**Invited update**

**Two-dimensional and three-dimensional imaging of gastric tumors using spiral CT**

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In the evaluation of gastric disease, upper gastrointestinal series (UGIS) and gastroscopy have been used for the detection of gastric abnormality. Computed tomography (CT) has been proved to be a valuable tool in addition to UGIS and gastroscopy in the evaluation of gastric disease [1, 2]. Spiral CT has been used for not only detection of gastric abnormality but also staging of gastric tumor. Two-dimensional imaging using a multiplanar reconstruction (MPR) algorithm may be helpful for the accurate staging of gastric tumors.

Three-dimensional (3D) spiral CT has been used to visualize the vascular system. Currently, 3D CT is used for gastrointestinal tract imaging [3, 4]. Gastric tumors may be evaluated by using 3D reconstruction images based on the shaded surface display (SSD) technique [5–10]. There are two 3D reconstruction algorithms for the evaluation of the stomach. One is 3D CT, and the other is virtual gastroscopy. Three-dimensional CT images correspond to UGIS findings, and virtual gastrosopic images correspond to real gastrosopic findings. Thus, 3D CT depicts images from the viewpoint of the surgeon, and virtual gastroscopy provides endoscopic images from the viewpoint of the internist. Surgeons prefer 3D CT images to virtual gastrosopic images. Software packages have been designed specifically for virtual endoscopic images: Fly on the Prominence workstation by Siemens, Navigator on the Advantage Windows workstation by General Electric, and Voyager on the Voxel Q workstation by Picker [11]. The effects of these software packages are not very different. The current status of 3D CT and virtual gastrosopic images are primitive, and further technical developments are necessary to obtain better 3D CT and virtual gastrosopic images.

This article describes the spectrum of clinical applications of 3D CT and virtual gastroscopy for imaging gastric lesions.

**Technique**

Spiral CT was performed with a Somatom Plus 4 scanner (Siemens, Erlangen, Germany) or a Hi-speed Advantage System (GE, Milwaukee, USA).

Two spiral acquisitions were performed in each patient. The first was performed to obtain 3D images. Before the first spiral CT examination, 6 g of Top effervescent granules (Taejoon Pharmaceuticals, Kyungkido, South Korea) were given orally to a fasting patient with a small amount of water. Immediately afterward, the patient was placed on the scanning table in the supine position. After a scout projection confirmed the stomach to be distended by gas, spiral CT was performed with a 3-mm collimation and a 4.5-mm/s table feed from the diaphragmatic dome to the lower edge of the stomach during a single breath-hold. Tube current was 230 mA, and voltage was 120 kVp. Up to 100–150 reconstruction images were obtained at 1–1.5-mm intervals. The stomach images were magnified maximally. When early gastric carcinoma was suspected on gastroscopy, 20 mg of scopolamine butylbromide (Buscopan; Boehringer Ingelheim Korea, Seoul, South Korea) were slowly injected intravenously before ingestion of effervescent granules to reduce the gastric peristalsis, and reconstruction images were obtained at 1-mm intervals. Three-dimensional images were obtained by using SSD technique with the Magic View (Siemens). Editing was done, and image segments that were not relevant were excluded. The images were then gathered and reconstructed by using the SSD technique with a threshold of –300 HU. All pixels less than this value were automatically removed from the image, leaving only the stomach and surrounding structures. This technique allowed visualization of the inner surface of the gastric wall, and this 3D image could be rotated and viewed from any orientation. When the lesion was located on the posterior wall of the stomach, the anterior wall was excised, and vice versa. Virtual gastrosopic images were also obtained by using the SSD technique with the Fly (Siemens) or the Navigator (GE) software. The dataset was loaded and reconstructed by using the SSD technique with a threshold from –300 HU to –600 HU. The stomach was segmented and displayed as a 3D structure. Using a view pointer, the stomach was interactively followed from the cardia to the pylorus while changing the display position. During this advancement, the inside surfaces of the stomach were displayed. Virtual gastrososcopic examination was viewed in a cine mode. Color coding was possible on the inner surface of the gastric wall.

The second spiral CT scan was done to assess the stage of gastric tumor. Before the second spiral CT examination, the patient eructated to empty the gas in the lumen of the stomach. Between 600 and 800 mL of tap water were administered orally. The patient reclined on the scanning
Fig. 1. Advanced gastric carcinoma (AGC), Borrmann type 1. A Axial CT of the stomach shows an intraluminal protruding mass (arrow) at the anterior wall of the angle. The mass is highly enhanced, but the outer margin is poorly defined at the center of the mass. B Coronal CT of the stomach shows a highly enhancing mass (arrow) at the angle portion of the lesser curvature of the stomach. The outer margin of the mass is clearly defined. AGC Borrmann type 1 was confirmed at surgery. The surgical stage of this patient was T2N0M0.

Fig. 2. T3 stage of advanced gastric carcinoma (AGC). A Axial CT of the stomach shows a heterogeneously, moderately enhancing thickened wall at the greater curvature of the antrum. The outer margin of the tumor is defined clearly, and perigastric fat is preserved around the tumor. The few streaky densities adjacent to the tumor are due to engorged perigastric vessels rather than to tumor infiltrations. CT stage using axial images is T2N0M0. B Coronal CT of the stomach shows diffuse wall thickening, with enhancement at the lesser and greater curvatures of the gastric antrum. Perigastric infiltrations with fibrostreaky densities (between arrows) are evident in the perigastric fat tissue. CT stage using coronal images is T3N0M0. AGC Borrmann type 3 was confirmed at surgery. Surgical stage of this patient was T3N0M0. (Courtesy of H. K. Kang, M.D.)

Fig. 3. Advanced gastric carcinoma, Borrmann type 1. After the greater curvature of the stomach is cut away, 3D CT shows a lobulated and endoluminal protruding mass (arrows) at the lesser curvature of the proximal antrum.

Fig. 4. Advanced gastric carcinoma, Borrmann type 2. After the pylorus of the stomach is cut away, 3D CT shows a tumor mass at the greater curvature of the proximal antrum. The mass has a large ulcer, and the outer margin of the tumor (arrows) is well demarcated.

Fig. 5. Advanced gastric carcinoma, Borrmann type 3. After the greater curvature of the stomach is cut away, 3D CT shows an infiltrative tumor mass (arrows) with a small ulceration (open arrow) at the lesser curvature of the distal body. The mucosal folds adjacent to the ulcer are clubbed and fused.