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Differentiation of gastric ulcers with MDCT

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Abstract

It is important to differentiate malignant from benign gastric ulcers (GUs) because the early detection of malignancy offers the best prognosis and is essential for planning optimal therapy. However, the differential diagnosis between a malignant and benign gastric ulcer is sometimes difficult, and remains a great challenge. Recent advances in multidetector row-computed tomography (MDCT) with three-dimensional imaging software and multiplanar reformatted (MPR) images provide a potentially powerful tool for noninvasive gastric evaluation. Virtual gastroscopy (VG) is helpful in the detection and evaluation of GU in the same way as gastroscopy. In comparison with gastroscopy, VG images can depict abnormal endoluminal lesions with a wider field of view and they have no blind point because retrospective reconstruction is available. MPR images allow the radiologist to choose the optimal imaging plane to accurately evaluate the change of the gastric wall around the gastric ulcer avoiding partial volume averaging effects. This report describes the clinical usefulness of MDCT in differentiating malignant from benign GUs by using VG and MPR images.

Key words: Multidetector row computed tomography—Virtual gastroscopy—Multiplanar reformatted—Benign gastric ulcer—Malignant gastric ulcer—Gastric carcinoma

Gastric ulcer (GU) is one of the common findings in patients undergoing endoscopy for dyspeptic symptoms, epigastralgia, or upper gastrointestinal bleeding. The differential diagnosis between a malignant and benign GU is sometimes difficult using morphological criteria and remains a considerable challenge at endoscopy [1, 2]. The exclusion of malignancy is crucial, because prognosis in gastric cancer is related to the stage of a neoplasm at the time of presentation. Early detection is directly connected to the prognosis and may influence the choice of an optimal therapeutic approach. However, there is no absolutely reliable method for distinguishing malignant from benign GUs.

Gastroscopy has been of great value for the evaluation of GUs, but reliability of endoscopic identification of a malignancy including biopsy of that malignancy is not satisfactory [3–5]. Clinically, long-term follow-up of the patients under suspicion with repeated multiple biopsies until healing is achieved [4, 6–8] is usually recommended; however, these are relatively invasive and costly [5, 9, 10]. The use of upper gastrointestinal series still makes diagnosis of the flat cancerous lesions extremely difficult [11], and early carcinomas sometimes have a radiographic appearance similar to those of benign lesions [12]. Previous studies with single detector helical CT [13, 14] showed that it is possible to diagnose advanced gastric carcinoma and evaluate metastatic neoplastic disease, but it is difficult to distinguish benign GUs from early malignant lesions. A current multidetector row-computed tomography (MDCT) scanner allows thinner and faster scanning, which in turn results in excellent imaging resolution and easy generation of virtual gastroscopy (VG) and multiplanar reformatted (MPR) images that are powerful tools for noninvasive evaluation of GUs. VG can offer an excellent overview of mucosal changes within the lumen of the stomach and has the potential to simulate morphologic characters of GU as seen on conventional gastroscopy. MPR images allow the ability to visualize an abnormality in multiple

Abbreviations MDCT, Multidetector row computed tomography; VG, Virtual gastroscopy; MPR, Multiplanar reformatted; GU, Gastric ulcer

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planes with increasing confidence and help to better characterize the ulcer. Proper injection techniques of a contrast material improve the differentiation of peri-ulcer malignant tissue from normal gastric wall [15]. Furthermore, MPR can also provide transmural and extraluminal information such as the enhancement pattern of the gastric wall, presence of lymphadenopathy and the abnormalities of other abdominal organs.

By using VG and MPR images, MDCT has made noninvasive differentiation of malignant from benign GUs possible. This report describes the role and the clinical usefulness of MDCT in the differential diagnosis between malignant and benign GUs.

CT protocol and technique

All patients fasted for at least 8 h before examination. The CT techniques in our department are preceded by two steps: (a) air distention of the stomach with non-enhanced CT is used for VG to evaluate gastric mucosal change, and (b) water distention of the stomach and portal venous phase contrast-enhanced CT with MPR are used for the evaluation of the thickness and enhancement around the peri-ulcer gastric wall.

