Non Enhanced Helical Ct Scan In Visualization Of Normal Appendix

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Summery

Purpose: *To evaluate the frequency of visualization, thickness, and anatomical features of the normal appendix at nonenhanced helical computed tomography (CT).*
Materials and methods : *Two radiologists prospectively iterpreted, in consensus, the abdominal CT scans of 140 patients who were examined for renal colic assessment. They were blinded to patients' surgical history regarding a previous appendectomy. No contrast material was used. The frequency of visualization, and the two – wall thickness of normal appendix were recorded, as well as the anatomical features of the appendix and the effect of adequasy of intraperitoneal fat on identification of the appendix.*
Results *: The prevalence of appendectomy was 9% (13 of 140 patients). The sensitivity, specificity, positive and negative predictive values, and accurasy of visualization of normal appendix were 77%, 85%, 98%, 27%, and 77% respectively. The frequency of visualization was lower in patients with less nintraperitoneal fat. The mean thickness of normal appendix if no intraluminal content was visualized was 6.6 mm± 1.0 mm, and the mean thickness excluding visualized intraluminal content was 3.6mm ± 0.8 mm.*
Conclusion *: Most normal appendices are seen at nonenhanced helical CT. The thickness of normal appendix, when the content is not recognizable, overlaps the values currently used to diagnose appendicitis at CT.*

Introduction:

Recently, thin section helical computed tomography (CT) for examining patients suspected to have acute appendicitis has been shown to be highly accurate, rapid, and cost-effective technique [1-4]. Elimination of the delay and risk of administering contrast material allows thin section helical CT performed without oral, rectal, or intravenous administration of contrast material to be ideally suited for the evaluation of patients with suspected acute appendicitis.

The primary imaging findings of acute appendicitis at non-enhanced CT include an appendix that measures greater than 6 mm in trsnsverse diameter,and periappendiceal inflammation [1-3]. Despite the widespread use of CT to diagnose appendicitis, our literature review failed to reveal studies in which a large number of normal appendices were evaluated. The reported thickness of a normal appendix at CT is based on US results [5-7], with use of 6 mm short-axis thickness as the upper limit of normal [1-4,8,9].This extrapolation of US findings of a normal appendiceal thickness is based on the size of a compressed, collapsed appendix without measurement of the luminal content, and consequently dose not apply to CT.

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AIM OF STUDY

To evaluate the frequency of visualization , thickness, and anatomical features of normal appendix at non-enhanced helical CT.

MATERIALS AND METHOD

Study Design

During a period of 21 months, a prospective study was performed to evaluate the frequency of visualization, thickness, and anatomy of normal appendix at non enhanced helical CT of the entire abdomen. CT scans of 140 consecutive patients undergoing evaluation for renal colic were studied .These 140 patients, there were patients who had a history of appendectomy and hence had no appendix, and others who had no such a history and hence had a normal appendix present. The standard of reference regarding the presence or absence of the appendix was history obtained from the patient or the patients' parents (in case of young children). These patients were followed up inorder to obtain there final diagnoses. The standard of reference for the final diagnosis was the diagnosis at discharge based on CT, clinical, and laborotory findings. The final diagnosis in these 140 patients included right ureteric calculi in 36 patients, left ureteric calculi in 45 patients, while the cause of pain was not determined in the remaining 32 patients. This study did not include any patient with a final diagnosis of colitis, or inflammatory bowel disease, or

spontaneously resolving appendicitis.No patient had surgery for appendicitis after the CT scan.

CT Technique

A single breath-hold helical scan of the entire abdomen was obtained in all patients using a 5 mm beam collimation and 8 mm/ sec. table speed (pitch 1.60). No oral, rectal, or intravenous contrast material was administered .

Image Interpretation

The CT images were interpreted by two experianced radiologists in cosensus

The CT images were reviewed by two experianced radiologists in concensus. They were blinded to the patients' surgical histories(regarding a previous appendectomy) but were aware of the clinical histories of renal colic.

The reviewers; in addition to interpritting the images for the presence of urinary tract abnormalities for which the patients were originally reffered to CT scaning; reviewed the CT images for the following points:

1. The appendix was interpreted as being either visualized or not visualized .
2. The maximum full thicknes of the appendix was measured . In a normal appendix, if the content of the appendix was of different attenuation than that of the wall, then reviewers were asked to measure the maximum thickness of the two walls on either side of the content, by means of subtracting the thickness of the content from the full thickness. If the content was of the same attenuation as the wall, then it is not possible to differentiate a collapsed appendix from a distended appendix with content of the same attenuation as the wall. In such cases , the reviewers were asked to measure the maximum full thickness of the appendix.
3. The ileocecal valve was marked as visible or not visible .
4. The presence or absence of periappendiceal stranding was documented.
5. The presence or absence of appendicoliths was recorded.
6. The location of the tip of the appendix was described as being : para-colic, retrocecal, pelvic, or midline.
7. The location of the base of the appendix relative to the ileocecal valve was described as being cephalic or caudal.
8. The adequasy of intraperitoneal fat was judged as being adequate (if any degree of fat completely surrounded the cecum), or as being inadequate if no fat surrounded the cecum.

