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• *BRIEF REPORTS* •

Evaluation of contrast-enhanced helical hydro-CT in staging gastric cancer

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Abstract

AIM: To discuss the helical computed tomography (CT) characteristics of gastric cancer and evaluate the diagnostic value of contrast-enhanced helical hydro-CT (HHCT) in staging gastric cancer.

METHODS: A total of 50 patients with gastric cancer were included in this study. The CT findings in them were retrospectively analyzed and correlated with pathologic findings at surgery. All patients were preoperatively imaged by plain and contrast-enhanced helical CT after orally ingesting 1 000-1 500 mL water. Peristalsis was minimized by intravenous administration of spasmolytics.

RESULTS: The foci of gastric cancer became more prominent in all the 50 patients and showed strong enhancement in contrast-enhanced HHCT. The tumor was located at the gastric cardia in 14 cases, at the gastric fundus in 3 cases, at the gastric body in 8 cases, at the gastric antrum in 4 cases, at the gastric fundus and the body in 8 cases, at the gastric body and antrum in 11 cases, and at three segments of the stomach in 2 cases. The CT features of gastric cancer were focal or diffuse mural thickening, soft tissue mass, cancerous ulcer, stenosis of stomach, infiltration to adjacent tissues, lymph node and distant metastases. Strong contrast enhancement of the gastric wall was closely related to gastric cancer. The accuracy rate of contrast-enhanced HHCT in staging gastric cancer was 86% (43/50). The detection rate of lymph node metastases by CT was 60% (12/20).

CONCLUSION: Contrast-enhanced HHCT is a reliable method to diagnose and stage gastric cancer.

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Key words: Stomach; Neoplasm; Tomography; X-ray; Staging

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INTRODUCTION

Gastric cancer is one of the most common malignancies in China. Its accurate staging contributes to its pre-operative management[1-4]. In the evaluation of gastric diseases, gastroscopy is used for the detection of gastric abnormality. Computed tomography (CT) is a valuable tool in addition to gastroscopy in the evaluation of gastric diseases[5-7]. With the clinical application of helical CT and the improvement of CT equipments, helical CT has been used for the detection of gastric abnormality and in staging of gastric cancer[8-11]. Since January 1999, 50 patients with gastric cancer have been scanned. CT results are correlated with surgical and pathologic findings. This work aimed to analyze the characteristic findings of gastric cancer, stage the tumor and evaluate the clinical value of CT imaging of the stomach.

MATERIALS AND METHODS

Patients

A total of 50 cases of gastric cancer were examined by helical hydro-CT (HHCT) and their clinical data were collected from January 1999 to April 2004. There were 36 male and 14 female patients with an age range of 39-81 years (mean 58.3 years).

CT examination

All patients included in the study were fasting for at least 5 h before CT imaging with a commercially available scanner (Hispeed CT/i unit GE Medical Systems, Milwaukee, WI, USA). Thirty minutes before scanning, the patients ingested 500-1 000 mL of water, and were then examined in the supine position during full inspiration. Immediately before helical scanning, the patients received 20-40 mg of anisodamine (raceanisodamine hydrochloride, Hangzhou, China) intramuscularly to minimize peristalsis. An additional 500 mL of water was then offered to improve distension of the proximal part of the stomach. First, a plain scan of the upper abdomen was obtained using 10-mm sections. If the tumor was located at the antral or pyloric antrum, patients were then examined in the prone position, followed by injection of 80-100 mL of contrast material (Omnipaque, Schering, Germany) at a rate of 2.5-3.0 mL/s (Madrid power injector, SA) into the antecubital vein. Helical scanning of

the stomach was performed at 30, 60-70, 150-180 s after contrast material was injected. It started above the diaphragm to cover the gastric cardia by obtaining contrast images with 5- or 7-mm collimation, a pitch of 1.5:1.0 or 1.1:1.0 (120 kV, 210 mA), and a matrix size of 512×512, then 3-mm axial scans were reconstructed for image evaluation.

Image interpretation

Without prior knowledge of endoscopic, surgical, or histological findings, one reviewer interpreted all CT studies. First, the gastric wall was evaluated for the presence of tumor. Carcinoma of the stomach was suspected if thickening and marked contrast enhancement of the gastric wall were visible on CT. The depth of infiltration and perigastric invasion of gastric tumors were evaluated according to the TNM system[11].

CT staging of gastric tumor was performed as follows: T1, invasion of the lamina propria or submucosa, when thickening was limited to the inner layer; T2, invasion of the muscularis propria, when all three layers of the gastric wall were grossly thickened and replaced by a homogeneous or inhomogeneous soft tissue mass with no serosal irregularity; T3, tumor invasion of the serosa, when high-density irregularities of the outer layer or micronodularity or strands in the fat planes contiguous to the lesion were evident; T4, invasion of adjacent organs and structures, when cleavage fat planes between neoplastic gastric wall and contiguous organs were replaced by mass or when the invasion was clearly demonstrated.

