梨花醫大誌：第 22 卷 第 3 號 1999
Ewha Med J Vol. 22, No. 3, 1999

Significance of Rapid MR Sequence(True-FISP) in the T-Staging of Advanced Gastric Carcinoma

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=국문초록=

진행성 위암의 T-병기 진단에 있어서의 빠른 자기공명영상(True-FISP)의 중요성

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목 적：빠른 자기공명영상(true-FISP)을 이용한 진행성위암의 T-병기결정의 정확성을 알아보고자 하였다.

대상 및 방법：1996년 4월에서 1997년 3월까지 47명의 진행성 위암환자를 대상으로 자기공명영상을 시행하였다. 자기공명영상은 빠른 자기공명영상 기법 중 true-FISP(Fast-Imaging Steady-state Procession)을 사용하였다. 종양에 의한 위벽의 침범 정도, 위벽 밖으로의 침범 그리고, 주변 장기로의 침범정도를 평가하기 위해, 위벽의 신호강도, 위벽 주변부의 저신호 강도의 단락 여부 및 위 주변의 신호 강도의 변화를 관찰하였다. 이렇게 얻은 수술 전 T-병기를 수술로 얻은 T-병기와 비교하였다.

결 과：위벽의 두께를 이용한 위암의 범위의 예측은 72%(34/47) 정도의 정확도를 나타내었다. 위벽 주변주의 저신호 강도의 무단락을 이용한 T2 병기를 예측은 73.7%(14/19)의 정확도를 나타내었다. 위벽 주변부의 저신호 강도의 단락과 위주변부 불규칙한 경계를 이용한 T3병기의 예측은 78.3%(18/23)의 정확도를 보였고, 주변 장기로의 암성 위벽의 신호 강도의 확장으로 진단한 T4의 정확도는 60%(3/5)였다.

결 론：빠른 자기공명영상 중 true-FISP 영상에서 위벽 주변부의 저신호 강도의 단락이나, 위주변부의 불규칙한 경계를 이용하면 T3병기의 수술 전 진단에 도움을 받을 수 있다.

중심 단어：Stomach cancer · Staging stomach cancer · MR true-FISP(Fast-Imaging steady-state procession).

Introduction

The prognosis of patients with gastric carcinoma depends on the lesion's stage and local resectability so, accurate preoperative staging is important in establishing appropriate therapeutic planning[1)2)]. Endoscopy, barium study and Contrast-enhanced computed tomography(CT) have been used in the detection of primary gastric cancer and evaluation of its staging[3-5)]. Endosonography(EUS) is regarded as the most accurate preoperative method for local staging of gastric carcinoma[1)6-8)] because EUS can depict the normal gastric wall with five-layered internal structures, the depth of tumor penetration can be evaluated in detail[1)6)]. However, EUS has a limitation in the depth of field and is operator dependent. In preoperative staging of gastric cancer, there are several factors other than T-staging that should be evaluated such as lymph-node and metastasis and peritoneal carcinomatosis.

MRI(magnetic resonance imaging) has recently been introduced for the staging of gastric cancer[9)13)]. Initially, MR imaging was considered to be inappropriate for the staging of stomach cancer compared with the CT, mainly due to the difficulty in obtaining clear images for stomach cancer because of its variable distensibility, active peristaltic motion and respiration. However, recent advance of fast MR imaging technique has allowed obtaining MR imaging during single breath hold for several seconds with less motion artifact. There were a few reported studies that applied fast MR imaging technique to predict the local staging of the stomach cancer[10)11)]. At present, there is no report what is the imaging tool for the accurate preoperative local staging of advanced gastric carcinoma between rapid MR images. So, we performed this study to evaluate the accuracy of T-staging of advanced gastric cancer with rapid MRI(with true-FISP).

