

# Diagnosis and Treatment of Acute Appendicitis

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**Abstract:** The diagnosis and treatment of acute appendicitis are described with emphasis on the significance of ultrasonography, computed tomography (CT), and laparoscopic appendectomy. The diagnosis of acute appendicitis has traditionally been made by physical examination and blood tests. However, use of ultrasonography and CT as well as these conventional methods makes more precise diagnosis possible. These imaging modalities are useful for determining whether surgery is necessary. Ultrasonography is easy to perform and minimally invasive, making it essential for diagnosis. This examination can visualize hypertrophy, disturbance, and disruption of the layered structure of the appendiceal wall, accumulation of purulent fluid, and the presence of a fecolith in the appendix. In catarrhal appendicitis, the wall of the appendix consists of three layers. In phlegmonous appendicitis, these layers become unclear, and in gangrenous appendicitis, the layered structure is lost. CT is superior to ultrasonography in objectivity, but is unable to depict the layers of the appendiceal wall. It is useful for demonstrating periappendiceal fat, ascites, and abscess formation, and for determining whether an operation is necessary based on these findings. Laparoscopic appendectomy is one of the choices for obese patients, young women, and patients in whom a condition other than acute appendicitis is suspected.

**Key words:** Acute appendicitis; Imaging diagnosis; Abdominal ultrasonography; Laparoscopic appendectomy

## Introduction

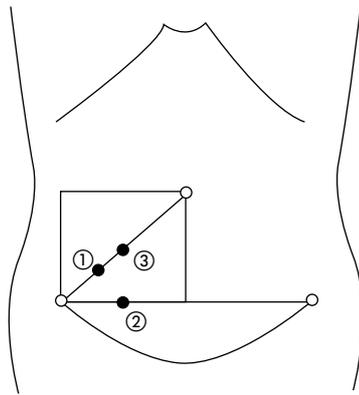
Acute appendicitis is one of the most common conditions treated by emergency operation. Physicians from a wide range of medical specialties including internal medicine and pe-

diatrics, as well as surgeons, encounter patients with this condition in their daily practice. When it presents with typical symptoms, it is relatively easy to diagnose and treat. In young children, elderly persons, and those presenting with various atypical symptoms, however, the diagnosis

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① McBurney's point ② Lanz's point ③ Munro's point

Fig. 1 Points at which tenderness can be elicited in acute appendicitis

may be delayed and treatment may become difficult.

The diagnosis and treatment of acute appendicitis, particularly the diagnostic role of imaging modalities such as ultrasonography and computed tomography (CT), and the therapeutic role of laparoscopic appendectomy (a new surgical procedure for this disease) are described in the following article.

### Pathology of Acute Appendicitis

The cause of appendicitis is considered to be obstruction of the appendiceal lumen and the subsequent onset of bacterial infection. Luminal obstruction can be produced by various mechanisms and it results in the retention of mucus. If bacterial infection supervenes, the intraluminal pressure increases, leading to interruption of lymphatic flow and the development of appendiceal edema. This process leads to acute appendicitis characterized by distension of the appendix and vascular congestion, which is designated as catarrhal appendicitis. If this condition progresses further, appendiceal edema and vascular congestion become pronounced with the formation of multiple abscesses in the wall and purulent fluid on the serosal surface. This condition is designated as phlegmonous

appendicitis. If it progresses further and causes local circulatory dysfunction, this will result in infarction opposite the junction between the mesoappendix and appendix, where the blood supply is inadequate. As a result, the appendix becomes congested dark red with black necrotic areas, a condition that is designated as gangrenous appendicitis. If perforation of the necrotic wall occurs, appendicitis becomes complicated by perforative peritonitis. Usually, peritonitis is localized, being confined to the ileocecal region. In young children, however, the omentum is not fully developed, so the clinical course is often complicated by diffuse peritonitis.

### Diagnosis of Acute Appendicitis

#### 1. Clinical manifestations

Abdominal pain, fever, and anorexia are classical symptoms. Pain occurs in the upper abdomen at first. It then moves slowly and localizes to the right lower quadrant. In many cases, a fever of around 38°C is present.

#### 2. Findings on physical examination

Physical examination is the most useful method for diagnosing appendicitis and for determining whether an operation is necessary. Tenderness can be elicited at various points in the right lower quadrant of the abdomen, including McBurney's, Lanz's, and Munro's points (Fig. 1). Among the indications for surgical treatment, the presence of peritoneal irritation is critical. Operation is indicated when Blumberg's sign is positive (the pain elicited by steadily increasing pressure at the site of tenderness increases on abrupt release of the pressure), and when Rosenstein's sign is elicited (tenderness in the right lower quadrant increases when the patient moves from the supine position to a recumbent posture on the left side). As a matter of course, the detection of abdominal muscular guarding and tenderness on rectal examination are among the surgical indications.

