

¹⁸F-FDG PET/CT Role in Staging of Gastric Carcinomas: Comparison with Conventional Contrast Enhancement Computed Tomography

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Abstract: The purpose of the report was to evaluate the role of fluorine-18 fluoro-2-deoxy-D-glucose positron emission tomography/computed tomography (¹⁸F-FDG PET/CT) in staging gastric cancer comparing it with contrast enhancement computed tomography (CECT).

This retrospective study included 45 patients who underwent performed whole body CECT and ¹⁸F-FDG PET/CT before any treatment. We calculated CECT and ¹⁸F-FDG PET/CT sensitivity, specificity, accuracy, positive and negative predictive values (PPV and NPV) for gastric, lymphnode, and distant localizations; furthermore, we compared the 2 techniques by McNemar test. The role of ¹⁸F-FDG PET/CT semiquantitative parameters in relation to histotype, grading, and site of gastric lesions were evaluated by ANOVA test.

Sensitivity, specificity, accuracy, PPV and NPV of CECT, and ¹⁸F-FDG PET/CT for gastric lesion were, respectively, 92.11%, 57.14%, 86.66%, 92.11%, 57.14% and 81.58%, 85.71%, 82.22%, 96.88%, 46.15%. No differences were identified between the 2 techniques about sensitivity and specificity. No statistical differences were observed between PET parameters and histotype, grading, and site of gastric lesion. The results of CECT and ¹⁸F-FDG PET/CT about lymphnode involvement were 70.83%, 61.90%, 66.66%, 68%, 65% and 58.33%, 95.24%, 75.55%, 93.33%, 66.67%. The results of CECT and ¹⁸F-FDG PET/CT about distant metastases were 80%, 62.86%, 66.66%, 38.10%, 91.67% and 60%, 88.57%, 82.22%, 60%, 88.57%. ¹⁸F-FDG PET/CT specificity was significantly higher both for lymphnode and distant metastases.

The ¹⁸F-FDG PET/CT is a useful tool for the evaluation of gastric carcinoma to detect primary lesion, lymphnode, and distant metastases using 1 single image whole-body technique. Integration of CECT with ¹⁸F-FDG PET/CT permits a more valid staging in these patients.

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Abbreviations: CECT = contrast enhancement computed tomography, ¹⁸F-FDG PET/CT = fluorine-18 fluoro-2-deoxy-D-glucose positron emission tomography/computed tomography, MTV = metabolic tumor volume, NPV = negative predictive value, PPV = positive predictive value, Pts = patients, SUV =

standardized uptake value, TLG = total lesion glycolysis, VOI = volume of interest.

INTRODUCTION

Gastric cancer is the 4th most common cancer worldwide.¹ Each year, 1 million patients (pts) are diagnosed, accounting for 12% of all cancer deaths.²

Although curative surgery remains the mainstay of gastric cancer treatment, surgical morbidity from gastrectomy is significant.³

Patients' selection prior to surgery is essential to avoid the morbidity and mortality of unnecessary surgery in those who will not benefit from the intervention but can be submitted to chemotherapy and radiotherapy.⁴

Diagnosis is mainly performed by endoscopy associated with biopsy. Accurate staging of the disease including the local invasion extent, lymphnode involvement, and distant metastases is important for patients management and surgical planning.³

At the state of art, gastric carcinoma is staged with endoscopic ultrasonography, contrast enhancement computed tomography (CECT), and occasionally laparoscopy.⁵⁻⁷

Conventionally, morphology-based imaging tools are helpful for preoperative staging, but they have been found incomplete due to their technical limitations.^{8,9}

In recent decades fluorine-18 fluoro-2-deoxy-D-glucose positron emission tomography/computed tomography (¹⁸F-FDG PET/CT) has proven to be useful in the diagnosis and evaluation of malignancies by providing metabolic information and apportioning advantages in staging, therapeutic evaluation, and recurrence surveillance.^{10,11} Several clinical guidelines, including those of the National Comprehensive Cancer Network and The European Society for Medical Oncology, suggest that ¹⁸F-FDG PET/CT imaging may improve staging.^{12,13} Although these recommendations, its value in staging gastric carcinomas is still controversial.

The purpose of this study was to evaluate the role of ¹⁸F-FDG PET/CT in staging gastric carcinoma comparing it with CECT. Furthermore, we investigated if morphological and functional parameters might play a role in staging gastric carcinomas.

