

# Abdominal ultrasonography for patients with abdominal pain as a first-line diagnostic imaging modality

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**Abstract.** The utility and limitations of abdominal ultrasonography (US) were retrospectively evaluated as a first-line diagnostic imaging modality in patients with abdominal pain. Hospital records from patients subjected to abdominal US as a first-line diagnostic imaging examination at the National Hospital Organization Shimoshizu Hospital (Yotsukaido, Japan) from April 2010 to April 2015 were analyzed. Only those patients who underwent abdominal US to diagnose abdominal symptoms were included in the present study. All patients with prior diagnostic imaging examination findings were excluded from the study in order to reduce bias of results. The analyzed patients included 39 males with an average (mean  $\pm$  standard deviation) age of  $65.8 \pm 18.8$  years and 37 females with an average age of  $53.7 \pm 19.3$  years. Diagnosis with abdominal US was in agreement with the final diagnosis in 66 of the 76 patients. Final diagnosis of symptoms by abdominal US was not successful in the remaining 10 patients who required further investigation. Acute cholangitis, acute cholecystitis, acute pancreatitis, acute appendicitis, colonic diverticulitis and spleen rupture were correctly diagnosed. Different types of cancer, including colorectal cancer, were also successfully diagnosed. Bile duct cancer and sigmoid colon volvulus could not be diagnosed by abdominal US due to the presence of intestinal gas. Abnormal findings were detected using abdominal US, but the diagnosis required additional consultation with gynecologists. Abdominal US was suitable for patients with abdominal symptoms. It is recommended that patients undergo further diagnostic imaging or consultation with gynecologists when large gas bubbles are present or gynecological conditions are suspected.

## Introduction

Abdominal pain is one of the most common symptoms prompting patients to visit hospitals. Among such individuals, a number of patients have serious diseases and require subsequent hospitalization or surgery. Diagnosis may consist of acute appendicitis, intestinal obstruction and other serious conditions such as bowel necrosis and intestinal volvulus (1). Correct and prompt diagnosis is essential for the appropriate management of patients. Diagnosis of patients with abdominal pain is primarily determined by imaging techniques, such as radiography, abdominal ultrasonography (US), computed tomography (CT) and magnetic resonance imaging (MRI) (2). Among these, abdominal US is a non-invasive procedure, which is readily available at most hospitals even during off-hours (weekends, nights and holidays) and may be performed at the bedside (3).

Abdominal US is indispensable for the diagnosis of diseases in the abdominal cavity in patients with abdominal symptoms (4,5). In addition, abdominal US is also useful for the diagnosis of solid organ conditions, including acute cholangitis, acute cholecystitis and acute pancreatitis (6-8). Abdominal US is also useful in the diagnosis of bowel disease based on pathological findings (9,10). Diagnostic criteria with abdominal US have been established for acute appendicitis and colonic diverticulitis (11-14) and colorectal cancer may be diagnosed with abdominal US (15). In numerous cases, patients are diagnosed by a combination of laboratory data and diagnostic imaging findings based on symptoms and physical examination. With regards to diagnostic imaging, CT is recommended as the first-line procedure (16); however, CT is not readily available during off-h at the majority of hospitals. In these cases, abdominal US is the first-line procedure performed.

On the basis of the aforementioned considerations, the current study retrospectively analyzed the records of patients who underwent abdominal US as a first-line diagnostic imaging procedure in order to evaluate its utility and limitations in determining the diagnosis of patients presenting with abdominal symptoms.

## Materials and methods

**Patients.** Medical records were retrospectively analyzed for 76 patients who were subjected to abdominal US as the

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first-line diagnostic imaging modality at the National Hospital Organization Shimoshizu Hospital (Yotsukaido, Japan) from April 2010 to April 2015. Abdominal US was performed at the time of consultation or during off-hours (weeknights, weekends and holidays). Recruited patients were restricted to those in which abdominal US was performed as a first diagnostic approach in order to evaluate the diagnostic performance solely from abdominal US without any potentially confounding information from other diagnostic imaging procedures. Thus, patients were excluded when abdominal US was performed following another diagnostic imaging procedures, such as radiography, CT or MRI because the sonographer may have been informed of the findings obtained. The analyzed patients included 39 males with an average (mean  $\pm$  standard deviation) age of  $65.8 \pm 18.8$  years and 37 females with an average age of  $53.7 \pm 19.3$  years.