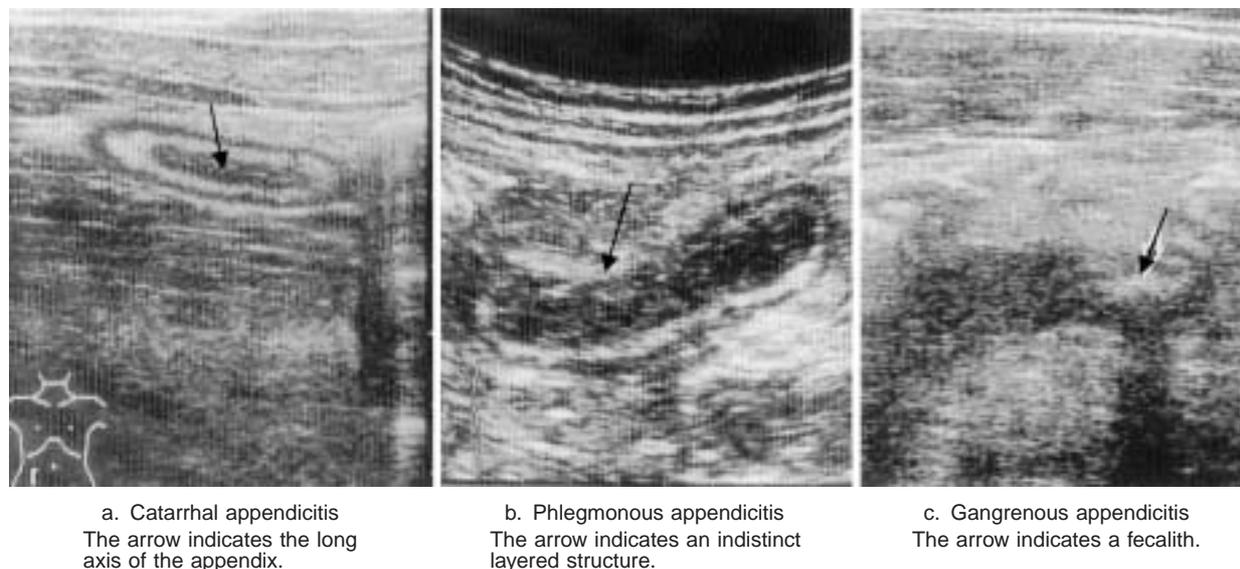


Fig. 2 Ultrasonographic features of each type of appendicitis<sup>1)</sup>

### 3. Laboratory tests

The white blood cell count (WBC) and CRP are of diagnostic value. The WBC usually exceeds  $10,000/\text{mm}^3$ . In severe cases associated with diffuse peritonitis, however, the WBC may be decreased rather than increased, so care must be taken. Although the CRP rises in appendicitis, the increase is not necessarily associated with the severity of inflammation.

### 4. Imaging diagnosis

Plain abdominal radiographs show no particular evidence of appendicitis. If an air-fluid level is seen in the lower abdomen, however, localized peritonitis should be suspected. Ultrasonography and CT scanning are of diagnostic value, and provide useful information for determining whether or not appendectomy is necessary.

#### (1) Abdominal ultrasonography

Because this minimally invasive examination is easy to perform and can be repeated, it is essential for diagnosing acute appendicitis. A normal appendix is usually not imaged by ultrasonography. When it is involved by inflammation and enlarges, however, it can be visualized. The features of appendicitis include hyper-

trophy of the appendiceal wall, disturbance of the normal layered structure, destruction of the wall, and purulent fluid or fecaliths within the appendiceal lumen.<sup>1)</sup> In catarrhal appendicitis, the wall of the appendix shows three layers, while this layered structure becomes unclear in phlegmonous appendicitis. No layered structure is depicted in the more advanced gangrenous appendicitis (Fig. 2). The periappendiceal accumulation of fluid suggests abscess formation secondary to perforation. A high periappendiceal echo suggests the aggregation of the omentum and other tissues that have been affected by inflammation. If some of these findings are recognized, an operation is indicated.

Kojima *et al.* divided appendicitis into three types depending on the ultrasonographic findings.<sup>2)</sup> The classification depended on the features of the high echo bands representing the submucosal layer, as described by Yuasa *et al.*,<sup>3)</sup> as well as the presence or absence of a visualized appendix and the length of the shorter diameter of the appendix (Table 1). The ultrasonographic pattern was type I in 76% of patients with catarrhal appendicitis, while it was type II in 82% of patients with phlegmonous appendicitis and type III in 94% of patients with gan-

Table 1 Classification of Acute Appendicitis According to Ultrasonographic Findings

	Pathological diagnosis	Layer structure of the appendiceal wall	Submucosal layer
Type I	Catarrhal	Clear	No hypertrophy
Type II	Phlegmonous	Indistinct	Hypertrophied
Type III	Gangrenous	Disrupted	Indistinct and partly lost

grenous appendicitis. They concluded that, the severity of appendicitis could be assessed by preoperative ultrasonography, so that unnecessary appendectomy could be avoided.

As described above, ultrasonography is an indispensable modality because it can be used to both diagnose appendicitis and assess its severity.

