CT gastrography using dual source MDCT; leading the new era of CT diagnosis of gastric cancer

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Learning objectives

CT gastrography (CTG) has been reported to be a good diagnostic tool for evaluating gastric cancer. There are some pearls to undergo this procedure well and to make accurate diagnosis in T staging of cancer. In addition to these information obtained with conventional CTG, CTG with novel technique of dual energy CT with dual radiation source gives us a useful information of iodine map in and around the tumor, with which we can assess histology of the tumor, as well as tumor extension.

In this poster, we propose

- how to gain a good data of CTG
- three-dimensional criteria of T-stage, as well as two-dimensional criteria
- the usefulness of iodine map reconstructed with dual energy data sets
Background

Besides CT gastrography, there are many modalities to assess gastric cancer, e.g. optical endoscopy, endoscopic ultrasound, upper GI barium study, etc. Among them, only CT gastrography can evaluate all of the T, M and N-stage. Moreover, with dynamic enhancement study, we can reconstruct CT angiography which can provide surgeons anatomical information of splanchnic vessels before operation.

Dynamic enhancement study is also useful to assess T stage two-dimensionally. Especially, early mucosal enhancement is very important to assess early stage (T1 stage) gastric cancer. However, with conventional CT, it is sometimes unclear because of the thinness of gastric wall extended with effervescent granules administered P.O. With the datasets obtained with dual energy scan, we can demonstrate iodine map using three-material-decomposition method and that makes it possible to demonstrate mucosal enhancement clearly.

To assess T stage three-dimensionally, gastric wall around the lesion should be properly extended with carbon dioxide gas. However it is sometimes difficult in supine position, especially in case of the cancer exists at posterior wall of gastric fundus or gastric antrum. So, some tips are necessary to obtain good data.
Imaging findings OR Procedure details

Patients' position on CT table

Effervescent granules should be administered P.O. with small amount of water in standing position. To reconstruct good 3D images, we have to wash out mucus and water to duodenum with carbon dioxide gas. At first, patient should lie on his or her back, and then lie on right side or slightly on abdomen, and then on back, and finally on 45-30 degrees right anterior oblique position. With this procedure, most of the site of stomach is properly extended and water with mucus that hides gastric mucosa goes to duodenum. Although supine and 30 degree left posterior oblique position is reported to be recommended, we think this procedure and position can obtain better gastric distension.

CT protocol

Conventional:

120kV with auto mA, Pitch: 0.9, Reconstruction thickness: 1-2mm

Dual energy:

80kV and 140kV with auto mA, pitch: 0.9

Reconstruction thickness: 1-2mm with CT scanner of Definition Flash

(Siemens Medical, Germany)

Dynamic enhancement study:

Contrast material: 2ml/kg of 370mgI2/ml or 300 mgI2/ml

Injection rate: 3.5-4ml/sec

Time delay:

25-30sec for early arterial phase

50-60sec for parenchymal phase

150-180sec for equilibrium phase

Iodine map: with VNC(virtual non-contrast) software on MMWP

(Siemens Medical, Germany)
Two and Three dimensional criteria of T stage

Normal gastric wall appears as three layers on early arterial phase. Inner enhanced line represents mucosa propria and muscularis mucosae, middle low attenuation line represents submucosa, and outer high density line represents muscularis propria and serosa (Fig.1). This three-layer pattern is not always seen, because the thickness of submucosal layer differs in patients and part of the stomach extended with gas.

In two dimensional assessment of tumor invasion, visible middle low attenuating submucosal layer line (SM line) and interruption of this line are important, especially for T1a, b and T2 cancer (Fig.2).

Three-dimensional criteria of tumor invasion is based on the upper GI barium study criteria and on the endoscopic criteria, widely accepted in Japan (Fig. 3).

Figure 3 to 8 show the two and three-dimensional findings of each T stage of gastric cancer (T1a - T4a). As shown on figures, accurate diagnosis between T3 and T4a is sometimes very difficult two-and three dimensionally, because subserosal space is so narrow as not to be distinguished with CT.

Dual energy CTG

With conventional CT scan, we have had some difficulties in assessing vascularity and hemodynamics of the alimentary tumor. Iodine blended images obtained with dual energy scan can assess characteristics of mucosal lesion, as well as massive tumor with its high sensitivity of iodine. Iodine composite image can select the ratio of iodine map blend from zero to hundred percent (Figure 9).

Histology is often homogeneous in T1a tumor and in case of poorly differentiated adenocarcinoma, tumor cells infiltrate into the interstitium of mucosa, causing mucosal detachment or defect. In these cases, it is assumed that normal early enhancement of mucosa lacks or decreases.

This mucosal enhancement defect is clearly demonstrated with iodine composite image (figure 10). In case of advanced cancer, histology varies, but in the case of poorly differentiated adenocarcinoma dominant, prominent fibrosis occurs in the tumor and that is well observed with dynamic enhancement study using iodine map, as well as extraserosal enhancement (Figure 11).

