

Esophageal cancer characterization with pneumo-64-MDCT

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Abstract

Early diagnosis and accurate staging of esophageal cancer are both essential for therapeutic strategy planning. Endoscopic ultrasound, CT, and positron emission tomography have all been used in the preoperative staging of esophageal cancer separately or in various combinations. Each imaging method has its strengths and weaknesses. Depiction of the tumor's anatomic location conditions the surgical strategy. Endoscopic ultrasound and PET have important advantages but neither provides information for surgical planning. CT scans have some limitations for hollow organ assessment in the absence of lumen distension, since the organ wall may be collapsed. Therefore, optimal esophageal distension could be very useful to overcome these limitations. This potential drawback is crucial at the level of the GE junction, a typically difficult region to evaluate. In order to optimize tumor visualization in the esophageal wall and in the GE junction, we developed a technique named pneumo-64-MDCT. We achieve maximum lumen distension, which better highlights the thickened areas in relation to the normal esophageal wall. At the present time, we have performed 200 studies with this technique and it proved useful, safe and accurate to identify esophageal wall thickening and to stage esophageal cancer. The additional stomach distension led to an adequate definition of both the upper and lower borders of the lesion in tumors located in the GE junction, which in turn was helpful to design the surgical approach.

Key words: Esophagus—Cancer—64-MDCT—Characterization—Surgery

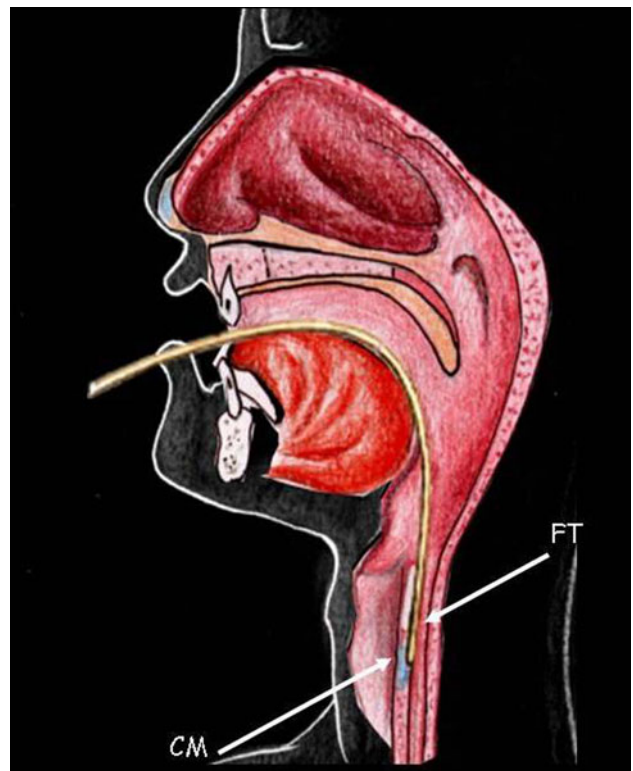


Fig. 1. Drawing showing the 14F Foley tube introduced trans-orally. CM, cricopharyngeal muscle; FT, Foley tube.

Esophageal cancer is the seventh leading cause of cancer deaths worldwide. While squamous cell carcinoma is the most prevalent histology internationally, adenocarcinoma of the distal esophagus accounts for nearly 50% of cases in developed countries due to the differences in the etiologic factors such as gastroesophageal reflux disease and obesity that predominate [1–3]. While surgery is the mainstay of treatment of this disease, the utilization of chemoradiation, either used postoperatively or neoadju-

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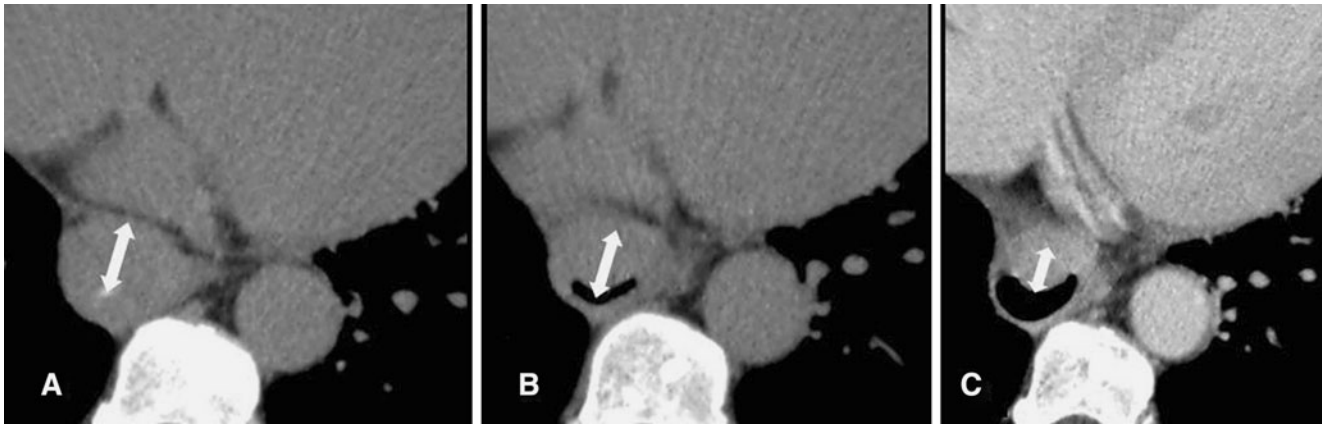


Fig. 2. Alternatives for distension. **A** Suboptimal distension with oral contrast agents. **B** Distension with effervescent granules shows better distension than **A**, but it is still subopti-

mal. **C** Optimal gastro-esophageal distension with Pn64MDCT. The *double arrow* shows how the wall thickening measurement is modified according to the degree of distension.