Patients were hospitalized or referred to a different hospital based on the diagnosis obtained by abdominal US, the results of blood examinations, clinical findings or diagnostic imaging following abdominal US. The National Hospital Organization Shimoshizu Hospital does not have a department of gynecology. Therefore, patients were referred to another hospital for gynecological consultation. The referred hospitals were National Hospital Organization Chiba Medical Center (Chiba, Japan) and Seirei Sakura Citizen Hospital (Sakura, Japan). During off-hours, the management of patients was determined on the basis of abdominal US and clinical symptoms. The present study was approved by the Ethics Committee of the National Hospital Organization Shimoshizu Hospital. It was not considered a clinical trial since abdominal US was performed as a part of routine clinical practice. Written informed consent for inclusion in the study was waived. Patient records/information was anonymized and de-identified prior to analysis.

**Abdominal US.** Abdominal US was performed by Senior Fellows of the Japan Society of Ultrasonics in Medicine (Tokyo, Japan; <http://www.jsu.or.jp/jsu-e/index.html>) using a SSA-700A US system (Toshiba Medical Systems Corporation, Ohtawara, Japan) with a 3.75-MHz curved-array probe (PVT-375BT; Toshiba Medical Systems Corporation) or an 8.0-MHz linear-array probe (PLT-805AT; Toshiba Medical Systems Corporation).

**Diagnostic criteria of diseases.** Acute cholangitis is defined as inflammation due to the obstruction of a bile duct (6). Findings detectable by abdominal US include bile duct dilatation and evidence of its etiology, such as stricture, stones or stent (6). In the present study, in the absence of these findings, acute cholangitis was not diagnosed by abdominal US, but was based on a combination of symptoms including systemic inflammation and cholestasis (6). Acute cholecystitis was diagnosed by a combination of local and systemic signs of inflammation (7). Abdominal US supported the diagnosis with findings of distension, wall thickening and sludge in the gallbladder (7). More specifically, the finding of a sonographic Murphy sign was considered the most reliable because it is considered to suggest inflammation of the gallbladder (17).

Acute pancreatitis is typically diagnosed as abdominal pain, elevated serum amylase and swelling of the pancreas by diagnostic imaging (18). In the current study, acute pancreatitis was

Table I. Diseases successfully diagnosed with abdominal ultrasonography.

Diagnosis	Number of patients	Number of off-hour <sup>a</sup> patients
Acute cholangitis	15	3
Acute appendicitis	11	9
Acute cholecystitis	7	0
Acute pancreatitis	7	4
Enteritis	7	4
Colonic diverticulitis	5	3
Ileus	2	2
Colorectal cancer	2	1
Hepatocellular carcinoma	2	0
Pancreatic cancer	2	0
Bile duct cancer	2	1
Bowel perforation	2	2
Spleen rupture	1	0
Upper gastrointestinal bleeding	1	1
Total	66	30

<sup>a</sup>Weeknights, weekends and holidays.

diagnosed when abdominal US revealed a swollen pancreas, fluid collection and inflammation of adjacent organs. Acute diverticulitis was diagnosed as diverticulum with thickened wall and high echo from the surrounding tissue (Fig. 1A) (12). Acute appendicitis was diagnosed as swollen appendix with a diameter >10 mm, and thickened wall (Fig. 1B) (13,14).

## Results

**Successful diagnosis of patients.** Initial diagnosis with abdominal US was in agreement with the final diagnosis in 66 patients. For the remaining 10 patients, the diagnosis obtained from abdominal US differed from the final diagnosis. To investigate the performance and limitations of abdominal US, patients were divided into two groups. The first included patients in whom abdominal US diagnosis agreed with the final diagnosis (Table I) and the other included patients whose initial abdominal US diagnosis differed from the final diagnosis (Table II).