METHODS

Patients

Five hundred and seventy-two ¹⁸F-FDG PET/CT were performed from March 2007 to March 2013 for gastric carcinoma evaluation. Fifty-seven of them were performed for staging, 301 for restaging and 214 in follow-up.

The 57 ¹⁸F-FDG PET/CT performed with staging intent corresponded to 57 pts; all of them had been pathologically diagnosed with gastric carcinoma by endoscopic biopsy.

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This retrospective study included only 45 pts who underwent whole-body CECT and ^{18}F -FDG PET/CT before any treatment and within 30 days between them.

The CECT scan was performed on average 18 days before the ^{18}F -FDG-PET/CT scan (range 2–30 days).

Pathological staging was evaluated according to the 7th edition of the American Joint Committee on Cancer Staging guidelines, and histologic types were classified according to the World Health Organization classifications.¹⁴

^{18}F -FDG PET/CT and CECT results were compared with the gold standard, established as histological examination in 29 pts who were submitted to surgery, and as very close clinical-instrumental follow-up (specific and/or not specific symptoms, US, CECT, and Magnetic Resonance) in remnant 16 pts.

All patients had already given their consent for the use of their data for clinical research.

Patients' clinical and pathological characteristics are described in Table 1.

CECT Technique

CT examinations were performed with equipment MDCT with 16 layers (TSX-101°, Aquilion 16, Toshiba Medical Systems, Tokyo, Japan), using the following acquisition parameters: slice thickness 1 mm, pitch 1.75; increment 0.6 mm, rotation time 0.5 seconds, kV/mAs 120/250. All examinations included contrast enhancer administration. Water was orally administered immediately prior to CT scanning to obtain gastric distension.

^{18}F -FDG PET/CT Technique

Images were acquired with a Discovery LSA PET/CT device (GE Healthcare, Waukesha, WI) that integrates a PET (advance $n \times I$) with 16-slice CT scanner (light speed plus). All patients, before ^{18}F -FDG administrations fasted for at least 8 hours and had a capillary blood glucose of $<160\text{ mg/mL}$. The image acquisition was obtained 50 minutes after the intravenous injection of 4.6 MBq/kg of ^{18}F -FDG.

Patients were hydrated by drinking 500 mL of water and urinated as needed. The CT scan was carried out from the

external acoustic meatus to the root of the thigh with patients lying on their back with hands above their head. The CT acquisition parameters were 340 mA (auto), 120 kV, slice thickness 3.75 mm, tube rotation time 0.8 milliseconds, and collimation field of view of 50 cm. The CT images were reconstructed with a filtered back projection. The CT data were used for the attenuation correction of PET scanning, which was performed immediately after the acquisition of CT images. The CT scans were performed without administration of contrast enhancer. The PET acquisition was obtained in caudal-cranial direction; PET was reconstructed with a matrix of 128×128 , ordered subset expectation maximum iterative reconstruction algorithm (2 iterations, 28 subsets), 8 mm Gaussian filter, and 50 cm field of view.

CECT and ^{18}F -FDG PET/CT Interpretations

CECT and ^{18}F -FDG PET/CT blindly and independently respectively by a radiologist and a nuclear physician with at least 8 years of experience were evaluated. Both were unaware of the patients medical history.

CECT was considered positive for gastric malignancy in case of description of a polipoid mass with or without ulceration or of a focal thickening of the wall with irregular mucosal^{6,15}; positive for lymphnode involvement if there was at least one lymphnode enlargement in the abdomen; positive for distant metastases if there was at least one lesion in sites different from stomach and lymphnodes.

^{18}F -FDG PET/CT was considered positive for gastric malignancy in case of any increased ^{18}F -FDG uptake exceeding that of the adjacent normal gastric wall; positive for lymphnode involvement for any increased ^{18}F -FDG uptake in at least 1 lymphnode; positive for distant metastases for at least 1 area of increased ^{18}F -FDG uptake in sites different from stomach and lymphnodes. Gastric distension obtained by drinking 500 mL of water before images acquisition was used to reduce false positive.

Volume of interest (VOI) was drawn semiautomatically on the high ^{18}F -FDG uptake area, with boundaries drawn large enough to incorporate each target lesion in the 3 axes of PET images.

Semiquantitative analysis was performed calculating max and mean standardized uptake values (SUVmax and SUVmean), using the maximum and mean activity values within each VOI with the highest radioactivity concentration, normalized to the injected dose, and patient's body weight.

