Evaluation of normal appendix in adults with multidetector computed tomography

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Purpose

Multidetector computed tomography (MDCT) has been used more frequently in evaluation of patients presenting with symptoms of appendicitis. Appropriate evaluation of appendicitis necessitates awareness of imaging features of normal appendix vermiformis on CT because visualization of the normal appendix excludes the presence of appendicitis [1]. With CT, the rate of visualization of a normal appendix varies from 43% to 91% [2-5]. The role of MDCT in the diagnosis of appendicitis has been reported for many times in the literature but we found few reports focused on the imaging features of normal appendix on MDCT [6,7,8]. In this study, our aim was to determine the most adequate imaging phase, section thickness and scanning plane parameters for evaluation of normal appendix on MDCT.
Methods and Materials

We retrospectively reviewed 600 abdominal CT examinations performed in 600 consecutive patients (294 female, 306 male; mean age: 54.4 year, age range: 18-97 years) for reasons other than appendicitis. Patients were examined in the supine position with a 64-MDCT scanner (Aquilion 64, Toshiba, Japan). CT scanning parameters were as follows;

Scanned area: between diaphragm and femur necks, kVp: 120, mAs: 150-200, slice thickness: 0.5 mm, reconstriction interval: 0.3 mm, FOV: 30 cm, pitch: 1-1.5, window width 350 HU (200-600), window level 50 HU (30-60). Arterial and venous phase images were obtained after 35 and 65 seconds following intravenous contrast administration, respectively.

CT examinations were obtained at unenhanced (n: 200), arterial (n: 200) and venous phase (n: 200). All CT examinations were reviewed in axial and coronal planes with three different section thickness (0.5 mm - 3 mm - 5 mm) in order to detect and evaluate normal appendix. After localization of cecum on CT, appendix was defined as a tubular structure with dead end related with cecum. Visualized appendices were classified according to localizations as paracecal, midline, pelvic, retrocecal and marginal. Diameter of appendix was measured between the outer margins of the appendix at the widest part of the appendix in the axial and coronal plane with different section thicknesses and phases. Analysis of images were performed on workstation (VitreaView, Toshiba Medical Systems). Detection rates of appendix on MDCT in different imaging phases, section thicknesses and scanning plane parameters were compared. Comparison of diameters and wall thicknesses of appendices were also obtained. Statistical analyses were performed with Student's t test and ANOVA test in SPSS 15.0 program.
Appendix was detected in 491 (81%) of 600 patients on MDCT examinations. Fifty seven of 109 cases in whom appendix could not be determined had previous appendectomy history. No significant difference was found between the axial and coronal planes on CT in terms of appendix detection ($P > 0.05$). Similarly, unenhanced, arterial and venous phase CT examinations and different section thicknesses did not reveal significant detection rates of appendix ($P > 0.05$) (Table 1). Among the 109 patients in whom appendix was not determined 35 (32.1%) of them were scanned at unenhanced phase, 39 (35.8%) and 35 (32.1%) of them were scanned at arterial and venous phases, respectively. The diameter of the appendix ranged between 2.8 - 13 mm in all phases and planes. Mean diameter of appendix in axial plane ($5.93 \pm 0.06$ mm) was significantly lower than mean diameter in coronal plane ($6.18 \pm 0.06$ mm) (Fig. 1 and 2). Wall thickness of appendix was ranged between 0.4 - 3 mm in all phases and imaging planes. No significant difference was found between mean wall thickness of appendices in axial and coronal planes (Fig. 3 and 4). Although it was found that wall thickness was increased minimally with the increase in slice thickness there was no significant correlation between the slice thickness of CT examination and wall thickness of appendix ($P > 0.05$). Localizations of 491 appendix were as follows: 230 in pelvis (46%), 104 paracecal (21.2%), 58 retrocecal (11.8%), 86 midline (17.5 %), 13 marginal (2.8%). Marginal localizations were defined as: subhepatic (n: 10), inguinal hernia (n: 2), lateral hernia (n: 1), left lower quadrant in situs inversus (n: 1) (Fig. 5,6,7).

Oral contrast material was given in 161 of 491 patients. Oral contrast material passage into the appendix lumen was observed in 45.3% (73/161) of patients.
Table 1: Detection rates of appendix on different phases of MDCT

<table>
<thead>
<tr>
<th>Phase</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Positive predictive value (%)</th>
<th>Negative predictive value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unenhanced</td>
<td>90.65</td>
<td>100</td>
<td>100</td>
<td>51.28</td>
</tr>
<tr>
<td>Arterial</td>
<td>90.65</td>
<td>100</td>
<td>100</td>
<td>54.28</td>
</tr>
<tr>
<td>Venous</td>
<td>91.11</td>
<td>100</td>
<td>100</td>
<td>51.42</td>
</tr>
</tbody>
</table>

Table 1: Table 1: Detection rates of appendix on different phases of MDCT

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**Fig. 1:** Axial contrast enhanced CT image at venous phase with 3 mm section thickness demonstrates air filled appendix (arrow). Appendix diameter was measured as 7 mm on axial image.

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**Fig. 2:** Coronal contrast enhanced CT image at venous phase with 3 mm section thickness demonstrates air filled appendix (arrow). Appendix diameter was measured as 8.6 mm (larger than axial image).

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**Fig. 3:** Wall thickness of appendix was measured as 2.7 mm on axial CT (arrow).

**Fig. 4:** Measurement of wall thickness of appendix on coronal CT revealed wall thickness as 2.9 mm.
**Fig. 5:** Axial unenhanced CT demonstrates appendix vermiformis in pelvis (arrow).
Fig. 6: Paracecal appendix is demonstrated on axial CT with diameter of 4.1 mm.

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Fig. 7: Coronal unenhanced CT demonstrates appendix in subhepatic localization.

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Conclusion

Multidetector computed tomography enables the acquisition of high spatial resolution volumetric imaging data during a single breath hold. In combination with 3-dimensional image reconstruction, MDCT is able to trace the course of the appendix accurately and consistently. Identification of a normal appendix is critical to exclude the diagnosis of appendicitis, particularly if an alternative etiology of the patient's symptoms is not apparent on the CT.

Our study concludes that:

- Detection rate of appendix on MDCT was 81.2%.
- Coronal CT images have additional value in evaluation of appendikis since diameter of appendix was measured higher than axial images. Coronal images can be helpful in patients whom appendix could not be determined on axial images.
- Evaluation of MDCT images with different slice thickness does not maintain additional diagnostic value in detection of appendix.
- Unenhanced and enhanced CT examinations do not demonstrate significant difference in detection rates and diameter - wall thickness measurements of appendix. Avoiding contrast administration in patients with a history of contrast allergy and renal dysfunction would not decrease detection accuracy of normal appendix on MDCT.
- The diameter of normal appendix may be ranged between 2.8 - 13 mm.
- Administration of oral contrast material does not increase accuracy of MDCT in diagnosis of appendicitis since passage of oral contrast material into the appendix lumen may occur in 45.3% of patients.
References


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