Chinese Expert Consensus and Guidelines on Oral Contrast Gastric Ultrasonography for Scanning Technique and Imaging Acquisition

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Abstract: Upper gastrointestinal (GI) abnormalities are one of the most common disease in clinical practice, and among them, gastric cancer is one of the most common causes of cancer-related death in China. However, conventional trans-abdominal ultrasound is difficult to evaluate GI diseases due to gas filled in the GI tract. With the development of oral contrast agents in China, ultrasonography with oral contrast agent has been used to visualize upper GI tract (i.e., stomach and duodenum) as well as its surrounding structures. The primary purposes of this consensus and guideline written by Chinese experts is to provide a coherent and clinical perspectives and practical protocol for using oral contrast in upper GI ultrasound, including four components: (1) indications and contraindications of gastric contrast ultrasound; (2) patients and instruments preparation; (3) scanning technique and imaging acquisition; (4) diagnosis of upper GI abnormalities.

Key Words: Gastric ultrasound; Oral contrast agent; Guideline; Upper GI abnormalities

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Introduction

Gastric cancer is one of the most common causes of cancer-related death in China which ranks the second in morbidity and the third in mortality after lung cancer. The incidence of gastric cancer in China accounts for about 40% of the new cases worldwide every year [1]. Since conventional trans-abdominal ultrasound is difficult to evaluate GI diseases due to gas filled in the GI tract, oral contrast agent has great value of eliminating the air in gastric cavity and to help display the gastric wall layers and lesions [2]. Previous studies have demonstrated the value of gastric contrast ultrasound in gastric cancer as well as other gastric lesions. In 2018, Chinese guidelines for diagnosis and treatment of gastric cancer proposed the use of gastric contrast ultrasound examination as one of the conventional imaging modality for initial diagnosis of gastric cancer were published by National Health commission of China [3]. However, despite substantial advances and multiple studies that have been published in gastric contrast ultrasound [4]. Most of the information is fragmented and disorganized, and there is no clinical guidance about rational sequencing of the scan procedure and interpretation of the images. Thus, in order to standardize the clinical application of gastric contrast ultrasound, we gathered many experts from Gastro-intestinal ultrasound group of China Association of Medical Education and developed this guideline. We intend to provide assistance to practitioners performing a sonographic examination of the upper GI tract, and we believe following this guideline will maximize the detection of upper GI abnormalities.

Reference Sources

Publications about gastric ultrasound from January 1985 to 2020 were searched through PubMed and China National Knowledge Infrastructure (CNKI) database, and a combination of the following medical subject headings (MeSH) were used for the literature retrieval: (gastric or stomach) AND (distention or contrast-enhanced or oral contrast-enhanced). Combined with the clinical work experience of many domestic experts on gastric contrast ultrasound and the selected articles, we put forward the standard and consensus of gastric contrast ultrasound examination.

Preparation of the guideline

In May 2018, several GI ultrasound experts agreed to develop a consensus of gastric contrast ultrasound examination at the founding meeting of Gastroenterology Group of China Association of Medical Education. Subsequently, the consensus was gradually formed through the repeated discussions and revisions on several offline and online conferences. According to the evidence-based clinical imaging guidelines [5], the recommended strength of consensus is divided into level A (Highly recommended, the intervention or examination has sufficient evidence to support the expected effect), level B (Recommended, the intervention or examination has moderate-sufficient evidence to support the expected effect), level C (Against recommendation, the intervention or examination has enough evidence to support the unexpected effect) and level D (Without recommendation, the intervention or examination does not have enough evidence to support or reject the effectiveness). In the future, this consensus will continue to be improved based on the clinical utilization and feedbacks.

Indications and Contraindications of Gastric Contrast Ultrasound

Indications of gastric contrast ultrasound:

(1) Organic diseases: gastritis, gastric and duodenal ulcer, carcinoma in gastric and duodenal, polyp in gastric and duodenum, adenoma in gastric and duodenum, gastric cyst, submucosal lesions (gastric stromal tumor, leiomyoma, lipoma, nerve sheath tumor, neuroendocrine tumor, ectopic pancreas, hemangioma, etc.), stomach repetitive malformation, hiatal hernia, achalasia of cardia, congenital pyloric stenosis, gastrolithiasis, gastric foreign body, and duodenal diverticulum.

(2) Functional diseases: gastroesophageal reflux, gastroduodenal reflux, gastroptosis, and gastric dysperistalsis.

(3) Congenital diseases: congenital hypertrophic pyloric stenosis, gastric duplication, heterotopic pyloric opening, duodenal atresia, and annular pancreas, etc.

(4) Patients intolerable for gastroscopy.

(5) Physical examination of healthy people and screening of high-risk population of gastric cancer.

(6) To examine and identify the compression and infiltration of gastric cavity caused by the lesions of adjacent organs (liver, biliary tract, pancreas, spleen, and kidney).