In order to collect the metabolic tumor volume (MTV) and total lesion glycolysis (TLG) a fixed threshold value of 40% of the SUVmax uptake was used to determine tumor margins automatically, according to the previously published method of Larson et al¹⁶ and Lee.¹⁷

SUVmax and SUVmean were collected in all 45 pts, while MTV and TLG were evaluated in the 32/45 pts in whom ^{18}F -FDG PET/CT resulted positive for the gastric lesion.

Statistical Analysis

We calculated CECT and ^{18}F -FDG PET/CT sensitivity, specificity, accuracy, positive predictive value (PPV) and negative predictive value (NPV) for gastric, lymphnode, and distant localizations; furthermore, we compared the performance of the 2 techniques by McNemar test.

The role of ^{18}F -FDG PET/CT semiquantitative parameters in relation to histotype, grading, and site of gastric lesions were evaluated by ANOVA test.

TABLE 1. Patients' Clinical and Pathological Characteristics

	n = 45	
Sex		
Male	27	60%
Female	18	40%
Median age, years	66	Range 44–86
Site		
Gastroesophageal junction	10	22.2%
Proximal	8	17.8%
Distant	13	28.9%
Proximal + distant	4	8.9%
All	10	22.2%
Histotype		
Intestinal type adenocarcinoma	34	75.6%
Signet ring cells carcinoma	5	11.1%
Mucinous carcinoma	6	13.3%
Grading		
G1	19	42.2%
G2	8	17.8%
G3	18	40.0%

Linear regression was performed to evaluate SUVmax and SUVmean in relation to lesion size.

A *P* value < 0.05 was considered statistically significant. The analyses were performed using MedCalc software version 14.12.0 (MedCalc Software bvba, Ostend, Belgium).

RESULTS

Gastric Lesions

CECT resulted positive for gastric localizations in 38/45 pts (84.4%) and negative in 7/45 pts (15.6%). ¹⁸F-FDG PET/CT resulted positive for gastric localization in 32/45 pts (71.1%) and negative in 13/45 pts (28.9%). An example of patient with ¹⁸F-FDG PET/CT positive for gastric localization is showed in Figure 1.

Results concerning sensitivity, specificity, accuracy, PPV and NPV, and McNemar analysis are reported in Table 2.

The mean value of the maximum diameter was 52.59 mm (range 4–≥100). Considering 30 mm, as a threshold value for maximum diameter we divided patients in 2 groups: size ≤30 mm and >30 mm.¹⁸ Results about CECT and ¹⁸F-FDG PET/CT sensitivity and specificity in the 2 groups are reported in Table 3.

SUVmax and SUVmean resulted positively related to lesion dimension (SUVmax = 3.53 + 0.11 × lesion size, *F* = 8.91, *P* = 0.005; SUVmean = 1.99 + 0.06 × lesion size, *F* = 7.07, *P* = 0.01)

The results about PET semiquantitative parameters are reported in Table 4. No statistical differences were observed between PET parameters and histotype, grading, and site of gastric lesion.

Lymphnodes Involvement

CECT resulted positive for abdominal lymphnode involvement in 25/45 pts (55.6%) and negative in 20/45 pts (44.4%).

¹⁸F-FDG PET/CT resulted positive for abdominal lymphnode involvement in 15/45 pts (33.3%) and negative in 30/45 pts (66.7%).

Results concerning sensitivity, specificity, accuracy, PPV and NPV, and McNemar analysis are reported in Table 5; it was

markable that ¹⁸F-FDG PET/CT specificity was significantly higher than CECT.

Distant Metastases

CECT resulted positive for distant metastases in 20/45 pts (44.4%) and negative in 25/45 pts (55.6%). ¹⁸F-FDG PET/CT resulted positive for distant metastases in 10/45 pts (22.2%) and negative in 35/45 pts (77.8%). An example of a patient in whom distant metastases observed at CECT resulted negative at ¹⁸F-FDG PET/CT is reported in Figure 2.

Results concerning sensitivity, specificity, accuracy, PPV and NPV, and McNemar analysis are reported in Table 6; it was markable that ¹⁸F-FDG PET/CT specificity was significantly higher than CECT.

DISCUSSION

Gastric Lesions

Literature reports a good performance of CECT in gastric lesions evaluation, with diagnostic accuracy that varies from 77% to 89%¹⁹; also in our population the performance of CECT was as much valid (accuracy of 86.6%).