**Colorectal cancer and spleen rupture.** Solid organ diseases, including acute cholangitis, acute cholecystitis and acute pancreatitis, were correctly diagnosed by abdominal US. Intestinal diseases, including acute appendicitis and colonic diverticulitis, were also correctly diagnosed. Abdominal US was useful for the diagnosis of various types of cancer, including hepatocellular carcinoma, pancreatic cancer, and colorectal cancer (Fig. 2A). Colorectal cancer findings included irregular shaped wall thickening and loss of stratification, also referred to as the 'pseudokidney' sign (15). Critical conditions, such as rupture of the spleen, were also successfully diagnosed with abdominal US (Fig. 2B). Fluid in the abdominal cavity and high echo in the spleen suggested bleeding and damaging

Table II. List of misdiagnosed patients and speculated causes of misdiagnosis following abdominal ultrasound.

Patient number	Gender	Age (years)	Final diagnosis	Cause of misdiagnosis	Consultation or off-hour
1	F	49	Acute cholangitis	Bile duct diameter within normal range	C
2	M	69	Bile duct cancer, acute cholangitis	Bile duct cancer not detected due to gas	O
3	M	88	Sigmoid colon volvulus	Difficult to examine due to presence of massive gas bubbles	O
4	F	87	Acute appendicitis	Appendix not detected	O
5	M	39	Intestinal anisakiasis	Anisakiasis not detected	O
6	F	89	Duodena Ulcer	Tentatively diagnosed as acute cholecystitis due to a positive sonographic Murphy sign	C
7	M	53	Spontaneous hemoperitoneum	Nature of ascites not examined with US	O
8	F	40	Recurrence of cervical cancer	Presence of a huge mass in the pelvis of unknown origin	O
9	F	48	Left ovarian torsion	Torsion not diagnosed by US	C
10	F	57	Inflammation of uterus	Inflammation of the uterus not diagnosed	C

F, female; M, male; O, off-hour (weeknights, weekends, and holidays); C, consultation; US, ultrasound.

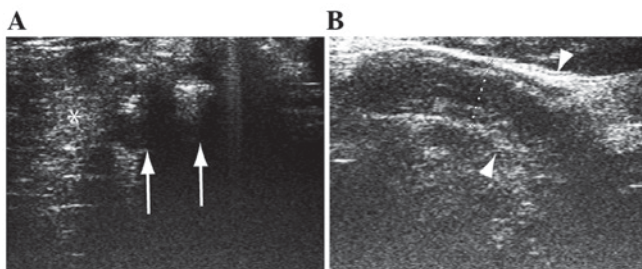


Figure 1. Acute appendicitis and colonic diverticulitis. (A) A 33-year-old male was admitted to hospital with right lower abdominal pain. Abdominal ultrasonography demonstrated diverticula with thickened wall containing air (arrows). High echo tissue surrounded the diverticulum (\*), suggesting an inflamed mesentery and omentum. The patient was diagnosed with colonic diverticulitis. (B) A 34-year-old male was admitted to hospital with right lower abdominal pain. Abdominal ultrasonography indicated a swollen appendix with a diameter of 11 mm (arrowheads; dotted line). The patient was diagnosed with acute appendicitis.

lesions, respectively (19). A total of 30 patients were admitted outside of regular working h and were subjected to abdominal US. They were correctly diagnosed without being subjected to CT or other diagnostic imaging procedures. These results clearly indicate that abdominal US is useful for the diagnosis of patients presenting with abdominal symptoms specifically during off-hours.

**Unsuccessful diagnosis of patients.** Table II summarizes data from those patients who were misdiagnosed by abdominal US and the potential reasons for misdiagnosis. These patients were subjected to additional diagnostic imaging procedures and were hospitalized for treatment because their conditions