Recommendations:

Oral contrast agent can eliminate the interference of gas in gastric cavity which allows ultrasound to display gastric wall, lesions, and the relationship with adjacent organs. It can be used as a supplementary method of gastroscopy based on its wide use in gastric diseases and clinical recognition. (Recommended level: A)

Contraindications of gastric contrast ultrasound were as follows:

(1) Patients with upper GI perforation, active massive hemorrhage of upper GI tract, upper GI obstruction, acute gastric distention, and other situations

that need fasting.

(2) Patients with factors affecting ultrasound examination including fat hypertrophy and a large amount of gas in gastric cavity.

Recommendations:

The contraindications of gastric contrast ultrasound examination should be carefully evaluated based on the actual clinical situation. (Recommended level: C)

Training and Instrumentation

Recommendations for staff training

Radiologists who want to perform gastric contrast ultrasound need to pass the training to understand the anatomy of the stomach and its adjacent areas, to master the treatment of common gastric diseases, and to correctly use gastric ultrasound contrast agents to identify gastric wall structure and lesions. If the oral contrast agents are not available, water can be used to dilate the gastric cavity for the ultrasound examination. It should point out that the administration of water is only useful in the detection of larger gastric hyperechoic lesions, small or hypoechoic lesions are easily to be missed. For the examination of cardia and remnant stomach anastomotic stoma, ultrasonic examination should be carried out along with drinking oral contrast agent, the entire process during drinking and swallowing contrast agent should be observed dynamically using real time ultrasound imaging. During the examination, it is necessary to properly select the ultrasonic probe and communicate with the patients during the procedure. (Recommended level: A)

Ultrasound Equipment

Color Doppler ultrasound equipped with abdominal convex array probe (3.0~5.0MHz) and high-frequency linear array probe (5.0~12MHz) is recommended for routine use in adults and children.

Oral contrast agent

The commercially available oral contrast agent in China is dry powder product which is derived from rice and soya. It is reconstituted by adding 500 ml of boiling water into powder agent to form a palatable homogeneous suspension according to the instructions. The routine gastric contrast agent is recommended to be 500ml/ person for adult patients, and the amount should be adjusted based on the patient's own conditions (300-400ml for children and thin patients, and 800-1000ml for patients with larger gastric volume.

Intravenous contrast agent:

The ultrasound with combination of oral and intravenous contrast agent is called Double Contrast-enhanced Ultrasound (DCUS). It could display the gastric wall structures and the surrounding tissues, as well as the vascular perfusion of the lesions. DCUS has been used in differentiating the malignant lesion from benign lesion, staging and classification of gastric carcinoma. However, the accuracies of DCUS are currently varied and inconsistent, which needs to be tested by more relevant studies.

Patient position and ultrasound scanning sequence:

Supine and right lateral decubitus positions are most commonly used, followed by left side supine position and sitting position. The whole examination process should be finished in 15-20 minutes to avoid the evacuation of oral contrast agent. By using a continuous multi-directional (longitudinally and transversely) scanning method, the cardia, fundus, pylorus and duodenal bulb, ascending, and horizontal and descending part of duodena are examined dynamically and sequentially. For some patients with gastroptosis, standing or semi-sitting position can be adopted for examination.

Normal Gastric Wall on Contrast Ultrasound

The five layers' structure of normal gastric wall could be seen on high frequency ultrasonic image with oral contrast administration (Fig. 1):

(1) The 1st hyperechoic layer is gastric mucous.
(2) The 2nd hypoechoic layer is muscularis mucosa.
(3) The 3rd hyperechoic layer is submucosa.
(4) The 4th hypoechoic layer is muscularis propria.
(5) The 5th hyperechoic layer is serosa.

Standard Imaging Sections and Precautions for Scanning

Recommendations:

The body position during examination should be chosen based on the habits of radiologists and the examination part, so that the oral contrast agent can fill the examination site satisfactorily to eliminate the interference of gas. The common body positions include erect position, sitting position, supine position, and lateral position etc. Among them, supine position and left lateral position are often used to observe cardia and gastric fundus; right lateral position is conducted to observe gastric body, gastric horn, antrum pyloric tube, duodenal bulb and descending parts; erect position is helpful for duodenum filling which allows the better observation of duodenum and the judgement of gastroptosis by showing the lowest edge of gastric fundus. (Recommended level: A)

(1) The imaging sections for cardia and lower esophagus (Fig. 2):

