SPECIAL ARTICLE

Current Standards in Gastrointestinal Ultrasound Diagnosis - A Surgical Review

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Introduction
Sonography using linear or curved sector scanners of 3.5 and 5 MHz has been an integral part of evaluation and management of postoperative patients in our department for the past ten years.

Although 'sonographic entropy' of the gastrointestinal tract has been considered in the past to preclude a satisfactory ultrasound examination, it has also provided characteristic diagnostic clues in several diseases of the gastrointestinal tract. Critical assessment of ultrasonic findings may provide diagnostic proof when combined with information obtained from history, clinical examination and laboratory findings.

General sonographic findings
Changes affecting the peritoneal cavity, alterations in the gastrointestinal wall and lumen, and changes in peristaltic movements may be interrelated. However, attempts to interpret an ultrasonic finding in isolation from clinical and laboratory data can be misleading. This is exemplified by detection of free fluid in the peritoneal cavity (Table 1) which can be associated with diverse conditions like gastroenteritis, ileus, obstruction, perforation, peritonitis, peritoneal carcinomatosis and even bleeding.

Free fluid can be detected in the following areas using a full bladder, (i) in the pouch of Douglas, in the left or right lateral position, (ii) in the paracolic spaces, and (iii) subphrenically on both sides or in the hepatorenal recess. Free fluid characteristically shifts when the patient's position is changed. A similar shift on position may be shown in fecal contamination of the peritoneal cavity, but this is distinguished by flocky-blotched particles swimming in fluid (Fig 1). Presence of free air and feces together also suggests bowel perforation and may be an indication for immediate laparotomy; following abdominal surgical interventions, it is a reliable evidence of anastomotic leakage.

The sonographic criteria for free air in the abdominal cavity have been described by Seitz who showed that as little as only a few milliliters of free air can be identified. Free air characteristically appears as linear or curvilinear echoes in the peritoneal cavity.

Table 1: Nonspecific sonographic findings in peritoneal cavity

<table>
<thead>
<tr>
<th>Echo-free fluid</th>
<th>Transudation</th>
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<tr>
<td>Echogenic fluid</td>
<td>Exudation</td>
</tr>
<tr>
<td>Foreign bodies</td>
<td>Blood</td>
</tr>
<tr>
<td>Free gas</td>
<td>Lavage</td>
</tr>
<tr>
<td></td>
<td>Abscess</td>
</tr>
<tr>
<td></td>
<td>Hematicoma</td>
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<tr>
<td></td>
<td>Ingesta or stools</td>
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</tbody>
</table>
reverberation echoes (Fig 1). The differential diagnosis of this finding includes intestinal gas which, however, causes a mushroom-shaped, breath-dependent column of air; this differentiation is easy in longitudinal and transverse scans. Abscesses, hematomas and infiltrations may also appear as fluid-lik e, hypodense areas with internal echoes depending on the extent of organization. In cases of a 'honeycomb' appearance; demonstration of this finding is not dependent on patient's position. Sonographic identification of these lesions can be done with high sensitivity and can guide surgical or other interventional therapeutic measures.

Sonographic detection of thickened gastrointestinal wall is considered to be a nonspecific finding when taken in isolation of clinical data and histology and may be found in several other diverse conditions such as inflammatory, neoplastic, and ischemic diseases and in benign and malignant tumors.

**Stomach-duodenum**

In 1973, Lutz described the sonographic phenomenon of 'cockade', which occurs due to circular echo-poor serosa mu cosa surrounding a central echogenic mucosa and intraluminal contents. In healthy subjects we found a hypodense layer of 3 ± 1 mm (mean ± SD) in the stomach corpus in the fasting state; when the stomach is distended with fluid, the wall thickness decreases to 2.5 ± 1 mm (statistically not significant, Student's t test).

Similar values are described by Rourke. With technical progress today, it is possible to strartify the gastric wall into individual layers with 5 to 7.5 MHz scanners (Fig 2). These make it possible to discern the depth of penetration and the extent of inflammatory or neoplastic changes of the gastric and intestinal walls.

A pathological cockade (Fig 2), i.e. wall thickness exceeding the limits, was initially considered diagnostic of a malignant gastric process. Today we know that such changes can occur even with benign gastric or duodenal ulcerations at any location. Diagnostic sensitivity ranges from 65%-83%.

