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# The Role of Computed Tomography in the Imaging of Gastric Carcinoma

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## 1. Introduction

Gastric carcinoma represents the most common gastric neoplasm accounting for 95% of all gastric tumors (Angelelli et al, 2001; Fishman et al, 1996; JH Kim et al, 2006; Levine & Megibow, 1994). Besides, it is one of the most common cancer in the world and a major cause of morbidity and mortality. It cause 30% of the cancer deaths in high risk areas, such as China and Japan. The peak of incidence of gastric carcinoma is estimated from between 50 and 70 years and its prevalence is variable in different countries. This pathological condition has a greater impact in certain geographical areas, such as Japan, Latin America and Eastern Europe. In fact, the prevalence of gastric carcinoma is very high in Japan, where the mortality rate is about 110 cases/100.000 inhabitants while a value of 50/100.000 has been estimated in Italy. Males are affected more commonly than females, with most patients presenting in the sixth decade.

Gastric carcinoma represents an aggressive tumor with a 5 year survival rate less than 20% (Lee DH, 2000). Superficial carcinoma forms are called "early gastric cancer" and have a better prognosis, with a 5 year survival rate of more than 90%. In fact, the 5 year survival rates range from 3% in case of stage IV to 85-90% in case of stage I, depending on tumor stage (Ba-Ssalamah et al, 2003; JH Kim et al, 2006).

Among etiological factors, some dietary habits have been identified, such as hot or salty food. Unlike the esophageal carcinoma, alcohol and smoking do not seem to influence the incidence of gastric carcinoma. Atrophic gastritis, gastric ulcers, intestinal metaplasia, reflux esophagitis, gastric polyps, Menetrier disease, partial gastrectomy, pernicious anemia, achlorhydria and hypochlorhydria represent risk conditions and may predispose to the development of adenocarcinoma of the stomach.

In 30% of cases gastric carcinoma is located on antrum, in 30% on gastric body and in other 30% on fundus or cardia; the remaining 10% is represented by diffuse infiltrating gastric lesions which affect all gastric walls at the time of diagnosis (Ba-Ssalamah et al, 2003).

Macroscopically, superficial forms, also called early gastric cancer, and advanced forms can be identified. Early gastric cancer is limited to the mucosal or submucosal layers and is characterized by variable incidence values from between 30% in Japan and 2 - 6% in other countries. Early gastric cancer can be difficult to recognize and can appear as a small, circumscribed, sometimes ulcerated thickening of the gastric wall (Angelelli et al, 2001).

The advanced gastric carcinoma reaches the muscolaris propria and four different kinds can be identified: polypoid, ulcerating, ulcerating-infiltrating and infiltrating forms, also called linitis plastica. Generally, in case of advanced gastric carcinoma, wall thickening exceeds 1 centimeter, with a variable extension, or a vegetating mass with irregular surfaces and a wide retracted base due to the invasion of the adjacent gastric wall can be identified.
The Jarvi and Lauren classification usually identifies intestinal or diffuse histological forms, the latest representing about the 80-90% of all gastric forms. The remaining 10-20% are represented by a third gastric form which collect all the other histological kinds. The intestinal form is usually moderately differentiated and originates from intestinal metaplasia areas; diffuse form represents an undifferentiated form which originated from gastric epithelium (Jarvi & Lauren, 1951).
In most of the cases gastric carcinoma has a preferential diffusion towards the cardia or it follows a contiguity, lymphatic or haematic mechanism. Usually, the intestinal form is less infiltrating, rarely can have a peritoneal involvement and can give hepatic metastatic nodules. On the contrary, diffuse gastric carcinoma rapidly involves adjacent structures and peritoneum.
However, metastatic diffusion usually depends on the extension and the depth of infiltration of the primary tumor. The most common metastatic sites are represented by lymph nodes (80% of cases), liver (40%), peritoneum (30%), lung (20%), pancreas (17%), retroperitoneum (12%), adrenal glands (10%), ovaries (5%) and diaphragm (5%).
Symptoms from gastric carcinoma are often non specific and also completely absent for a long time and tumor can be already advanced at the time of the diagnosis. Epigastric pain syndrome, dyspepsia, anemia, weight loss and weakness represent the most common symptoms.
Prognosis and therapy of gastric carcinoma depend on the stage of the disease at the time of the diagnosis and the first challenge for clinicians is to define the extent of the tumor in order to plan the best treatment (Kim JH et al, 2007; Moschetta et al, 2010).
Besides, an early diagnosis and accurate staging are crucial for the choice of an accurate therapeutic approach and can also influence the survival rate (Habermann et al, 2004). Surgery remains the main therapeutic option and the choice of the most suitable treatment is determined by preoperative staging, which is based on diagnostic imaging.
Radiation therapy or chemotherapy are reserved in selected cases.

