Practical considerations in preoperative evaluation of gastric cancer with MDCT: Guideline for the radiological report.

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Learning objectives

Provide a structured, complete and easy guide to report preoperative gastric cancer staging studies.

Highlight useful aspects of MDCT for the surgery and the management of patients with gastric carcinoma through a pictorial review.

Background

Gastric cancer is a disease with high incidence and mortality in our population. Its prognosis is closely related to the neoplasm stage at diagnosis. For localized tumors characterized by invasion of mucosa or submucosa at diagnosis, survival rates at five years are between 70 and 95%; however, when higher extension into the gastric wall and/or locoregional nodal involvement are present, survival decreases to 20-30% at five years.

Accurate preoperative staging of gastric cancer is therefore essential for planning the optimal management of these patients, and it is based on imaging modalities. Complete surgical resection is still the main therapeutic approach for complete cure of gastric cancer. However new therapeutic options such as endoscopic mucosal resection and neoadjuvant chemotherapy have been introduced, and precise preoperative staging is becoming even more important.

In our environment, only 40% of patients are diagnosed of localized gastric tumors susceptible of surgical escision. After the histological analysis of the surgical piece, just one third of these patients truly correspond to early disease (state IA and IB) and the other two thirds have locally advanced disease (stage II and III and M0).

About the remaining 60% of patients, one half have locally advanced disease and the other half correspond to metastatic disease.

Preoperative staging is based on the 7th edition of the UICC/AJCC (Union Internationale Contre le Cancer/American Joint Committee on Cancer) TNM (Tumor Node Metastases) and a new revision of the Japanese Classification for Gastric Cancer and Treatment Guidelines (Japanese Gastric Cancer Association), available since the beginning of 2010.
Over the past decades, **endoscopic ultrasonography (EUS)** was used as the modality of choice for preoperative T and N staging of gastric cancer, and conventional computed tomography (CT) was routinely used to exclude the presence of distant metastases. The introduction of **multidetector computed tomography (MDCT)** allowed faster imaging acquisition, less respiratory artefact and thinner imaging thickness, so multiphasic imaging acquisitions and highquality multiplanar and 3D image reconstructions could be performed. MDCT improved the accuracy of T and N staging in gastric cancer from helicoidal CT.

Some recent studies using MDCT have shown comparable results to those using EUS. The reported accuracy of MDCT for T-staging varies from 75 to 90% and between 65 to 75% for N-staging.

In general terms, MDCT is the preferred technique for staging gastric cancer (GC) because of its ability to assess tumor depth, nodal disease and metastases and because it is widely available, non-invasive and can be performed in most patients.

EUS seems more accurate for assessing the depth of wall invasion in early cancer but is limited in the assessment of advanced local or stenotic cancer and detection of distant metastases.

**MRI** and **PET** may also be useful on specific cases.

**Exploratory laparoscopy** takes part in the preoperative staging of potentially respectable patients, especially in those with neoadjuvant chemotherapy treatment, with inexplicable rising tumoral markers and patients with plastic linitis.

In everyday clinical practice a combination of diagnostic modalities is used for preoperative staging.

**Findings and procedure details**

As we said before, MDCT is the preferred technique for staging GC.

One of the main objectives is to identify any **irreseccability criteria** in these patients:

- tumoral adenopathies at level 3 or 4 by the Japanese Research Society for Gastric Cancer (JRSGC), pathologically confirmed
• invasion of major vascular structures
• distant metastases (hepatic and/or peritoneal, including positive peritoneal washing citology)
• Impossibility to achieve complete resection.

A. CT TECHNIQUE

The scans are usually obtained in the portal venous phase performed at 60-70s from the start of intravenous injection of 100-150ml of iodinated contrast at 3-4ml/s. Additional arterial phase scans may also be obtained at 30-35s from the start of intravenous injection, which may be useful to differentiate enhancing tumors from normal gastric mucosa Fig. 1 on page 9

Gastric distention is known to be helpful for defining the gastric wall and evaluating the depth of gastric wall tumoral involvement. Negative oral contrast (water or gas) is preferred.

B. RADIOLOGICAL REPORT

These are the items that must be included in the radiological report of the preoperative MDCT study in a patient diagnosed of gastric cancer.

1. LOCATION of the tumor (fundus / body / antrum / cardia) Fig. 2 on page 10
Approximately 30% of tumors are located in the antrum, 30% in the body and 40% in the fundus and cardia.