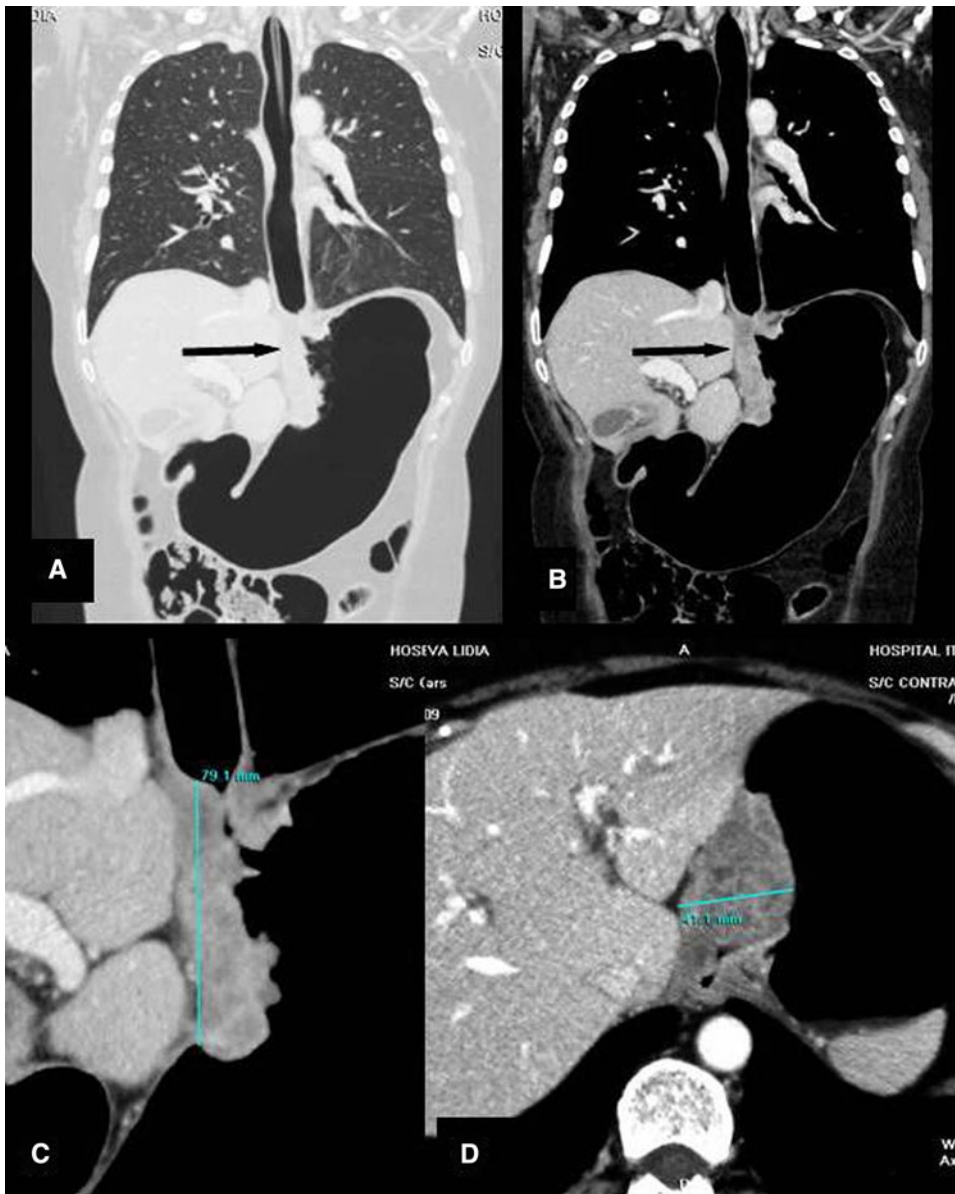


Fig. 3. Lesion characterization. **A** Lung window curved MPR. **B** Soft window curved MPR. **C** Magnification of image **B** showing the longitudinal extension of wall thickening. **D** Axial image showing the transverse measurement of the lesion.

vantly, has become a standard practice in the United States [4–6].

Despite the importance of pretreatment staging, no single test or combination of tests for staging esophageal cancer have been accepted as the standard of care [7, 8].

Conventional endoscopy (CE) is the established primary diagnostic investigation. Its strengths are that it is a simple diagnostic and available method, and it has low cost and is of rapid evaluation. Its weaknesses are that it is an invasive method, inaccurate for staging, or characterizing the lesion. High grade stenoses are difficult to be overcome by endoscopy [9, 10].

Barium studies (BS) are conventionally used; they share some advantages of CE adding evaluation of the long axis of the esophagus. However, BS is not a diagnostic method and also is inaccurate for staging [11, 12].

Endoscopic ultrasound (EUS) has been found to be the most accurate imaging modality for local T staging and loco regional lymphadenopathy, with a T staging accuracy of 75%–85% and N stage accuracy of 65%–75% [13–16]. However, EUS is unable to detect distant metastases, which obviously is the most important factor in determining when a cancer will be resectable at surgery and it provides no information for surgical planning. Another weakness of the method is the inability of current probes to cross-stenotic tumors [17].

Positron emission tomography (PET) scan has been more recently used in staging esophageal cancer. Examining biologic function by examining the uptake of glucose PET has the strength to evaluate both locoregional and distant spread of tumor [18–20]. PET weaknesses are its low availability and also lack of information for surgical planning [21].

