Application of ultrasound in the diagnosis of gastrointestinal tumors

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Abstract
Gastrointestinal tumors are common tumors in the digestive system. Early diagnosis of gastrointestinal tumors is the key to improve prognosis and curative effect of patients with tumors. Compared with other methods of examination and diagnosis, ultrasound examination has the advantages of simple operation, non-invasive, economical, and repeatable operation. With the advancement of ultrasound technology and the development of ultrasound contrast agents, ultrasound examination is more and more applied to gastrointestinal examination. Ultrasound cannot only observe the gastrointestinal wall, but also evaluate the surrounding lesions and metastases, as well as preoperative analysis and postoperative follow-up of gastrointestinal tumors. We reviewed the diagnostic applications of ultrasound in gastrointestinal tumors.

Keywords
diagnosis, gastrointestinal tract, ultrasound

Introduction
Gastrointestinal tumors account for a large proportion of all neoplasms. They pose a major problem in oncology, and are a major cause of apprehension in patient with abdominal complaint, in which the fear of the cancer is the greatest.1 The gastrointestinal tract includes pharynx, esophagus, stomach, small intestine, large intestine and perianal region.2 Computed tomography (CT), endoscopic ultrasound (EUS), and 18F-fluorodeoxyglucose positron emission tomography (FDG-PET) are applied in diagnosis of gastrointestinal tumors. Fine-needle aspiration biopsy (FNAB) under EUS enables definitive diagnosis for gastrointestinal tumors.3,4

Ultrasound has been widely used and popularized in the clinic.5 The frequency range of medical ultrasound systems for most scanners is from 2 to 20 MHz. Ultrasound systems of much higher frequency ranges have been introduced to the clinical setting, which permit a significant increase in resolution. Utilizing low frequency (3–9 MHz) ultrasound (US) imaging techniques provide a general outline. The best applications of the high frequency ultrasound (7–15 MHz) system are neuromusculoskeletal, dermatology, lymphatic, vascular, thyroid, and other small-part imaging.5,6 Ultrasonic devices with operation frequencies above 30 MHz can provide microscopic spatial resolution making these devices especially ideal.6 High-frequency ultrasound can distinguish normal nerve tissue from the surrounding muscles, tendons, fascia, and vascular tissues. It can also clearly show the morphology, diameter and internal echo of peripheral nerve, and its anatomy relationship with the surrounding tissue, and accurately predict the location and extent.9

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Ultrasound mainly uses the physical properties of ultrasound and the histological properties of human body, so that it can be displayed in the form of images. It is conducive to the clinical judgment of physiological and pathological conditions based on its image characteristics, so as to formulate treatment program. In addition, the technology can directly observe the structure of the tissues, the size of the lesion, etc. They are beneficial to observe whether the adjacent tissue is involved. At the same time, it has the advantages of convenient inspection, intuitive image and non-invasiveness, which are not available in other inspections.10,11

This review aimed to take a closer look at the role of ultrasound in the diagnosis of gastrointestinal tumors and elaborate on application of ultrasound in the diagnosis of gastric cancer and colorectal cancer.

The application of ultrasound in the diagnosis of gastric cancer

Gastric cancer, a common malignant tumor of the digestive tract, is one of the most malignant tumors with the highest morbidity and mortality.12 The prognosis of gastric cancer is closely related to the timing of diagnosis and treatment. The 5-year survival rate of early gastric cancer is over 90%, while that of stage III and IV gastric cancer is less than 20%.13 Therefore, early detection is of great significance in improving the survival rate and reducing the mortality of gastric cancer.14 At present, there are various methods for examination of gastric cancer, including X-ray angiography, ultrasound examination, CT examination, MRI examination, gastroscopy, and endoscopic ultrasonography.15–17

The advantages and disadvantages of Ultrasound compared to CT, MRI, and endoscopy were shown in Table 1.