CT protocol

CT was performed with a 16-channel MDCT scanner (Light Speed 16, GE Medical Systems, Milwaukee, WI, USA). The scan parameters were 16 × 1.25-mm collimation, 27.5-mm/s table speed, 250–300 mAs and 120 kV. Each patient received orally 6 g of gas-producing crystals shortly before non-enhanced CT examination for VG images. In the case of insufficient air filling of the stomach, an additional 3 g of gas-producing crystals was given. Unenhanced CT scans of the upper abdomen from the diaphragmatic domes to 2 cm below the lower margin of the air-distended gastric body were performed. If too much residual fluid covered the stomach, the patient's position was changed to the other side and additional scanning was performed. Immediately after unenhanced CT, and while on the table of the CT scanner, each patient drank 800–1000 mL tap water as a negative gastric contrast agent for contrast-enhanced CT. Nonionic iodinated contrast agent (100 mL; Ultravist; Schering, Berlin, Germany) was administered via the antecubital vein at 3 mL/s through a 20-gauge needle using an automatic injector. All CT acquisitions were performed in the portal venous phase (70 s) and the range of CT scanning was from the diaphragmatic domes to the iliac crest.

Techniques of VG and MPR images

We reconstructed raw datasets at 1.25-mm slice thickness and 0.9-mm reconstruction intervals for VG and MPR images on a workstation (Advantage 4.1, GE Medical Systems). Image analysis consists primarily of a review of two-dimensional (2D) axial, coronal and sagittal images. When a suspected lesion was identified on 2D images, proper planes of MPR and VG images were generated to better characterize the lesion (gastric ulcer). In addition, the entire stomach was assessed by VG for the detection of minute mucosal changes. The whole procedure took approximately 20–30 min per patient for volumetric data analysis.

Image criteria for differentiating between malignant and benign gastric ulcers in VG and MPR images

VG images

Virtual gastroscopy has the potential to simulate the gastric mucosal change within the lumen as seen on conventional gastroscopy [16]. Endoscopic criteria for benign and malignant GUs have been well established [17, 18]. The VG criteria we established for differentiating malignant from benign ulcers are similar to the criteria used by most endoscopists. VG features of GU with an irregular, angulated or geographic shape; uneven base; irregular elevated or asymmetric edge; bulbous enlargement, fusion or disruption of the gastric folds reaching the crater edge usually suggest malignant GUs (Fig. 1A, B). Contrarily, benign GUs have a smooth, regular, round or oval shape; an even base; are sharply demarcated or rounded edges; and have converging gastric folds with smooth tapering and radiation (Fig. 2A, B). The associated peri-ulcer gastric fold change was a good evaluation criterion. However, in a well-distended stomach, ulcers in the antrum and angle were always free of folds.

MPR images

The pre- and post-contrast-enhanced MPR images in optimal vertical planes were selected around the ulcer to avoid partial volume effects. To differentiate malignant from benign ulcers, we used MPR images focusing on the enhancement patterns, the stratification of gastric wall around the ulcer, thickness of the peri-ulcer gastric wall and peri-ulcer gastric tissue morphologies. A malignant ulcer was defined as strong enhancement by the contrast agent with greater attenuation than the adjacent normal gastric wall (Fig. 3A), while the gastric wall showing no excessive enhancement by the contrast agent was taken to be a benign ulcer (Fig. 3B). Mild peri-ulcer wall thickening was noted in almost all benign ulcers and rarely in early malignant ulcers. In benign ulcers, thickening of walls with preservation of wall stratification was expected to be due to edema (Fig. 4A). On the other hand, peri-ulcer wall thickening with or without wall stratification might be due to tumor parts in the early malignant ulcer (Fig. 4B). However, marked peri-ulcer wall thickening and loss of normal wall stratification