Conventional CT is a simple, available, and a rapid evaluation method. It has been the first staging method used for staging esophageal cancer; with high accuracy for the detection of liver metastases but poor ability to accurately detect T4 disease because of local invasion or N1 local lymph node spread [7, 14, 22]. Conventional CT weakness for hollow organ assessment is that in the absence of lumen distension the organ wall may be collapsed [23].

Technique

In order to optimize tumor visualization in the esophageal wall and in the GE junction and to give information to the surgeon for the surgical approach, we developed a technique named pneumo-64-MDCT (Pn64MDCT) [24].

It consists in the transorally or transnasally introduction of a Foley catheter under local spray anesthesia. We settled it right below the cricopharyngeal muscles; continuous CO₂ is supplied and sustained during the acquisition with a pressure between 10 and 20 mmHG (Fig. 1). We achieve maximum lumen distension, which

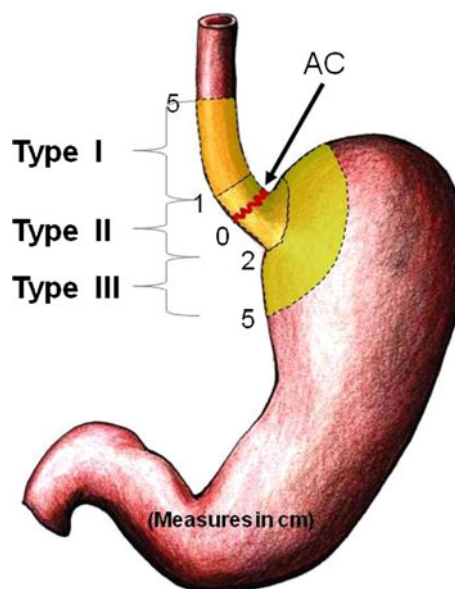


Fig. 4. Drawing showing Siewert classification. AC = anatomical cardia.

would better highlight the thickened areas in relation to the normal esophageal wall.

There are other well-known alternatives for esophageal and gastric lumen distension such as oral contrast agents or effervescent granules, but may be suboptimal due to contrast rapid transit, therefore, the required esophageal distension is not always achieved [25, 26]. Oral contrast enhancement may generate confusing images, with the same density as the tumor [22, 23]. Moreover, when wall thickening is quantified it can be distorted by the degree of lumen distension (Fig. 2).

At the present time, we have performed approximately 200 studies with this technique, demonstrating that the distension obtained was optimal in all cases. The additional stomach distension led to an adequate definition of both the upper and lower borders of the lesion in tumors located in the GE junction. Accordingly, surgeons find it useful to design the surgical approach and accurate to identify esophageal wall thickening [27].

Post-processing technique

First step

Multiphase reconstructions (MPR) and curved MPR are performed with different window settings in order to characterize the lesion. Also, a description of shape and location of the lesion as well as measurements of size and wall thickening are done (Fig. 3).

It is important for radiologists to become familiar and include in their reports the Siewert classification which is used by surgeons, endoscopists, and pathologists. It clearly specifies the subtype of GE junction adenocarcinoma (Fig. 4). Type I corresponds to adenocarcinoma of

