



## Imaging for Diagnosis of Appendicitis

- **Appendiceal CT allows for rapid and accurate diagnosis of appendicitis**
- **Appendiceal CT can be modified to a full abdominal and pelvic examination to detect alternate pathologies**
- **Appendiceal CT is cost effective because it avoids unnecessary appendectomy and/or hospitalization for observation**

In the past decade, the clinical evaluation of patients with suspected appendicitis has dramatically improved in speed and accuracy due to the focused appendiceal CT developed at Massachusetts General Hospital. Clinical signs and laboratory tests are not sufficiently accurate to unequivocally diagnose or rule out appendicitis. Because of the seriousness of a perforated appendix, prior to the availability of appendiceal CT, appendectomy or in hospital observation was routine for those with suspected appendicitis. As many as 15-20% of appendectomies resulted in the removal of a normal appendix; and since the annual number of appendectomies performed in the United States exceeded 250,000, both the monetary and personal costs of unnecessary surgery and/or hospitalization were considerable. Thus, appendiceal CT has not only improved the quality but decreased the cost of caring for patients with suspected appendicitis.

### Imaging for Appendicitis

Appendiceal CT is a highly accurate radiological diagnosis of appendicitis when conducted by an experienced radiologist (Table 1). Ultrasonography can be used to aid in the diagnosis of appendicitis and has the advantage of avoiding any ionizing radiation. Although it has been used effectively in small children, it is only moderately accurate in adults and adolescents (Table 1). It is often difficult or impossible to characterize the normal appendix with ultrasonography and rule out appendicitis, especially if the appendix is located in a retrocecal position, if there is overlying bowel gas, or in obese patients.

Because the radiation dose from appendiceal CT can be minimized by a computerized dose reduction technique and by performing a focused lower abdominal scan, appendiceal CT can be performed relatively safely on pregnant women and children. Ionizing radiation can be avoided with MRI; but this modality produces lower



**Figure 1.** Normal appendix. Contrast is seen filling a normal appearing appendix (arrows) demonstrating a thin wall.

resolution images. Although there are some preliminary studies demonstrating that it can be used to evaluate pregnant women in whom appendicitis is suspected and to diagnose other causes of right lower quadrant pain, the accuracy of this technique is yet to be determined.

### Economic Impact of Appendiceal CT

In 1997, two years after the introduction of appendiceal CT at Massachusetts General Hospital, the rate of negative appendectomies was found to be 7% and the appendiceal perforation rate was 14%. In comparison, in the three years prior to the introduction of appendiceal CT the rates were 20% and 22%,

respectively. This significant improvement was achieved even though only 59% of patients who received appendectomies had their diagnoses confirmed by appendiceal CT. In addition, for about half those patients in whom no evidence of appendicitis was found, specific alternative conditions were diagnosed (Table 2). The overall cost savings from unnecessary surgery and in hospital observation attributable to appendiceal CT were estimated to be \$45,000 for the 100 patients in the study.

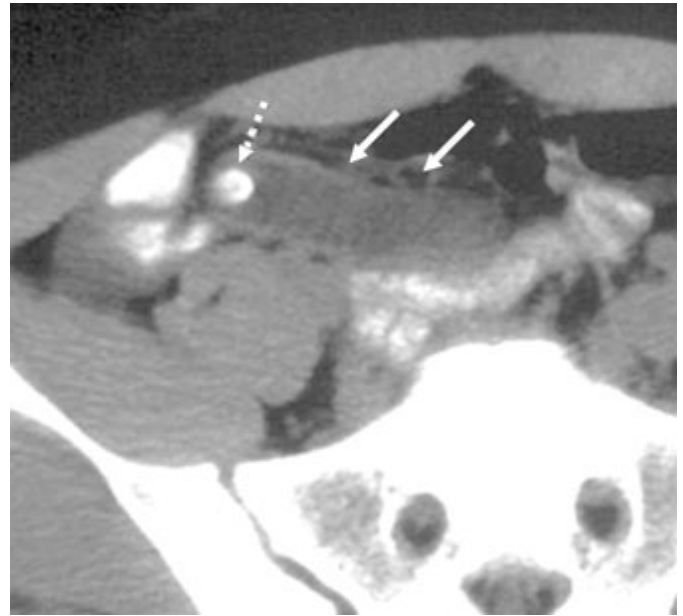
### Appendiceal CT Procedure

The appendiceal CT protocol in use at Massachusetts General Hospital Emergency Department uses intravenous contrast material and rectal contrast to opacify the bowel. The rectal contrast agent used is a solution of up to 1500 mL of iodinated contrast agent in saline, administered by gravity from an IV bag via a pediatric rectal tube while lying on the CT table. Most patients tolerate this procedure well; but if cramps develop, administration of contrast may be halted temporarily until the symptoms subside. A scout image is taken to observe whether the contrast agent has reached the right colon. If not, more rectal contrast may be instilled and another scout image obtained. A focused abdominal CT scan is then performed, which gives high-resolution images of the right lower quadrant. When the appendix is normal, the radiologist may choose to extend the anatomic range of the scan to search for alternate diagnoses.