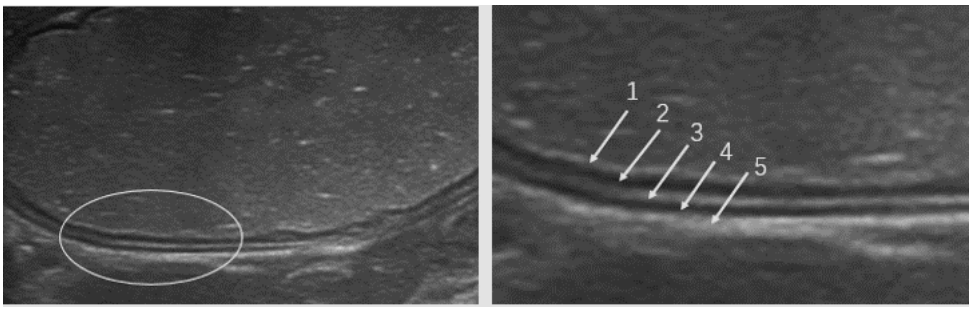

Figure 1 The five layers' structure of normal gastric wall

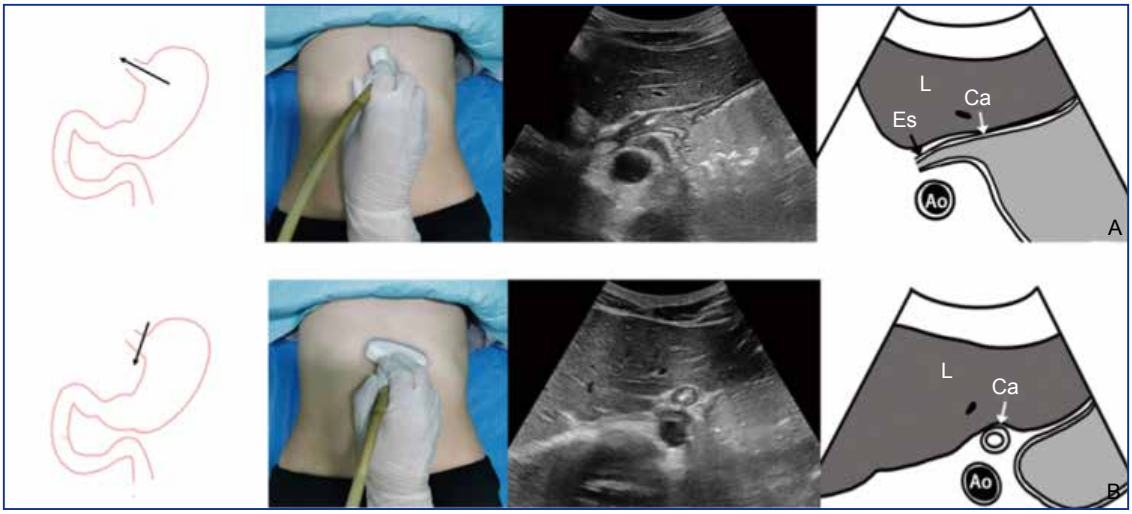

Figure 2 The imaging sections of cardia and lower esophagus. (A) The long-axis sections of the cardia and lower esophagus; (B) The short-axis sections of the cardia and lower esophagus. L, liver; Ca, cardia; AO, abdominal aorta; Es, esophagus.

Patient position: supine

Transducer position: under the xiphoid and left hypochondrial region

(2) The imaging sections for the fundus (Fig. 3)

