Sandwich sign of Borrmann type 4 gastric cancer on diffusion-weighted magnetic resonance imaging

Lei Tang[1], Xiao-Peng Zhang[1], Ying-Shi Sun[1], Zi-Yu Li[2], Jia-Fu Ji[2], Xiao-Ting Li[1], and Yi-Qiang Liu[3]

[1]Radiology, Peking University Cancer Hospital, Beijing, China, People's Republic of, [2]Gastroenterology Surgery, Peking University Cancer Hospital, [3]Pathology, Peking University Cancer Hospital

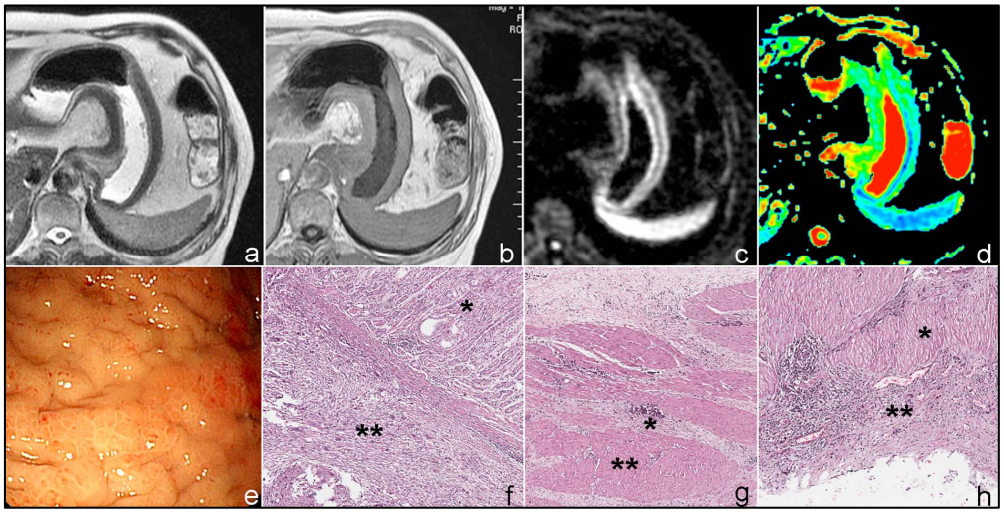
Purpose To assess the appearance of Borrmann type 4 (BT-4) gastric cancer on diffusion-weighted magnetic resonance imaging (DWI) and to investigate the potential of qualitative and quantitative DW images analysis to differentiate BT-4 gastric cancer from poorly distended normal stomach.

Methods Abdominal MRI was performed on 23 patients with BT-4 gastric cancer and 23 healthy volunteers. The MR examination was performed in a 1.5-T scanner and DWI was performed using a SS-EPI with *b*-factors of 0 and 1000 s/mm^2. The signal intensity, uniformity and distribution of gastric cancer on DWI, T1WI and T2WI were recorded. One radiologist and one pathologist correlated the DWI signals with the histopathologic findings by means of a layer-to-layer comparison. The histopathological basis of the signs on DWI was analyzed. An oval region of interest (ROI-1) was placed on the slice in which the largest area of the lesion was located, to enclose the high-signal intensity area visible on DWI. Another oval ROI-2 was placed on the nearby apparently normal gastric wall; if the signal intensity of the normal wall was too low, a *b*=0 EPI image was taken as reference. In choosing the ROIs, artifacts and distortions were carefully avoided. The contrast-to-noise ratios of cancer to normal stomach wall [$CNR_{Ca\text{-}wall}$= (S_{Ca}-S_{wall})/Sd_{bg}] were calculated and compared between DWI, T1WI and T2WI. The apparent diffusion coefficient (ADC) of cancer and the normal stomach wall were compared. The frequencies of layered patterns in images from patients with BT-4 gastric cancer were compared for DWI and conventional MRI sequences using Fisher's exact chi-square test. Student t-test analyses of the mean values of ADC between gastric cancer and the normal stomach wall and of $CNR_{Ca\text{-}wall}$ between DWI and conventional sequences (T1WI and T2WI) were performed. Statistical significance was declared for $P < 0.05$.

