديد الزائدة الدودية الطبيعية، وإن كشف الزائدة الدودية قد تحسن بشكل ملحوظ عند استخدام محاور التصوير المختلفة في تقييمها، وبشكل خاص عند استخدام المقاطع الأكلية. وأظهرت النتائج أن هناك تبايناً واسعاً في القطر الخارجي للزائدة الدودية الطبيعية، الأمر الذي قد يؤدي إلى الاختلاط بين الزائدة الدودية الطبيعية وغير الطبيعية (المتنهة) في حال استخدامه كمؤشر وحيد للتمييز بينهما، وبالتالي، للحد من التشخيصات الإيجابية الكاذبة أو السلبية الكاذبة لالتهاب الزائدة الدودية فإنه ينبغي علينا الأخذ بعين الاعتبار العلامات الثانوية الأخرى لالتهاب الزائدة بالإضافة لقياس قطرها الخارجي، مثل قياس سماكة جدار الزائدة الدودية ووجود علامات التهاب في الأنسجة الدهنية المحيطة.

الكلمات الدالة: الزائدة الدودية الطبيعية، التصوير الطبقي متعدد المقاطع، متعدد المحاور، بالغين.