Table 1. The advantages and disadvantages of ultrasound compared to CT, MRI, and endoscopy.

| Items          | Ultrasound                        | CT                   | MRI                   | Endoscope                  |
|----------------|-----------------------------------|----------------------|-----------------------|----------------------------|
| Advantages     | Simple, no invasive, economical, repeatable | Judgment transition, no invasive | High resolution, involvement | Direct observation, take biopsy |
| Disadvantages  | Missed diagnosis                  |                      | Susceptible to interference | Invasive                  |

Ultrasound examinations were easily interfered by gastrointestinal gases and intestinal contents, and were once considered unsuitable for the examination of gastrointestinal diseases. However, with the gradual accumulation of ultrasound experience and the application of oral gastrointestinal ultrasound contrast agents, the effects of gastrointestinal gases can be reduced, thereby improving the display of sonograms. Contrast-enhanced ultrasound scans the patient through the color and energy Doppler signals of the internal tumor, which can improve the quality of the contrast image and the contrast effect, and help to improve the contrast resolution and spatial resolution of the ultrasound image.22 The lesion boundary is clearer and has a
clear advantage in showing microcirculation perfusion in tissues, which makes ultrasound more and more widely used in gastrointestinal diseases.

Ultrasound sonogram features of early gastric cancer are as follows: (1) lesions are confined to the mucosa or submucosa; (2) mild thickening of the stomach wall or bulging with echo reduction; (3) rough or uneven mucosal surface or echo failure. Ultrasound sonogram characteristics of advanced gastric cancer are as follows: (1) According to Bommann classification, it can be divided into mass type (type I), ulcer type (type II), infiltrating ulcer type (type III); (2) lesions occur in gastric sinus and corpus, especially in the small curved side of the stomach; (3) abnormal thickening or swelling of the local stomach wall, destruction of hierarchical structure; (4) thickest part of the stomach wall $\geq 15$ mm, diameter $\geq 50$ mm; (5) the mucosal surface of stomach is rough and uneven, and the "crater" is irregularly concave, and the concave bottom is larger than the notch; (6) the peristaltic wall of the lesion is weakened and stiff. In addition, ultrasound examination shows the lymph nodes of the stomach and distant metastasis.23

The main manifestations for the images of contrast-enhanced ultrasonography of gastric cancer mainly include destruction of the stomach wall, interruption of the submucosal layer of the stomach wall, abnormal thickening of the stomach wall and relatively stiff peristalsis. The gastric wall thickening of different types of gastric cancer is different. The stomach wall of diffuse gastric cancer is diffuse thickening, and it is very stiff. The gastric peristalsis is weakened or even disappeared, and the gastric cavity is deformed. The gastric wall of massive gastric cancer protrudes to the gastric cavity. The ulcerated gastric cancer has thickened stomach wall and the gastric mucosa is full of unevenness.24,25 A schematic illustration of Ultrasonographic features of gastric cancer was shown in Figure 1.

Ultrasound contrast imaging (OCUS) has the advantages of simple operation, no pain, and strong acceptance of the elderly.26 The diagnosis of gastric cancer has high accuracy. Related studies have shown that OCUS’s ability to detect and diagnose gastric cancer is similar to gastroscopy.27,28 The results show that OCUS can be used as an effective way to detect and diagnose elderly gastric cancer, and reduce the frequency of gastroscopy. OCUS is easy to learn and master, and can be carried out in primary hospitals, and it is worth promoting in primary hospitals, especially community hospitals.29

The application of ultrasound in the diagnosis of colorectal cancer

Colorectal cancer (CRC) is one of the common malignant tumors in the clinic.30 Its incidence rate ranks third among men and second among women, which brings a heavy burden to society.31 Although these patients undergo radical surgery, the recurrence and metastasis rate are higher and the prognosis is worse.32 Therefore, it is of great clinical significance to explore good early diagnosis methods and improve the early diagnosis of CRC. At
present, the main diagnostic methods for colorectal cancer include endoscopy, double contrast of colonic gas, CT and ultrasound.

Endoscopy includes colonoscopy and sigmoidoscopy. Endoscopy can directly observe the general shape of the lesion in the intestine, whether there is ulcer in the mucosa of the intestine. It can also measure the length and the distance between the distal end and the anal margin. At the same time, biopsy can be taken to judge the tumor nature by pathology with providing a direct basis for surgical treatment. However, although it invades the intestinal wall or the pelvic cavity, the depth of the infiltration of the tumor wall cannot be judged, and it is impossible to carry out the staging of the tumor. The pain during the examination is poor and the compliance is poor. It is an invasive examination. Intestinal perforation and risk of bleeding may occur during detection. In addition, colonoscopy requires calming, special care and stability to cope with the examination, and there is a certain risk of bowel preparation. These complications constitute a limitation of colonoscopy, and new diagnostics with less nociceptivity, sensitivity, and specificity are needed to screen for CRC.

