Contrast computed tomography versus PET/CT in the assessment of bronchogenic carcinoma

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Background

In the past decades, diagnostic imaging modalities of bronchogenic carcinoma were chest radiography and computed tomography (CT) to determine the tumor size and mediastinal lymph nodes involved, as well as liver and adrenal metastases. Now PET/CT has become a routine procedure for the primary assessment (initial staging) in the detection of functional tumor activity (viable cells).

Objective

The objective of this study was to compare between contrast CT and PET/CT in the assessment of bronchogenic carcinoma (initial staging) and impact of weight and BMI on it.

Patients and methods

This was a cross-sectional study that involved 100 patients for initial staging of newly diagnosed bronchogenic carcinoma examined by contrast CT and PET/CT. In addition to anthropometry measures, weight and height were taken and BMI was calculated.

Results

The initial staging of bronchogenic carcinoma showed significant differences between PET/CT versus contrast CT (P=0.001). Upstaging done by PET/CT in six patients (stages I and II), as well as an agreement between CT and PET/CT in stage III and IV was detected. The evaluation showed a sensitivity and specificity of 75.2–89.4% and 78.2–90.0% for CT and 97.2–100% and 98.5–100% for PET/CT, respectively. There is a significant positive correlation between tumor size and its metabolic activity measured by the maximum standardized uptake value. However, there was no significant correlation between BMI and maximum standardized uptake value; moreover not any significant association between BMI and metastatic deposits was detected.

Conclusion

PET/CT is a powerful imaging modality for the assessment of functional behavior of tumor cells to avoid false results depending on the morphology only as contrast CT, which leads to change the decision taken for the management of bronchogenic carcinomas.

Keywords:
bronchogenic carcinoma, contrast computed tomography, PET/CT

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Introduction

Cancer is considered one of the major public health problems in the world [1,2]. Lung cancer or bronchogenic carcinoma incidence and mortality have rapidly increased to become the most commonly diagnosed cancer worldwide representing 11.6% of the total cases and 18.4% of the total cancer deaths [3]. Egyptian statistics showed that lung cancer in men represents 8.2% according to the Egyptian National Cancer Program in 2014 [1].

In the past decades, diagnostic imaging modalities of bronchogenic carcinoma were chest radiography and computed tomography (CT), which has been considered the gold-standard imaging modality used for staging [4], as it can determine the accurate size of the tumor and if there were any mediastinal involvement, vascular invasion, and lymph node affected (axial diameter>1 cm) [4]. The examination also included the upper abdomen cuts to evaluate the liver and adrenal metastases [5].

Now PET/CT has become a routine procedure for the primary assessment (initial staging) to detect functional tumor activity (viable cells) [6,7], to select the proper management plan [8]; as in early stage it is curable and benefit to surgery, while unresectable tumor better response to radiotherapy and chemotherapy [9,10].

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The aim of this study was to compare between contrast CT and PET/CT in the assessment of bronchogenic carcinoma (initial staging) and impact of weight and BMI on it. Cross-sectional data were collected and reported in this study.

Patients and methods

Patients

A cross-sectional study of 100 patients with bronchogenic carcinoma of both sexes were included in this study (72 men and 28 women); their ages ranged from 45 to 75 years; they were referred from the clinical oncologists and pulmonologists for initial staging of newly diagnosed bronchogenic carcinoma.

The Research Ethics Committee of the Faculty of Medicine, Ain Shams University approved this study by FMASU R 40/2018 and informed written consent was taken from each patient. Study procedures were conducted at the Private Radiology Center, Cairo, Egypt. Exclusion criteria included patients with a blood glucose level of more than 200 mg/dl at the time of the examination and those with bad general condition.