## 2. Diagnostic imaging

Gastric carcinoma diagnosis usually bases on conventional barium radiological studies and endoscopy which often remain the first-line examination in the diagnostic approach to patients suspected of having gastric carcinoma. Both these techniques can identify initial mucosal lesions and endoscopy also allows to perform biopsies which are crucial for differentiating benign from malignant lesions, especially in case of ulcerative forms.
Transparietal ultrasound is often used in order to search for liver metastases and lymph node metastases (Stabile Ianora et al, 2001). Usually, the use of this tool complements computed tomography examination and could be useful in case of thin patients with low representation of fat planes.
Endoscopic ultrasound allows the identification of gastric wall stratification and the visualization of the different layers composing the gastric wall both in normal and pathological conditions. Diagnostic accuracy values from between 85% and 91% are

reported in literature for the evaluation of T parameter and from between 74% and 78% for N staging (Botet et al, 1991; Dittler & Siewert, 1993; Tunaci et al, 2002).
However, it represents an invasive and operator-dependent technique which does not allow the study of gastric walls below stenosing tumors or the visualization of distant lymphadenopathies or metastases (Ahn et al, 2009; Kwee et al, 2007; Moschetta et al, 2010).
The role of magnetic resonance imaging in the staging of gastric carcinoma is still unclear, but the use of this technique is increasing in this field, especially in case of pregnant women or in case of patients for whom uro-angiographic contrast agents are contraindicated. The reported accuracy values for magnetic resonance imaging range from 73% to 88% for T staging and from 55% to 65% for N staging (Arocena et al, 2006; Kim AY et al, 2000a, 2000b; Motohara et al, 2002; Sohn et al, 2000; Wang C-K et al, 2000). However, magnetic resonance imaging has some limitations, represented by longer examination time, motion artifacts and high cost.

## 3. Computed tomography

Computed tomography actually remains the most common and widespread tool for the staging of the disease and its reported accuracy values vary depending on the study technique and the device used (Moschetta et al, 2010; Stabile Ianora et al, 2001). In fact, computed tomography represents a valuable tool in addiction to gastroscopy and endoscopic ultrasound in the preoperative staging of gastric cancer.
It is the modality of choice for planning curative or palliative surgery and provides useful information for comparison during chemotherapy in patients with inoperable carcinomas (Yang et al, 2007).
The depth evaluation of gastric carcinoma mural invasion is improved with the clinical application of multidetector devices and multiplanar reconstructions. Therefore, multidetector computed tomography currently remains the most commonly used examination in the preoperative gastric cancer staging, with faster examination times and higher spatial resolution. In fact, it allows to acquire isotropic voxels and to reduce motion artifacts as compared to single-detector devices and the resulting benefits are represented by a better image quality in axial, coronal and sagittal planes and also better quality reconstructions, with an overall greater diagnostic accuracy.
Besides, the depth of tumor invasion has been shown to be a very important prognostic factor for these patients and the role of computed tomography is becoming stronger as technology improves, especially with bi-dimensional imaging (multi-planar reconstructions), tridimensional reconstructions (Volume Rendering) and virtual endoscopy (Blackshaw et al, 2005; Horton & Fishman, 2003; Moschetta et al, 2010).
The role of computed tomography in the study of gastric carcinoma is mainly represented by preoperative local and distant staging; post-therapeutic control and follow-up; incidental detection of gastric carcinoma during CT examination performed for other pathological conditions.

## 4. CT protocol

CT protocol is very important because it can affect the quality of CT examination.
First of all, before computed tomography examination, patients should be prepared by at least five hour fasting in order to empty the stomach.

Then, an adequate gastric distension is mandatory for the study of gastric walls; in fact, if stomach is not adequately distended, small gastric carcinomas can be misdiagnosed or collapsed gastric walls can simulate pathological conditions.
The gastric study on computed tomography examination needs therefore an adequate distension that can be obtained by using endoluminal contrast agents in order to distinguish gastric lumen and walls from adjacent structures and to allow an accurate evaluation of gastric wall thickness.
Gastrointestinal contrast agents can be subdivided in high density or positive and low density or negative agents, basing on the density values as compared with gastric walls. High density agents are mostly represented by diatrizoate and methyl-glucamine water solutions or barium solutions, the latest rarely used in this field.
Low density contrast agents are represented by water, air or CO2.
High density contrast agents are usually used in order to evaluate extra-gastric conditions, and in these cases gastric lumen and bowel loops are accurately delineated.
On the contrary, when a detailed study of gastric walls is required, it is better to avoid high density contrast agents because gastric walls present an increment of density after intravenous injection of contrast material in the site of lesion and small parietal lesions can be misdiagnosed because of the high density of gastric content. Occasionally, positive oral contrast agents may not mix uniformly with gastric contents and pseudotumors can be created.
Besides, also vascular or tridimensional studies can be difficult in case of high density agent's use. In fact, positive contrast agents can interfere with data manipulation during tri-dimensional imaging of the abdomen and necessitate extensive editing (Kim AY et al, 2005).
Therefore, in case of CT gastric carcinoma staging, the use of low density contrast material is preferred (Angelelli et al, 1987; Angelelli & Macarini, 1988; Moschetta et al, 2010; Rossi et al, 1997; Shimizu et al, 2005).
Among low density contrast materials, water represents a simple agent, with no cost or complication rate, well tolerated by patients and able to accurately distend the gastric cavity. Generally, a variable quantity from between 400 ml and 750 ml is ingested by patients ten minutes before CT examination, with a supplementary dose of 250 ml immediately before the scan.
Air also represents an accurate contrast agent for gastric evaluation on computed tomography, especially when virtual gastric endoscopy is planned in patients suspected of having gastric carcinoma. It can be administered as effervescent powders of bicarbonate or citric acid, which allow an optimal gastric distension.
Computed tomography examination also requires intravenous injection of iodinated contrast material which is mandatory to differentiate pathological tissue from normal mucosa and to obtain useful information for tumor characterization.
Usually, a quantity of 100-150 ml (mean value of 1.5 ml/kg body weight) is injected at 3-4 ml/sec.
The optimization of contrast material injection is essential in the era of multi-detector computed tomography, with higher time resolution. Although portal venous phase performed at 60-70 seconds from the intravenous injection is generally sufficient for a correct study of gastric walls, an additional arterial phase performed at 30-35 seconds from intravenous injection is useful for the staging of gastric primary lesions and for a better evaluation of the enhancement difference between gastric lesions and the adjacent normal tissue. Usually, the arterial phase is performed for upper abdomen while portal venous