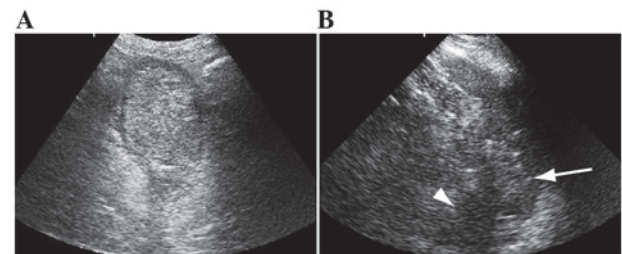


Figure 2. Colorectal cancer and spleen rupture. (A) A 79-year-old female was admitted to hospital with lower abdominal pain. Abdominal ultrasonography demonstrated a mass-like lesion in the sigmoid colon (pseudokidney sign). The patient was diagnosed with sigmoid colorectal cancer. (B) A 64-year-old male was hospitalized following a rib fracture. The patient had left upper back pain and was subjected to abdominal ultrasonography. An irregular-shaped high echo lesion was detected in the spleen (arrow) and fluid was observed near the spleen (arrowhead). The patient was diagnosed with spleen rupture.

suggested the necessity of further management. Two patients were referred to another hospital for gynecological consultation. All patients described in Table II were appropriately managed, according to their condition.

One major cause of misdiagnosis was intestinal gas. Gas over the site of the disease made the examination difficult to execute. Gas over the bile duct (patient 2) hindered the detection of bile duct cancer. Gas in the sigmoid colon made the examination difficult for patient 3.

**Unsuccessful diagnosis of acute appendicitis and duodenal ulcer.** A diagnosis of acute appendicitis was hampered when it was not possible to detect the appendix (patient 4; Fig. 3A) (20).



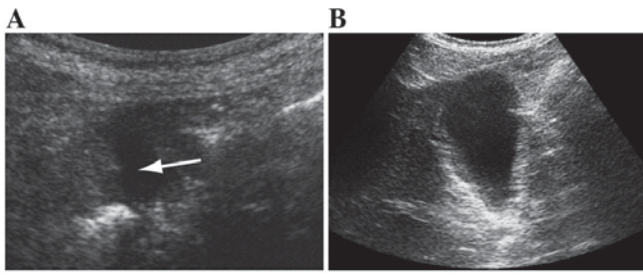


Figure 3. Misdiagnosis by abdominal ultrasonography. (A) An 87-year-old female was admitted to hospital with right lower abdominal pain. The patient's abdominal ultrasonography indicated that there was fluid (arrow) near the terminal ileum and cecum. The appendix was not identified. The patient was diagnosed with acute appendicitis following further investigation. (B) An 89-year-old male was referred to the National Hospital Organization Shimoshizu Hospital with right upper abdominal pain. An abdominal ultrasound indicated a distended gallbladder. The patient presented with tenderness at the gallbladder, suggesting a sonographic Murphy sign. Wall thickening of the gallbladder was not conclusive. The patient was diagnosed with acute cholecystitis. The diagnosis was controversial due to the lack of evident wall thickening therefore, an upper gastrointestinal endoscopy was performed and the patient was subsequently diagnosed with a duodenal ulcer.

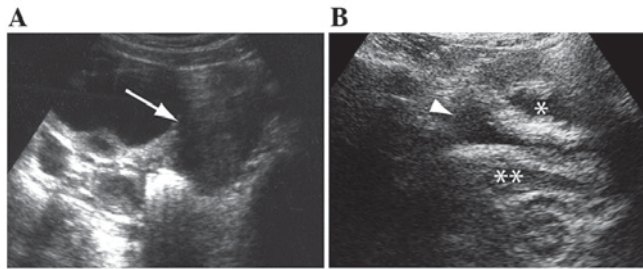


Figure 4. Misdiagnosis of gynecological diseases. (A) A 48-year-old female was admitted to hospital with lower abdominal pain. The patient's abdominal ultrasonography indicated a cystic lesion with sludge-like material (arrow) in the left ovary. The patient was referred for a gynecological consultation at different institution and was subsequently diagnosed with left ovary torsion. (B) A 57-year-old female was admitted to hospital with lower abdominal pain. The abdominal ultrasonography indicated the presence of fluid (arrowhead) between the sigmoid colon (\*) and the uterus (\*\*). Peristalsis was weakened in the sigmoid colon. The patient was referred for a gynecological consultation at a different institution and was subsequently diagnosed with inflammation of the uterus.