Until now, it has been reported that ¹⁸F-FDG PET/CT has 21% to 100% of sensitivity and 78% to 100% of specificity for detecting gastric tumors.^{20–23} Our results of sensitivity (81.58%) and specificity (85.71%) are among the best ones and showed a good performance of both techniques, although ¹⁸F-FDG PET/CT specificity was slightly higher than CECT (57.14%) the difference was not statistically significant.

It is necessary to consider the technical and histopathological factors affecting the visibility of primary tumors on ¹⁸F-FDG PET/CT. ¹⁸F-FDG is not a tumor-specific tracer so many benign lesions in the stomach, such as gastritis, leiomyoma, and polyps can have moderate to intense ¹⁸F-FDG uptakes and obscure the primary tumor.³ Moreover, empty stomach states further reduces the specificity of the technique as low as 50% due to the high incidence of normal gastric wall uptakes.²⁴ To decrease the physiological uptake, many methods have been experimented, including the ingestion of food, but it has been

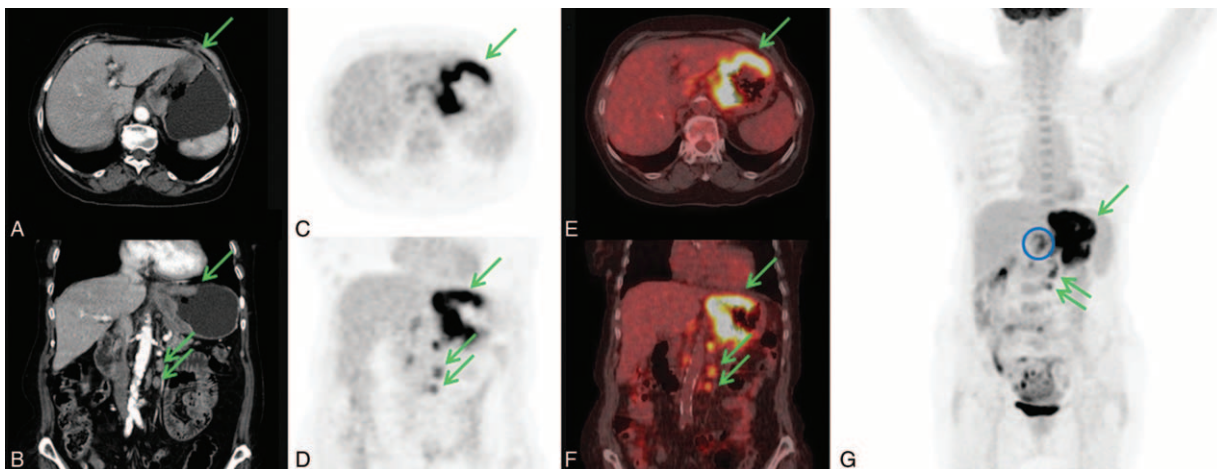


FIGURE 1. An 83-years-old woman with diagnosis of signet ring cell carcinoma obtained by cardias biopsy. CECT axial and coronal images (A, D) showed regular and diffuse thickening larger than 10 cm in the upper part of the stomach and in left paraortic lymphnodes (green arrows). ¹⁸F-FDG PET/CT axial and coronal PET and fused images (B, C, E, F) showed the gastric lesion (SUVmax 13.3) and the left paraortic lymphnodes (SUVmax 7.2) (green arrows). Furthermore, ¹⁸F-FDG PET/CT detected celiac lymphnodes involvement (SUVmax 5.1) as is better showed in MIP image (blue circle). CECT = contrast enhancement computed tomography, ¹⁸F-FDG PET/CT = fluorine-18 fluoro-2-deoxy-D-glucose positron emission tomography/computed tomography, SUV = standardized uptake value.

TABLE 2. CECT and ¹⁸F-FDG PET/CT Gastric Lesions Diagnostic Performance

	CECT	¹⁸ F-FDG PET/CT	P
Sensitivity	92.11% (95%CI: 78.60% to 98.25%)	81.58% (95%CI: 65.67% to 92.22%)	0.34
Specificity	57.14% (95%CI: 18.75% to 89.58%)	85.71% (95%CI: 42.23% to 97.63%)	0.62
Accuracy	86.66%	82.22%	
PPV	92.11% (95%CI: 78.60% to 98.25%)	96.88% (95%CI: 83.73% to 99.48%)	
NPV	57.14% (95%CI: 18.75% to 89.58%)	46.15% (95%CI: 19.33% to 74.78%)	

CECT = contrast enhancement computed tomography, ¹⁸F-FDG PET/CT = fluorine-18 fluoro-2-deoxy-D-glucose positron emission tomography/computed tomography, NPV = negative predictive value, PPV = positive predictive value.

demonstrated that simple distention of the stomach using water improves the diagnostic performance of ¹⁸F-FDG PET/CT in detecting and localizing primary tumors^{25,26}; in our experience drinking 500 mL of water before images acquisition was useful for a sufficient gastric distension.