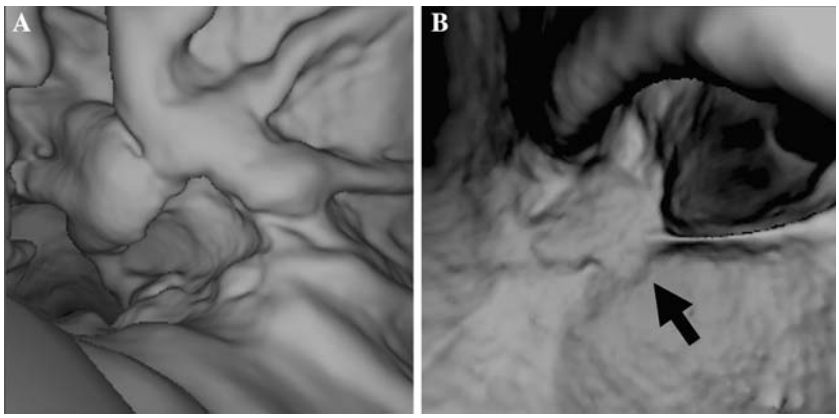

Fig. 1. Malignant gastric ulcers. **A** VG image of oblique ulcer view in the gastric body shows an ulcer with uneven base, irregular shape, irregular margin and associated abrupt terminate gastric folds with bulbous enlargement. **B** VG image of enface ulcer view at the gastric angle shows an ulcer (*arrow*) with uneven base, irregular shape, irregular margin and no associated peri-ulcer gastric folds change.

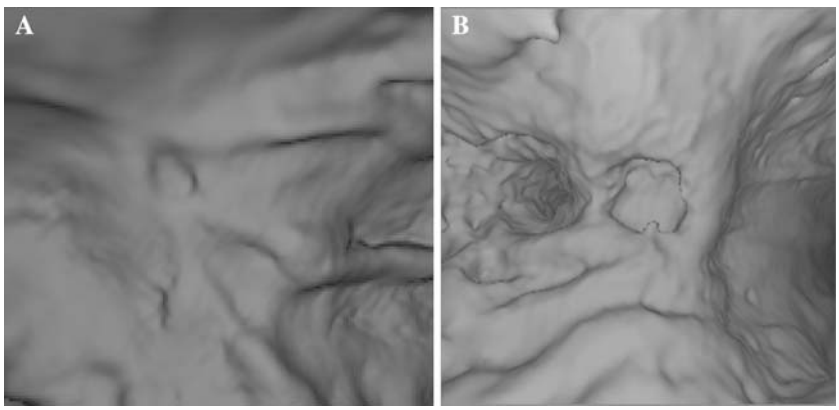

Fig. 2. Benign gastric ulcers. **A** VG image of enface ulcer view in the lower gastric body shows an ulcer with even base, oval shape, regular margin and associated regular gastric folds terminating at the ulcer margin. **B** VG image of enface ulcer view in the gastric angle shows an ulcer with even base, mild lobular shape, regular margin and no associated peri-ulcer gastric folds change.

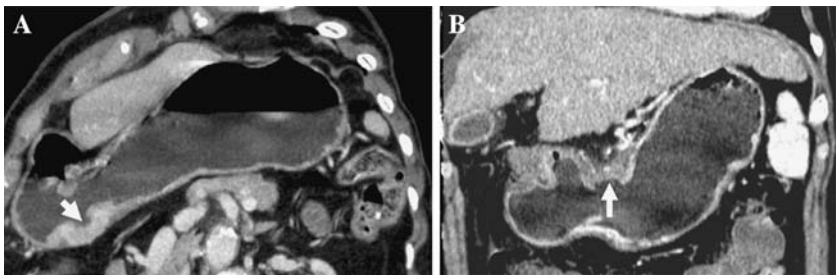

Fig. 3. Malignant gastric ulcer. **A** Enhanced oblique axial MPR image shows focal wall thickening with a marked transmural-enhanced ulcer and loss of wall stratification in the lower gastric body (*white arrow*). Benign gastric ulcer. **B** Enhanced coronal MPR image shows focal wall thickening with a normal-enhanced ulcer and preservation of wall stratification at the gastric angle (*white arrow*).

were observed in malignant ulcers [14]. Ulcers with perigastric fat plane infiltration or presence of lymphadenopathy (Fig. 5) or liver metastases suggested advanced malignant gastric cancer.

Pitfalls in differentiating between malignant and benign gastric ulcers with VG and MPR images

A few acute stage benign ulcers with severe peri-ulcer edema might have been mimicking malignant ulcers in the shape and margin of the ulcers (Fig. 6). Conversely, some malignant ulcers might have been mimicking benign ulcers due to small ulcer size with minimal peri-ulcer edema (Fig. 7). An ulcer of early stage signet ring cell carcinomas might reveal no peri-ulcer enhancement due to its characteristically being an adenocarcinoma with a predominant component ($>50\%$) of isolated carcinoma cells which contain mucin. Signet ring cell carcinomas have been variously classified as diffuse, infiltrative and undifferentiated [19].