Some considerations:

• The tumors arising at the esophagogastric junction and in the proximal stomach #5 cm to the union are managed as esophageal adenocarcinomas. Fig. 3 on page 11
• In the case of tumors located in the antrum, subtotal gastrectomy has demonstrated the same survival and mortality rates as total gastrectomy, with less complications and nutritional disorders associated. Fig. 4 on page 12
• The distance between the boundary of the tumor and the surgical resection must be at least 5 cm, and microscopic tumoral involvement of margins increases the risk or local recurrence. Therefore, if the tumor affects cardias
or margins of resection are threatened, intraoperative analysis of margins should be performed.

2. MORPHOLOGY of the tumor (nodular / plaque-like / polypoid / ulcerated / infiltrating / diffusely infiltrating)

Based on the level of invasion GC is divided into:

- **Early gastric cancer** (limited to mucosa and submucosa regardless the presence or absence of lymph node metastases) # can appear as a small circumscribed sometimes ulcerated thickening of the gastric wall.

- **Advanced gastric cancer** (involves muscularis propria or beyond) # can be polypoid, ulcerating, ulcerating infiltrating and diffusely infiltrating.

* Differentiation between early and advanced GC allows for potential endoscopic resection versus more invasive surgical resection and/or neoadjuvant chemotherapy, respectively.

Histologically GC is usually classified as: Fig. 5 on page 13

- **Intestinal type**# usually nodular, polypoid or fungating morphology.

- **Diffuse type**# plaque or linitis plastica.

* In case of linitis plastica, neoadjuvant therapy is recommended.

3. **SIZE** of the tumor (longitudinal / depth)

When the tumor size is more than 5 cm it is considered to be a voluminous tumor, and adjuvant treatment may be required.

4. **Invasion of VASCULAR STRUCTURES.** Fig. 6 on page 14

*When infiltration of major vascular structures is detected, tumor becomes irresectable.*

5. **TNM CLASSIFICATION** of gastric tumor.
The table bellow summarizes the principal differences between the 6th and 7th TNM edition. **Fig. 7 on page 15**

Based on the TNM classification previously revised, tumors are grouped into different stages. **Stage 0** means carcinoma in situ, **stage I** local disease, **stage II** early locally advanced disease, **stage III** late locally advanced disease and **stage IV** metastasized disease. **Fig. 8 on page 16**

6. **Primary tumor or T stage (T1/T2/T3/T4).**

The T stage defines the **depth of invasion of the tumour in the gastric wall.**

Layers of the stomach wall on MDCT: **Fig. 9 on page 17**

- The inner most enhancing layer corresponds histologically to the gastric mucosa.
- The intermediate hypoattenuating layer of 2-3mm represents the submucosa.
- The outer slightly hyperattenuating layer of variable thickness corresponds to the muscular propia and the serosa layer.

* However, this multilayered pattern may not be visualized in all cases and not in all parts of the stomach. The gastric wall may be seen as a single layer especially when hypotonia is induced.

Focal thickening greater than 5mm in a well-distended stomach is considered to indicate a neoplastic lesion.

The table below defines the T stages and correlates them with the MDCT findings **Fig. 10 on page 18** (Pathologic T stages and MDCT criteria for T stages of GC compiled from Moschetta et al. and Kim et al.)

It is very difficult to differentiate T2 and T3 tumor. They all are seen as a thickening of the stomach wall to variable extent with a regular surface of outer layer of gastric wall and normal appearance of perigastric fat.- Sometimes the T staging may be overestimated because reticular strands may not be perigastric tumor infiltrations but fibrosis and venous congestion, and it can be misinterpreted as T4.

Extension of the tumor into the gastrohepatic or gastrocolic ligament or into the epiplon is not always T4 stage because visceral peritoneum may not be affected.
If voluminous T3 or T4 in the gastric wall, adjuvant treatment is recommended. Fig. 11 on page 19

If there is invasion of neighbouring organs (T4b), total extended gastrectomy should be considered. It implies the escision of the stomach and other organs or a part of them involved.

Some recent reports explain the value of CT tumor volumetry in gastric carcinoma. It seems to have high accuracy in predicting the stage of disease: Larger tumors are likely to invade several layers of the stomach and also more likely to invade lymphatics which are usually present in the submucosal layer.

CT volumetry can be performed using a special software available free online. Regions of interest including areas of abnormal thickening of the stomach wall need to be drawn on every axial slice where the tumor is identified. Finally, tumor volume is the product of the sum of area of ROIs of tumor and the slice thickness.

It can be useful adjunct CT volumetry to standard CT staging of gastric carcinomas.

7. Lymph nodes involvement or N stage (size / number / N1-N2-N3 / location or station)

There is higher risk of lymph nodes involvement when the depth of invasion of the tumor in the gastric wall is deeper.

One lymph node #8 mm in short axis diameter or #3 clustered perilesional lymph nodes are considered suspicious for malignancy.

Obviously MDCT has inherent limitations on nodal staging because of the high frequency of microscopic invasion in normal-sized lymph nodes and the poor differentiation between reactive and metastatic nodal enlargement.