phase includes thorax, abdomen and pelvis scanning, in order to perform distant staging of the disease.
Actually, bolus tracking and automated triggering technologies are generally used in order to obtain a correct biphasic technique basing on patient's characteristics.
Finally, in order to induce gastric wall hypotonia and decrease peristaltic bowel movement, 20 mg of scopolamine-N-butyl bromide can be intramuscularly or intravenously injected before CT examination.
CT scans are usually acquired in supine position; in rare cases, oblique patient position is recommended in order to evaluate some gastric portions, such as antrum or fundus (Moschetta et al, 2010; Shirakawa et al, 1996).

## 5. Image analysis

Computed tomography axial images and reconstructions are usually examined for diagnosis. Bi-dimensional multi-planar reconstructions on coronal and sagittal planes and tridimensional volume rendering reconstructions can be used in order to accurately diagnose and stage primary lesions (D'Elia et al, 2000) (Fig. 1).

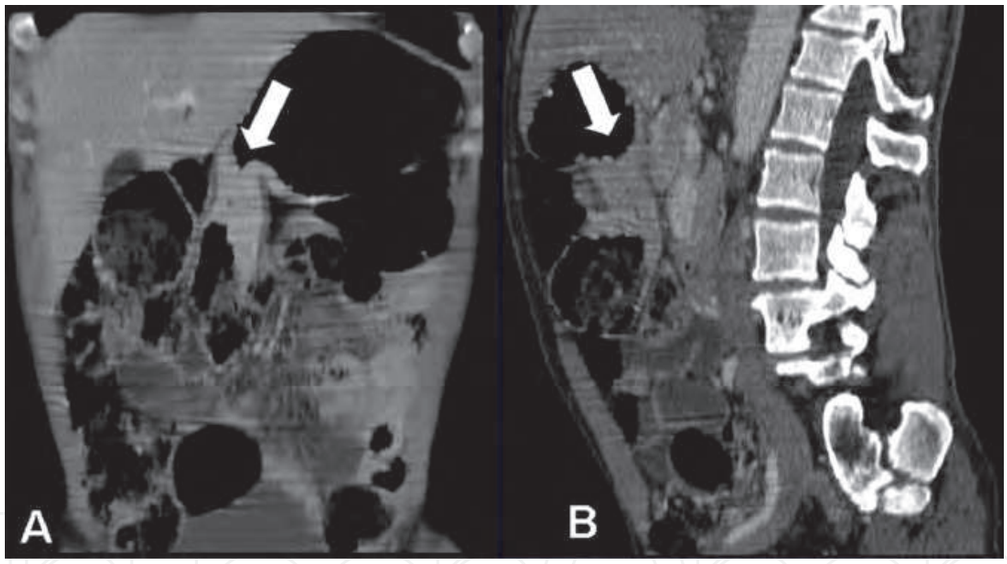


Fig. 1. Gastric carcinoma. A. CT Coronal Reconstruction. B. CT Sagittal Reconstruction. The tumor appears as an irregular wall thickening (arrows).

In case of air distension, virtual gastroscopy can be performed with endoluminal navigation and a direct visualization of gastric mucosal features (Fig. 2). Virtual endoscopy represents a tri-dimensional endoluminal-perspective image, which simulates the endoluminal views at gastroscopy. The detection of gastric cancer may be improved by multi-detector computed tomography with virtual gastroscopy (Bhandari et al, 2004; Kim HJ et al, 2005).
Besides, when ulcerative forms occur, virtual gastroscopy can also provide useful information for differentiating benign from malignant ulcers. In fact, benign ulcers usually present smooth and regular shapes, clearly demarcated and regular edges, with gastric fold tapering and converging toward the ulcer; on the contrary, in case of malignant ulcers, irregular shaped and asymmetric edges, disrupted appearance of peri-ulcer folds near the crater edge and fused folds can be identified.

On the other side, the use of a multiphasic technique after intravenous injection of contrast material allows to obtain an accurate imaging of gastric carcinoma and computed tomography can provide a complete dynamic visualization of the gastric walls in the site of carcinoma, enabling the calculation of whole-organ perfusion maps. In fact, computed tomography perfusion carries the potential to improve detection of gastric carcinoma due to the perfusion differences.

Recently, a new computed tomography reconstruction protocol called Vessel Probe in multi-planar mode has been shown to increase the diagnostic accuracy in T staging of gastric carcinoma in association with the water-filling technique for gastric distension (Moschetta et al, 2010).

The arterial phase is generally used to evaluate the T staging in these cases, in order to take advantage of the maximum enhancement of the gastric wall, which is essential to use vessel probe software.

Vessel Probe is a programme that allows vessels to be simultaneously examined in tri-dimensional, curved reformat and cross-sectional reformat views. It can study and measure arteries from between 0.5 and 18 mm in diameter and calculate the degree of stenosis. It can display images in a variety of formats, including automatic and simultaneous orthogonal cross-sections, orthogonal multi-planar, oblique and curved reconstructions, tri-dimensional and curved reformat views.