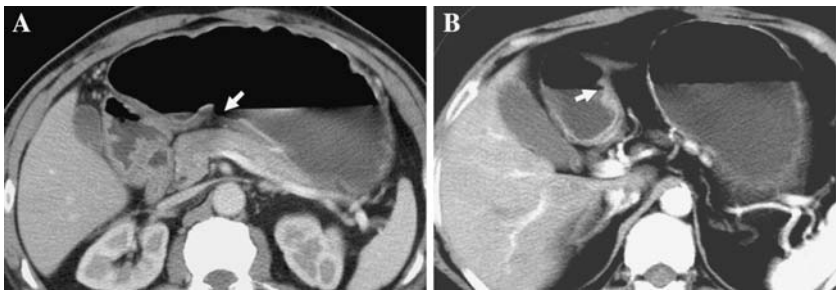

Fig. 4. **A** Axial image shows a benign ulcer (*white arrow*) with minimal thickened wall and preservation of wall stratification in the gastric body. **B** Axial image shows an early malignant ulcer (*white arrow*) in the gastric antrum, which shows mild focal wall thickening with a strong enhancement and preserved submucosal low density.

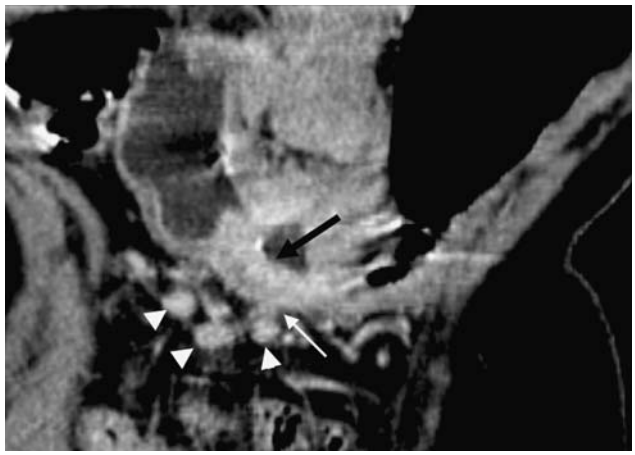

Fig. 5. Enhanced coronal MPR image shows an advanced malignant ulcer with marked enhanced peri-ulcer wall thickening (*arrow*), peri-gastric fat plane infiltration (*white arrow*) and metastatic lymphadenopathy (*white arrow*).

Clinical value and advantages of MDCT in the differential diagnosis between malignant and benign gastric ulcers

Gastric ulcer is a risk factor for gastric cancer. The early detection of gastric cancer is important for patients because it will improve their prognosis. Advanced gastric cancer is an aggressive tumor, with a 5-year survival rate lower than 20%. However, the early gastric cancer is a curable disease, with a 5-year survival rate higher than 90%. Therefore, the early detection and accurate staging of gastric cancer are essential [20–22]. The differential diagnosis between malignant and benign GUs using single detector CT was inadequate, and it was considered difficult to distinguish benign GUs from early malignant lesions with CT [13, 14]. There have been several reports regarding the clinical usefulness of 3D images for gastric disease [23–28]. Recently, MDCT with VG and MPR images is a promising new technique that combines the features of endoscopic viewing and multiplanar cross-sectional imaging [23–28] and can be used as a powerful tool for noninvasive evaluation of the endoluminal morphologic change and intra- and extra-luminal information of GUs.

Another advantage is that VG provides an excellent overview of mucosal change within the lumen of the stomach. VG is helpful in the detection and evaluation of GU in a similar way as gastroscopy is. With gastroscopy, the field of view is limited and blind areas exist. However, VG displays a wider field of view without restriction, and it has relatively less blind points because retrospective reconstruction is available.

An additional advantage of VG vs. gastroscopy is that the computer allows the operator to measure the size of abnormality exactly. Furthermore, VG is a less invasive method.

Finally, the use of 2D-MPR is a promising method in the evaluation of peri-ulcer gastric wall changes. Viewing an abnormality in proper planes increases the confidence level and is best suited for distinguishing malignant from benign GUs. In addition, 2D CT images also contribute to detecting pathologic findings in the abdomen outside the stomach. Furthermore, it helps pre-operative staging of gastric cancer because it can detect the primary tumor, assess the depth of tumor invasion, and evaluate nodal involvement and distant metastases as well [29, 30]

Limitations of MDCT in the differential diagnosis between malignant and benign gastric ulcers

Despite substantial advances introduced by the MDCT technology, there are several limitations.