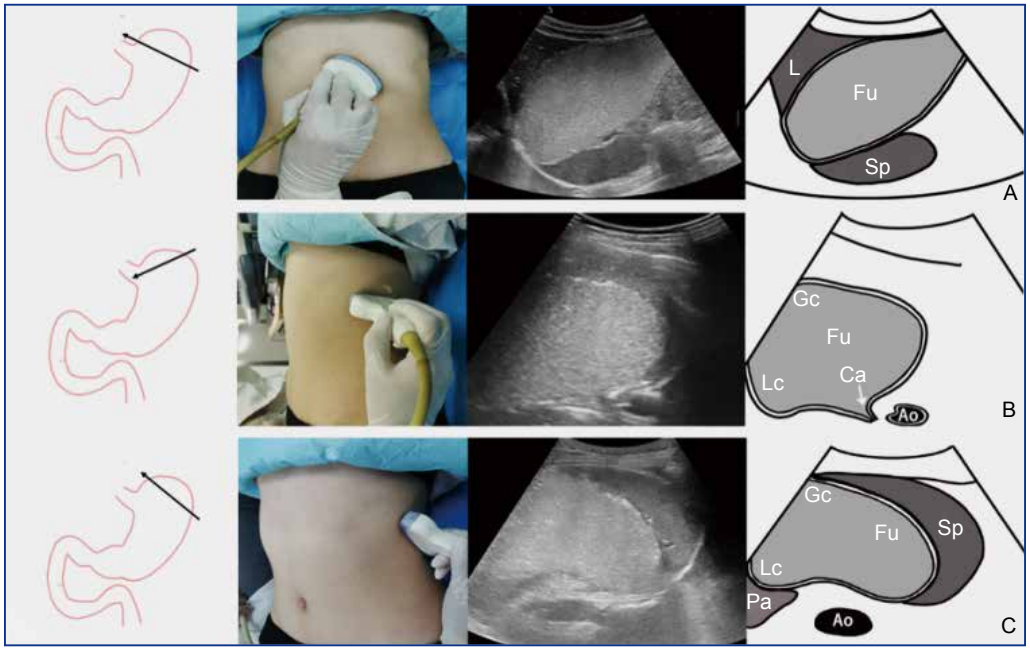

Figure 3 The imaging sections of the fundus. (A) In supine position, the transducer was placed under the xiphoid and left hypochondrium; (B and C) In supine position, the transducer was placed in intercostal. L, liver; Fu, fundus; SP, spleen; Gc, greater curvature; Lc, lesser curvature; Ca, cardia; AO, abdominal aorta; Pa, pancreas.

Patient position: supine

Transducer position: under the xiphoid and left hypochondrium

(3) The imaging sections for gastric body (Fig. 4):

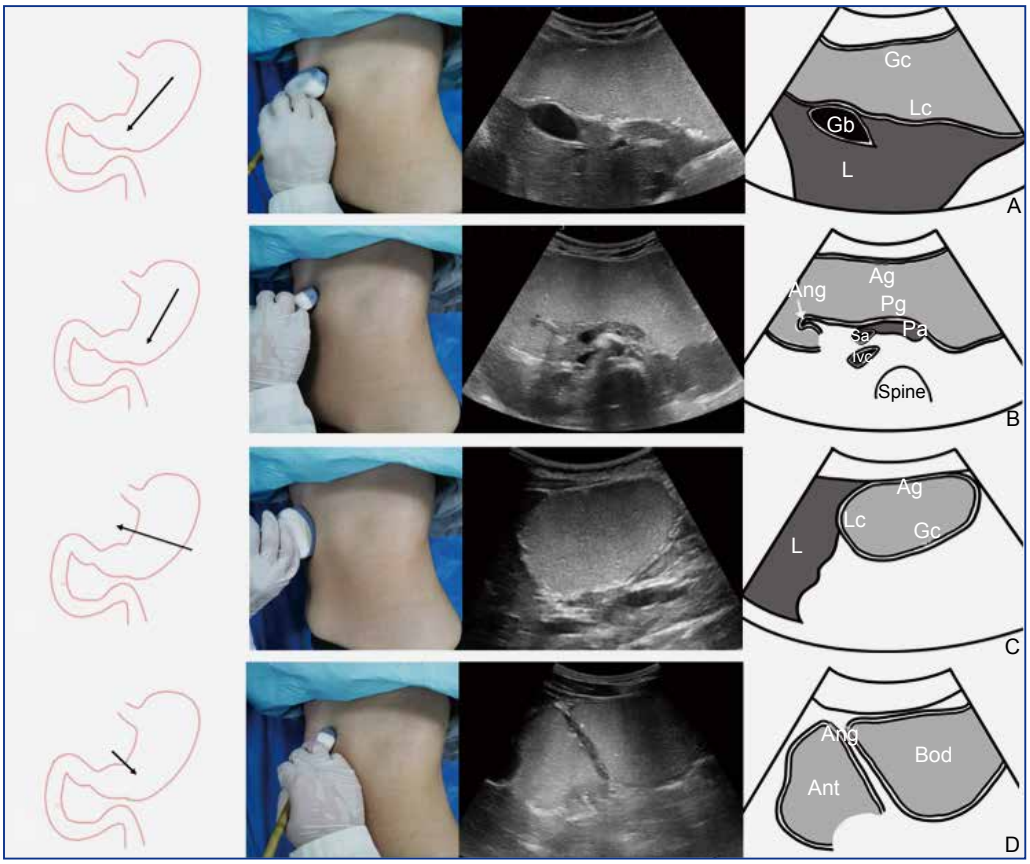

Figure 4 The imaging sections of gastric body. (A) The long-axis section of the greater and lesser curvature of the stomach (Vertical transverse view of the upper abdomen in the right lateral position); (B) The long-axis section of gastric body (vertical transverse section of upper abdomen in right lateral position); (C) The short-axis section of gastric body (vertical transverse section of upper abdomen in right lateral position); (D) The transverse section of gastric horn (oblique longitudinal section of upper abdomen in right lateral position). Gc, greater curvature; Lc, lesser curvature; Gb, gallbladder; L, liver; Ag, anterior gastric; Ang, gastric angle; Pg, posterior gastric; Pa, pancreas; Bod, gastric body; Ant, antrum.