Evaluation of patients included the following:

(1) Patient preparation: avoid vigorous activities, high carbohydrate diet, caffeine and smoking as well before examination (48 h) and allow high protein diet and liquids. Fasting is recommended for 6 h.
(2) The day of examination: the patient was given a gown to wear and all metallic items were removed and then serum glucose level was measured (should be <200 mg/dl).
(3) Anthropometric measurements: Height and weight measurements following the recommendations of the International Biological Program [11]. Weight was taken to the nearest 0.01 kg, whereas height was measured to the nearest 0.1 cm. Then the BMI was calculated by divided weight in kilograms to height in meters squared.
(4) An average of 5–10 mCi for adults (370 MBq; approximate dose to patient, 3–5 MBq/kg) of fluorine-18 flurodeoxyglucose (^{18}F-FDG) was administered to each patient 50–60 min before examination.
(5) PET/CT technique: A low-dose non-contrast CT for attenuation correction and anatomic localization was conducted using Phillips Ingenuity TF PET/CT 128 slice machine (Cleveland, OH, USA) followed by PET images from the skull vault to the mid thigh were obtained, then a diagnostic post contrast examination was taken after intravenous nonionic contrast administration of the same regions. Images of CT and the corresponding functional PET images are taken in axial, coronal, and sagittal planes.
(6) Interpretation: Staging of each case was done according to the 8th edition, tumor–node-metastasis (TNM) classification which was issued by the International Association for the Study of Lung Cancer; T-stage, for the tumor size, N-Stage, for assessment of the affected lymph nodes (LNs) level, and M-stage, to detect metastatic lesions. Lesions were identified by the presence of metabolically active tumor tissue with high ^{18}F-FDG accumulation and correlate this activity to its anatomical site in the combined PET/CT images. Those images were assessed visually and quantitatively at pathologic tracer accumulation by using the standardized uptake value. The LNs and distant metastases sites were evaluated including the liver, adrenal glands, bone, brain, and another lung. In CT images, LN assessment was based on the size of a short-axis diameter of more than 1 cm.
(7) After the examination: the patients were advised to drink water, avoid contact with pregnant women or children for at least 6–8 h later.

Statistical analysis

The Statistical Package for the Social Sciences (Windows, version 22; IBM Corp., Armonk, New York, USA) was used to analyze data. Parametric data were expressed as mean±SD, whereas the nonparametric data (qualitative) were expressed as frequency distribution (*n*). Comparisons between CT and PET/CT findings were done using crosstabs and then sensitivity and specificity were calculated. Pearson's correlation test was used to examine the association and correlation. The statistical significance was set at a *P*-value of less than 0.05.

Results

This study included 100 patients: 72 men and 28 women, their age ranged from 45 to 75 years (mean ±SD: 60.1±1.0 years), weight, 52–117 kg (77.9±1.6 kg); height, 140–181 cm (163.0±0.01 kg); BMI, 20.1–39.7 kg/m^2 (28.5±0.5 kg/m^2); and fasting blood sugar, 79–132 mg/dl (102.2±1.6 mg/dl).

The initial staging of bronchogenic carcinoma showed significant differences between PET/CT versus contrast CT (*P*=0.001) according to TNM staging as follows: T-staging: the upper lung lobe was the most frequent site of location (64%), followed by the lower lung lobe (32%) and then the right middle lobe (4%). The lung lesion mass size by contrast CT was 1.5–14.5 cm, whereas the maximum standardized uptake values (SUV_{max}) by PET/CT was 3.5–55.7 (mean 25.5±1.4 SD). There was downstaging by PET/CT comparing to contrast CT by 4% (four patients), which was larger by CT due to distal lung consolidation. N-staging: there were 92 patients with positive nodal affection, with upstaging by PET/CT from N1 to N2 in 20 patients and downstaging from N3 to N2 in 15 patients. M-staging: PET/CT detected more metastasis at the following sites. The osseous (54 patients) which was the most frequent site after nodal affection, followed by hepatic (39 patients), then the pleural (37 patients), adrenal glands (33 patients), the brain (11 patients), and the contralateral lung (seven patients). SUV_{max} values of the metastatic deposits are shown in Table 1. Finally, six patients were diagnosed at stage I, 10 were at stage II, 20 were at stage III, and 64 were at stage IV. There is upstaged by PET/CT in six patients from stages I and II, as well as an agreement between PET/CT and six CT in stages III and IV was detected. The evaluation showed a sensitivity of 75.2–89.4% for CT and 97.2–100% for PET/CT, whereas a specificity of 78.2–90.0% for CT and 98.5–100% for PET/CT as shown in Table 2.