Pathological cockade can be diagnosed in only 70% of cases with proved malignant infiltration.

By filling the stomach with fluid, Workle et al. could achieve a sonographic diagnostic sensitivity of 85% for benign and malignant gastric tumors. Early carcinoma evades objective sonographic proof; therefore while sonography provides important information, it does not permit histomorphological differentiation and hence is not a replacement for conventional endoscopic diagnosis in the digestive tract.

Sonography has a special significance in the diagnosis of ulcer perforation. It is common knowledge that approximately 30% to 40% of ulcer perforations evade simple plain X-ray procedures. Endoscopic evaluation too is inadequate in this situation. Among 65 patients with proven gastro-duodenal perforation, we found free air radiologically in the peritoneal cavity in only 73%. Sonographically too, diagnosis could be established in 73%; however, a combination of sonography and X-ray films gave a diagnostic accuracy of 91% for detection of free gasses.

In ulcer perforation, the following changes may serve as useful criteria: pathological cockade (76%), gastric distension caused by fluid retention (84%), edema of the rest of the gastric wall (95%), free feces and fluid (87%), free anecholic fluid (83%) and air in the peritoneal cavity (73%). Pathological duodenal cockades are found occasionally in duodenal diverticula and in malignant tumors in the duodenal area.

Sonographically, a swollen, fluid-filled stomach appearing like a balloon is found in pyloric stenosis, atomic stomach, proximal intestinal obstruction, and anastomotic secondary bleeding. Again, clinical and laboratory findings help in interpretation of sonographic findings.

Hypertrrophic pyloric stenosis in early infancy has now been recognized to have classical ultrasound features.

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**Fig 2:** Perforated duodenal ulcer. UC = pathological wall thickening (ulcer cockade) and free gasses (g) in the recessus hepatorenalis marked by arrows, L = Liver, R = rightkidney, W = normal gastric wall layers.
Small Intestine

Enteritis

In patients with mild diarrhea, intraluminal fluid sequestration can be detected on sonography, along with minimal anechoic peritoneal fluid. There is no uniform intestinal dilatation. Hyperperistalsis may result in quick changes in appearance (Table 2) which may be noticed or measured on real-time observation.5,67

Incomplete intestinal obstruction

Establishing the diagnosis in a patient with chronic relapsing 'abdominal colics' is one of the most remarkable achievements of sonography. The common clinical diagnoses include gastrointestinal, biliary or renal colic, and psychosomatic disorders. In about 70% of cases, a history of abdominal surgery is obtained, leading to suspicion of adhesions. Frequently a careful dietary history may reveal intake of bulky food (mushrooms, cabbage, granular diet, salad, beans, oranges, wholemeal bread). Real-time sonography reveals fluid-filled intestinal segments, dilated up to 2.5 cm and with limited amplitude of contraction with hypodense wall edema (≥3 mm). The ratio of luminal diameter during contraction and relaxation is more important than absolute values. Often thick intraluminal bulk food products and free transmural fluid can also be visualized. It is also possible to observe dilated and collapsed loops ('hungry intestinal segments') lying side by side. Peristaltic wall movements are animated, and intraluminal mobility of particles paradoxical (Table 2). Sonographic diagnosis of incomplete bowel obstruction can be made with a sensitivity of 90% and specificity of 95%. It is possible to advise conservative management with confidence under adequate ultrasonic monitoring.26

Obstruction of small and large intestine — Ileus

Stasis of luminal contents in the poststenotic intestinal segment is the major pathophysiologic phenomenon of intestinal obstruction. Obstruction leads to progressive intestinal distension with massive proliferation of bacteria, formation of putrefactive gases, hypoxic, endotoxin-related damage of the mucosa and edema of the intestinal wall. Each of these phenomena helps in sonographic diagnosis. Numerous studies have enabled compilation of the pathognomonic criteria (Table 2, Fig 3).5,6,7,19,26

Sonography has a sensitivity of 98% and a specificity of 99% and is superior to simple X-ray examinations in so far as X-ray negative cases (up to 20% of the total) can be recognized by sonography. The approximate site of obstruction can be determined since typical mucosal features like Kerckring's folds and haustations are easily identifiable. In addition, direct objective proof of the cause of ileus is available in more than 70%; differentiation between paralysis and persistent peristalsis can also be done.