The principal factors that can influence gastric lesions' detectability are tumor size, histological type, and localization.³

Tumor size is the major factor; Mukai et al showed that ¹⁸F-FDG PET/CT had a sensitivity of 76.7% for the detection of gastric carcinomas >30 mm but only 16.8% for those less than 30 mm.¹⁸ Because late-stage tumors are usually larger in size with deeper invasion, advanced gastric carcinomas tend to yield a higher sensitivity in ¹⁸F-FDG PET/CT imaging (from 93% to 98%) than early gastric carcinomas (from 26% to 63%).²⁷ According to literature, we choosed 30 mm as a threshold and observed a markable reduction in sensitivity and negligible in specificity respect to overall patients results if size ≤30 mm (33.33% vs 81.58%; 83.33 vs 85.71%), while there were negligible increase both in sensitivity and specificity if size >30 mm (96.55% vs 81.58%; 100% vs 85.71%). Obviously ¹⁸F-FDG PET/CT had a very good performance in larger lesion, but also in small lesions its specificity was high.

Most studies reported that ¹⁸F-FDG PET/CT has significantly lower sensitivities in detecting mucinous and signet ring cells carcinomas than the intestinal-type adenocarcinoma.^{4,18,20,28}

The lower ¹⁸F-FDG uptake in these hystotypes may depend by the low-density diffuse infiltration of adenocarcinoma cells, the existence of extracellular or intracellular metabolically inert mucus content and the low expression level of glucose transporter 1.^{20,28}

We did not perform a comparison among histotypes because our population included 75.5% of intestinal type carcinomas. However in our population only 1/6 mucinous carcinoma and 1/5 signet ring cells carcinoma (also with 5 mm diameter) resulted false negative at ¹⁸F-FDG PET/CT.

Regarding the differentiation, lower ¹⁸F-FDG uptake may be observed in poorly differentiated histotypes, which is likely due to the low concentration of cancer cells in primary lesions.²⁹ In our population only 2/18 G3 pts resulted false negative at ¹⁸F-FDG PET/CT and one of them was the 5 mm signet ring cells carcinoma.

About the tumor's localization, ¹⁸F-FDG PET/CT detection of gastroesophageal junction carcinomas was reported to be more sensitive than other stomach parts, probably due to the higher incidence of intestinal types in this site, but some researchers reported that ¹⁸F-FDG PET/CT had a similar detectability for gastric carcinomas independently by site.^{20,30}

In our population only 1/13 pts with gastric lesion localized in the distant part of the stomach resulted false negative; anyway we did not perform a comparison among localizations because of the variability of size and histotypes.

PET semiquantitative parameters have been investigated for their role in ¹⁸F-FDG PET/CT interpretations. The commonly accepted parameters are SUVmax and SUVmean, while MTV and TLG are not accepted for clinical use. Some authors refer these results are affected by many factors including those influencing gastric lesion detection; others did not find any differences in their values respect to histological type and localization.^{4,11,31,32}

In our study we analyzed SUVmax, SUVmean, MTV, and TLG of gastric lesions, and we found a positive relation between SUVmax and lesion size, and SUVmean and lesion size; otherwise, no differences in none of the PET parameter were identified among the influencing factors histotype, grading, and localization (Table 3).

Lymphnode Involvement

The presence of lymphnode metastases is one of the most important prognostic factors in gastric carcinoma, and a correct

TABLE 3. CECT and ¹⁸F-FDG PET/CT Results in the Groups of Patients Divided Considering 30 mm as Size Threshold

	Sensitivity		Specificity	
	CECT	¹⁸ F-FDG PET/CT	CECT	¹⁸ F-FDG PET/CT
Size ≤ 30 mm (n = 15)	80% (95%CI: 44.43% to 96.89%)	33.33% (95%CI: 7.88% to 69.93%)	80% (95%CI: 28.81% to 96.70%)	83.33% (95%CI: 36.10% to 97.24%)
Size > 30 mm (n = 30)	88.89% (95%CI: 70.81% to 97.52%)	96.55% (95%CI: 82.17% to 99.42%)	66.67% (95%CI: 11.55% to 94.53%)	100% (95%CI: 16.55% to 100%)

CECT = contrast enhancement computed tomography, ¹⁸F-FDG PET/CT = fluorine-18 fluoro-2-deoxy-D-glucose positron emission tomography/computed tomography.