The association between BMI and metastatic deposits of bronchogenic carcinoma in both sexes is shown in Table 3 with no statistical significance; however, more LN metastases were detected in obese men.

Then the correlation between size of the primary lung mass measured by contrast CT and its metabolic activity measured by PET/CT showed a positive highly significant correlation between tumor size and its metabolic activity measured by SUV_{max} (Fig. 1) (r=0.529 and P<0.001). However, no statistically significant correlation was found between SUV_{max} and BMI (r=0.007 and P=0.94) (Fig. 2).

Discussion

Worldwide bronchogenic carcinoma or lung cancer is considered the most leading cause of mortality from cancer (1.6 million deaths/year) in both sexes,

Table 1 Maximum standardized uptake value, maximum value, and mean±SD of the metastatic deposits

	Maximum standardized uptake value of the metastatic deposits	
	Maximum value	Mean±SD
Lymph node metastasis	29.70	8.7±1.9
Osseous deposits	11.80	3.7±1.5
Hepatic deposits	23.20	4.8±2.2
Adrenal deposits	15.13	5.9±1.4
Brain deposits	9.80	1.7±1.8
Pleural deposits	19.43	2.5±2.8
Contralateral lung deposits	27.38	5.4±4.3

Table 2 Sensitivity, specificity of contrast computed tomography versus PET/CT to detect metastatic lesions

	Sensitivity (%)	Specificity (%)	NPV (%)	PPV (%)
LN metastasis				
Contrast CT	84.2	89.1	75.5	78.3
PET/CT	100	100	100	100
Osseous deposits				
Contrast CT	82.5	78.6	74.2	80.2
PET/CT	98.1	99.0	98.2	96.1
Hepatic deposits				
Contrast CT	88.0	90.0	89.2	90.1
PET/CT	98.2	100.0	100	99.2
Adrenal deposits				
Contrast CT	75.2	78.2	77.6	79.2
PET/CT	97.2	98.5	98.1	99.2
Brain deposits				
Contrast CT	85.2	88.3	90.1	89.2
PET/CT	100	100	100	100
Pleural deposits				
Contrast CT	82.1	80.2	82.2	86.0
PET/CT	100	100	100	100
Contralateral lung				
Contrast CT	89.4	80.2	85.2	86.2
PET/CT	98.3	99.0	99.6	99.6

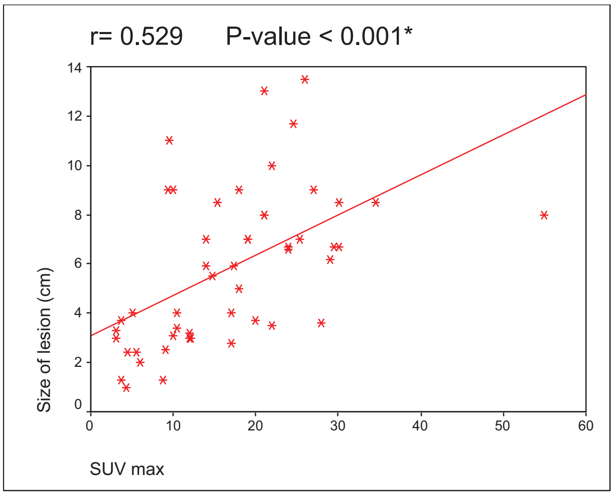
CT, computed tomography; LN, lymph node; NPV, negative predictive value; PPV, positive predictive value.

Table 3 Association between BMI and metastatic deposits of bronchogenic carcinoma in both sexes

	Normal weight	Overweight	Obese	Total (*N*)	*P*-value
Lymph node metastasis					
Male	22	20	26	68	0.896
Female	6	8	10	24	
Osseous deposits					
Male	11	13	14	38	0.495
Female	5	3	8	16	
Hepatic deposits					
Male	4	3	2	9	0.722
Female	11	8	11	30	
Adrenal deposits					
Male	7	7	9	23	0.755
Female	2	3	5	10	
Brain deposits					
Male	0	3	6	9	0.474
Female	0	0	2	2	
Pleural deposits					
Male	7	9	11	27	0.952
Female	3	3	4	10	
Contralateral lung deposits					
Male	0	1	3	4	0.742
Female	0	1	2	3	

$P<0.05$ (Pearson's χ^2), significant.