This fast and simple to use software can also be useful for examining the gastric wall on contrast-enhanced multi-detector computed tomography, clicking on the gastric wall in the lesion site. Starting from simple transverse images, Vessel Probe in multi-planar mode

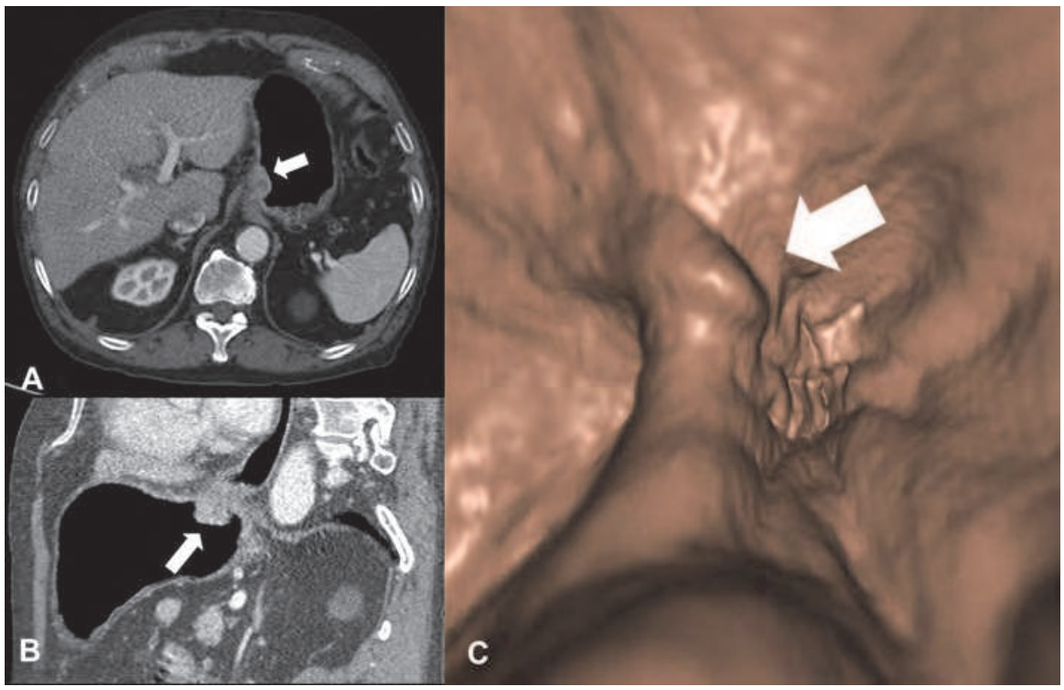


Fig. 2. Gastric carcinoma. A. CT transverse scan. B. CT multi-planar reconstruction on sagittal plane. C. Tri-dimensional virtual gastroscopy. The tumor appears as an irregular wall thickening protruding within gastric lumen and affecting the proximal tract of the stomach (arrows). Stomach has been distended by air.

automatically generates a reference line along the major axis of structures with the maximum enhancement values and displays the best views in multiple curved planes.
It also explores the whole thickness of the gastric wall and adjacent structures, which can be useful for T staging.

## 6. CT findings

Gastric carcinoma usually appears as an irregular wall thickening with high density after intravenous injection of contrast material, as compared with the contiguous normal gastric walls (Fig. 3). In the arterial phase, the neoplasm features a markedly greater density than the adjacent gastric walls, while in the venous phase this enhancement usually fades (Angelelli et al, 2001). More voluminous lesions can appear inhomogeneous because of the presence of necrotic areas.

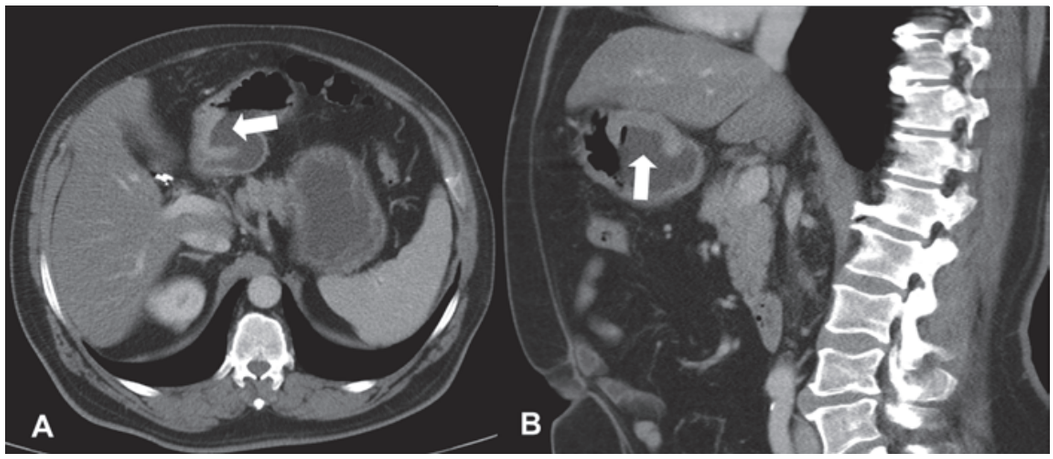


Fig. 3. Gastric carcinoma located on the antro-pyloric tract. A. CT transverse scan. B. CT reconstruction on sagittal plane. The tumor causes a focal area of irregular wall thickening with ulcerative features (arrows). Stomach has been distended by water.

