Imaging in gastric cancer
Gastric cancer remains a deadly disease because of late diagnosis. Adenocarcinoma represents 90% of malignant tumors. **Diagnosis is based on endoscopic examination with biopsies.**

Only a few patients can benefit from a curative surgical treatment.

**The role of imaging** is to evaluate tumor extension and metastatic localizations before treatment.

Also, pretreatment imaging must answer two questions:
- Is the patient eligible for surgery?
- What kind of treatment, including perioperative chemotherapy, is appropriate?
How to explore stomach cancer in imaging?

- Upper gastrointestinal (UGI) tract radiography
  - Limited utility
  - Utility of double contrast barium radiography (best performance for lesion detection and fundus visualization)
  - Borrmann classification

- Endoscopic ultrasound (EUS):
  - Wall extension
  - Perigastric lymph node metastases

- Multidetector Computed Tomography (MDCT)
  - First-line examination for pretreatment staging
  - Proper gastric distension is necessary
  - Isodensity oral contrast material (water)
  - Without injection, arterial and portal venous phases on abdominal acquisition
  - Multiplanar reformation analysis with high spacial resolution
Magnetic Resonance Imaging (MRI) :
• Alternative imaging method if MDCT cannot be used
• Superiority in wall extension
• Utility of diffusion-weighted sequences
- Positron Emission Tomography - Computed Tomography :
• Useful in distant metastasis staging
• Risk of false-negative results in some histological types
UGI tract radiography

**Borrmann classification**

- **Type 1:**
  - Polypoid and lobulated mass
  - Often greater than 3 cm in diameter

- **Type 2:**
  - Exophytic formation with ulceration
  - Elevated edges
  - Often greater than 3 cm in diameter
Borrmann classification

- **Type 3:**
  - Large excavation in the gastric wall
  - Irregular outline
  - Hard and thickened edges protruding from the gastric surface

- **Type 4:**
  - Wall thickening due to diffuse tumor infiltration
  - Local retraction of the antral region in most cases, or of the entire stomach (limitis plastica)
  - Decrease of stomach distensibility
  - Gastric folds deformation
Borrmann’s classification

Type I: Polypoid (44%)
Type II: Fungating (7%)
Type III: Ulcerated (40%)
Type IV: Infiltrative:
  - superficial spread (2%)
  - limitis plastica (7%)
A precise staging allows to plan the best treatment strategy for gastric cancinomas. MDCT analysis must identify in patients with resectable gastric adenocarcinoma, those with T2 stage or higher (through the submucosa), and who will benefit from perioperative chemotherapy to reduce tumor size, stage and to improve progression-free and overall survival.

**Essential role of MDCT:**

- Identify patient with resectable gastric cancer (with no evidence of distant metastases or locally advanced inoperable disease)

- Identify, in patients with resectable gastric adenocarcinoma, those with T2 stage or higher (through the submucosa), and who will benefit from perioperative chemotherapy

A precise staging allows to plan the best treatment strategy for gastric cancinomas. MDCT analysis must identify in patients with resectable gastric adenocarcinoma, those with T2 stage or higher who would benefit from perioperative chemotherapy to reduce tumor size, stage and to improve progression-free and overall survival.
Computed tomography (CT) has been the modality of choice for preoperative evaluation and staging in patients with gastric carcinoma. In addition, CT has been the primary tool in determining both the presence of recurrent tumors and their response to chemotherapy; however, its use is limited, particularly in the diagnosis of lymph node metastasis, peritoneal metastasis, and small hematogenous metastasis.

FDG-PET appears to be highly accurate in determining resectability and detecting distant metastatic disease at the time of initial diagnosis, but it may be of limited use in locoregional staging.
in the past, CT has been the imaging modality of choice for the preoperative staging of gastric cancer and the follow-up of affected patients. However, FDG PET may be superior to anatomic imaging modalities in the detection of distant metastases and significant nodal metastases. In addition, FDG PET may play a valuable role in monitoring response to therapy in patients who undergo surgery or chemotherapy. Therefore, the combined use of CT and PET can be helpful in preoperative staging and therapeutic monitoring in patients with stomach cancer.
<table>
<thead>
<tr>
<th>Phase of examination</th>
<th>Aspect of technique</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Preparation</td>
<td>Fasting</td>
<td>No solid food for at least 6h</td>
</tr>
<tr>
<td></td>
<td>Oral contrast material</td>
<td>1000 – 1500 mL of water</td>
</tr>
<tr>
<td></td>
<td>Hypotonia</td>
<td>20 mg of intravenous scopolamine</td>
</tr>
<tr>
<td></td>
<td>Patient position</td>
<td>Supine. Interest of prone in the antrum or pyloric wall lesions.</td>
</tr>
<tr>
<td>Scanning and Image</td>
<td>Section Collimation</td>
<td>0.5-1.25 mm (four to 64-row scanner)</td>
</tr>
<tr>
<td>Processing</td>
<td>Volume CT Dose index</td>
<td>15-30 mGy according to patient size</td>
</tr>
<tr>
<td></td>
<td>Reconstruction section thickness Increment</td>
<td>1-1.5 mm 0.7 mm</td>
</tr>
<tr>
<td></td>
<td>Image processing</td>
<td>MPR axial, coronal and sagittal Virtual endoscopy after air distension</td>
</tr>
<tr>
<td></td>
<td>Contrast media</td>
<td>100-120 ml (or 1.5 ml/kg), 3-4 ml/sec 60 ml of saline solution for flushing Arterial phase (30-40 sec) and portal venous phase (70-90 sec)</td>
</tr>
</tbody>
</table>
CT Report:

- Tumor location
- Local extension (T stage)
- Complications (abscess, perforation ...)
- Number and location of CT positive nodes (N stage)
- Metastasis (M stage)
- Anatomical variants (vessels) for surgeon
- Radiological TNM staging in conclusion
Tumor stages are defined according to the American Joint Committee on Cancer (AJCC) staging system as follows:

**T1**, tumor invades lamina propria or submucosa;

**T2**, tumor invades muscularis propria or subserosa;

**T3**, tumor penetrates serosa (visceral peritoneum) without invasion of adjacent structures; and

**T4**, tumor invades adjacent structures.

Accurate T staging is the most significant element in determining appropriate treatment plans.
Endoscopic ultrasonography (US) is currently the most reliable method available for preoperative determination of T stage, with a diagnostic rate of 78%–93%.

Recently, an advanced CT technique that makes use of thin sections, optimal contrast material enhancement, and multiplanar reformation has been used for more accurate staging.
**Mural invasion: T stage**

**T0**: no MDCT anomaly

**T1**: focal thickening of gastric wall without transmural enhancement
- marked enhancement only without wall thickening in a single-layer pattern
- thickening and marked enhancement without abrupt obliteration of the middle and outer layers in a multilayered pattern
**T2:**
- Transmural enhancement with focal wall thickening in a single-layer pattern
- Both abnormal enhancement and abrupt obliteration of the middle layer in a three-layered pattern, or of the outer layer in a two-layered pattern
- Smooth outer border of the thickened gastric wall or a few small linear strands of soft tissue extending into the fat plane

**T3:**
- Reticular or irregular outer border of the thickened gastric wall
- Blurred fat plane around the lesion
**T3/T4 (indeterminate stage):**
Obliteration of the fat plane between the gastric tumor and adjacent organs

**T4:** Gross infiltration of adjacent organs
Transmural enhancement
Focal thickening
Small linear strands into the fat plane
T4 lesion with diaphragmatic pillar invasion

T3 lesion: perigastric fat infiltration
The invasion of cancer into the gastric wall as visualized at CT has been classified as follows:

In T1 and T2 lesions, invasion is limited to the gastric wall, whose outer border may be smooth.

Coronal reformatted image shows a stage T1 tumor (arrows) with focal nontransmural enhancement in the upper body.
axial CT scan shows a stage T2 tumor (arrow), a localized, transmurally enhancing ulcerative mass without perigastric extension, in the lower body
in T3 lesions, the serosal contour becomes blurred, and strand-like areas of increased attenuation may be seen extending into the Perigastric fat.

Coronal reformatted image shows a stage T3 tumor (arrows), with gross infiltration of the perigastric fat tissue in the antrum.
and in T4 lesions, tumor spread frequently occurs via ligamentous and peritoneal reflections to adjacent organs.

The transverse colon may be invaded via the gastrocolic ligament, the pancreas via the lesser sac, and the liver via the gastrohepatic ligament.
Axial CT scan shows a stage T4 tumor with invasion of the colon. The tumor represents an advanced cancer of the antrum and is accompanied by obliteration of the fat plane and thickening of the colonic wall (arrows).
Coronal reformatted image shows a stage T4 tumor (arrow) infiltrating the distal pancreatic body.
Axial CT scan shows a stage T4 tumor (arrows), an advanced cancer with gross infiltration of the lateral segment of the liver.
Differentiation between T3 and T4 lesions is particularly important because extensive invasion of T4 lesions into adjacent structures makes surgery difficult, and with massive tumor invasion there is little possibility of resection
PET is not helpful in T staging because it is a functional imaging modality.