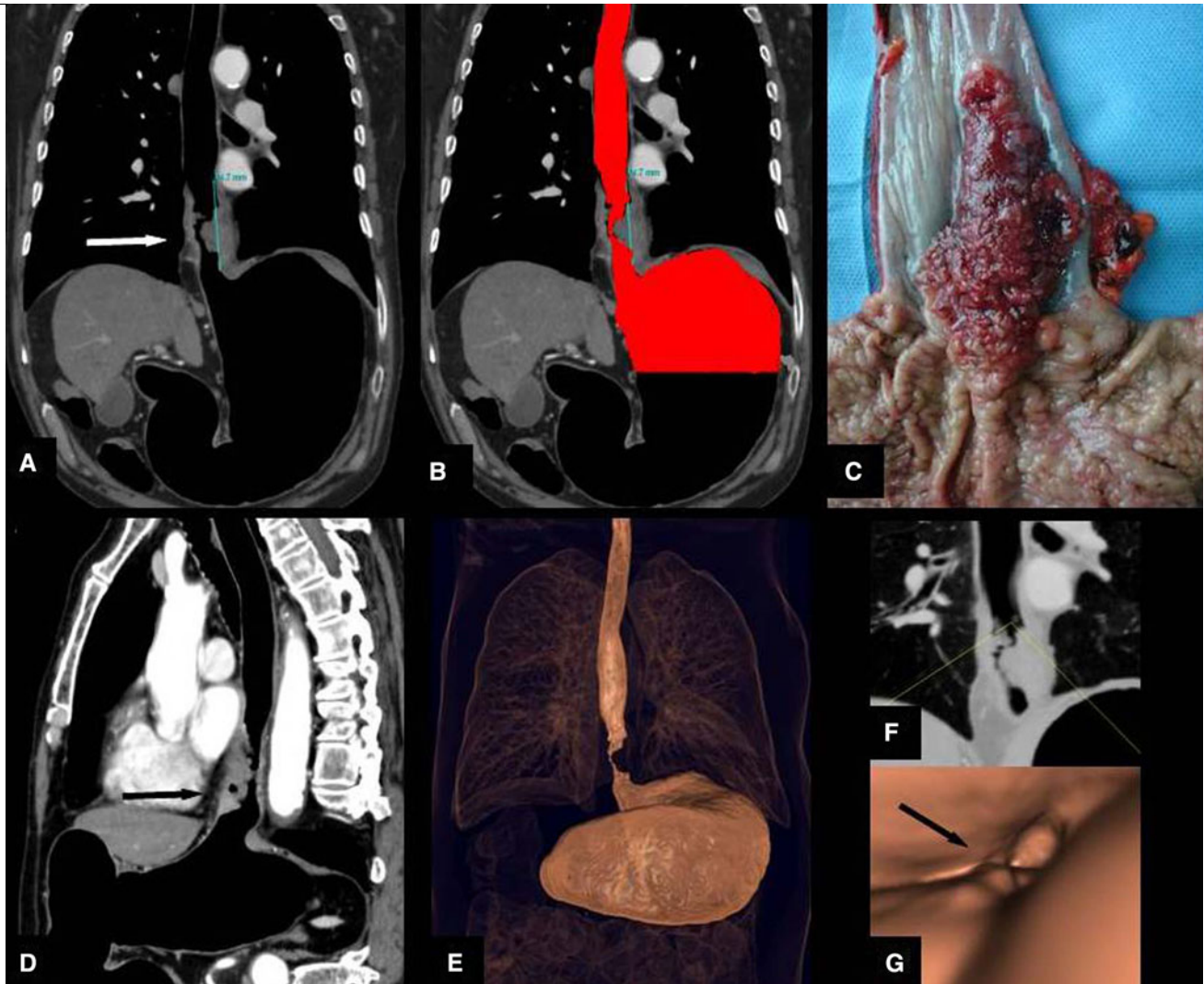


Fig. 5. Siewert type I adenocarcinoma. **A** Coronal MPR with soft tissue window showing an adenocarcinoma of the distal esophagus. **B** Coronal MPR with soft tissue window showing the surgical plan in *red* (total esophagectomy with partial gas-

trectomy). **C** Open specimen. **D** Sagittal MPR with soft tissue window. **E** 3D reconstruction with bone window. **F** Coronal MPR showing the reference of the virtual endoscopy image. **G** Virtual endoscopy. *White* and *black arrows* show the lesion.

the distal esophagus (Fig. 5), type II is a true adenocarcinoma of the cardia (Fig. 6), and type III is the subcardial adenocarcinoma (Fig. 7).

The utilization of chemoradiation, either used post-operatively or neoadjuvantly has become a standard of practice in the United States. Neoadjuvancy reduces the disease and improves the results of the radical surgery and long term survival rate [4–6]. In such cases, the use of pneumo-64-MDCT may be useful to compare the efficacy of pre-surgical treatment (Fig. 8).

Second step

Staging criteria for esophageal cancer include: depth of local invasion, regional and distant lymph node

involvement, and distant metastases. Therefore, at this step, evaluation of periesophageal fat stranding (Fig. 9), detection of lymph nodes (Fig. 10), and extraesophageal disease (Fig. 11) were performed. With good distension of the organ, MPR permits an improved characterization of the perivisceral extension of the tumor into the surrounding fat and the adjacent organs.

Third step

At this step, 3D reconstructions with different window settings (surface-shaded and transparent mode similar to the images obtained in single- and double-contrast barium studies) are done (Fig. 12). These images are easy-to-