STATISTICAL ANALYSIS

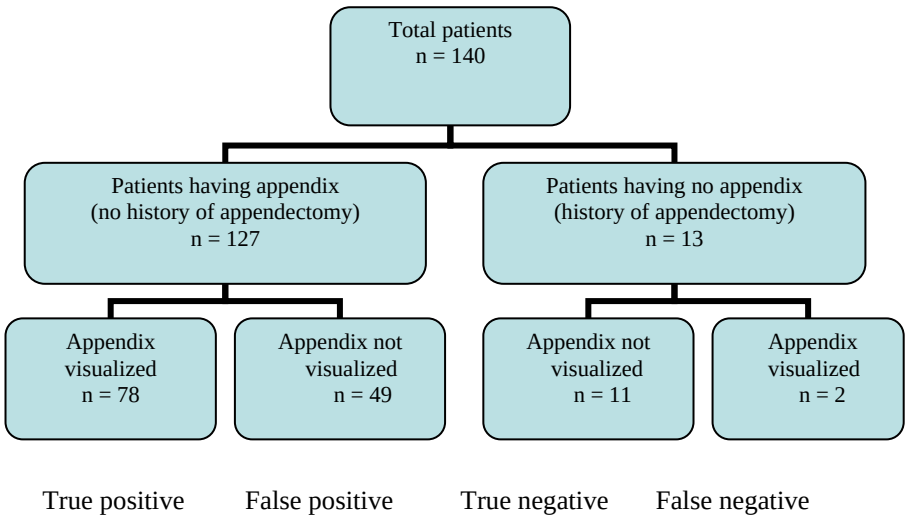
The sensitivity, specificity, accurasy, positive predictive value, and negative predictive value for visualization of the appendix were calculated .

RESULTS

The prevalence of appendectomy in this study was 9%(13 of 140), thus 127 patients in this study had their appendix, and 13 patients had no appendix.

Fig. 1 demonstrates the frequency of visualization or non visualization of the appendix in the study population. Of the 127 patients who had appendix, the appendix was visualizedn by CT scans in 98 patients, and not visualized in 29 patients. Of the 13 patients with no appendix (who had a previous appendectomy)**,** the appendix was correctly reported as non visualized in 11 patients , and was recorded as being visualized in two patients. These two patients were considered as false positive in statistical analysis.

Fig. 1 : The frequency of visualization of the appendix in the study population.



The sensitivity of non enhanced helical CT in visalizing a normal appenix in this study was 77%, the specificity was 85%, the accurasy was 77%, the negative predictive value (NPV) was 27%, and the positive predictive value (PPV) was 98% .

Table 1 shows the mean and the range of thickness of the appendix in 78 correctly visualized normal appendices .

Table 1 : Mean and Range of the Thickness of Normal Appendix		
Appendix Thickness	**Mean (in mm)**	**Range (in mm)**
Without luminal content visualize	**6.0 ±1.0**	**4.0 - 11.0**
With luminal content visualized	**3.6 ± 0.8**	**2.0 - 6.0**

When the luminal content was not visualized and the full thickness of the appendix was measured, the mean full thickness was 6.6 mm ± 1.0 mm (range 4.0 - 11.0 mm). When the luminal content was visualized and therefore, the wall itself could be measured, the mean thickness of the normal appendix was 3.6 mm ± 0.8 mm (range 2.0 - 6.0 mm).

Table 2 demonstrates the locatin of appendiceal tip in 78 correctly visualized appendices. A paracolic location was the most common location of the appendiceal tip, seen in 66.3 % of cases.

Table 2 : The Location of Appendiceal Tip		
Location	**Number of patients**	**Perecentage**
Paracolic	**65**	**66.3%**
Pelvic	**18**	**18.3%**
Retrocecal	**8**	**8.2%**
Midline	**7**	**7.2%**
Total	**98**	**100%**

The relationship of the base of the appendix relative to the ileocecal valve is demonstrated in table 3 .

Table 3 : The Relationship of The Base of Appendix to the Ileocecal valve		
Relationship	**No. of Patients**	**Percentage**
Cephalic	**94**	**96 %**
Caudal	**4**	**4 %**
Total	**98**	**100 %**

An appendicolith was seen in 2 (2 %) of 98 correctly visualized appendices.

The ileocecal valve was visualized in 88 of 127 patients with normal appendices.

The pericecal fat was considered not adequate in 23 of the 127 patients with having appendix, and adequate in 104 patients. The appendix was seen in 10(43 %) of the 23 patients with nonadequate pericecal fat, compared to 88 (85 %) of the 104 patients with adequate pericecal fat.