Gastric adenocarcinomas, such as mucinous carcinoma, signet ring cell carcinoma, and poorly differentiated adenocarcinomas, tend to show significantly lower FDG uptake than do other histologic types of gastric cancer.
Node Staging

Under the new AJCC classification system, N staging is based on the number of positive nodes (N1, metastasis in one to six regional lymph nodes; N2, metastasis in seven to 15 lymph nodes; and N3, metastasis in more than 15 lymph nodes)
Several studies have confirmed the superiority of number of positive nodes in the estimation of prognosis, but anatomic nodal location remains a valuable criterion because the D classification, a description of the extent of lymphadenectomy, is determined according to the level of lymph node dissection (D1–D4).
### Topographic Classification of Lymph Nodes in Gastric Cancer

<table>
<thead>
<tr>
<th>Station</th>
<th>Node Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Right paracardium</td>
</tr>
<tr>
<td>2</td>
<td>Left paracardium</td>
</tr>
<tr>
<td>3</td>
<td>Along the lesser curvature</td>
</tr>
<tr>
<td>4</td>
<td>Along the greater curvature</td>
</tr>
<tr>
<td>5</td>
<td>Suprapylorum</td>
</tr>
<tr>
<td>6</td>
<td>Infrapylorum</td>
</tr>
<tr>
<td>7</td>
<td>Along the left gastric artery</td>
</tr>
<tr>
<td>8</td>
<td>Along the common hepatic artery</td>
</tr>
<tr>
<td>9</td>
<td>Around the celiac artery</td>
</tr>
<tr>
<td>10</td>
<td>At the splenic hilum</td>
</tr>
<tr>
<td>11</td>
<td>Along the proximal splenic artery</td>
</tr>
<tr>
<td>12</td>
<td>In the hepatoduodenal ligament</td>
</tr>
<tr>
<td>12a</td>
<td>Along the hepatic artery</td>
</tr>
<tr>
<td>12b</td>
<td>Along the bile duct</td>
</tr>
<tr>
<td>12p</td>
<td>Behind the portal vein</td>
</tr>
<tr>
<td>13</td>
<td>On the posterior surface of the pancreatic head</td>
</tr>
<tr>
<td>14</td>
<td>Along the superior mesenteric vessels</td>
</tr>
<tr>
<td>15</td>
<td>Along the middle colic vessels</td>
</tr>
<tr>
<td>16</td>
<td>Around the abdominal aorta</td>
</tr>
</tbody>
</table>

[Image: Illustration of lymph nodes and their locations in the gastrointestinal tract]
Nodal extension: N stage

- 1. Right paracardium
- 2. Left paracardium
- 3. Along the lesser curvature
- 4. Along the greater curvature
- 5. Suprapylorum
- 6. Infrafylorum
- 7. Along the left gastric artery
- 8. Along the common hepatic artery
- 9. Around the celiac artery
- 10. At the splenic hilum
- 11. Along the proximal splenic artery
- 12. In the hepatoduodenal ligament
  - Along the hepatic artery (a)
  - Along the bile duct (b)
  - Behind the portal vein (p)
- 13. On the posterior surface of the pancreatic head
- 14. Along the superior mesenteric vessels
- 15. Along the middle colic vessels
- 16. Around the abdominal aorta

Classified as distant metastases (M1)
T3 lesion with adenomegaly of the chain 3, lesser curvature

Adenomegaly of the chain 10, splenic hilium
Compartment I includes the perigastric lymph nodes (stations 1–6).

Compartment II includes lymph nodes along the left gastric artery (station 7) and common hepatic artery (station 8), around the celiac axis (station 9), at the splenic hilum (station 10), and along the splenic artery (station 11).

Compartment III includes lymph nodes in the hepatoduodenal ligament (station 12), at the posterior aspect of the head of the pancreas (station 13), and at the root of the mesentery (station 14).
When the cancer is located in the lower third of the stomach, lymph nodes along the splenic artery are classified as compartment III nodes. Compartment IV includes lymph nodes along the middle colic vessels (station 15) and the paraaortic lymph nodes (station 16).
In addition, the regional lymph nodes of stations 12p–16 are classified as distant metastases (M1) according to the new AJCC classification system. Therefore, detailed anatomic nodal descriptions based on lymph node location remain a significant component of preoperative nodal staging.
CT has a major limitation in that it cannot help detect cancerous involvement of normal-size nodes and cannot help distinguish between reactive hyperplasia and metastatic enlargement.
PET is less sensitive than CT in the detection of lymph node metastasis in compartments I and II, mainly due to its poor spatial resolution, which makes it unhelpful in discriminating between lymph nodes and the primary tumor. However, the presence of metastatic perigastric lymph nodes may not be important in planning surgical extent, since these nodes would be removed at the time of surgery.
Metastasis: M stage

- Liver
- Lung
- Adrenal glands
- Kidneys
- Bone
- Distant metastatic lymph nodes (chains 12p to 16)
- Advanced cancer:
  - Peritoneal carcinosis
  - Krukenberg tumors (ovarian)

T3/T4 lesion with adenomegaly of the chain 16 (around the abdominal aorta), classified as M1