Figure 1



Correlation between size of the primary lung mass measured by contrast computed tomography (CT) and its metabolic activity measured by PET/CT. SUV_{max}, maximum standardized uptake value.

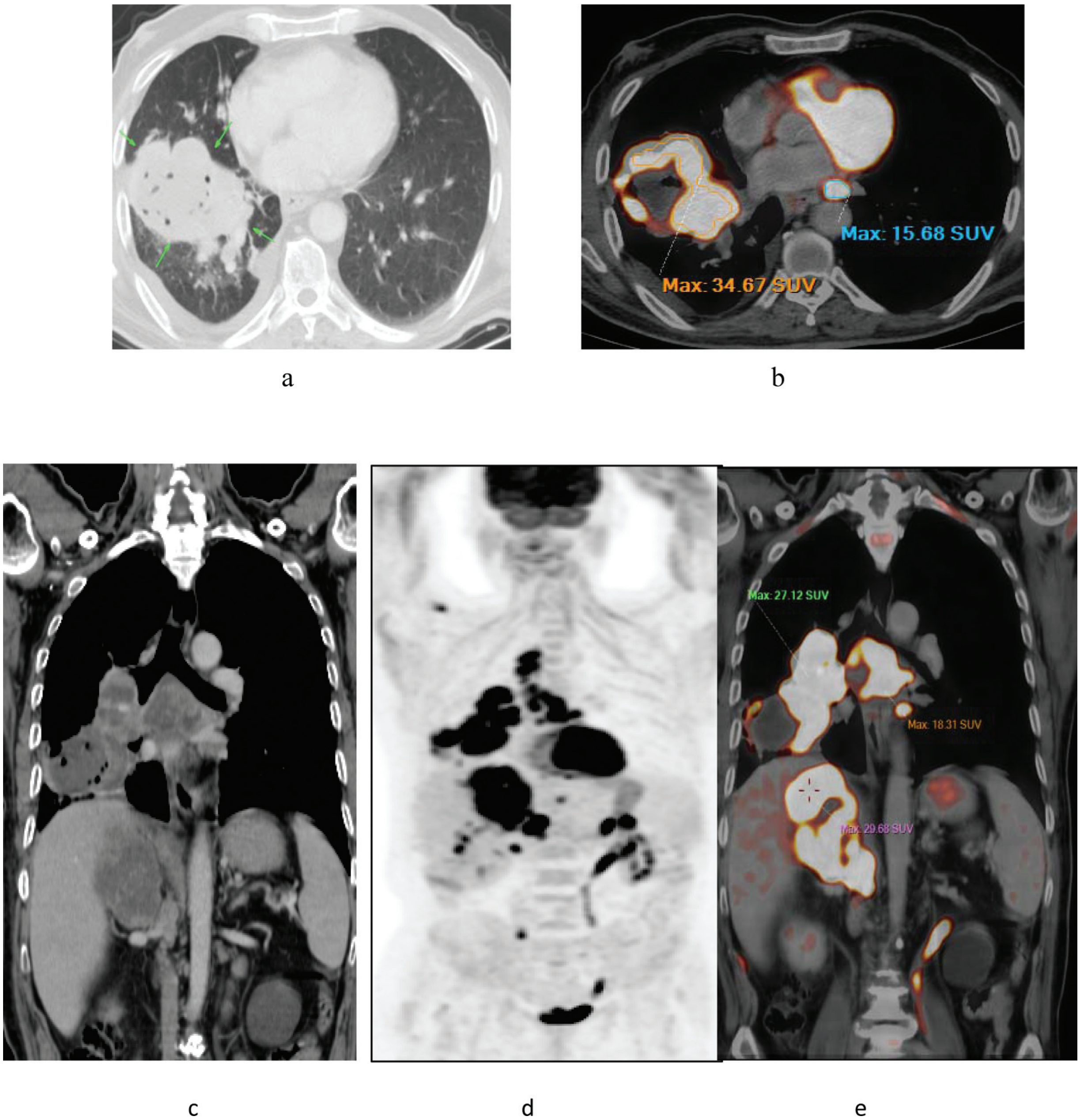
according to the International Agency for Research on Cancer (IARC), according to the database from 185 countries for 36 types of cancer [3,12]. Regarding the microscopic appearance, lung cancer has been divided into two main types; non-small-cell lung cancer (NSCLC) (85%) and small-cell lung cancer (SCLC) (15%) [6,13], they grow and spread in two different ways and their treatments also differ and therefore differentiation between those two types is important [12–14]. Although researchers discovered targeted therapies and immunotherapy approaches especially at earlier stages of lung cancer, this will change the prognosis which were 17.4% for a 5-year survival rate [15–18].