Therapeutic plans of early gastric cancer according to its histopathology

Histology of T1a tumor determines therapeutic plan, i.e. cases of well differentiated adenocarcinoma are good indication for endoscopic mucosal resection (EMR; Figure 12). On the other hand, cases of poorly differentiated adenocarcinoma tend to undergo operation, including laparoscopic partial gastrectomy. It is certain that histopathologic
Diagnosis of the tumor should be given with biopsied specimen, but sometimes histopathologic discrepancies between biopsied and resected specimen may occur because of inadequately small amount of biopsied specimen, etc. So, it is thought to be important to suggest histopathology of T1a tumor with imaging modalities. As upper gastrointestinal barium study and magnifying endoscopy, CTG with dynamic enhancement study has the potential to refer histopathology of T1a cancer, and give consistency to histopathologic diagnosis obtained with biopsied specimen.
Fig. 1: Figure 1 represents CT and pathologic correlation of normal gastric wall.

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Fig. 2: Two-dimensional CT diagnostic criteria of tumor invasion based on the 7th UICC TMN staging of gastric cancer

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**Three-dimensional CT Diagnostic criteria of T stage**

T1a (M): Superficial depression / broad based low elevation
   Fold convergence without fold thickening
T1b(SM): Low elevation around the superficial depression
   Mild thickening at the end of converging folds
T2(MP): Elevation around the relatively deep ulcer
   Fusion and the thickening of converging folds
T3(SS): Prominent elevation around the deep, giant ulcer
T4a(SE): Prominent elevation around the deep, giant ulcer
T4b(SEi): Prominent elevation around the deep, giant ulcer

**Fig. 3:** Three-dimensional CT diagnostic criteria of tumor invasion based on the 7th UICC TMN staging of gastric cancer.

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Fig. 4: Conventional endoscopy shows converging folds to the superficial depression at the anterior wall of gastric body, better demonstrated on CTG (right slides: white and yellow arrow). On sagittal images of dynamic enhancement study, early mucosal enhancement lacks at the lesion in arterial and parenchymal phase (left three slides: marks).

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**Fig. 5:** Converging folds with slightly thickened ends to relatively deep ulcer at the anterior wall of gastric antrum is well demonstrated both conventional endoscopy and CTG. Two-dimensional image shows tumor (red line) invasion to submucosa (black line) without penetration of SM line, well corresponded with pathology.

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Fig. 6: Moderate elevation around relatively deep ulcer with converging fold at sub-fundus represents massive submucosal invasion of the tumor well demonstrated on CTG, as well as endoscopy (right slides). Axial image of arterial phase shows that tumor penetrates low attenuating SM line, but not protrudes to serosal side, which represents tumor invasion within the muscularis propria.

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Fig. 7: Prominent elevation around ulcer is noted at the lessor curvature of gastric body on both endoscopy and CTG, representing tumor invasion deeper than muscularis propria. Axial image of arterial phase shows tumor protrusion to the serosal side (arrow) with low attenuating SM line penetration (curved arrow). Although perigastric strands is not noted, accurate diagnosis of serosal invasion is difficult on CT image.

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Fig. 8: Large and prominent elevation around giant ulcer is noted at the posterior to greater curvature of gastric body on both endoscopy and CTG. Sagittal image shows prominent gastric wall thickening with slight deformity with perigastric strands (thick arrow).

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Fig. 9: Iodine blended images in advanced gastric cancer with deep ulcer. We chose 75% blend for the case of gastric cancer.

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**Fig. 10:** Left upper image shows small and superficial ulcer at the posterior wall of gastric body. This finding is also demonstrated on CTG (depression is between surgical marker clips). Conventional CT of arterial phase shows early mucosal enhancement defect at the lesion, but it is not clear (right upper image, between arrows). On a 75% blended iodine image, enhancement defect is clearly demonstrated (right lower image, between arrows), and note that normal mucosal enhancement of other areas are much better demonstrated comparing with conventional CT.

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Fig. 11: Triple phase of conventional CT shows soft tissue mass at gastric body and gradually enhanced from arterial to equilibrium phase. On a 75% blended iodine images shows that the tumor mainly affects posterior wall (parenchymal, equilibrium: arrow), and extended to perigastric fat tissue (equilibrium: arrow) represents serosal invasion or reaction of deep ulcer. These images means that this tumor consists of rich fibrosis and thus suggested that poorly differentiated adenocarcinoma is dominant.

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**Fig. 12:** T1a early gastric cancer consisted of well differentiated adenocarcinoma. Positive early mucosal enhancement is noted at the posterior wall of gastric body (left 2 slides, arrows). Endoscopic mucosal resection was performed successfully (right slide, tumor: arrows).

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Conclusion

CT gastrography with dynamic enhancement study has the potential to assess all TNM staging, moreover, with use of dual energy scanner, histologic diagnosis may also be assessed.
References