Double contrast barium enema (DCBE) is a non-invasive, radiological examination that provides a comprehensive assessment of the colon. The basic method is to inject air and sputum into the colon to form a double contrast image. Intramuscular anticholinergic drugs can reduce the tension of the intestinal motility. As we know, we opened the possibility to expand knowledge of the gastrointestinal motility. However, coronary heart disease, glaucoma and benign prostatic hyperplasia are contraindications due to the application of anticholinergic drugs. The density resolution of DCBE is not high, which may lead to missed diagnosis and misdiagnosis. At the same time, DCBE does not show the extent of invasion outside the tumor wall and whether there are other organs and lymph node metastasis. Moreover, the length of obstruction cannot be clearly defined for tumor-induced obstruction.

CT examination is now more and more widely used in clinical examination. Traditional CT scan and enhanced scan have lower accuracy of TNM staging in colorectal cancer. In recent years, the development of multi-slice spiral CT has improved the detection rate of lesions to some extent. The accuracy of lesion size measurement and multi-slice spiral CT arbitrarily choose to scan the observation surface such as cross section, coronal plane, sagittal plane, upper or curved surface. Therefore, it can find more tumor lesions that are easily missed due to partial volume effect and can better judge the metastasis of the primary tumor. Furthermore, it is better for judging the lymph node N and M staging. However, many middle-level hospitals still use single-slice spiral CT, which can only do axial scan and lead to low soft tissue resolution affecting observation and diagnosis.

In addition, CT examination also has obvious deficiencies. It cannot accurately display the intestinal wall stratification, although multi-slice spiral CT compensates for this deficiency by increasing the density contrast between tumor tissue and normal tissue. For small lesion observation and intestinal wall, the diagnosis of the degree of infiltration still has certain and missed diagnosis. MRI has a multi-planar examination function, which can better show the involvement of muscles and bones in patients with partial pelvic floor involvement. However, MRI provides cross-sectional imaging of the entire pelvis with a resolution of \( \geq 1.5 \text{ cm} \), which limits its ability to assess small malignant tumors or abnormalities in the digestive tract. Simultaneous MRI examination requires high operator experience, equipment and equipment, and requires intracavitary MRI mirrors and contrast enhancers. The cost is high, so it is difficult to promote as the first choice for clinical diagnosis. It has been reported that MRI application in staging of advanced colorectal cancer was evaluated against histopathological staging and it was found to be reliable in assessing T3-T4 colorectal cancer. Developments in MRI imaging techniques have opened up the possibility to expand knowledge of the gastrointestinal motility. As we know, we need the antiperistaltic drugs to reduction motion artifacts. This adds complexity to the inspection.

With the improvement of the ultrasonic diagnostic technology and the resolution of the ultrasonic instrument, the color Doppler ultrasound has the advantages of simple examination method, safe and non-invasive, displaying the tumor size and internal structure of the intestinal wall thickness, and directly obtaining the advantages of tumor blood flow information, which receive clinical attention. However, the level of wealth differs across the world, medical conditions are different. It is considered that ultrasound is a primary screening tool for gastrointestinal tumors.
After the application of the ultrasonic auxiliary agent enema, the intestinal tract completely eliminates the interference of feces and gas, and forms a good sound-transparent window, which enhances the penetration and reflectivity of the ultrasound. In this case, the abdominal examination of the colorectal improves the contrast between the colorectal wall and the lumen and surrounding tissues, and it can more clearly show the size and shape of the lesion, the depth of the infiltrating intestinal wall, the changes of intestinal morphology and peristalsis and its relationship with surrounding tissues, thus improving the possibility of early diagnosis of ultrasound. A schematic illustration of Ultrasonographic features of colorectal cancer was shown in Figure 2.