Patient position: supine; right lateral

Transducer position: upper abdomen

(4) The imaging sections for the antrum and duodenal bulb (Fig. 5):

Patient position: supine

Transducer position: right upper abdomen

(5) The imaging sections for the duodenum (Fig. 6):

Patient position: supine

Transducer position: right upper abdomen

Imaging Measurement

Recommendations:

Standard measurement methods are as follows: In patients with tumors, the length, width, and thickness of gastric solid mass should be measured on the largest section of the tumor. It should be noted that in order to avoid the error of linear measurement, the larger lesions should be measured at multiple points along the gastric wall; For patients with ulcer, the diameter and depth of ulcer should be measured. (Recommended level: A)

Diagnosis of Upper GI Abnormalities

(1) Gastroesophageal reflux [6-9] (Fig. 7):

Recommendations: The probe should be placed under the xiphoid during the gastric filling process, the opening of the sphincter at the lower esophagus should be dynamically observed on the long axis section. The manifestation of gastroesophageal reflux can be seen as intermittent reflux along the gastric - cardia - esophageal pathway to the lower esophagus. (Recommended level: A)

(2) Esophageal hiatus hernia [10-13] (Fig. 8):

Recommendations: The probe should be placed under the xiphoid. The long axis section of the cardia should show that the gap of esophageal hiatusis enlarged (larger than 2cm), and some gastric echoes are detected above the diaphragm (Recommended level: A)

(3) Gastritis [14-17] (Fig. 9):

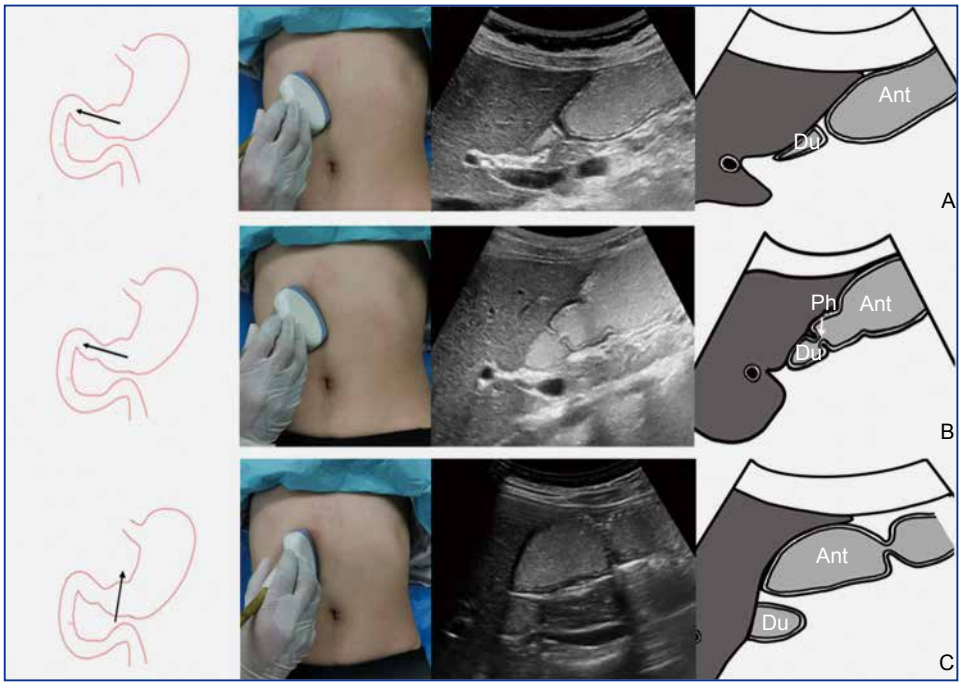

Figure 5 The imaging sections of the antrum and duodenal bulb. (A) The long axis view of antrum (Oblique section of right upper abdomen in supine position); (B) The long axis view of antrum, pylorus and duodenal bulb (oblique section of right upper abdomen in supine position); (C) The short-axis view of antrum (transverse section of right upper abdomen in supine position). Ant, antrum; Ph, pylorus hole; Du, duodenal bulb.