Discussion:

Recently, thin-section helical CT scan has been shown to be a highly accurate, rapid, and cost effective technique for examining patients suspected to have acute appendicitis with accuracy rates ranging from 93% - 98% [1-3] using different combinations of oral, rectal, and intravenous contrast agents.

CT evaluation of appendicitis without the use of intravenously administered contrast material is a growing trend. However, in the absence of intravenously administered contrast material, the true wall thickness can be measured only if the luminal content of the appendix can be recognized. Since normal appendices do not always fill with orally or rectally administered contrast material and the content is not always recognizable from the wall, it is important to determine the range of thickness of the normal appendix at nonenhanced CT.

The ease of identification of the normal appendix at CT accounts for the high negative predictive value of CT in the evaluation of acute appendicitis. In this study, the frequency of viusualization of a normal appendix at nonenhanced helical CT was 77 % and the positive predictive value of the existence of an appendix was 98 % . These results are in agreement with those of a study performed by Lane et al [10], in which an appendix was identified in 79 % of normal appendices examined with nonenhanced CT. At US, on the other hand, a normal appendix is less frequently identified and the results are variable between 0% and 82% reflecting the operator dependency of US [5-7,11].In studies in wich orally and rectally administered contrast material was used, [3,9], a normal appendix was visualized in 90 % - 100 % of patients.

This study results demonstrated increased identification of the appendix when an adequate amount of pericecal fat was present.

Understanding the anatomy of the ascending colon, cecum, and the appendix is of great value in improving the visualization of both the normal and abnormal appendix. The cecum is a highly mobile structure that can varry in position due to variation in its posterior peritoneal attachment. Furthermore, when unusually large, the cecum may extend down , overlap the psoas muscle, and drap into the true pelvis. In these instances, identification of the appendix arising from the posteromedial base of the cecum may be difficult and may result in false negative interpretations.

Because of the highly variable position of the cecum and ascending colon, we always try to identify the fatty lips of the ileocecal valve. We found it usefull to identify the appendix by initially locating the ileocec al valve, which was visualized in 114 (81%) of 140 patients in this studt. The location of the ileocecal valve helps to define the contour of the cecum and consequently facilitates the search for the base of the appendix as it arises from the posteromedial border. Because of this attachment, the appendix is frequently seen drapped over the right external iliac artey and vein. Hence, the right common and external iliac artery and vein may be used as "vascular probes" from their origin at the bifurcatin of the aorta into the femoral canal to improve detection of the overlying appendix. This usually helps to avoid the pitfall of not seing a pelvic appendix.

The main CT criteria for the diagnosis of acute appendicitis published in literature include identification of a thickened appendix with a two wall diameter greater than 6.0- 7.0 mm, periappendiceal inflammatory changes, and a calcified appendicolith [1- 3,12,13].

In a study by Jacob et al [14], there was no periappendiceal stranding at nonenhanced CT in 22% of cases of appendicitis. Thus the size criterion to diagnose appendicitis is especially important in the absence of periappendiceal stranding.

The mean full thickness of the normal appendix in this study was 6.6 mm ±1.0 (range 4.0-11.0 mm) when the luminal content was not visible. When the luminal content was recognizable, the mean thickness of the normal appendix was 3.6 mm ± 0.8 mm (range 2.0-6.0 mm) which is comparable with the reported US values [5-7]. Consequently we can infer that an upper limit of 6.0 mm for normal appendiceal thickness can be used reliably at CT only if the luminal content is visualized. If the content is not visualized; we suggest 10.0 mm as the upper limit of normal in the absence of extra appendiceal inflammatory changes; as in this study, among the 98 normal visualized appendices, only one was thicker than 10.0 mm. Patients with equivocal signs of appendicitis with an appendiceal thickness of 6.0-10.0 mm in the absence of periappendiceal stranding should better be further evaluated with CT with rectal or oral contrast material since the range of 6.0-10.0 mm is the area were normal and abnormal overlaps.

The presence of a calcified appendicolith associated with periappendiceal inflammation is one of the CT criteria used to diagnose acute appendicitis [1,3,10,12]. Appendicoliths were found in only 2% of the healthy population in this study. This is comparable with that found in previous

studies [1,3,10] which documented 0% - 2% appendicoliths in healthy population.

The main limitation in this study was the lack of a reference standard as a proof for a normal appendix. However, it is not possible to design a study of a normal appendix with pathologic confirmation.

Furthermore, it is also theoratically possible that some of the patients in whom the appendix was not visualizsd could have congenital absence of the appendix. However, considering that the reported incidence of appendicular agenesis is only one in 100,000 laparotomies [15], agenesis of the appendix was an unlikely occurence in this study.

In conclusion, this study shows that most normal appendices can be seen at nonenhanced helical CT. The full thickness of the normal appendix when the content is not recognizable overlaps the values used to diagnose appendicitis at CT, but is similar to US values when the content is visualized and subtracted from the total thickness.

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