Table 2: Sonographic differences in number and amplitude of peristalsis in intestinal diseases.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>n</th>
<th>Bowel peristals (no/min)</th>
<th>Amplitude of peristalsis (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enteritis</td>
<td>100</td>
<td>10±5</td>
<td>12±18</td>
</tr>
<tr>
<td>Incomplete intestinal obstruction</td>
<td>100</td>
<td>8±2</td>
<td>7±3</td>
</tr>
<tr>
<td>X-ray negative complete intestinal obstruction</td>
<td>25</td>
<td>4±1</td>
<td>3±1</td>
</tr>
<tr>
<td>X-ray positive complete intestinal obstruction</td>
<td>257</td>
<td>0±3</td>
<td>1±3</td>
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Mesenteric Ischemia

At the onset, hyperactive peristalsis with rapidly increasing edema of intestinal wall and mesenteric edema measuring up to 10 mm can be seen sonographically along with a radiologically gasless abdomen. At the same time, large amounts of transudative fluid can be found. Similar findings can be seen also in mesenteric vascular insufficiency (low cardiac output syndrome). These findings are present with a sensitivity of approximately 65%.3,29 Therefore, selective angiography of the superior mesenteric artery is necessary for confirmation of diagnosis. Intestinal wall phlegmoms5,30 and hemorhages9 also appear as long infiltrative changes in the intestinal walls.

Inflammatory Disease

Sonographically, findings identical to those mentioned above are also seen in the so-called chronic inflammatory intestinal diseases.3,30-38 In these cases the intestinal wall is thickened to 1 cm. Though sonographic stratiﬁcation of the bowel wall is altered, it is not disrupted in most cases; this feature helps in differentiating from carcinomas (Fig 4). The marginal wall which is echo-poor is most clearly thickened.3,23,34,35,36 Peristalsis is slow and compressibility is reduced. The sensitivity of sonographic diagnosis of Crohn's disease ranges from 87%-94%. Ulcerative colitis can be diagnosed with a lower sensitivity rate of 53%-87%.3,24,32,34,35,36

Limberg36 defined sonographic criteria for primary chronic granulomatous or ulcerative disease of the colon which can be diagnosed in approximately 85%; this was achieved by fluid irrigation. In ulcerative diseases there is a sonographically detectable loss of fat stratiﬁcation; only tender, echo-poor wall thickening as well as edema of the mucosa can be seen in the beginning. Complications requiring surgery, such as paralytic or mechanical ileus and formation of fistulas or abscesses, can be recognized in time by sonographic monitoring and clinical signs and laboratory tests. Nevertheless difﬁculty in making the sonographic differentiation between hemorrhage, phlegmon and edema is well known.36,38,39,47 Retrogression of the original wall thickness to normal range (3 mm), longitudinal and transverse distance, change of layer stratiﬁcation and compressibility, and identiﬁcation of accompanying features like fistulas, abscesses and peritonitis provide information about the course of the disease.36,32,35 Endoscopy and biopsy, however, are necessary. Ultrasound thus allows diagnosis in seriously ill patient with the least possible stress, while obviating invasive radiologic procedures.

Intussusception and Carcinomas

The 'target sign' is a sonographic feature of intestinal intussusception (Fig 5).38 It appears as a double coaccale formation in the luminal cross-section and provides pediatricians an alarming signal of clinical relevance. In early infancy sonographic monitoring should be routinely employed when this potentially serious condition is suspected; identiﬁcation of 'target sign' then should provide an absolute indication for surgery in adult patients as it is usually secondary to a neoplasm. Ultrasound examination has failed as an adequate screening investigation for the diagnosis of malignant tumors. The sonographic detection of poorly distended, occasionally irregularly limited coaccales is at best an incidental ﬁnding. By retrograde

Fig 4: Sonographic differential diagnostic criteria of ulcerative colitis (UC) in longitudinal (L) and transverse (T) scans, and of Crohn's disease (CD). L: coaccale formation. Thickening of the echo-poor mucous membrane (m) is seen in ulcerative colitis, with stratiﬁcation of the wall layers. Crohn's disease is characterized by thickening of the echo-rich submucous layer and indistinct wall stratiﬁcation.