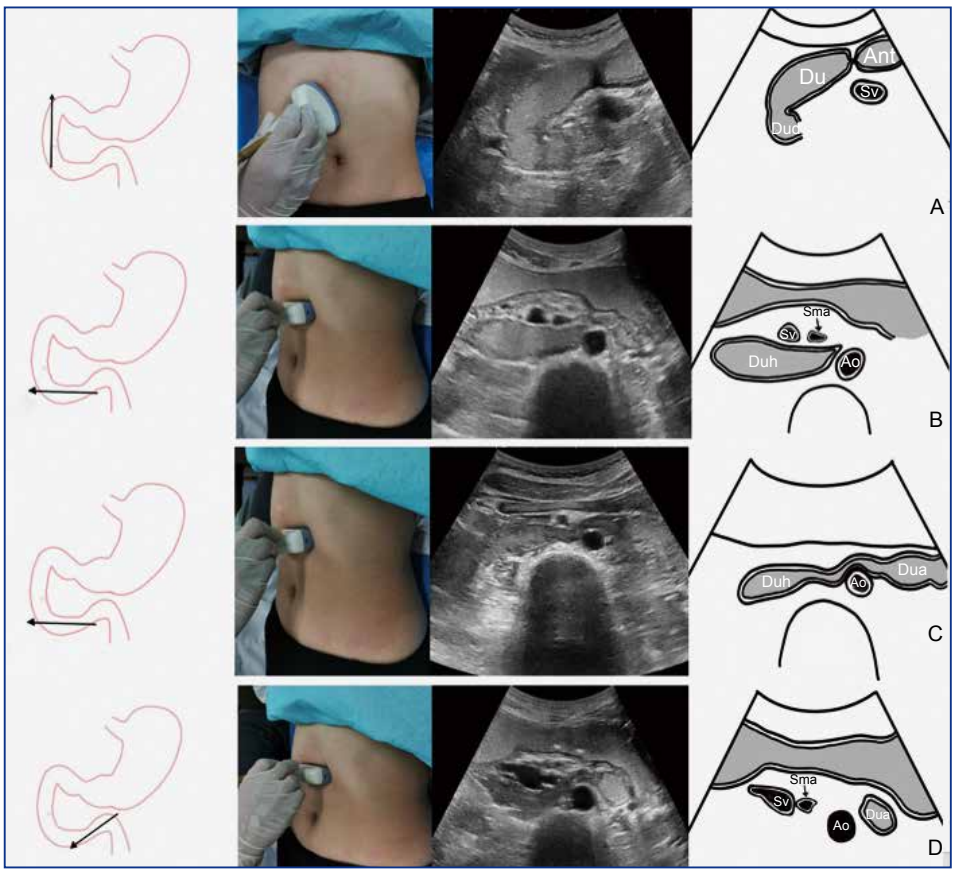

Figure 6 The imaging sections of the duodenum. (A) The section of duodenal bulb, descending part, horizontal part (transverse oblique section of right upper abdomen in supine position); (B) The section of horizontal part of the twelfth rectum (oblique cross section of abdomen above umbilicus in supine position); (C and D) The section of ascending part of duodenum (vertical transverse section of abdomen above umbilicus in supine position). Du, duodenal bulb; Dud, descending part of duodenum; Duh, duodenal horizontal part; Dua, duodenal ascending part; Sma, superior mesenteric artery; Sv, spleen vein; Ao, abdominal aorta.

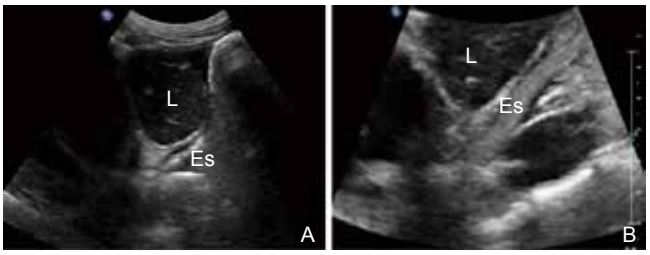

Figure 7 Gastroesophageal reflux. (A) Contrast ultrasound imaging shown a pre-phase of gastroesophageal reflux; (B) Contrast agent appears at the period of gastroesophageal reflux. L, liver; Es, esophagus.

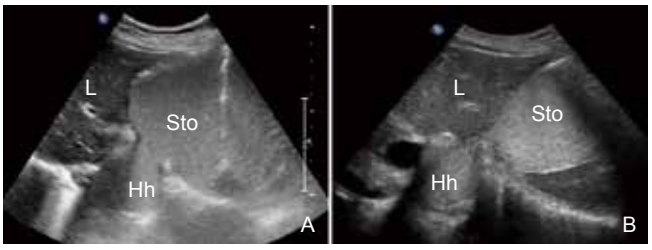

Figure 8 Esophageal hiatus hernia. (A) Contrast ultrasound imaging shown the dilation of cardia; (B) Oral contrast agent fills the supradiaphragmatic hernia sac. Sto, stomach; Hh, hiatus hernia.

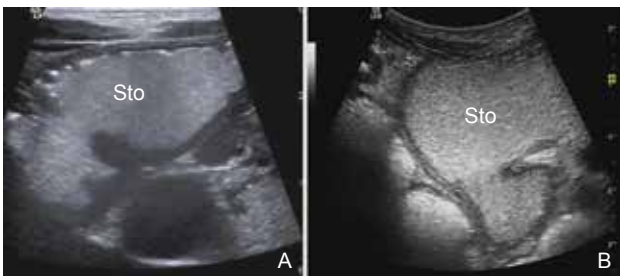

Figure 9 Contrast ultrasound imaging shown gastritis. (A) Acute gastritis (lesser curvature of gastric body); (B) Chronic gastritis (gastric angle). Sto, stomach.