Sometimes, during computed tomography examination of the abdomen performed for variable clinical or pathological conditions, gastric wall neoplastic thickenings can be incidentally detected.
Gastric carcinoma is generally subdivided in "early gastric cancer" and "advanced gastric cancer".
Early gastric cancer could have different forms:
Type I: lesion protruding more than 5 mm within gastric lumen;
Type IIa: lesion protruding less than 5 mm;
Type IIb: flat lesion;
Type IIc: concave lesion (not reaching muscularis mucosae);
Type III: ulcerative lesion (it reaches the muscolaris mucosae but not the muscolaris propria).
Multi-detector computed tomography examination allows to identify type I initial lesions while type II and III lesions can be more difficult to detect (Ba-Ssalamah et al, 2003). Sometimes, the histological characteristics can also influence the enhancement pattern of the primary lesion; in fact, it has been demonstrated that when a high mucin content is present,

the tumor can have low enhancement values also in the arterial phase and it can be very difficult to identify, especially when a thickening of gastric walls is not associated (Chen et al, 2007; Moschetta et al, 2010; Tunaci et al, 2002).

On the contrary, when adequate gastric distension is obtained, advanced cancer is usually easy to recognize at computed tomography examination and in 94% of cases it causes a circumscribed or diffuse wall thickening with associate ulcers or protruding lesions.

In case of linitis plastica, wall thickening is diffuse and circumferential with absence of the normal gastric folding. Besides, wall thickening can be variable and in some cases it can reach a diameter of some centimeters (Angelelli et al, 1990; Fukuya, 1997; Stabile Ianora et al, 2001).

In 6% of cases, tumor appears like a polypoid mass with a large implant base, or a vegetating lesion within gastric lumen and contiguous gastric walls can generally be thickened.

Neoplastic tissue usually presents low density values on computed tomography examination without contrast material injection as compared with normal gastric walls.

After intravenous injection of contrast medium, an increment of density values can be detected in most of the cases and rarely the tumor can appear isodense. The most voluminous tumors are inhomogeneous because of the presence of intralesional low density and colliquative areas. Rarely, some intralesional calcifications can also be detected.

Generally, a high density wall thickening should indicate gastric carcinoma; however, diagnosis should be always controlled by endoscopy and biopsy.

On the contrary, an isodense wall thickening is generally unspecific, and differential diagnosis with lymphomas, peptic ulcers, chronic gastritis, intestinal metaplasia, Zollinger-Ellison syndrome, amiloidosis, eosinophilic gastritis and Menetrier syndrome could be difficult in these cases.

In case of gastric carcinoma diagnosis, depth of intramural infiltration, extension towards contiguous structures and local and distant metastasis need to be evaluated.

Based on its appearance in the arterial phase, the gastric wall is defined as single-layered when only one high density layer can be visualised, or multi-layered when an inner high density and an outer low density layer can be identified.

T staging performed by computed tomography is crucial for the therapeutic approach to these patients and its precise diagnostic accuracy remains controversial (Kadowaki et al, 2000; Kumano S et al, 2005; Minami et al, 1997).

According to the TNM classification and computed tomography staging criteria, T1 tumors invade lamina propria or submucosal layer and can appear as circumscribed wall thickening with intense focal enhancement or intense enhancement only, without wall thickening or circumscribed wall thickening with intense enhancement of inner layer and a low density streak corresponding to the non infiltrated muscolaris propria coat on computed tomography examination.

T2 tumors invade the muscolaris propria or subserosa and appear as thickening of entire gastric wall with homogeneous or inhomogeneous enhancement, regular surface of the outer layer of gastric wall at the lesion site and normal appearance of perigastric fat.

T3 gastric carcinomas invade serosa without infiltration of adjacent structures and generally are represented by thickening of entire gastric wall with homogeneous or inhomogeneous enhancement, irregular surface of the outer layer of gastric wall at the lesion site and presence of micronodules or dense stranding in the perigastric fat on computed tomography examination.

Finally, T4 gastric tumors are characterized by the invasion of adjacent structures and the obliteration of the fat cleavage plane between the neoplastic lesion and adjacent organs.

Diagnostic accuracy values from between 41% and 98% have been reported in literature for the computed tomography evaluation of T parameter (Moschetta, 2010; Stabile Ianora, 2003); the controversy with regard to the effective role of this tool for the T staging of gastric cancer, especially in the evaluation of early gastric cancer, probably bases on the different used technique. In fact, the increasing values reported in recent studies are probably due to the high quality of multi-planar images produced by using a thin-slice collimation, isotropic voxels and better z-axis resolution.

As already reported before, some interesting new data emerge with regard to the differentiation between various T stages by using the Vessel Probe reconstructions (Moschetta et al, 2010).

This programme allows good detail of the gastric wall architecture to be obtained after the intravenous injection of contrast material and it can improve the diagnostic accuracy in the evaluation of the tumor invasion depth by analysing the wall enhancement in the lesion site. Generally, images obtained during the arterial phase are useful for the application of the Vessel Probe in the T staging because of the tumor hypervascularity and neovascularity (Lee JH et al, 2007; Moschetta et al, 2010). In fact, by using the tumor enhancement, the Vessel Probe algorithm permits a more accurate view of the gastric wall stratification as compared with the other computed tomography reconstructions. The high quality of these new reconstructions can also help to solve the problem of the differentiation between T2 and T3 gastric carcinoma. In fact, the reticular and dense stranding in the perilesional fat and the irregular appearance of the outer surface of the gastric walls can usually identify T3 carcinomas, but can also be seen in inflammatory reactions without cancer infiltration (Chen et al, 2006; Takao et al, 1998).