Endorectal ultrasound (EUS) was the imaging modality recommended for staging rectal cancer, with sensitivity and specificity of 94% and 86%, respectively. The accuracy of EUS in T staging rectal cancer has shown to range from 74% to 94%, The accuracy of EUS for N staging has been less precise ranging from 63% to 86%. Sensitivity of advanced lesions using EUS has been found to be higher than in early T stage (T1 87.8%, T2 80.5%, T3 96.4%, T4 95.4%). EUS has been used extensively for staging rectal cancer with specificity and sensitivity of EUS dependent on the stage at the time of diagnosis. On the technical side, EUS is basically not applicable in tumors obstructing the rectal lumen as MRI is for patients carrying older pacemaker models. On the practical side, EUS proved to be highly accurate in early T stages but less so for advanced cancer, resulting in overall levels ranging from 63% to 95%. Staging accuracy for nodal status has been reported to be 64% to 84%. CT may be used to assess both local tumor extent and regional or distant metastases; MRI may be useful in identifying infiltration of the mesorectal fascia; and EUS is considered more accurate for assessing tumor growth in the mucosa and rectal wall.

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been reported that the accuracy (94%) and specificity (86%) are higher for evaluating the local infiltration depth of rectal cancer by transrectal ultrasound endoscopy, but its sensitivity (67%) and specificity (78%) for assessing the lymph node metastasis.48 Rectal cancer staging suggested by MDCT axial images sensitivity and specificity of 80.4% and 75%, positive predictive value (PPV) 80.4%, negative predictive value (NPV) 75% and accuracy 78%.49 The accuracy, sensitivity, specificity, PPV, and NPV of MRI-based assessment of CRM were 94.6%, 84.6%, 97.6%, 91.4, and 94.6%, respectively.50

The limitations and prospects of ultrasound in the diagnosis of gastrointestinal tumors

The limitation of ultrasound in gastrointestinal tumors is that the detection rate is related to the awareness, technical operation and experience level of the gastrointestinal tumor by the sonographer. The comprehensive level of ultrasound doctors affects the detection rate. It cannot directly observe the surface of the gastrointestinal mucosa, obtain biopsy tissue, and be qualitative disease. For lesions located on the surface of the mucosa or a small range, it is prone to be misdiagnosed. If ultrasound contrast examination is performed for some patients with more abdominal gas and thicker subcutaneous fat, the quality of the patient’s visit may be affected.51

Ultrasound can accurately determine the lesion site, and has the characteristics of small invasiveness, easy accessibility, comfort, and high diagnostic accuracy. Ultrasound is an effective tool for the diagnosis of gastrointestinal tumors and is a supplement to traditional endoscopy diagnostic methods.52 With the development of new gastrointestinal ultrasound developers, the diagnostic accuracy and sensitivity of ultrasound developer combined with ultrasound examination have been improved. The gas and mucus in the intestine can be echoed orally or enema to eliminate the gas artifacts, enhance the contrast resolution of the hypoechoic lesions of the gastrointestinal wall, and facilitate the detailed observation of the lesions and peristalsis of the gastrointestinal wall.

TRUS (Transrectal Ultrasonography) is a non-invasive and nonradiative examination technique, which is characterized by convenient operation and low cost, and considered as the most convenient, quick and accurate imaging method. TRUS can clearly show the intestinal wall layer. The size and echo of lymph nodes in the rectum and mesorectal lymph node region can be used as imaging reference indexes for cancer. TRUS can identify T1 and T2 stage tumors more accurately than CT.53 The crucial limitation of TRUS assessment techniques is the limited views of the whole mesorectum and pelvis to exclude tumor deposits, discontinuous vascular invasion and mesorectal fascia involvement by tumor.54 It shows that a new type of Gastrointestinal ultrasound imaging combined with ultrasound examination of gastrointestinal tumors is accurate and effective.

Conclusion

In summary, ultrasonography can be a preliminary examination for the diagnosis of gastrointestinal tumors. If there is an abnormality, gastrointestinal endoscopy and pathological examination are needed to perform, and it is a useful supplement for gastrointestinal endoscopy. It can be used as a physical examination, and also a dynamic observation of the lesions of patients, which is worthy of clinical promotion.

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