Materials and Methods

From May 1996 to Mar 1997, 47 patients with a diagnosis of advanced gastric cancer underwent abdominal CT and MR. There were 33 men and 14 women raging in age from 26 to 68 years(mean +/- SD, 56 +/- 10.3 years). Diagnosis was made by endoscopic biopsy and surgery in all patients. Forty-one patients underwent either a total or partial gastrectomy depending on their clinical stage and findings at surgery. Remaining six patients had explolaparotomy or palliative gastrectomy and gastrojejunostomy. In patients underwent gastrectomy, the resected stomach was submitted for pathologic study, and the area of the gastric cancer along with the surrounding normal-appearing gastric wall was microscopically examined to determine the depth of tumor penetration.

Pathologic T-staging was based on the international TNM Classification[14)] as follows : pT1, tumor invades lamina propria or submucosal layer ; pT2, tumor invades muscularis propria or submucosa(19 lesions) ; pT3, tumor penetrates the subseroa without invasion of adjacent organs(23 lesions) ; and pT4, tumor invades adjacent organs(5 lesions).

True-FISP(Fast-Imaging Steady-state Procession) sequences were used for rapid MR imaging. All patients were prepared by skipping the meal at least 4 hours before MR imaging in order to empty the stomach. Incomplete emptying of the stomach was observed in seven patients. Before undergoing the MR examination, the patients drank about 400-600ml of spring water for gastric distension with im or iv injection of 20mg of scopolamine(Buscopan, Boehringer Ingelheim, Germany). All imagings were done in the supine position, and were performed with 1.5 T superconducting magneting unit(Vision, Siemens, Erlangen, Germany).

True-FISP(Fast-Imaging Steady-state Procession) sequence was the true FISP images with repetition time of 4.7-4.8msec, an echo time of 2.3msec, a flip angle of 70 degree, one acquisition and acquisition time of 12 sec. The matrix size was 192×256 rectangular, and the section thickness was 5mm. The field of view(FOV) was 248-260×300-330mm, and the pixel was 1.29-1.35×1.17-1.29mm. We obtained the nine to eleven images per one sequence with one breath hold. For the full abdominal scan, we usually three or four times of axial scan. Sometime, coronal or sagittal scanning were performed.

The MR images were analyzed with the consent of two radiologist preoperatively. Thickness of the gastric wall in cancerous and normal portion were arbitrarily classified into 3 groups ; less than 3mm, 3-7mm, and thicker than 7mm, when measured at the thickest point on its images. With surgicopathologic correlation, we observed signal intensities and the layers in cancerous and normal wall on true-FISP images. For analysis of the signal intensities of the gastric wall, we used the region of interest(ROI), at least $1 \times 1mm^2$. And it was also measured at the central portion of cancerous and normal gastric wall on FISP images using ROI cursor. Measured signal intensity was expressed as the signal-to-noise ration (SNR). With measured SNR, we evaluated the difference between the cancerous and normal gastric wall by means of statistical method(2-test).

Degree of local invasion of the advanced gastric cancer seen at MR imaging was classified into MRT 2(clear continued outer low signal intensity line, or enhanced cancerous portion not penetrating the outer low signal line), MRT3(Interrupted outer low signal intensity line or enhancing cancerous portion penetrating the outer low signal line), or MRT4(Continuous extension of the cancerous portion to the adjacent organs with or without interrupted low signal intensity line)[10)12)].

T staging obtained from MR imaging was correlated with the surgicopathologic specimen.

Results

We could predict gastric cancer by measuring the thickness of the gastric wall in 34/47(72%) patients on FISP(Table 1). But, it is not significant statistically($p > 0.05$, 2-test). The preoperative predictability of

Table 1. The thickness cancerous and normal gastric wall measured at the thickest portion

	Normal wall	Cancerous wall
< 3mm	28	7
3 - 7mm	17	27
> 7mm	2	13

($p > 0.05$, χ^2-test)

Table 2. Relation between preoperative staging and histopathologic staging at T-Factor in AGC

Histopathologic T-staging	Preoperative T-staging determined rapid MRI(FISP)		
	mT2	mT3	mT4
pT2	14	5	
pT3	3	18	2
pT4		2	3

($p > 0.05$, χ^2-test)