Vessel Probe reformatting images reduce partial volume artifacts and improve the evaluation of the gastric wall surface in orthogonal views.

Besides, the high spatial resolution may be helpful when the fat cleavage plane between the tumor and the adjacent organs is oblique or parallel to the imaging direction.

Finally, this kind of automatic post-processing can be obtained in a few minutes per patient and is therefore faster than tri-dimensional imaging of the gastric cancer, especially with regard to virtual gastroscopy; compared with simple multi-planar reconstructions, Vessel Probe algorithm allows the best view of gastric wall stratification to be automatically displayed in the lesion site, by simultaneously reconstructing images in multiplanar, perpendicular curved and oblique planar reformats (Fig. 4).

Gastric tumor located on the proximal part of the stomach can involve peritoneum, left liver lobe, diaphragm, spleen and aorta; tumors located on the distal tract can also involve the pancreas.

The main criteria for the diagnosis of tumor diffusion towards contiguous structures are based on the evaluation of perigastric fat tissue which can be preserved or infiltrated by high density stranding. However, in patients with poor nutritional conditions with a low representation of fat tissue, it could be difficult to evaluate the anatomical relationships of a tumor located on the posterior gastric surface with adjacent structures, such as pancreas. Besides, as reported before, the irregular extern gastric surface or the presence of dense tissue within the perigastric fat tissue could sometimes be determined by desmoplastic or inflammatory reactions. In these cases, overstaging can occur.

Some experiences also reported that a neoplastic involvement of adjacent organs was present, although a clear perigastric adipose clivage was identifiable, thus determining understaging mistakes.

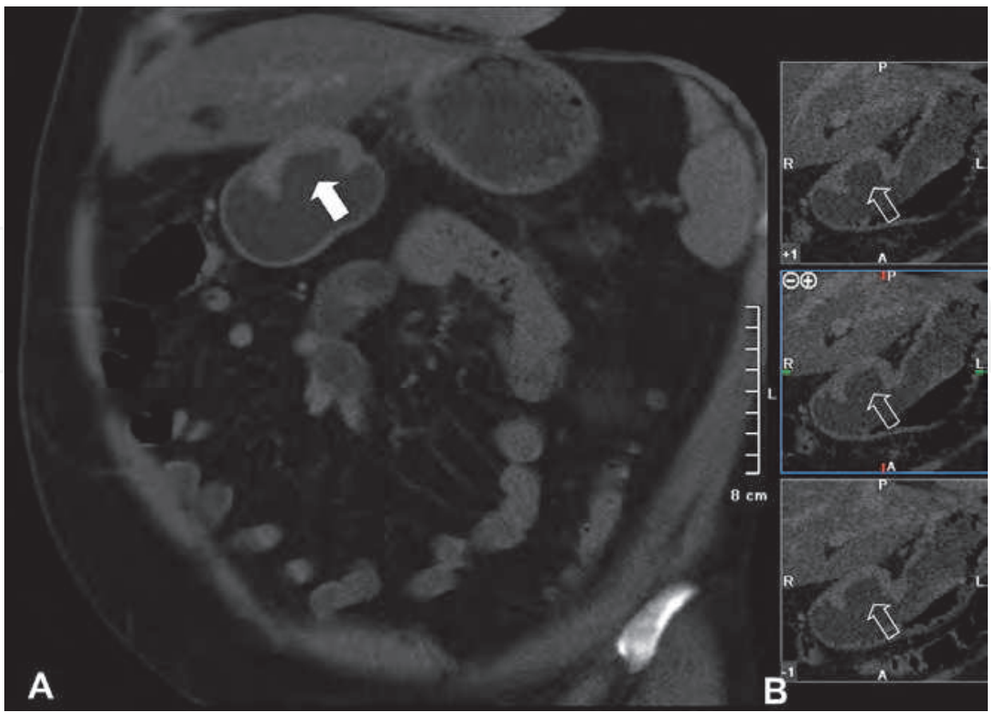


Fig. 4. Gastric ulcerative carcinoma. Same patient as in Fig. 3. A. CT reconstruction on oblique coronal plane. The tumor appears as an ulcerating wall thickening (arrow). B. Vessel Probe reconstructions allow to obtain a better identification of the gastric wall in the lesion site (empty arrows).

Sometimes, gastric carcinoma can also involve the mesocolon or gastro-splenic, gastro-hepatic and hepato-duodenal ligaments through the sierosa.

The identification of peritoneal involvement could be very difficult on computed tomography and often it can be possible only in advanced forms. Ascites and peritoneal nodules, mostly located on the mesocolon, represent the most common signs in these cases.