Recommendations:

Acute gastritis is characterized by thickening of hypoechoic gastric wall mainly involved in mucosa and submucosa, accompanied by tiny pitting of mucosa. Chronic gastritis is characterized by localized or diffuse thickening and hypoechoic changes of the gastric wall with rough mucosa. (Recommended level: acute gastritis in level A; Chronic gastritis in level B)

(4) Gastric ulcer [14-15,18-20] (Fig. 10):

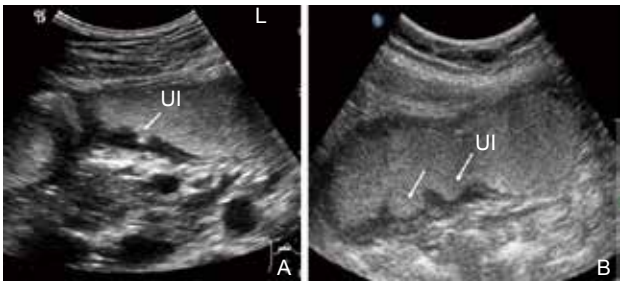

Figure 10 Gastric ulcer. (A) contrast ultrasound imaging shown superficial gastric ulcer (arrow); (B) Contrast ultrasound imaging identified deep gastric ulcers (arrows). Ul, ulcers.

Recommendations:

Gastric ulcer is characterized by pitting in mucosa with a regular and symmetrical shape on both sides. The continuity of mucosal is interrupted, but the gastric wall layers at the bottom of the shallow ulcer are clear. However, in some cases, the submucosal at the bottom of the deep ulcer can be interrupted, which should be carefully distinguished from ulcerative gastric cancer. (Recommended level: A)

(5) Gastric polyps [15,21-25] (Fig. 11):

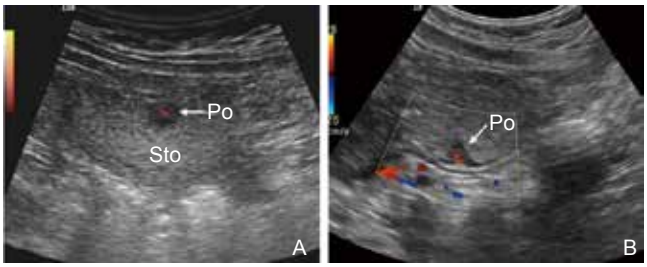

Figure 11 Contrast ultrasound imaging shown gastric polyps (arrows). (A) Inflammatory polyp; (B) Hyperplastic polyp. Po, polyp; Sto, stomach.

Recommendations:

Gastric polyps consist of inflammatory polyps, hyperplastic polyps, and adenomatous polyps. By measure the features and sizes using gastric ultrasound, the subtypes of polyps cannot be identified, and some small or iso-echoic polyps will be misdiagnosed. DCUS, to some extent, can improve the detection rate of adenomatous polyps. With regard to some polyps with malignant tendencies, DCUS might provide certain help in the differential diagnosis. (Recommended level: B)

(6) Gastric carcinoma [26-37] (Fig. 12,13):

Figure 12 Contrast ultrasound imaging shown early gastric cancer (arrows). (A) Flat type; (B) Concave type; (C) Uplift type.

Figure 13 Contrast ultrasound imaging shown advanced gastric cancer. (A) Mass type (M); (B) Ulcer infiltrating type (arrow indicates the ulcer); (C) Diffuse infiltrating type (arrow indicates the diffused thickened gastric wall). Sto, stomach; M, mass.

Recommendations:

Based on the clinical stage, gastric cancer can be roughly divided into early and advanced gastric cancer. Early gastric cancer mostly shows slight thickening (≤5mm) and hypoechoic changes of the gastric wall with interrupted mucosal or submucosa layer. Gastric contrast ultrasonography, however, is not sensitive enough to differentiate early gastric cancer from gastric ulcer or gastritis. Advanced gastric cancer is characterized by obvious local or diffuse thickening (>5mm) and hypoechoic changes of the gastric wall with abnormal structures. According to the invasion depth of gastric wall, T staging can be evaluated by gastric contrast ultrasound, and the use of DCUS might improve the diagnostic performance of T staging of gastric cancer. (Recommended level: advanced gastric cancer in level A; early gastric cancer in level B)

(7) Gastric stromal tumor [38-44] (Fig. 14):

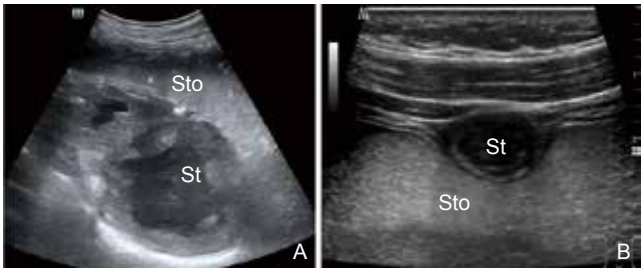

Figure 14 Contrast ultrasound imaging shown gastric stromal tumor. (A) Larger one with necrosis; (B) Smaller one. Sto, stomach; St, stromal tumor.