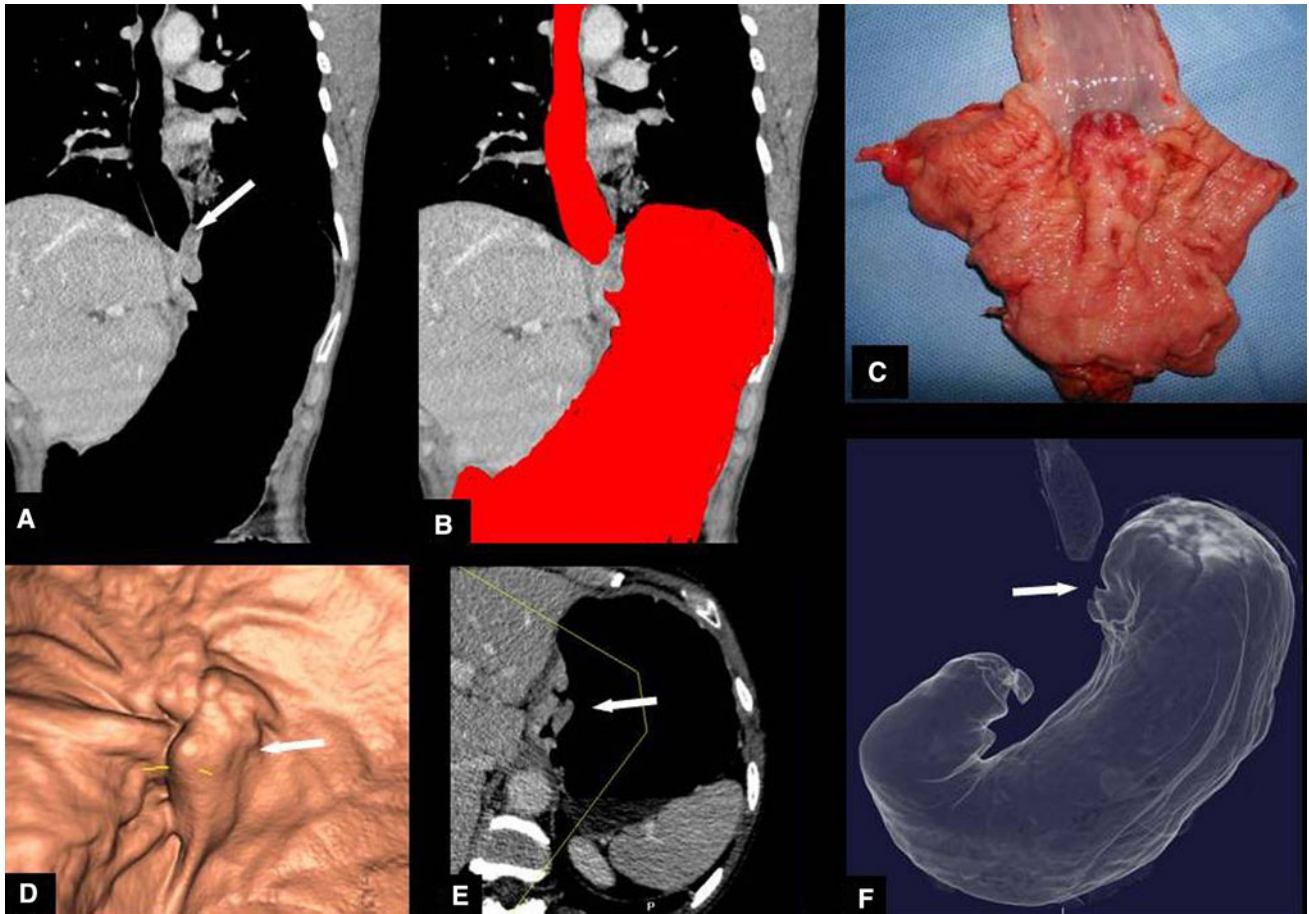


Fig. 6. Siewert type II adenocarcinoma. **A** Coronal MPR with soft tissue window showing an adenocarcinoma at the GE junction with cardia infiltration. **B** Coronal MPR with soft tissue window showing the surgical plan in red (total esoph-

agectomy and gastrectomy). **C** Open specimen. **D** Virtual endoscopy. **E** Axial image showing the reference of the virtual endoscopy image. **F** 3D reconstruction with transparency window. *White arrows* show the lesion.

understand and allow visualization of the pathology. Information regarding, panoramic and longitudinal extent of esophageal tumors may be obtained.

Fourth step

In this last step, we virtually introduce inside the esophagus lumen and generate endoluminal views that show the lesion morphology.

Virtual endoscopy images provide a view of the tumor from the back (Fig. 13). Complete or severe lumen occlusions do not represent an obstacle. With the virtual endoscopy tool, complete rotations can be performed and the cavity can be fully examined. It is also possible to navigate inside diverticula. At the same time, the relation to anatomic structures located outside the surface is continuously maintained and displayed in reference to the position of the viewed segment. Therefore, tumor site is accurately determined.

This combined interpretation of 2D axial and MPR images may provide enhanced diagnostic capability to stage cancers not only in the esophagus and stomach, also in other organs including the colon, pancreas, and biliary tree [27–33].

A CT drawback is that it cannot effectively differentiate paraesophageal nontumoral infiltration from tumor infiltration into adventitia and cannot exactly determine adjacent organ invasion [7, 9–14].

For the N stage, CT cannot differentiate benign causes of enlargement from metastatic tumor. In addition, enlarged lymph nodes adjacent to an esophageal cancer may not be detected because they are inseparable from the primary lesion [34].

In the case of exophytic malignant narrowing impeding the passage of the endoscope and in the cases of patients not amenable for endoscopy, there is a need for a noninvasive method for characterizing endoluminal tumors, for grading the stenosis, and visualizing the rest of the esophagus and the stomach beyond the stricture [17].



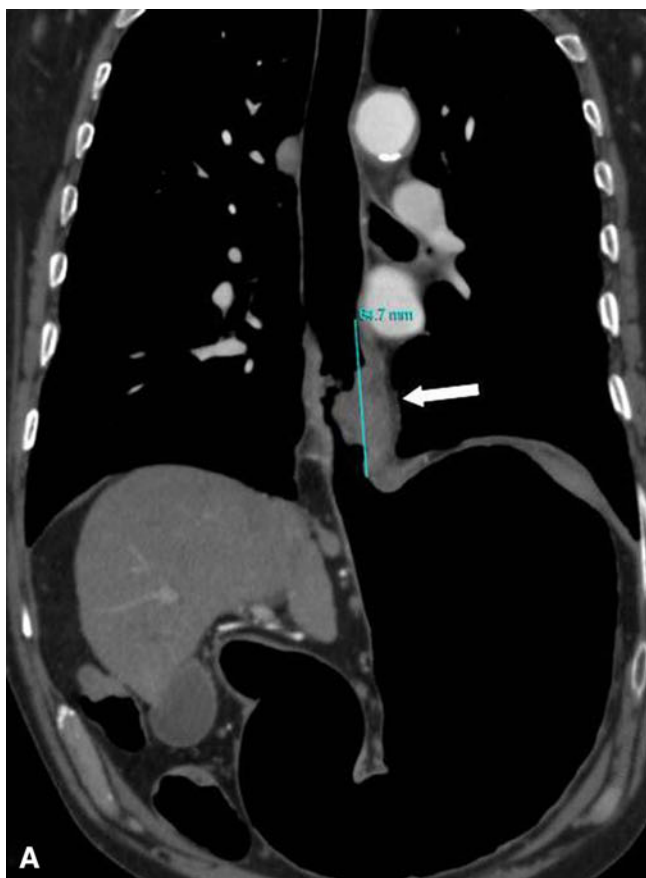
Fig. 7. Siewert type III adenocarcinoma. **A** Coronal MPR with soft tissue window showing a subcardial adenocarcinoma. **B** Coronal MPR with soft tissue window showing the surgical planification in *red* painted (partial esophagectomy and total

gastrectomy). **C** Sagittal MPR with soft tissue window. **D** Open specimen. **E** 3D reconstruction with transparency window. **F** 3D reconstruction with bone window. **G** Magnification of image **A**. **H** Virtual endoscopy. *White arrows* show the lesion.