Fig 5: Intussusception of the terminal ileum (I) into the cecum. CW = cecal wall, Typical sandwich phenomenon of the wall layers structure in longitudinal scan. On transverse scan this looks like a target sign.
instillation of fluid, sonographic assessment of the colon is significantly improved. Thus the sensitivity of the conventional abdominal sonography for carcinoma could be increased from approximately 20% to 90%. Intravenous-intraluminal ultrasound examination may allow further improvement in diagnostic yield.

Acute sigmoid diverticulitis

Clinically, acute sigmoid diverticulitis is described as 'left-sided appendicitis' and traditionally it is diagnosed by endoscopy or by contrast examinations during remission. This disease can often be erroneously diagnosed as ureteric colic, urinary tract infection, extra-uterine pregnancy, ovarian cyst or hematoma of the rectus muscle. Because of its retroperitoneal fixation, proximity to the abdominal wall and close vicinity to the bladder, which yields an ideal contrast medium, the sigmoid colon is especially accessible for ultrasonic examination. The inflammatory changes in the diverticula can be visualized in almost 70% of cases. The diverticula look like a number appendicular structures with a hypodense sound pattern (Fig. 6). Within the diverticula, particles of feces or intestinal gas can be easily seen. The wall layer stratification can also be frequently discerned. The sensitivity and specificity of ultrasound diagnosis ranges from 90% to 98% and 60% to 98% respectively. In our patients, sonographic diagnosis proved to be superior to both radiological and endoscopy examinations. Combined with radiology, a sensitivity of 92% as compared to 100% with computed tomography could be achieved. Complications such as abscess formation, perforation, obstruction and paralysis could also be easily ascertained sonographically. Thus, with the use of sonography, a patient may be spared stress of invasive investigations in the acute stage. During remission, however, endoscopy is absolutely essential to exclude malignant growth.

Acute appendicitis

Over the last 3 to 4 years sonographic diagnosis of disease of the appendix has gained significance especially because negative appendectomy rates are still as high as 15 to 30%, and perforation rates are around 15%. In our patients, although sonography allows correct diagnosis in only 83% patients as against 87% with clinical diagnosis, a combination of both clinical and sonographic findings resulted in a sensitivity of 93%. The rate of negative appendectomies can thus be reduced to 9%; the perforation rate however remains unaltered because it is usually due to delay in reporting to the hospital.

A 5 MHz or even 7.5 MHz linear probe is used for sonographic evaluation of the appendix. The ilio-psoas as well as iliac vessels which are situated medial to the former serve as anatomic guides. Individually cored compression with the scanner enables easier detection of the inflamed appendix which is seen as a pathological 'soda cracker' with pain provoked by compression (Fig. 7). Occasionally, intraluminal fecoliths, small omental pouches as well as appendicular infiltrates and even abscesses can be located. Sonography is useful in the evaluation of right lower abdominal pain by immediate identification of an inflamed vermiform appendix, and also by recognizing other diseases. These include perforated peptic ulcer, torsion of ovarian cysts, extra-uterine pregnancies, phlegmonous cholecystitis, retroperitoneal inflammation, hematoma of the rectus muscle, retroperitoneal bleeding, Crohn's disease, ureteric colic, incomplete intestinal obstruction and inflammation of the urinary bladder which have a similar clinical presentation.

In conclusion, abdominal ultrasound diagnosis has gained immense significance due to technical improvements in equipment in recent years. Diagnoses can be
made with high sensitivity at admission itself, and without stress to the patient. Acute surgical complications can also be identified. But it must be emphasized that sonography can achieve optimal results only when interpreted in conjunction with history, clinical, laboratory and endoscopic findings. To achieve reasonable diagnostic sonographic standards, constant practice as well as clinical experience are required. More stringent, well versed in correlating clinical, laboratory and endoscopic data, should develop expertise in sonographic evaluation of the gastrointestinal tract in order to exploit the great potential of this widely available, non-invasive technique.

References
1. Donat BD, Quirke F, Stewart JM, Ultrasonic distinction of abscesses from other intra-abdominal fluid collections. Radiology 1975; 133: 213-68.

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Dr Yuan Fang Chen, MD
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Prof of Medicine
Peking Union Medical College Hospital
Beijing 100730, China.

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The 4th World Congress of International Gastro-Surgical Club is to be held in Madrid, October 27-30, 1993. For details, please contact:

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