TABLE 4. Semiquantitative Parameters Results

Parameter (Mean; range)		Value	F	P
SUVmax (3.163; 0.9–56)	Intestinal type adenocarcinoma	9.50	0.852	0.434
	Signet ring cells carcinoma	3.92		
	Mucinous carcinoma	9.73		
	G1	8.61	1.562	
	G2	14.06		
	G3	7.53		
	Gastroesophageal junction	7.74	0.959	
	Proximal	9.1		
	Distant	6.96		
	Proximal + distant	7.7		
All	13.95			
SUVmean (5.08; 0.5–36.6)	Intestinal type adenocarcinoma	5.42	0.235	0.791
	Signet ring cells carcinoma	3.54		
	Mucinous carcinoma	5.45		
	G1	5.52	1.147	
	G2	7.45		
	G3	3.88		
	Gastroesophageal junction	4.15	1.070	
	Proximal	4.92		
	Distant	3.67		
	Proximal + distant	4.27		
All	8.28			
MTV (48.69; 4.47–349)	Intestinal type adenocarcinoma	41	1.565	0.221
	Signet ring cells carcinoma	93.5		
	Mucinous carcinoma	55.1		
	G1	93.86	1.782	
	G2	35.18		
	G3	49.23		
	Gastroesophageal junction	22.99	1.549	
	Proximal	34.43		
	Distant	45.97		
	Proximal + distant	77.88		
All	102.51			
TLG (547,257.2; 9970–9,916,557)	Intestinal type adenocarcinoma	578,846.82	1.631	0.984
	Signet ring cells carcinoma	2,152,315		
	Mucinous carcinoma	360,035		
	G1	1,443,200.61	1.850	
	G2	204,775.15		
	G3	194,551.15		
	Gastroesophageal junction	184,039	0.868	
	Proximal	235,173		
	Distant	195,602.35		
	Proximal + distant	322,548		
All	1,510,828			

staging is fundamental to define the necessity and the extension of the lymphodenectomy.²⁶

To date, CECT effectiveness in predicting lymphnode metastases has not been satisfactory using any criteria, and there is still no worldwide consensus. Although there is a clear correlation between the lymphnode size and metastases, microscopic metastases in normal-size lymphnodes and lymphnode enlargement resulting from reactive or inflammatory changes are common in gastric cancer patients.³³

The overall accuracy, sensitivity, and specificity of lymphnode staging by CECT reported in literature varies from 69% to 92%, 78% to 92%, and 73.9%, respectively, and they are strictly dependent on the size of lymphnodes.¹⁹

One meta-analysis reported that the sensitivity and specificity of ¹⁸F-FDG PET/CT in staging lymphnode involvement ranged between 85.7% and 97.0%. Other individual studies reported that ¹⁸F-FDG PET/CT was less sensitive but more specific compared with commonly used CECT.^{22,34} The reasons for the low sensitivity of ¹⁸F-FDG PET/CT are the histological type of the primary tumor and the size of metastatic lymphnodes that could be smaller than 3 mm.^{22,35} In spite of the low sensitivity, ¹⁸F-FDG PET/CT usually showed a higher specificity than most other imaging modalities, including CECT because ¹⁸F-FDG PET/CT diagnose lymphnode metastases using glucose metabolism rather than the size change.³ A limit reported for ¹⁸F-FDG PET/CT is the detection of perigastric lymphnodes

TABLE 5. CECT and ¹⁸F-FDG PET/CT Lymphnode Involvement Diagnostic Performance

	CECT	¹⁸ F-FDG PET/CT	P
Sensitivity	70.83% (95%CI: 48.91% to 87.33%)	58.33% (95%CI: 36.66% to 77.86%)	0.507
Specificity	61.90% (95%CI: 38.45% to 81.84%)	95.24% (95%CI: 76.11% to 99.21%)	0.039
Accuracy	66.66%	75.55%	
PPV	68% (95%CI: 46.50% to 85.01%)	93.33% (95%CI: 67.98% to 98.89%)	
NPV	65% (95%CI: 40.79% to 84.55%)	66.67% (95%CI: 47.19% to 82.69%)	