Lymph nodal involvement is generally recognized in 74 - 88% of patients with gastric carcinoma because of a wide perigastric net of lymphatic drain and its incidence can be related to tumor size and depth of infiltration. N staging need to involve all 16 nodal perigastric stations and it is recommended to distinguish between the involvement of perigastric nodal sites, with a distance of less then 3 cm from the organ, and extragastric nodal sites, for example following the left gastric artery, the common hepatic artery, the splenic artery or the celiac trunk, or distant nodal metastases, for example at the hepato-duodenal ligament, retropancreatic, mesenteric or para-aortic sites (Fig. 5). In fact, all gastric carcinomas with involvement of perigastric lymph nodes located at less than 3 cm away from the primary lesion are classified as N1; those with involvement of extragastric lymph nodes located at more than 3 cm away from the primary lesion as N2; finally, N3 forms involve lymph nodes of retroperitoneum or the hepatic-duodenal ligament.

Because of the panoramic view and anatomical detail, computed tomography represents a fundamental examination for recognizing locoregional, perigastric and distant adenopathies.

However, computed tomography evaluation of N parameter is still actually challenging and still has several limitations in this field, with a reported accuracy value of 70%. In fact,

computed tomography is not able to identify neoplastic lymph nodes with normal size (false negatives) or it can not differentiate larger reactive lymph nodes (false positives).
In order to reduce the number of false positives, number and enhancement values of lymph nodes could be also considered. The presence of numerous lymphadenopathies suggest a metastatic disease in 96% of cases while a single larger lymph node in 48% of cases. Metastatic lymph nodes are often characterized by different enhancement values as compared with normal nodes.
Other difficulties in this field can be represented by the site of lymph nodes, the morphology of the tumor and the patient characteristics. In fact, in case of voluminous tumors with a prevalent extragastric development it can be difficult to detect lymph nodes strictly adherent to the gastric walls.
Moreover, some nodal sites are more difficult to explore, such as paracardial or hepato-duodenal sites.
Finally, patient's characteristics are also important because, in case of cachectic subjects with poor adipose representation, it can be more difficult to recognize lymphadenopaties.
Therefore, computed tomography is relatively insensitive and also non specific for detecting nodal metastases because of its inability to recognize microscopic nodal invasion, which is common in gastric carcinoma, and the presence of reactive lymph nodes that may have increased size. Multi-planar reconstruction seem slightly better than transverse images for N staging (Chen et al, 2007). In fact, they can provide more accurate measurement of lymph node size and better differentiation between lymph nodes and small perigastric vessels (Fig. 6).
Thus, it is recommended to indicate all visible lymph nodes, independently from diameter and indicating histology for definitive diagnosis and an accurate N staging.

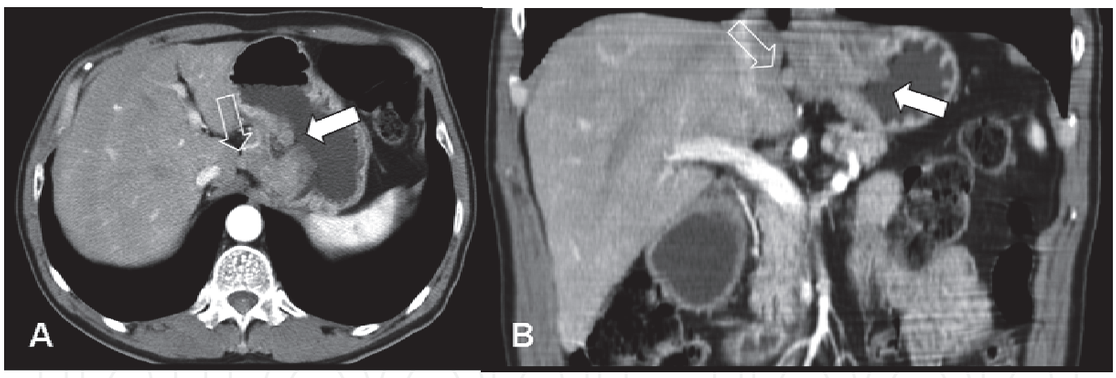


Fig. 5. A. CT Transverse Scan. B. CT Coronal Reconstruction. Gastric carcinoma causes an irregular wall thickening on the proximal tract of the stomach (arrows). Peri-gastric suspected lymph nodes are associated (empty arrows).

In planning treatment, it is essential to define the presence of any secondary localization of the disease. The staging of M parameter includes M0 stage, in case of absence of distant metastases and M1 stage, in case of presence of distant metastases. Haematic metastases more often involve the liver, because gastric venous drain is mostly performed by portal circle; less commonly, lungs, adrenal glands, kidneys, bone and brain can be involved. In advanced forms, peritoneal involvement occurs for contiguity and in women it can also cause ovarian metastases (Krukenberg tumors).
The diagnostic accuracy of computed tomography for the evaluation of the M parameter reaches 97% and 100% (Stabile Ianora et al, 2003).