Another application of pneumo-64-MCT may be evaluation of the stomach pathology due to the optimal gastric distension (Fig. 14).

Although pneumo-64-MDCT showed the presence of asymmetric thickening of the wall in most of the tumors tested, we did not compare the thickening observed on CT with the surgical specimen. This analysis is underway and will result in a forthcoming publication.

In conclusion, pneumo-64-MDCT provides key information for therapeutic strategy due to the additional gastric distension. It helps to define both upper and lower borders of tumors located in the GE transition zone. It can be considered a useful and non-invasive imaging technique for evaluating esophageal and GE junction wall thickening and extraesophageal disease in a single examination.



◀ Fig. 8. Usefulness of Pn64MDCT in the evaluation of the response to neoadjuvancy. **A** MPR with soft window showing the thickening of esophageal wall before chemo and radiotherapy. **B** Same patient, showing markedly reduced thickening of esophageal wall after chemo and radiotherapy. *White arrows* show the lesion.

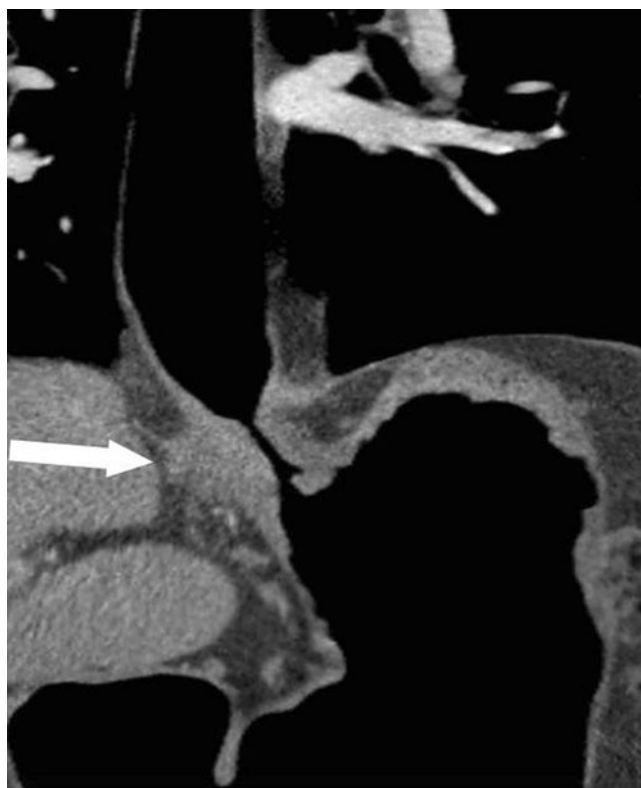


Fig. 9. Evaluation of periesophageal fat stranding. *White arrow* shows the extension of lesion compromising the periesophageal fat.

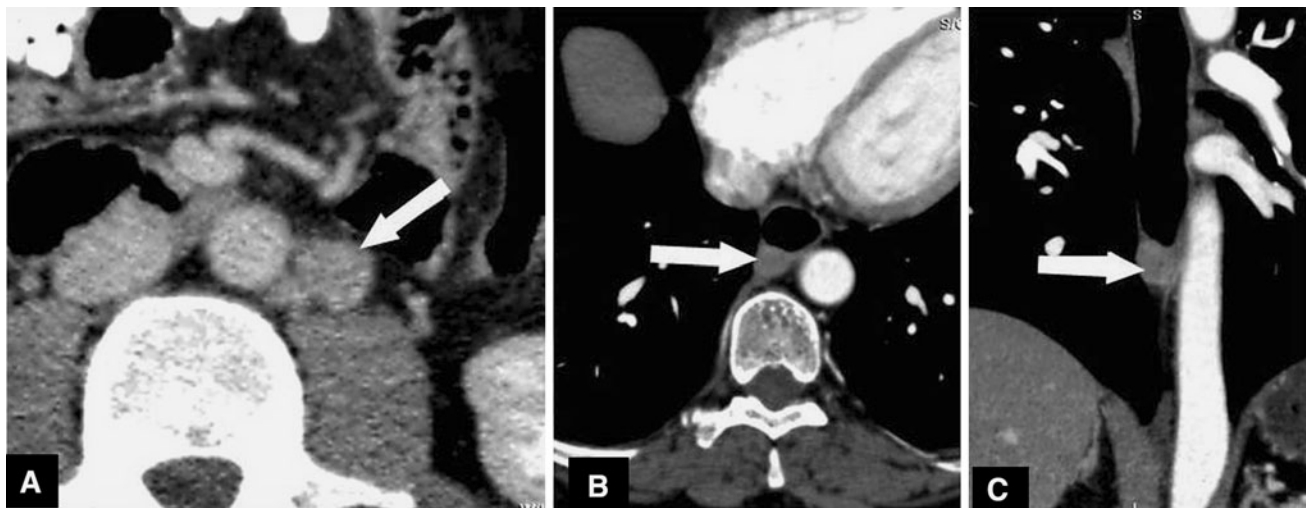


Fig. 10. Lymph node detection. **A** Axial image showing a retroperitoneal lymphadenopathy next to the aorta. **B** and **C** Axial and coronal image showing a mediastinum lymphadenopathy next to the esophagus. *White arrows* show the lymphadenopathy.