## (2) Abdominal CT

CT is superior to ultrasonography in some respects, because its findings are more objective and it is not affected by the presence of intestinal gas. The diagnosis of appendicitis by CT depends on hypertrophy of the appendiceal wall, enlargement of the appendix, periappendiceal abscess formation, the presence of a fecalith, increased density of periappendiceal adipose tissue, and/or the presence of ascites in the pouch of Douglas.<sup>1)</sup> CT can depict an enlarged appendix, but cannot visualize the structure of the wall unlike ultrasonography.

Thus, ultrasonography is superior to CT for assessing the severity of appendicitis depending on the mural changes.

## Management of Acute Appendicitis

### 1. Medical therapy

Catarrhal appendicitis should be treated conservatively. It is diagnosed by physical examination, blood tests, ultrasonography, and CT, or is characterized by tenderness without peritoneal irritation. On ultrasonography, the appendix cannot be visualized or is not enlarged if it is detected. Patients with catarrhal appendicitis should generally be hospitalized for treatment with antibiotics, bed rest, intravenous fluids,

and nil orally. For outpatient management, antibiotics are administered and the course is followed closely.

### 2. Surgical therapy

Phlegmonous or more advanced appendicitis should be treated surgically. Ultrasonographic findings are the most important factor for deciding whether surgery is necessary. In addition to the symptoms of phlegmonous appendicitis described above in the section on diagnosis, the presence of ascites or an abscess indicates the necessity for surgery. Among the abdominal findings on physical examination, the presence of peritoneal irritation is critical. If this is positive, an operation is indicated.

In the field of surgery for acute appendicitis, laparoscopic appendectomy is attracting much attention (Fig. 3). This procedure has become established in Japan and other countries. Although its usefulness has been gradually accepted, whether it is superior to conventional open appendectomy remains controversial, so it is not yet considered to be a standard therapy for acute appendicitis. The advantages and drawbacks of this procedure are described next. For the technical details that are not described in this article, see the relevant textbooks and reports.

For the patient, the advantages of laparoscopic appendectomy are reported to include decreased postoperative pain, faster recovery of muscle tone, earlier return to normal activities, minimal scarring, a low risk of wound infection, no ventral hernia, and a reduced risk of postoperative adhesions.<sup>4)</sup> On the other hand, conventional open appendectomy seldom causes

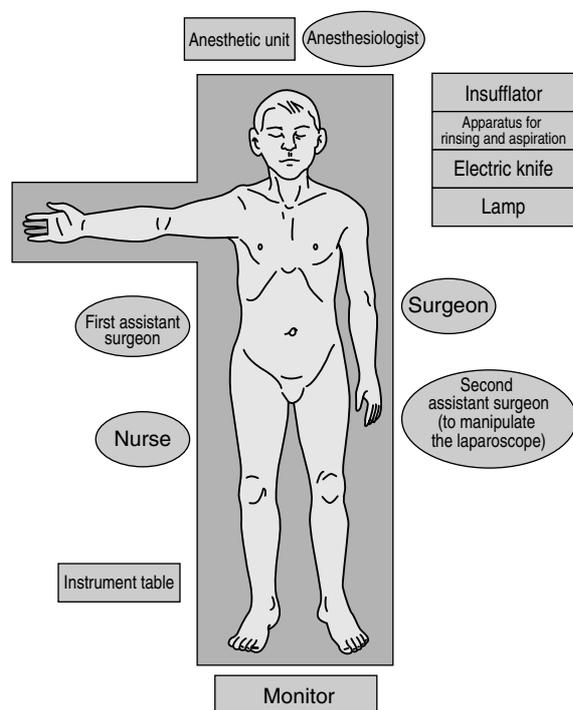


Fig. 3 Illustration of the arrangement of personnel and apparatus for laparoscopic appendectomy<sup>4)</sup>

problematic postoperative pain, scarring, or ventral hernia. In other words, the laparoscopic and open procedures may only be different in their degree of difficulty.

From the standpoint of the surgeon, laparoscopy is useful to rule out appendicitis in patients with confusing symptoms. Also, if a diagnosis of appendicitis is established, wide-ranging examination of the peritoneal cavity becomes possible. Furthermore, intraperitoneal cleansing of the site can be done under vision on the monitor. It has even been reported that a drain could be inserted and placed appropriately under laparoscopic vision.<sup>4)</sup>

Drawbacks of laparoscopic appendectomy include the necessity for general anesthesia, the need for special apparatus including an insufflator to create pneumoperitonium, the need for more staff including surgeons and anesthesiologists, and the risk of complications due to special procedures for laparoscopic surgery such as peritoneal insufflation and inser-

tion of trocars.

The greatest merit of laparoscopic appendectomy is being “minimally invasive.” Because conventional open appendectomy is already relatively simple and not so invasive, however, this merit itself is not highly attractive. In particular cases, such as obese patients, young female patients seeking a better cosmetic outcome, and patients with suspected appendicitis who may have other conditions, it would seem that laparoscopic appendectomy may be useful.

## Conclusion

The diagnosis and management of acute appendicitis have been described with a focus on some current issues. For diagnosis, findings on ultrasonography and CT are important. For management, laparoscopic appendectomy should be considered as a possible choice if there are indications for this procedure.

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