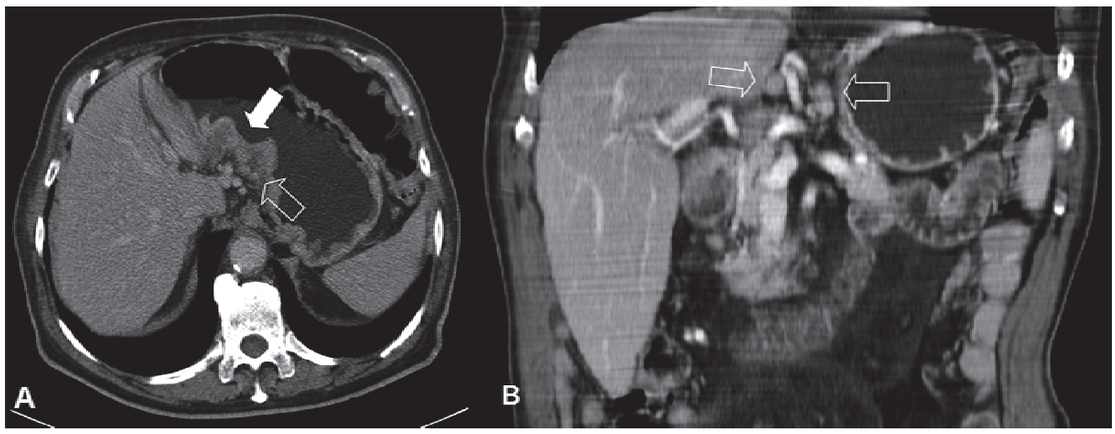


Fig. 6. A. CT Transverse Scan. B. CT Coronal Reconstruction. The tumoral tissue is well evident (arrow). Several suspected peri-gastric lymph nodes are associated (empty arrows).

## 7. Post-therapy control

In the past, traditional radiological studies were used in surgically treated patients with the possibility of providing morphological and functional information on the anastomosis and identifying mucosal lesions. These techniques are actually reserved to selected cases and widely replaced in clinical practice by endoscopy which allows a direct visualization of gastric mucosa with the possibility of performing biopsies in suspected areas.

Computed tomography imaging also represents an accurate technique in this field, because it allows to evaluate the anatomical relationships after surgical treatment and also the presence of complications, such as anastomosis dehiscence, hemorrhage or abscesses.

Neoplastic relapse such as extramural tumor or gastric stump carcinoma and distant metastases can be easily detected at follow-up performed by computed tomography examinations.

Gastric stump carcinoma is defined as primary tumor arising from the gastric stump, usually 15-20 years later partial gastrectomy.

Generally, the affected patients underwent gastro-jejunumstomy (Billroth II) rather than gastro-duodenostomy (Billroth I). These tumors are usually located on the distal tract of gastric stump, close to the anastomosis (Ba-Ssalamah et al, 2003).

A pathogenetic theory related to a biliary reflux above the anastomosis with consequent chronic gastritis and metaplasia has been proposed in these cases. Gastric stump carcinoma and neoplastic recurrences are detected on computed tomography as wall thickenings or small masses close to the anastomosis.

However, not all peri-anastomotic thickenings are caused by neoplastic recurrence, because they can be determined by surgical folds, bowel adhesions or polypoid hypertrophic gastritis.

An adequate technique and the use of multi-planar and tri-dimensional reconstructions with the possibility of virtual navigation within the lumen allow to increase diagnostic accuracy values, but in suspected cases it is mandatory an endoscopic and histological control (Quarticelli et al, 2004).

The contribution of computed tomography is also reliable in case of patients subjected to chemo-radiotherapy in order to evaluate the response to the therapy, although when

residual masses are detected, it can be difficult to differentiate the neoplastic or fibrotic nature of these lesions.

## 8. Conclusions

Computed tomography represents an accurate tool in case of gastric carcinoma. It is important to associate the axial image examination with the analysis of multi-planar, Vessel Probe and tri-dimensional reconstructions.
Multi-planar images are widely used; they increase diagnostic accuracy for the evaluation of the tumor extension, the anatomical relationships with contiguous organs and facilitate the identification of lymph nodal and distant metastases.
Vessel Probe reconstructions can facilitate T staging of gastric carcinoma, especially in the arterial phase of computed tomography examination.
Tri-dimensional reconstructions provide a volumetric evaluation of the gastric walls, with consequent diagnostic advantages in modifying the transparency levels and detecting vascular structures or gastric walls.
Virtual gastroscopy is also accurate in detecting gastric lesions, with the possibility of information which well correlate with traditional endoscopy findings.

## 9. References

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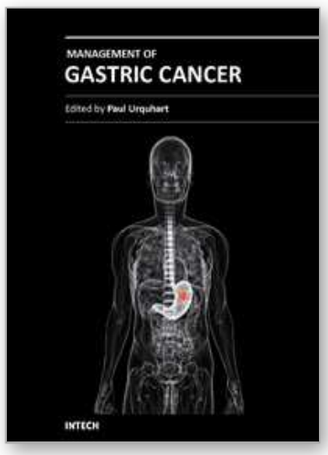


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Gastric cancer is the fifth most common cancer and the second most common cause of cancer death worldwide. More than 50% of the patients have advanced disease at diagnosis and in this case the disease has a poor outcome. The staging of gastric cancers is based on endoscopic ultrasound, computed tomography, magnetic resonance imaging, positron emission tomography, in addition to the laparoscopic staging. Many improvements in the surgical techniques have been seen in the last decade. Laparoscopic surgery is an emerging approach which offers important advantages: less blood loss, reduced postoperative pain, accelerated recovery, early return to normal bowel function and reduced hospital stay. D1 lymphadenectomy, with a goal of examining 15 or greater lymph nodes is a standard. D2 dissection is considered as a standard in several institutions especially in eastern Asia. Perioperative chemotherapy and adjuvant concurrent radiochemotherapy are recognized as standards treatments. Palliative chemotherapy is the mainstay treatment of advanced stages of the disease (metastatic and non-operable tumors). Despite these treatment advances, the prognosis of gastric cancer remains poor with a 5-year survival ranging from 10 to 15% in all stages combined.



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