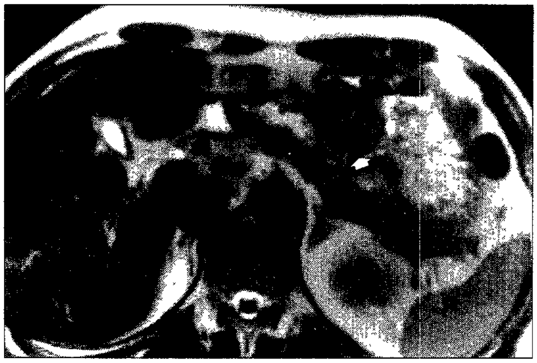

Fig. 1. Postoperative changes of MPT in thyroplasty type I and arytenoid adduction cases(N=22).

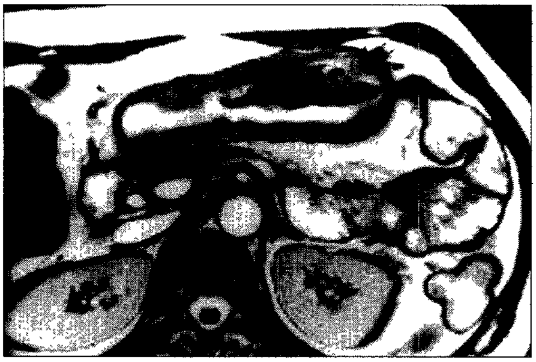

Fig. 1. 58-year-old man with advanced gastric cancer(pT2). Axial image shows a large polypoid tumor(white arrows) at the anterior wall of the lower body with perigastric lymph node(black arrowhead). On this MR images, we also found that the outer low signal intensity band is somewhat interrupted(thin arrow), which had erroneouly suggested that the gastric tumor has penetrated the gastric serosa.

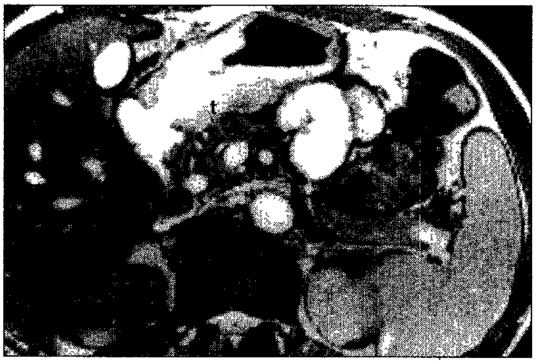

Fig. 2. 25-year-old woman with advanced gastric cancer (pT3). Axial image shows diffusely thickened wall of the gastric body with protruding-out appearance (thin arrows), with interrupting the outer low signal intensity band(arrowhead).

MRT determined by true-FISP image were as follows(Table 2). Preoperative MR T-stagings were well-correlated with the postoperative pathologic T-staging, and it is significant statistically($p<0.05$, 2-test). We could predict pT2(Fig. 1) by presence of low signal intensity band in 14/19(73.7%) on FISP. We could predict the extraserosal invasion(pT3, Fig. 2) by the disrupted low signal intensity band or irregular perigastric margins in 18/23(78.3%) on FISP. We could also predict the perigastric adjacent organ invasion(pT4, Fig. 3) by the tumorous continuation in 3/5(60%) on FISP.

Discussion

Incremental dynamic or spiral CT of the stomach with bolus IV injection of contrast medium after intake of water have been used for the preoperative evaluation of the stomach cancer staging. Cho, et al[2] and Minami, et al[4] studied the dynamic CT-determined tumor T staging with the histopathologic findings with stomach cancer and reported that the accuracy of dynamic CT according in determining the depth of tumor invasion was 65%, 80% and the degree of serosal invasion was 83%, 80%, respectively. With spiral CT, Rho, et al[5] reported preoperative T-staging of the gastric cancer as 76%. And there have been few studies about the staging with the MR imaging 7-10 ; some of them showed that the accuracy of T staging of advanced gastric cancer with MR imaging was equal or superior to the results with use of CT. In this CT studies, the normal gastric wall showed a two- or three-layered(multi-layered) structure, which is correspond to an inner mucosal layer with marked enhancement, an outer submucosal layer with lower attenuation, and another outer muscular-serosal layer with moderate enhancement[2,4,5]. Previous study[7] performed with contrast-enhanced MR imaging have been reported that the gastric tumor was markedly enhanced in all patients. Because the distribution of gadopentetate dimeglumine(DTPA) in the body is similar to that of the contrast media using CT, stomach cancer was strongly enhanced in earlier period on dynamic and delayed MR imaging. Normal wall showed two-layered structure in all cases, on the other hand, the cancerous wall showed two-(5/46) or three-layered(41/46)structure with IV Gd-DTPA administration in our preliminary report.