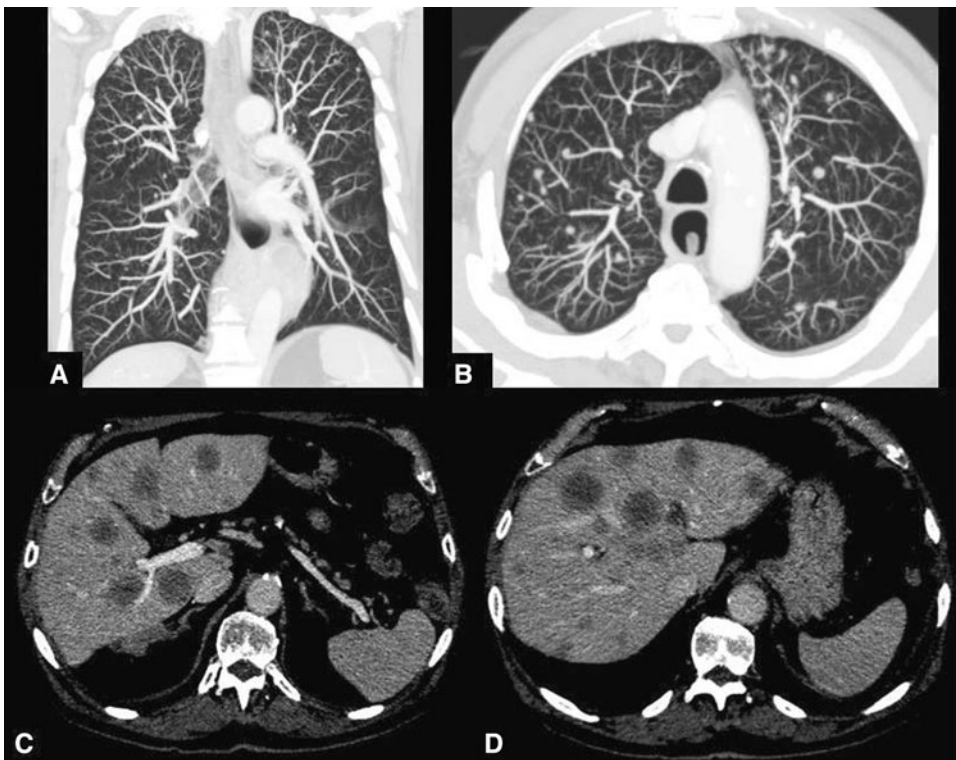


Fig. 11. Extraesophageal disease. **A** and **B** Coronal and axial MIP showing lung distant metastases. **C** and **D** Axial images showing liver distant metastases.

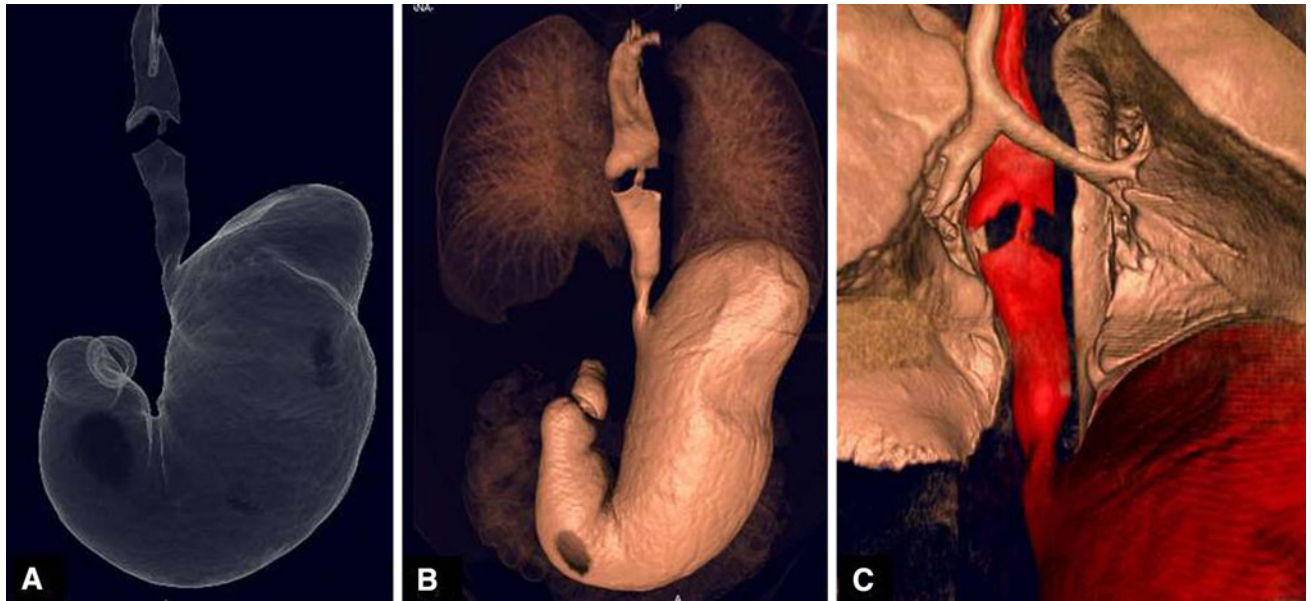


Fig. 12. 3D reconstructions. **A** Transparency window image. **B** Bone window reconstruction. **C** Bone window reconstruction showing the anatomical detail and relationship of the tumor to tracheo-bronchial structures.