The main disadvantage of 2D MPR and 3D VG is that they are time consuming. Although greater computer processing power makes faster construction available, it takes approximately 20–30 min per patient for the whole procedure. With increased data volume, the results may require a longer time to read.

The second limitation is the inability to obtain samples for histological evaluation. VG is not playing out in a role of competitor but rather as a complement to gastroscopy [31].

The third limitation is a significantly long learning curve before one becomes proficient in the use of these tools. For differential diagnosis between malignant and benign GUs on VG, radiologists should be familiar with these lesions and be able to recognize their characteristic morphologic changes and abnormal mucosal patterns.

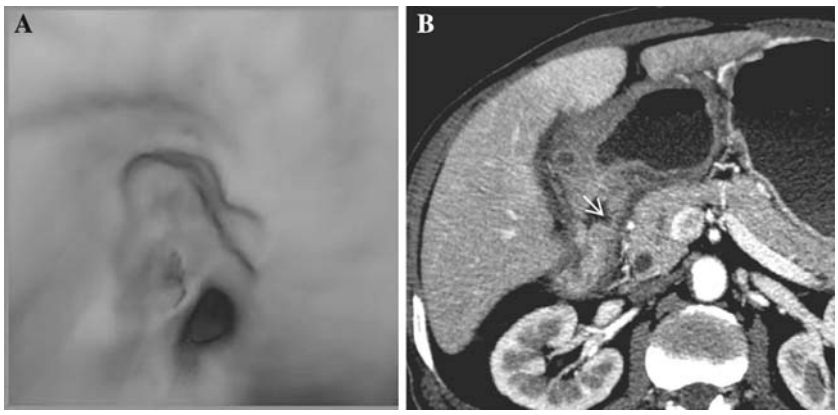

Fig. 6. An acute benign gastric ulcer mimicking malignant ulcer. **A** VG image of enface ulcer view of the gastric antrum shows an ulcer with uneven base, irregular shape, irregular margin and no associated peri-ulcer gastric folds changes, which is mimic malignant ulcer. **B** Enhanced axial image shows marked peri-ulcer thickening with mild increased mucosa enhancement and preservation of wall stratification, which suggests peri-ulcer edema (*white arrow*).

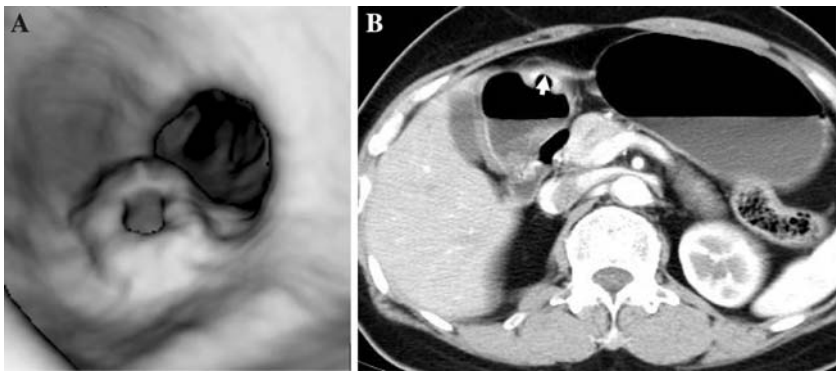

Fig. 7. A small malignant gastric ulcer mimicking benign ulcer. **A** VG image of mild oblique ulcer view of the gastric antrum shows an ulcer with even base, oval shape, mildly irregular ulcer margin and no associated peri-ulcer gastric folds change, which mimics a benign ulcer. **B** Enhanced axial image shows focal wall thickening with a marked enhanced ulcer (*white arrow*), which suggests peri-ulcer malignant tumor.

The fourth limitation is patient exposure to substantial doses of ionizing radiation.

Finally, VG lacks color change, which can be demonstrated on actual gastroscopy. In the evaluation of the ulcer base, VG might be relatively insensitive compared to a real gastroscopy.

Conclusion

Recent advances in the CT technology and 3D imaging software allow more accuracy in the detection and characterization of gastric lesions. MDCT using VG and MPR images offers significant morphologic characters, enhancement patterns of GUs as well as intra- and extraluminal gastric information around the GUs. Therefore, it is a very valuable tool for differentiating malignant from benign GUs.

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