CECT = contrast enhancement computed tomography, ¹⁸F-FDG PET/CT = fluorine-18 fluoro-2-deoxy-D-glucose positron emission tomography/computed tomography, NPV = negative predictive value, PPV = positive predictive value.

involvement difficult to discriminate because of the radioactive volume effect generated by the nearby primary tumor.³⁶

Our population's results were lower than literature for CECT such as ¹⁸F-FDG PET/CT sensitivity, but they confirmed

the higher specificity of ¹⁸F-FDG PET/CT than CECT (95.24% vs 61.90%, P = 0.039) probably due to the lymphnodes small size and the primitive histological subtype. Localization in perigastric lymphnodes cannot be considered as an influencing

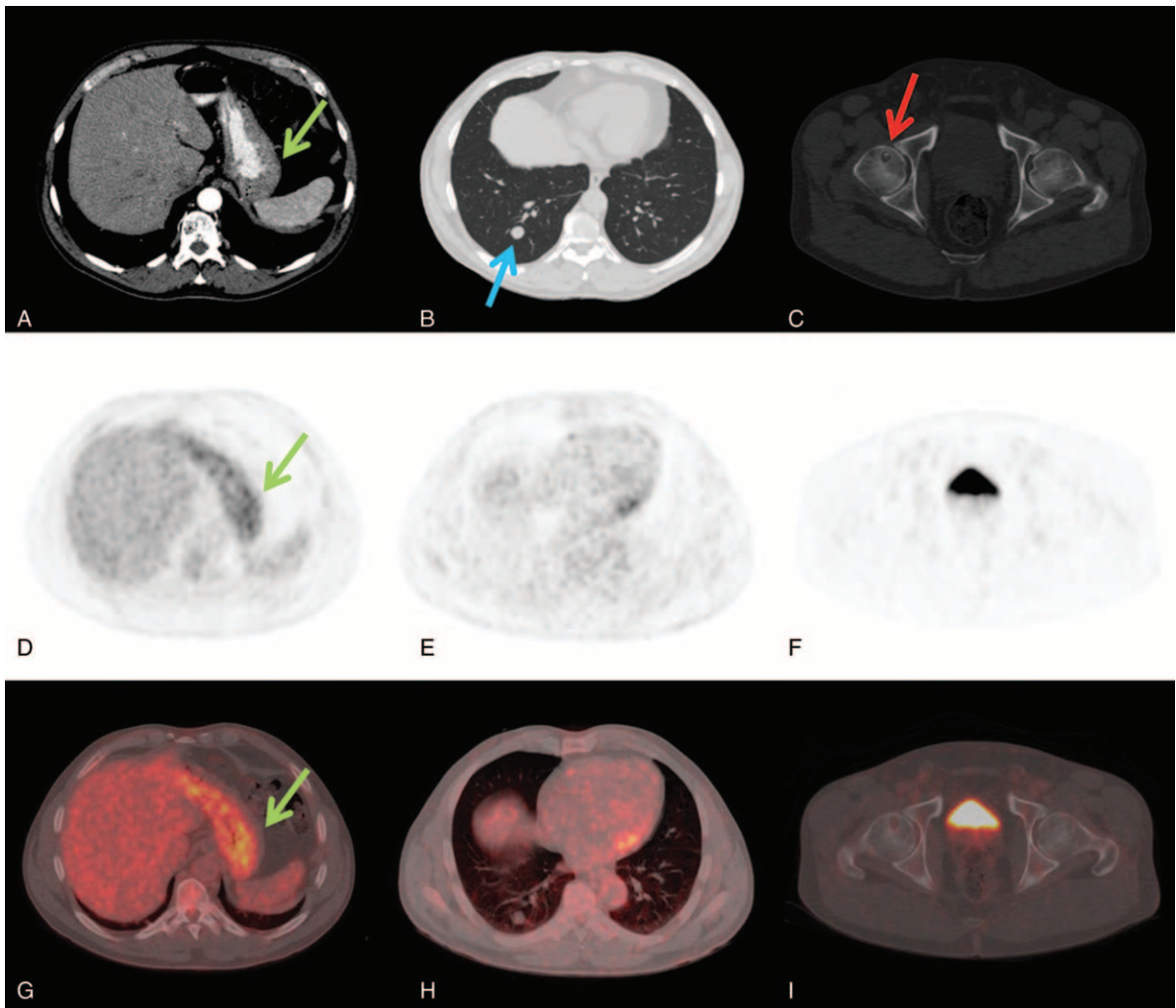


FIGURE 2. A 54-year-old man with intestinal type gastric carcinoma. CECT axial images showed localized gastric wall thickening (A, green arrow), a right lung nodule of 15 mm suspected for metastases (B, blue arrow) and a osteolytic lesion in the right femoral head doubtful for herniation pit (C, red arrow). ¹⁸F-FDG PET/CT axial PET and fused images confirmed the gastric lesion with SUVmax of 4.8 (D, G) but did not showed any ¹⁸F-FDG uptake in the lung nodule (E, H) and in the right femoral head (F, I). CECT = contrast enhancement computed tomography, ¹⁸F-FDG PET/CT = fluorine-18 fluoro-2-deoxy-D-glucose positron emission tomography/computed tomography, SUV = standardized uptake value.

TABLE 6. CECT and ¹⁸F-FDG PET/CT Distant Metastases Diagnostic Performance

	CECT	¹⁸ F-FDG PET/CT	P
Sensitivity	80% (95%CI: 44.43% to 96.89%)	60% (95%CI: 26.37% to 87.60%)	0.687
Specificity	62.86% (95%CI: 44.93% to 78.51%)	88.57% (95%CI: 73.24% to 96.73%)	0.017
Accuracy	66.66%	82.22%	
PPV	38.10% (95%CI: 18.16% to 61.55%)	60% (95%CI: 26.37% to 87.60%)	
NPV	91.67% (95%CI: 72.96% to 98.73%)	88.57% (95%CI: 73.24% to 96.73%)	

CECT = contrast enhancement computed tomography, ¹⁸F-FDG PET/CT = fluorine-18 fluoro-2-deoxy-D-glucose positron emission tomography/computed tomography, NPV = negative predictive value, PPV = positive predictive value.

factor in our population because they were detected only in 6 pts, 5 of them correctly interpreted.

Distant Metastases

The most frequent sites of distant metastases include liver, lungs, bones, adrenal glands, and peritoneum.

CECT is actually the conventional tool for detecting distant metastases also from gastric cancer, but it may present limits especially for areas such as peritoneum.³