Results The cancers displayed hyperintensity (52.2%, 12/23), isointensity (43.5%, 10/23), or hypointensity (4.3%, 1/23) signal intensities on T2WI, and isointensity (60.9%, 14/23), hypointensity (26.1%, 6/23), or hyperintensity (13.0%, 3/23) signal intensities on T1WI. All of the gastric cancers displayed hyperintensity signal intensity compared to the nearby normal gastric wall on DWI. The $CNR_{Ca\text{-}wall}$ obtained by DWI was higher than that obtained with T1WI and T2WI (P<0.001). A three-layer sandwich sign that demonstrated high signal intensities in the inner and outer layer, and low signal intensities in the intermediate layer was observed in 69.6% of cases of BT-4 cancers on DWI (fig c). By comparison with pathological large sections, we found that the high signal of the inner and outer layers seen on DWI corresponded to the mucosa/ submucosa and subserosa/ serosa and that the intermediate low signal layer corresponded to the muscularis propria. Further enlargement of the pathological sections demonstrated that the cancer cells diffusely infiltrated the submucosa and/or deep mucosa (fig f), sparing the superficial mucosa, and that the subserosa/ serosa (fig h) were also diffusely infiltrated by cancer cells. However, the cancer cells were interspersed in the intermuscular space, and abundant remnants of normal muscular tissue were presented (fig g). There was no statistically significant difference between the thickness of gastric cancers (15.7±2.2 mm) and that of the poorly distended normal stomach wall (14.5±2.5 mm) (P>0.05). The mean ADC value of BT-4 gastric cancer was significantly lower than the poorly distended normal stomach wall (1.12±0.23 ×10^{-3} mm^2/s vs. 1.93±0.22x10^{-3} mm^2/s, P<0.01).

Disscusion (1) BT-4 gastric cancer demonstrated mainly isointensity on T1WI and hyperintensity on T2WI. These signal intensities were detected in just above half the total number of cancers, resulting in poor signal consistency. On DWI, however, all of the cancers demonstrated high signal and apparent contrast to nearby stomach wall, with higher CNR of cancer to normal stomach wall than T1WI and T2WI. DWI can be helpful in highlighting gastric cancers, especially in those patients who cannot receive intravenous contrast. (2) The increased cell density in the mucosal/ submucosal and subserosal/ serosal layers caused by cancer infiltration, which promotes the restricted diffusion of water molecules, resulted in high signals on DWI. On the other hand, because the cancer cells scattered in the intermuscular space caused less damage to the normal muscularis propria, the tissues in that region were relatively looser and there was less restriction of water movement; this may explain the low signal of the muscularis propria layer on DWI. Additional comparative studies that include larger samples are needed to test this hypothesis. (3) In the patients who cannot drink sufficient water or empty fast because of poor hypotonic effect, the conventional non-enhanced sequences maybe hard to discriminate BT-4 cancer from poorly distended normal wall because of lack of ulceration shape and atypical signals. In this study, we used the empty stomach of healthy volunteers to simulate poorly distended normal wall, and found there was no significant difference in thickness between cancer and normal wall. However, the mean ADC of gastric cancer was markedly lower than that of the normal stomach of healthy volunteers. The combination of DW signals and ADC values has the potential in the strengthening of diagnostic confidence and preventing of misdiagnosis.

Conclusion DWI can provide distinctive appearance of Borrmann type 4 gastric cancer which may present a characteristic three-layer sandwich sign, and provide ADC values to help the quantitative discrimination of gastric cancer from poorly distended normal stomach wall.



References

1. Borrmann R. Geschwulste des Magens und des Duodenums.In: Henke F, Lubarsch O, eds. Handbuch der Speziellen Pathologischen Anatomie und Histologie. Bd 4/1. Berlin: Verlag von J Springer 1926; 812-1054.

2. Park MS, Ha HK, Choi BS, et al. Scirrhous gastric carcinoma: endoscopy versus upper gastrointestinal radiography. Radiology 2004; 231(2): 421-6.

3. Shinya S, Sasaki T, Nakagawa Y, et al. The usefulness of diffusion-weighted imaging (DWI) for the detection of gastric cancer. Hepatogastroenterol 2007; 54 (77): 1378-81.

4. Takeuchi M, Sasaki S, Ito M, et al. Urinary bladder cancer: diffusion-weighted MR imaging--accuracy for diagnosing T stage and estimating histologic grade. Radiology 2009; 251(1): 112-21.

Fig 1. Three-layer sandwich sign of Borrrmann type 4 gastric cancer on DWI and comparison with endoscopy and pathology. a. Gastric fundus-corpus cancer that displayed low signal on T2WI with a vague high signal of the inner layer. b. Homogeneous isointensity signal on T1WI. c. Three-layer sandwich sign on DWI. d. ADC=0.88 x 10 $^{-3}$ mm ^{2}/ s. e. Gastroscopy demonstrated the gyrus-like bulge without noticeable ulcers on mucosal surface. f. Diffuse infiltration of cancer in the submucosa (**). The mucosa (*) was free of cancer cells. g. Cancer cells scattered in the intermuscular space (*), with abundant remnants of normal muscular tissue (**). h. Diffuse infiltration of cancer in the subserosa (**). The nearby normal muscular tissue (*).