The N stage depends on the number of lymph nodes invaded:

* N1# 1 or 2 LN
* N2# 3-6 LN
* N3# > 6 LN

* N3 stage is divided in N3a (7-15 LN) and N3b (16 or more).
Information about the location of the suspicious lymph nodes (LN) needs to be reported. There are 16 lymph node stations that surround the stomach. These levels are defined by the JRSGC, and also approved by the AJCC and the International Union Against Cancer (UICC). They are grouped according to the location and extension of the primary tumor (N0-N4) and the extent of the lymphadenectomy performed (D1-D4). Fig. 12 on page 20

- **D1 dissection** (stations 1-6, N1 level) includes lesser curvature lymph nodes (stations 1, 3 and 5) and greater curvature lymph nodes (stations 2, 4 and 6)

* An incomplete N1 dissection is labelled a **D0 lymphadenectomy**.

- **D2 dissection** (stations 7-11, N2 level) adds the removal of the left gastric artery LN (station 7), common hepatic artery (station 8), celiac trunk (station 9), splenic hilus (station 10) and splenic artery (station 11*)

*Station 11 can be subdivided into "11p"-proximal- if ganglia are located between the origin of splenic artery and the half part of pancreatic corp, and "11d" -distal- if located from the half part of pancreatic corpus and splenic hilia

- **D3 dissection** (N3 level) includes the dissection of lymph nodes at stations 12-14, along the hepatoduodenal ligament (12) and the root of mesentery (14)

- **D4 dissection** (N4 level) adds the stations 14 (paraaortic region) and 16 (paracolic region)

The ideal lymphadenectomy for gastric cancer should accurately stage the extent of disease and predict the prognosis. It also should have the potential to improve survival by selectively and completely removing all metastatic lymph nodes with minimal morbidity and mortality.

There is increasing evidence that examination of an insufficient number of lymph nodes may have a detrimental effect on the overall survival of patients with GC who receive curative treatment. An adequate D1 dissection must include at least 15 lymph nodes, and a D2 dissection should include more than 20 lymph nodes.

* In our institution, surgical treatment with curative intention usually follows this scheme:

- if the tumor is distal, less than 3 cm, without invasion of the serosa (T1-T3) and intestinal subtype # subtotal gastrectomy
• on the rest of resectable gastric tumors total gastrectomy and Roux-en-Y reconstruction

• in cT1 tumors or advanced-age patients plus D1 lymphadenectomy (N1 level)

• in cT2-T4 tumors or N(+) plus D2 lymphadenectomy (N1 and N2 level) with pancreas and spleen preserving gastric surgery (except in cases of greater curve tumors, direct invasion of these organs or invasion of 10 and/or 11 level lymph nodes in which panreatosplenectomy is mandatory)

8. M stage (distant metastases)

Liver is the most frequent site of distant metastases of gastric cancer. Fig. 13 on page 21

Peritoneal positive cytology is considered as M1 and therefore stage IV on the latest 7th Edition of TNM classification. It is known that MDCT has high specificity and low sensitivity for the evaluation of peritoneal seeding. The presence of ascites, peritoneal nodules, mesenteric thickening and fat stranding are suspicious for peritoneal spread of disease. Factors predictive of peritoneal metastases include greater tumor size, more advanced T stage, and the presence of ascites.

Peritoneal spread of disease is important to decide whether to perform a minimally invasive diagnostic laparoscopy for confirmation or a laparotomy for resection.

Images for this section:
Arterial phase CT obtained at 35s from the start of intravenous injection. Axial CT image shows an irregular thickening of the gastric wall, with early enhancing regarding to the normal mucosa.

Fig. 1
Fig. 2
Esophagogastric junction carcinoma

Fig. 3

MDCT study using a GC protocol. A. Axial CT image shows a polypoid mass, located in the esophagogastric junction, protruding into the lumen of the stomach (yellow arrow). B. Coronal CT shows para-aortic lymphadenopathies (blue arrows). Note the mural thickening of the gastroesophageal junction (green arrows). C. Focal hepatic lesions compatible with metastasis were observed.
Gastric carcinoma in a 77 year-old women. Axial and coronal CT images show a polypoid mass with enhancing, located in the ventral wall of the gastric antrum (yellow arrow). The tumour causes partial gastric outlet obstruction. Local lymph nodes in the greater omentum were observed (green arrow). Subtotal gastrectomy and D2 dissection were conducted.
Fig. 5
Sagital and axial MDCT images show a polypoid mural thickening with extramural extension that surround the splenic artery (red arrows).