The PET/CT imaging has been increasingly used in last decades during the assessment of patients with lung cancer, as its ability to combine anatomical and functional information of lung cancer [16], especially at an early stage (initial diagnosis) for planning management strategies to improve the overall survival rate [17]. The strategy of management of NSCLC is different from SCLC, as in the early stages of NSCLC, surgery alone or associated with radiotherapy or chemotherapy provides the best result of cure. Although SCLC responds well to radiotherapy and chemotherapy, surgery should be considered only for stage I [2,19,20].

Some studies concluded that PET/CT is the noninvasive imaging modality for an accurate diagnosis of T-staging, as it provides important data about mediastinal invasion, chest wall infiltration, and differentiation between peritumoral atelectasis and tumor [19,21–24].

In this study, sensitivity was 75.2–89.4% and 97.2–100%, whereas specificity was 78.2–90.0% and 98.5–100% for CT and PET/CT, respectively. This agrees with Wever *et al.* [23] that showed sensitivity in patients with NSCLC to be 68% for CT and 86% for PET/CT. Ambrosini *et al.* [22] reported CT sensitivity

Figure 2



A 69-year-old male patient, presented with recently diagnosed lung cancer. (a) Axial computed tomography (CT) image shows a large heterogeneously enhancing irregular soft tissue mass lesion at the right lower lung lobe with internal hypodense area of necrosis and multiple air locules, (green arrows). (b) Axial PET/CT image shows hypermetabolic malignant right lung neoplasia with irregular marginal intense fluorine-18 flurodeoxyglucose avidity reaching up to 34.6 maximum standardized uptake value (SUV_{max}) and internal photopenic areas of necrosis, although left hilar lymph node is noted, achieving 15.6 SUV_{max}. (c) Coronal contrast-CT image, (d) coronal PET image, and (e) coronal combined PET/CT image. Large hypermetabolic malignant right lung neoplasia with multiple hypermetabolic nodal, pleural, right adrenal [intense fluorine-18 flurodeoxyglucose avidity (32.3 SUV_{max})], and osseous metastatic deposits (the lateral end of right clavicle achieving 13.7 SUV_{max}) T3N3M1b (stage IVA).

for LN detection to be (51–64%) and specificity to be (74–86%), whereas PET/CT had higher sensitivity (58–94%) and specificity (76–96%).

Boland *et al.* [25] have assessed adrenal lesion characterization from a meta-analysis and showed that the SUV_{max} cutoff value was 2.5 to differentiate malignant from benign lesions, whereas the sensitivity and specificity of PET/CT using the standardized uptake value was 94% and 82% in lung cancer, respectively.

The findings of this study showed significant correlation between tumor size by CT and its metabolic activity measured by PET/CT (SUV_{max}). This agrees with Ambrosini *et al.* [22], who had found that the degree of ^{18}F-FDG uptake by PET/CT correlate with tumor size by CT.

In this study, the relation between obesity and lung cancer diagnosed by PET/CT showed no significant association between BMI and metastatic deposits; also the study could not detect significant correlation between BMI and SUV_{max} of the primary lung cancer.

Several meta-analyses suggested an inverse relation between high BMI which reflect general obesity and lung cancer [26–28].

Conclusion

PET/CT is a powerful imaging modality for the assessment of functional behavior of tumor cells to avoid false results depending on the morphology only as contrast CT, which leads to change the decision taken for the management of bronchogenic carcinoma.

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Conflicts of interest

There are no conflicts of interest.

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