Soft tissue nodules were classified as lymph nodes, which were divided into loco regional peri-gastric lymph nodes (N1/N2 = 3 cm away from the gastric tumor) and distant nodes which were classified as metastatic disease (M1) according to the TNM system if it has tumor infiltration. All visible lymph nodes were judged to be infiltrated by carcinoma independent of size or contrast enhancement. In abdominal M staging, any hepatic or splenic lesion other than a cyst was regarded as potentially malignant. Nodular thickening of the peritoneum or ascites without signs of liver cirrhosis was assumed to be peritoneal carcinomatosis.

CT-histopathologic correlation

All resected specimens were carefully examined both macroscopically and microscopically. A lesion-by-lesion analysis was performed, and gastric carcinoma was staged according to the American Joint Committee on Cancer (AJCC) classification[11]. The histological studies were correlated with the CT data, and comparative evaluation of location, size, depth of tumor infiltration, and extent of the primary tumor was performed. The presence of lymph node metastasis was histologically determined, and the histological N stage of the tumor was correlated with CT findings. In all patients who underwent surgery, the abdomen was carefully explored to exclude metastatic disease.

Statistical analysis

According to the AJCC classification, TNM staging criteria were applied to all cases. The accuracy of CT imaging to predict the T, N, and M stage of gastric cancer was determined. The overall detection rate of gastric cancer was determined. The maximum diameter of each cancer was calculated and compared with the maximum diameter of the tumor determined by pathology. The largest tumor diameter was used for correlation with the pathologic size of the tumor.

RESULTS

All CT studies were successfully completed. A lesion-by-lesion analysis revealed that 43 of 50 (86%) gastric cancer were correctly staged by HHCT. Gastrectomy was performed in 46 patients, 4 patients with T1 tumor underwent partial gastrectomy. In all cases, histology revealed malignant ulcer corresponding to early gastric cancer.

Location and histological classification of the tumor

The maximum diameter of the resected gastric tumors ranged 0.7-15 cm (mean 5.3 cm). Fourteen cancers were located at the gastric cardia, three of them showed infiltration of the distal esophagus, three of them invaded the gastric body, and two of them infiltrated both the distal esophagus and the gastric body. The remaining cancers were located at the gastric fundus (n = 3), the gastric body (n = 8), the gastric antrum (n = 4), the gastric fundus and the body (n = 8), and the gastric body and antrum (n = 11). In two cases, the gastric cancer involved three segments of the stomach (*linitis plastica*).

The histological classifications were papillary adenocarcinoma (5 cases), mucous carcinoma (2 cases), low-grade adenocarcinoma (35 cases), undifferentiated carcinoma (2 cases), squamous carcinoma (3 cases), and adenosquamous carcinoma (3 cases).

Contrast-enhanced HHCT findings of gastric cancer

In 13 of 50 cases (26%), single layer normal gastric wall was demonstrated. In the remaining 37 cases (74%), two- or three-layer structure was shown at arterial phase of contrast-enhanced HHCT scans. Abnormal local gastric wall thickening and area of strong contrast medium enhancement were found in one of four early gastric cancers confirmed by pathology. Two layers of gastric wall were found in 3 patients with early gastric cancer and in 5 of 46 patients with advanced gastric cancer. In the three advanced gastric cancers, low attenuation was found with no enhancement below the strong enhancement inner layer, their pathological diagnosis was mucous carcinoma. Single or triple layer gastric wall with homogeneous or heterogeneous strong enhancement was shown in the remaining advanced gastric cancer, their mean increase of CT values was 26.47±6.67 HU. Gastric wall thickening was found in 37 cases (Figures 1A and B), intramural soft mass in 23 cases (Figure 1C), lymph node metastasis in 12 cases, tumor spread to perigastric area and infiltration to adjacent organs in 9 cases, and distant metastasis in 7 cases. In our study, the detection rate of lymph node metastasis by CT was 60% (12/20).

Gastric cancer staging by CT and pathology

The TNM staging of gastric cancer by contrast-enhanced HHCT was compared to the pathological results in 50 cases (Table 1). In 43 of 50 cases, HHCT staging of gastric cancer was in accordance with pathological staging. The accurate