In the emergency room, rectal rather than oral contrast administration is preferred for several reasons. First, the contrast quickly passes through the colon and reaches the appendix within minutes, whereas oral contrast may take 1-2 hours. Second, it is easier to predict the time of optimal cecal opacification. Third, rectal rather than oral contrast is preferred in case of emergency surgery requiring general anesthesia. Finally, some patients find administration of rectal contrast preferable to drinking a large volume of oral contrast when feeling unwell.

However, in a non-emergent setting, rectal contrast is usually not preferable to oral contrast. First, oral contrast opacifies the small bowel, which allows for more accurate diagnoses of other bowel-related cases of abdominal pain, e.g. inflammatory bowel disease, bowel obstruction. Second, in many patients, especially the elderly and the hospitalized who have poor anal sphincter control, retention of rectal contrast for adequate opacification of the cecum is often difficult to achieve and causes patient discomfort. Thus, for non-emergent patients with abdominal pain where appendicitis is only one of several diagnoses under consideration, or in patients where rectal contrast is unlikely to achieve adequate cecal opacification, oral contrast is used. Oral contrast is typically administered as 300-500 cc of dilute barium sulphate suspension ingested over 1-2 hours.

Intravenous contrast is also administered unless contraindicated because it makes it easier to visualize

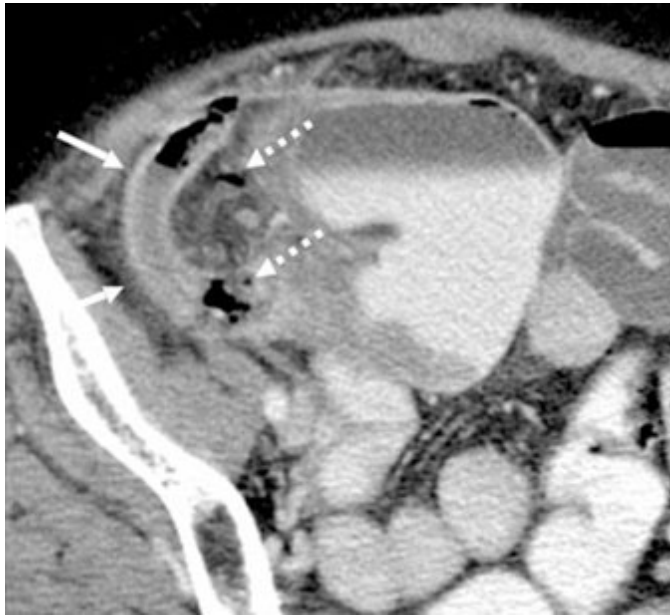


**Figure 2.** Appendicitis with appendicolith. An enlarged appendix (solid arrows) is seen with an appendicolith (dashed arrows) at the base.



**Figure 3.** Appendicitis. The appendix (solid arrows) is abnormally dilated and demonstrates a thickened enhancing wall and no filling with contrast.

the normal appendix, especially in children and in older and/or thin patients. The contrast agent highlights the dilated vasculature in inflamed tissue and also make it easier to characterize complications such as appendiceal perforation and extra-appendiceal abscess formation, as well as for diagnosing alternate causes of abdominal pain, such as inflammatory bowel disease, pancreatitis, pelvic inflammatory disease, and pyelonephritis.



**Figure 4.** Perforated appendicitis. The appendix (solid arrows) is abnormally dilated with a thickened enhancing wall. Small pockets of extraluminal air (dashed arrows) indicate perforation.

Imaging Technique	Sensitivity	Specificity
Appendiceal CT with rectal contrast (adults)	100%	95%
Appendiceal CT with rectal contrast (children)	97%	99%
Abdominal CT with oral contrast	93-95%	88-96%
Appendiceal CT with no bowel opacification	90-96%	94-97%
Ultrasonography (adults and adolescents)	83-88%	78-84%
Ultrasonography (children)	85%	92%
MRI	Not available	Not available

Diverticulitis
Renal calculi
Pyelonephritis
Epiploic appendagitis
Omental infarction
Adnexal conditions

### Scheduling

Acutely ill patients with suspected appendicitis should be sent to the Emergency Department for clinical evaluation where a focused appendiceal CT may be performed. For patients who have been clinically evaluated, an abdominal CT to look for appendicitis can be ordered for the same day through ROE (<http://mghroe/>) at the Main Campus, Waltham, and Chelsea), or by telephone for Mass General West Imaging Waltham (781-895-1199) and Mass General Imaging Chelsea (617-887-3500).

### Further Information

For further questions, please contact [Robert Novelline, M.D.](#), Director of Emergency Radiology, at 671-726-8796.

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