Fig. 6

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>T1a Tumor invades the lamina propria</td>
<td>T1</td>
</tr>
<tr>
<td>T1b Tumor invades the submucosa</td>
<td>T1</td>
</tr>
<tr>
<td>T2 Tumor invades the muscularis mucosae</td>
<td>T2a</td>
</tr>
<tr>
<td>T3 Tumor invades the subserosa</td>
<td>T2b</td>
</tr>
<tr>
<td>T4a Tumor perforates the serosa</td>
<td>T3</td>
</tr>
<tr>
<td>T4b Tumor invades adjacent structures</td>
<td>T4</td>
</tr>
<tr>
<td>N1 (1-2 lymph nodes)</td>
<td>N1</td>
</tr>
<tr>
<td>N2 (3-6 ganglios)</td>
<td>N1</td>
</tr>
<tr>
<td>N3a (7-15 ganglios)</td>
<td>N2</td>
</tr>
<tr>
<td>N3b (≥16 ganglios)</td>
<td>N3</td>
</tr>
</tbody>
</table>

Fig. 7
### TNM - 7th edition 2009 (UICC/AJCC)

<table>
<thead>
<tr>
<th>T Stage</th>
<th>N0</th>
<th>N1(1-2)</th>
<th>N2(3-6)</th>
<th>N3a(7-15)</th>
<th>N3b(≥16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 Mucosa/submucosa</td>
<td>IA</td>
<td>IB</td>
<td>IIA</td>
<td>IIIB</td>
<td>IIIB</td>
</tr>
<tr>
<td>T2 Muscularis propria</td>
<td>IB</td>
<td>IIA</td>
<td>IIIB</td>
<td>IIIA</td>
<td>IIIA</td>
</tr>
<tr>
<td>T3 Subserosa</td>
<td>IIA</td>
<td>IIB</td>
<td>IIIA</td>
<td>IIIB</td>
<td>IIIB</td>
</tr>
<tr>
<td>T4a Serosa</td>
<td>IIB</td>
<td>IIIA</td>
<td>IIIB</td>
<td>IIIC</td>
<td>IIIC</td>
</tr>
<tr>
<td>T4b Adjacent organs</td>
<td>IIIB</td>
<td>IIIB</td>
<td>IIIC</td>
<td>IIIC</td>
<td>IIIC</td>
</tr>
<tr>
<td>Any T or N, M1</td>
<td>IV</td>
<td></td>
<td></td>
<td></td>
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</table>
Stomach layers on MDCT

Fig. 9
<table>
<thead>
<tr>
<th>Pathologic T state</th>
<th>MDCT criteria</th>
</tr>
</thead>
</table>
| **T1** (Tumor invades lamina propria, muscularis mucosae or submucosa)           | - Gastric wall thickening of ≥ 6 mm with/without enhancement of the inner surface with extension <50% through the low density stripe or submucosal layer (the outer layer shows no enhancement),  
- or marked enhancement only without wall thickening in a single-layer pattern |
| **T2** (Tumor invades muscularis propria)                                         | Gastric wall thickening with disruption of the low-attenuation submucosal layer extending >50% through the gastric wall without involvement of the high attenuation outer stripe |
| **T3** (Tumor penetrates subserosal connective tissue without invasion of visceral peritoneum or adjacent structures) | Penetration of the tumor through the entire thickness of the stomach wall with a smooth outer gastric surface and clear perigastric                                                                              |
| **T4a** (Tumor invades serosa - visceral peritoneum-)                             | Penetration of the tumor through the entire thickness of the stomach wall with a nodular, irregular or blurred outer border of the thickened gastric wall, perigastric fat stranding or both |
| **T4b** (Tumor invades adjacent structures)                                       | Extension of the tumor into adjacent organ or structure in addition to gastric wall thickening                                                                                                                                 |

**Fig. 10**
Gastric malignant ulcer.

Multiplanar CT view of the upper gastrointestinal tract. In the posterior wall of the gastric atrium we can observe a gas-liquid filled ulcer crater within a tumoral mass. The lesion infiltrates the adjacent fat of the minor omentum (T4).

Fig. 11
Lymph node stations in gastric cancer

**D1 lymphadenectomy**

**D2 lymphadenectomy**

(* Station 12 is included in D3)

Fig. 12
Liver focal lesions. A. MDCT without contrast medium shows multiple hypodense lesions within the liver. B. Arterial phase MDCT demonstrates peripheral enhancing of the lesions. C. Portal phase with hypercaptaion of the lesions regarding to the liver parenchyma. Note adenopathies in the gastrocolic ligament.

Fig. 13
Conclusion

MDCT plays a pivotal role in the pre-treatment assessment of primary gastric cancer. Radiologists should know which features need to be assessed to provide the surgeon clear and concise information for thorough preoperative evaluation.

Personal information


References