A sonographic Murphy sign markedly suggests acute cholecystitis when abdominal US findings include distension and wall thickening of the gallbladder (17). Since the duodenum is close to the gallbladder, the tenderness perceived in duodenal ulcer may occasionally resemble a sonographic Murphy sign (patient 6; Fig. 3B).

**Unsuccessful diagnosis of gynecological diseases.** A major difficulty in successful diagnosis with abdominal US was the presence of gynecological disorders. It was not difficult to detect a mass in the pelvis (patient 8) or a cystic lesion in the ovary (patient 9; Fig. 4A), however it was difficult to diagnose the site or organ of the original lesion, or relative torsion. The abdominal US clearly illustrated ascites and weakened peristalsis of the sigmoid colon (patient 10; Fig. 4B), but the correct diagnosis required subsequent referral to a gynecologist. Thus, these results suggested that patients should be referred for gynecological consultation when the abdominal US indicates

abnormal findings in the pelvis, particularly in the ovary and uterus.

## Discussion

The presence of gas bubbles makes abdominal US difficult to perform (21). Large amounts of gases arise due to perforation and obstruction of the bowel (22,23). In the current study, bile duct cancer and sigmoid colon volvulus were not diagnosed using abdominal US due to the presence of intestinal gas. Sigmoid colon volvulus requires prompt diagnosis followed by surgical or endoscopic treatment (24). An upside down U-shaped loop of dilated bowel is a typical radiological finding (25). With regards to abdominal US, findings specific to sigmoid colon volvulus have not been reported (26). Abdominal US is not, therefore, suitable for the diagnosis of sigmoid colon volvulus. It is recommended that patients should be subjected to radiography and CT when sigmoid colon volvulus is suspected (27).

The diagnosis of acute appendicitis with abdominal US is challenging when the appendix is unable to be visualized (20). In such cases, a large amount of fluid, phlegmon and periceal inflammatory fat changes are clear indications for the diagnosis of acute appendicitis (20). In the present study, fluid and high echo tissues were detected (Fig. 3A) and these findings suggested acute appendicitis. However, it was not possible to exclude the diagnosis of colonic diverticulitis or peritonitis. It was concluded that acute appendicitis is difficult to diagnose without the direct observation of the appendix.

Abdominal US is useful for gynecologists in the diagnosis of gynecological emergencies (28). Abnormal findings in the pelvis were detected in the current study, although a precise diagnosis was delayed since patients had to be referred to a gynecologist at a different institution for consultation. Among patients in the present study, ovarian torsion was the most critical condition. Ovarian torsion is diagnosed based on clinical symptoms, abdominal US, CT, and MRI (29). Color Doppler US reveals absent or diminished central venous flow in patients with ovarian torsion (5). However, a diagnosis of ovarian torsion is difficult to achieve (29). A previous report, in addition to the results from the patients in the current study, has suggested that gynecological diseases are difficult to correctly diagnose with abdominal US alone (28). It is recommended that a patient should be promptly referred to a gynecologist if an emergency condition is suspected.

One of the limitations of the present study was the relatively small number of patients examined. The number of patients was limited as the study was restricted to patients subjected to abdominal US as the first diagnostic imaging method. The initial aim of the present study was to evaluate the diagnostic performance of first-line abdominal US for patients presenting with abdominal symptoms. If information from the other diagnostic imaging examinations was available prior to abdominal US, this information may have interfere with the overall outcome of the abdominal US.

In the present study, performing an abdominal US was suitable for the correct diagnosis of patients presenting with abdominal symptoms. CT is sensitive, but requires exposure to radiation; abdominal US reduces the necessity of CT, and

lowers the exposure (30). It is recommended that patients should undergo further diagnostic imaging examinations when large gas bubbles are observed (31). It is also recommended that patients should be referred to a gynecologist when gynecological diseases are suspected.

In conclusion, abdominal US was suitable for the diagnosis of patients with abdominal symptoms. It is recommended that further diagnostic imaging be performed for patients with a large gas bubbles and that patients be referred to a gynecologist when gynecological diseases are suspected.

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