The detectability of tumors is strongly influenced by their size, T-staging, enhancing pattern of gastric wall during dynamic MR images. We could easily detect early cancer(MT1) in cases of elevated lesions by observing the enhancement pattern and thickness of the gastric wall(Fig. 1). However, partial volume effect prevented us from detecting one of four early cancers that were small(3mm in size).

We also found that early advanced cancer(pT2) could not be distinguished from early cancer(pT1) on true-FISP MR images, particularly when the tumorous wall representing as a two-layered pattern was located in regions scanned obliquely, such as the gastric angle. Therefore, we considered the differentiation between pT1 and pT2 lesion(Fig. 3) to be difficult with MR image. Previous studies with enhanced CT[2,13] reported that an enhanced thickened wall with low-attenuation stripe, which is probably caused by edematous change or fat deposit in the submucosal layer, usually did not represent tumor infiltration. But, on our MR images, we could also observe middle intermediate-signal layers at the cancerous wall, in cases of advanced gastric cancer.

Various oral contrast agents have been reported in gastrointestinal MR imaging. Like CT, water also act as a negative contrast agent on true-FISP images obtained with the parameters employed in our study because it depends only on longitudinal magnetization. In our study, a large amount of spring water was used to distend the stomach. Water does not produce susceptibility artifacts and washes out gastric juice attached to the gastric wall and is also safe. Thus, the water-filling method have been thought to be appropriate for gastrointestinal MR imaging[7].

In the previous report, the normal gastric wall thickness was variable, less than 5-10mm, when stomach is well-distended by air or water[8-10,12] and relative early enhanced with IV contrast material on CT[2,3,5,7,13].

In our study, the definite cut-off thickness between the normal and cancerous gastric wall did not existed, because the gastric wall could not be sufficiently distended by 600cc spring water occasionally. In advanced gastric cancer invading beyond the muscularis mucosa, the infiltrated wall is well visualized with MR imaging as a thickened area and can be easily demarcated from normal wall.

The primary benefit of MR imaging has been reported to be visualized the low-signal-intensity band occurring as a chemical shift or a phase cancellation artifact between fat and water[13]. The signal intensity of this band is lower than that of the gastric wall or fat in the perigastrium, and its width is nearly constant. Based on our result, the interrupted low-signal-intensity band on MR can be observed in gastric cancer with extraserosal invasion(pT3), which is corresponding to previous report[13]. And, the enhancing tumorous area through the low-signal-intensity band will be the additional finding to predict the T3 staging of the advanced gastric cancer(Fig. 2). In one patients(Fig. 1), however, extraserosal invasion was absent, even in the presence of interrupted low-signal-intensity band with well-enhanced outer layer. In gastric cancers associated with perigastric inflammation, the degree of serosal invasion were overestimated because of strong enhancement of the inflammatory lesion in previous study[13].

We can readily diagnose perigastric organ invasion, especially pancreas, because of the obscuring fat signal between stomach and perigastric organ(Fig. 4). Invasion of the transverse colon was also readily diagnosed by subsiding the peristalsis by the IV Buscopan and breath-holding technique. Invasion of the left lobe of the liver could be predicted by observing the interrupted low signal between liver and stomach, which is the phase cancellation artifact.

In summary, with disrupted low signal intensity band or irregular perigastric margin on rapid MRI, especially FISP and enhanced FLASH sequences, T3 staging can be preoperatively predicted in advanced gastric cancer.

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