Even if Pan et al³⁷ reported more than 96.6% accuracy of CECT in distant metastases detection in 350 pts with gastric cancer, a following meta-analysis by Wang and Chen³⁸ reported a large difference in CECT sensitivities between hepatic metastases and peritoneal carcinomatosis (74% vs 33%).

¹⁸F-FDG PET/CT showed a good performance in detecting solid organ metastases with a sensitivity of 95.2% and a specificity of 100%, even if it resulted less effective in the detection of bone metastases.^{29,39}

Some studies reported ¹⁸F-FDG PET/CT lower sensitivity compared with CECT for the diagnosis of peritoneal seeding, nevertheless ¹⁸F-FDG PET/CT could still be useful for detecting peritoneal metastases, especially when the CECT results are equivocal, avoiding unnecessary laparotomy in a considerable portion of patients. Even Lim et al showed its better specificity than CECT (99% vs 92%).^{4,36,40,41}

Results of our population were quite different from literature; we found lower values for CECT accuracy (66.6%), higher for CECT sensitivity (80%), and lower for ¹⁸F-FDG PET/CT sensitivity (60%). The difference between ¹⁸F-FDG PET/CT and CECT specificities resulted statistically significant (88.57 vs 62.86%, $P = 0.017$) for distant metastases.

The explanation of these differences is the metastases sites observed in our population in only 10/45 pts: liver was involved in 6 pts, lungs in 2 pts, bones in 3 pts, and adrenal gland and peritoneum in 1 pts, respectively.

The low specificity of CECT can be explained mostly with the high rate of lung nodules misinterpreted (7/45 pts).

There were some limitations in our study such as the retrospective nature that implies selection bias and the small number of the sample, even if in line with literature.

Furthermore, histological confirmation of lymphnode and distant metastases should be obtained if feasible but biopsy of each lesion is not ethically recommended, so clinical-instrumental follow-up has also been considered the gold standard.

CONCLUSION

¹⁸F-FDG PET/CT is a useful tool for the evaluation of gastric carcinoma; it can detect primary lesion, lymphnode, and distant metastases using 1 single image whole-body technique.

Our result of higher specificity of ¹⁸F-FDG PET/CT for lymphnode and distant metastases detection may suggest the important role of this technique in changing the extent of lymphadenectomy or reducing futile laparotomies.

We believe that integration of conventional imaging such as CECT with ¹⁸F-FDG PET/CT permits a more valid whole-body staging in patients with gastric carcinomas.

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