Recommendations:

Gastric stromal tumor originates from the muscularis propria of the gastric wall can be shown in gastric contrast ultrasound. The tumor presents with a round or lobulated lesion with a clear boundary and smooth surface. Small tumors are isoechoic, while some larger ones are hetero-echoic due to the necrosis in the tumor. DCUS might help to diagnose of gastric stromal tumor and locate the liquefaction necrosis. (Recommended level: A)

(8) Other gastric protuberant lesions [22,24-25,39,41,45-46] (Fig. 15):

Recommendations:

In addition to gastric stromal tumors, gastric contrast ultrasound was shown to have high sensitivity but low specificity to gastric lymphoma, neuroendocrine tumor, heterotopic pancreas, and lipoma etc. Therefore, its value of evaluating gastric protuberant lesions needs to be further verified. (Recommended level: B)

(9) Gastric varices (Fig. 16):

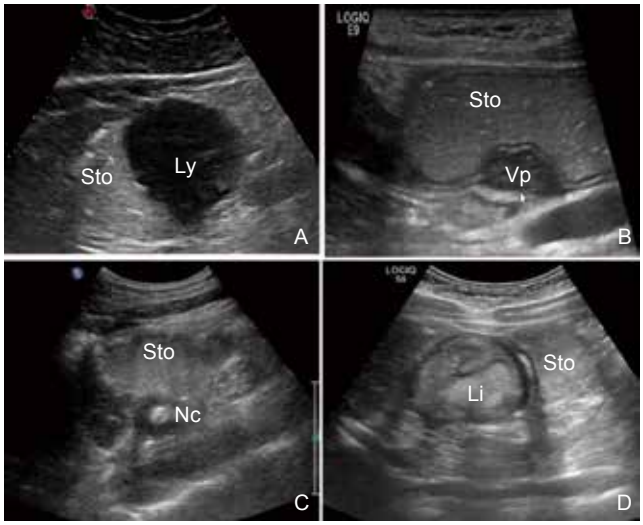

Figure15 Other gastric protuberant lesions shown on contrast ultrasound imaging. (A) Gastric lymphoma; (B) Heterotopic pancreas; (C) Neuroendocrine tumor; (D) Lipoma. Ly, lymphoma; Vp, Heterotopic pancreas; Nc, Neuroendocrine tumor; Li, lipoma.

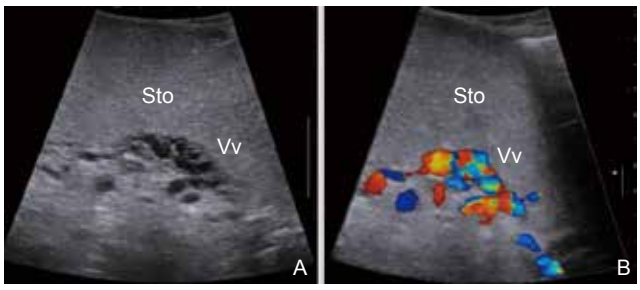

Figure 16 Contrast ultrasound imaging shown gastric varices. (A) Gray-scale image; (B) CDFI image. Sto, stomach; Vv, varices.

Recommendations:

Gastric varices is characterized by dilation and

tortuosity of the gastric wall veins in the gastric fundus and cardia in gastric contrast ultrasound. The veins display as tubular reticular or honeycomb like anechoic dark area with abundant blood flow signals. Low-speed venous spectrum could be detected by Doppler technique. (Recommended level: A)

Examination Report

A formal gastric contrast ultrasound examination report should include: the description about the condition of the cardia and pylorus (opening, closing, and reflux), gastric wall(smoothness, thickness, continuity, and activity),and masses(location, shape, size, boundary, the relationship with the hierarchical structure of gastric wall, blood flow, the relationship with surrounding organs whether there are enlarged lymph nodes around the stomach).

Recommendations:

The above items list the contents should be included in the final report of a gastric contrast ultrasound examination. (Recommended level: A)

Summary

Gastric contrast ultrasound has been more widely used than ever, the clinical value of this technology in some gastric diseases needs to be further evaluated by more high quality studies. Therefore, this consensus mainly focused on the indications and contraindications of gastric contrast ultrasound, patients and instruments preparation, scanning technique and imaging acquisitions, as well as diagnosis of upper GI abnormalities hoping to help standardize the applications of GI contrast ultrasound, and maximize the detection of upper GI abnormalities.

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Conflicts of Interest

The authors declare no conflict of interests.

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