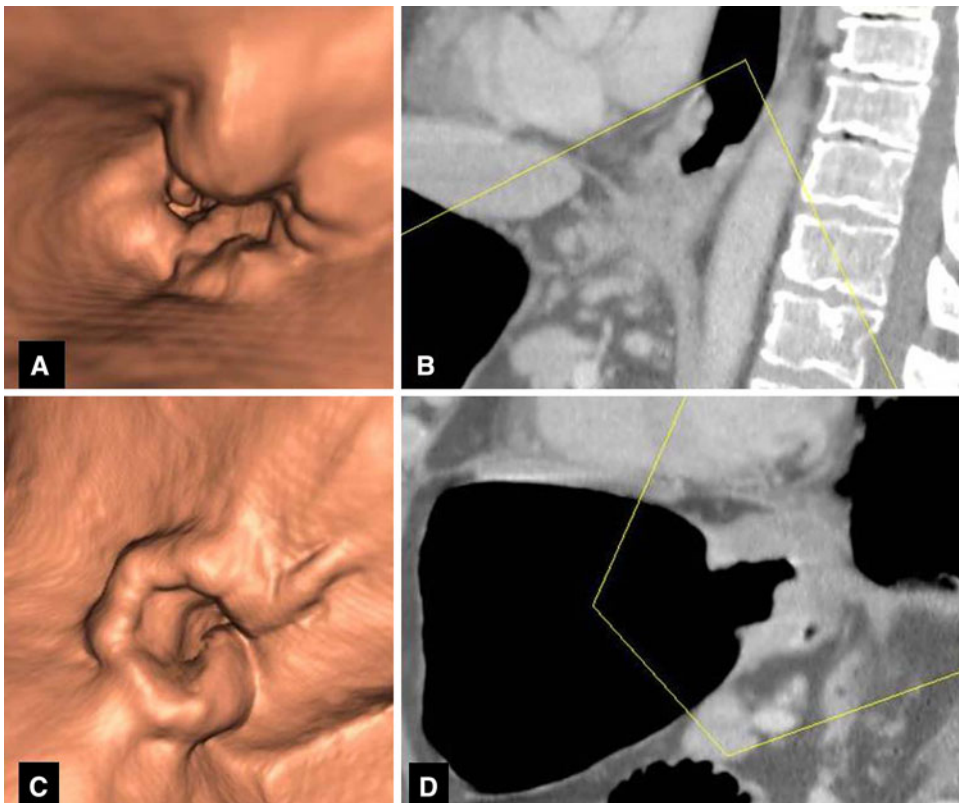


Fig. 13. Virtual endoscopy. **A** Virtual endoscopy view of the esophagus depicting the endoluminal vegetation and stenosis. **B** Sagittal image showing the reference of the virtual endoscopy image. **C** Virtual endoscopy view from the stomach, crossing the stenosis depicting the endoluminal vegetation. **D** Sagittal image showing the reference of the virtual endoscopy image.

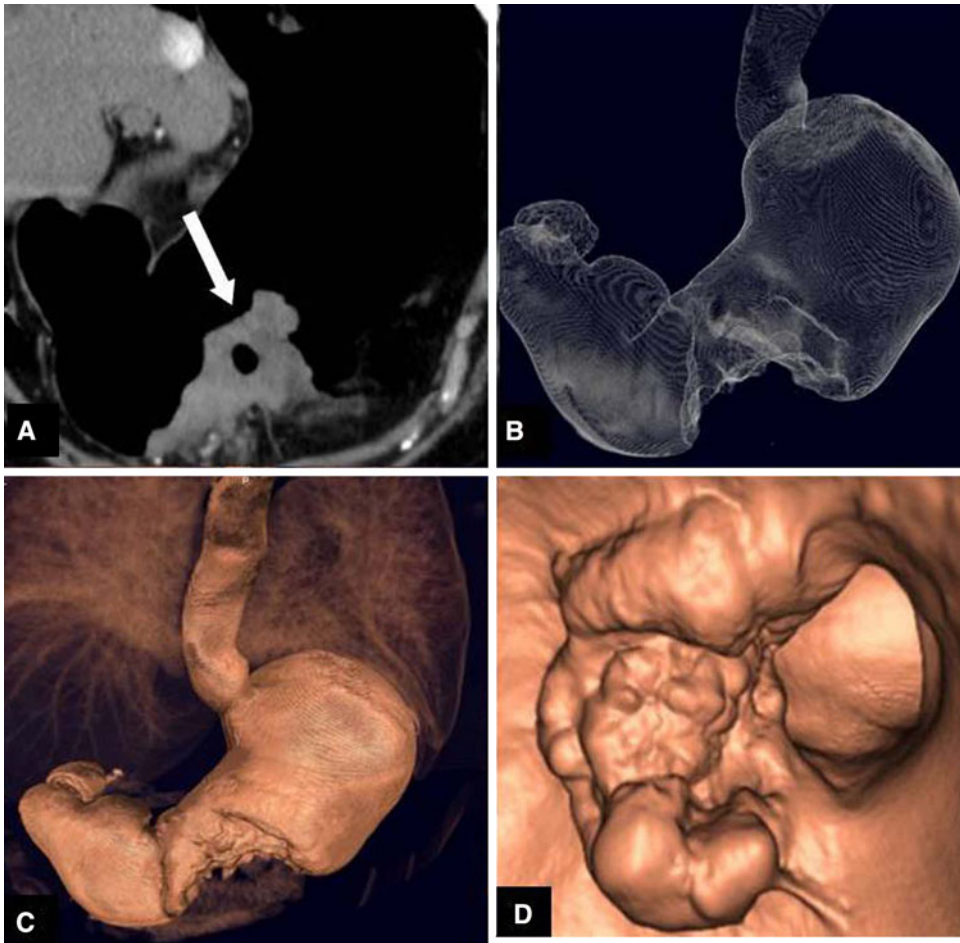


Fig. 14. Advanced gastric cancer located in the major gastric curvature. **A** Coronal MPR with soft tissue window. **B** and **C** 3D reconstruction with transparency and bone window. **D** Virtual endoscopy view.

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