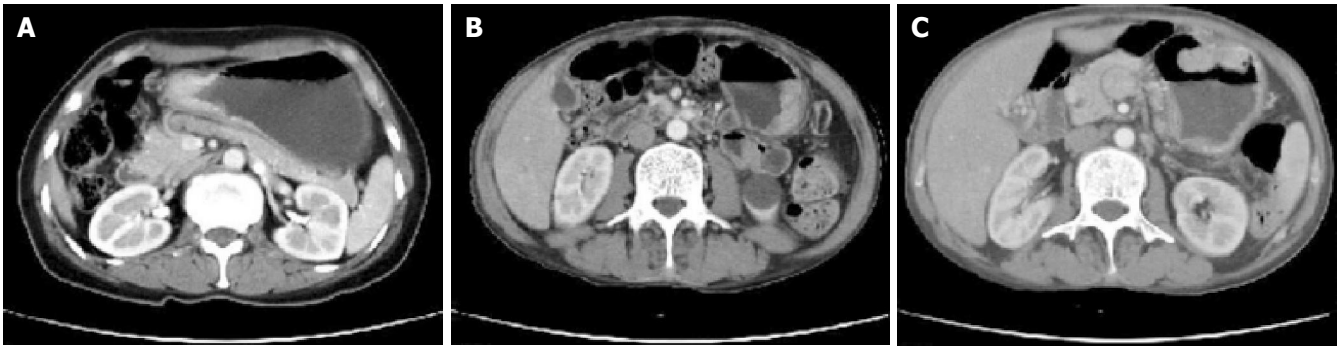

Figure 1 Enhancement patterns of gastric cancer on contrast-enhanced HHCT. **A:** Focal wall thickening in gastric antrum with marked enhancement of mucosal layer and narrowing of gastric lumina; **B:** focal wall thickening with marked enhancement of mucosal layer in greater curvature of the gastric body; **C:** homogeneous enhancement of soft tissue mass in anterior wall of the gastric body.

rate of T staging by HHCT was 86.0% (43/50). Findings at HHCT were concordant with histological findings in 2 of 4 T1 tumors (50%), in 17 of 20 T2 tumors (85%), in 15 of 17 T3 tumors (83.3%), and in 7 of 9 T4 tumors (77.8%). Overstaging occurred in 2 T1 tumors and in 3 T2 tumors on CT images. In addition, 2 T4 tumors were understaged.

Table 1 T staging of gastric carcinoma (n = 50)

Staging at CT	Staging at pathology			
	T1	T2	T3	T4
T1	2			
T2	2	17	2	
T3		3	15	2
T4				7

DISCUSSION

Normal architecture of gastric wall and enhancement pattern of gastric cancer on contrast-enhanced HHCT

Normal gastric wall is histologically classified as four slices: mucosa, submucosa, muscular layer, and serosa. The structure of gastric wall is shown as a single slice in conventional CT. The excellent spatial resolution of helical CT makes it possible to identify the triple-layer structure of the gastric wall after contrast material is intravenously injected. The inner layer with high attenuation corresponds to the mucosa and its muscular layer, the middle layer with low attenuation corresponds to the submucosal layer, and the outer layer with slightly high attenuation corresponds to the muscular layer and serosa[12-15]. The results of our study are concordant with the previous reports[16,17]. After gastric lumen was sufficiently filled, the mean thickness of normal gastric wall was 2-3 mm on CT image, while it was 4-5 mm at cardia and antrum[18]. Otherwise it was regarded as abnormal. The thickness of gastric lumen may be equal to 1.0 cm or above, if not being sufficiently filled. Therefore, it is a prerequisite to fill gastric lumen before CT examination.

Significance of contrast-enhanced HHCT in staging gastric cancer

CT is most frequently used in staging gastric cancer. Helical CT in combination with the water-filling method has led to marked improvements in the detection and characterization of gastric cancer[19]. The main CT findings of gastric cancer are local or diffuse thickenings of gastric wall with variable enhancement and intraluminal soft tissue mass. In this study, gastric wall thickening was found in 37 cases, intraluminal soft tissue mass in 13 cases, local and distant lymph metastasis in 12 cases. Tumor can also infiltrate into perigastric tissue, encroach on adjacent organs and metastasize to distant places. Contrast-enhanced HHCT can reflect blood supply to gastric cancer.

Reports on staging gastric cancer by conventional CT prior to surgery are available[20]. Recently more and more studies have been focused on staging gastric cancer by helical CT[21]. Our study demonstrated that TNM staging by CT was closely related with pathology. The accuracy of HHCT (86.0%) in our study was higher than that of conventional CT (72%)[13]. TNM staging by HCT depends upon the improvement of CT equipments and stomach filling with water. Contrast-enhanced HHCT can further improve the accuracy of gastric cancer staging before operation.

Our results showed 60.0% of all lymph nodes were detected by HHCT. The sensitivity of detecting lymph node metastasis was not high. The detection of regional lymph nodes can be improved by hypotension of the stomach, because the delineation of regional lymph nodes and gastric wall can be improved[22]. Enlarged lymph nodes may be missed if they are located close to the gastric cancer. For the assessment of lymph node metastasis, the size of lymph nodes is the most frequently used criterion. But there is no agreement concerning the upper limits of normal lymph node size. The diameter of normal lymph nodes in the upper abdomen may vary from 6 to 11 mm depending on their location[23-25]. Lymph nodes in the gastro-hepatic ligament region have to be considered as abnormal if they exceed 8 mm in diameter. A diameter of lymph nodes in 8-15 mm is used in studies as the upper limit for normal lymph nodes[26-28]. However, when these criteria are used, false-negative and false-positive results may occur because micrometastases do not result in enlargement or inflammatory changes in lymph nodes[4,13,29,30]. Contrast enhancement of lymph nodes can be useful in differentiating lymph nodes with and without metastasis[11]. Further study is needed to improve methods for the detection of lymph node metastasis such as dynamic CT[4,31].

In conclusion, the primary pathologic condition of gastric cancer and its metastasis to adjacent or distant structures can be demonstrated by contrast-enhanced HHCT. HHCT can provide more information for surgeons to make an appropriate therapy for gastric cancer patients.

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