2 Lung Neoplasms

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Case 2.1: Solitary Pulmonary Nodule

History

A 50-year-old male, incidentally diagnosed with a lung nodule in the right lung apex on X-ray and confirmed on CT. Patient was referred for PET/CT evaluation of solitary pulmonary nodule.

Findings (Fig. 2.1)

Hypermetabolic right upper lobe pulmonary nodule with pleural tag (yellow arrow), measures 1.9 × 0.9 cm, anterolaterally, SUVmax 2.9, worrisome for neoplastic process. Remainder of the study was unremarkable.

Impression

Hypermetabolic solitary pulmonary nodule, worrisome for primary neoplasm. (Patient underwent Rt. Upper lobe wedge resection. Pathology: granulomatous caseating inflammation.)

Pearls and Pitfalls

A major application of PET is in the workup of indeterminate solitary pulmonary nodules, defined as noncalcified nodules, 3 cm or smaller, in the lung parenchyma that are found on chest radiography or CT (both of which play vital role in the diagnosis and management of many pulmonary disorders) [1]. However, FDG-PET studies can be falsely positive, primarily due to inflammatory and granulomatous changes, as might be seen in tuberculosis, fungal infections, and sarcoidosis [1].

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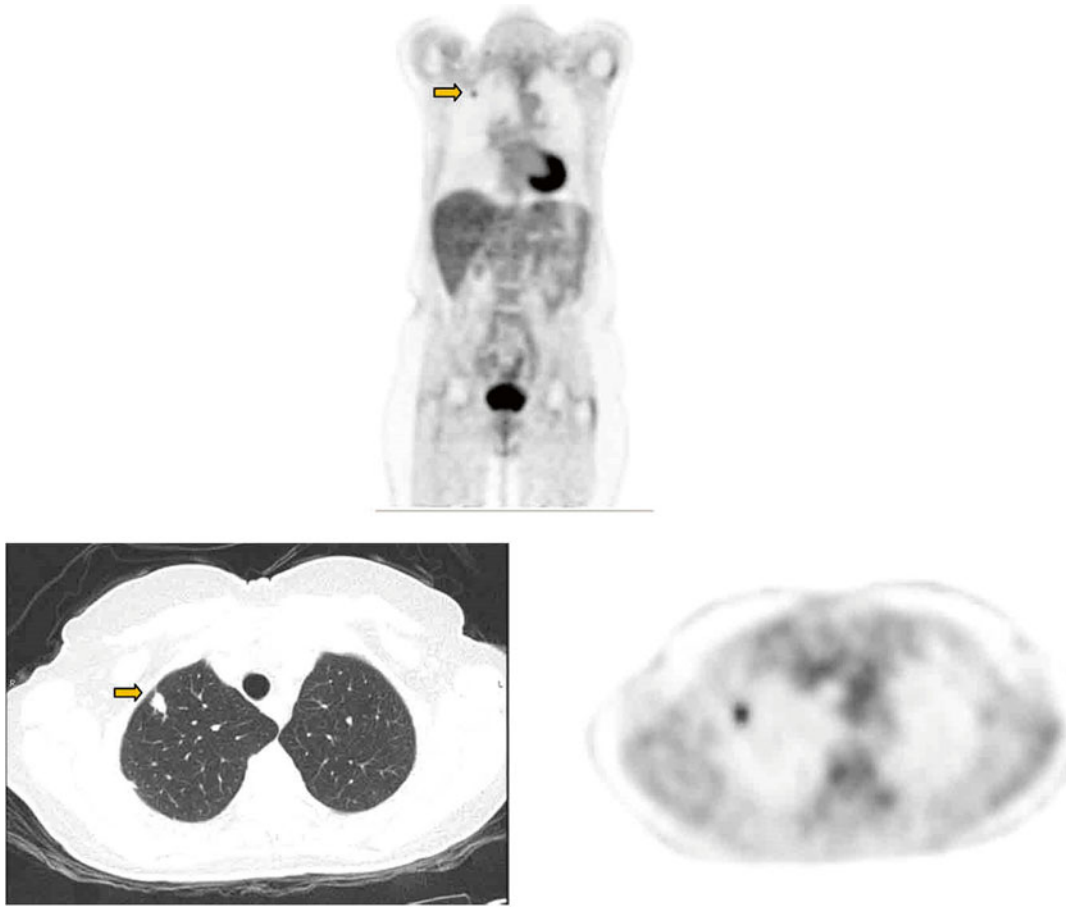

Fig. 2.1

Discussion

Solitary pulmonary nodule (SPN) is defined as a single spherical lesion within the lung parenchyma without associated atelectasis or adenopathy. Current convention is that SPNs are 3 cm or less in diameter. Larger lesions should be referred to as pulmonary masses and should be managed with the understanding that they are most likely malignant; prompt diagnosis and resection are usually advisable [2].

SPNs are caused by a variety of benign and malignant processes. Solitary pulmonary nodules are commonly encountered in clinical practice—about 150,000 new ones are discovered each year in the United States, of which 30–50 % are malignant [1]. Of the benign lesions, 80 % are caused by infectious granulomas, 10 % are caused by hamartomas, and the remaining 10 % are caused by a variety of rarer disorders including noninfectious granulomas and other benign tumors [2].

Fine-needle aspiration (FNA) biopsy is recommended as the first-line diagnostic approach in the workup of SPN.

PET should be reserved for those situations in which a biopsy is inconclusive or contraindicated [3].

Initial studies indicated that a standardized uptake value of 2.5 might distinguish benign from malignant processes; however, later studies have shown that there can be some overlap in these values between benign and malignant processes [1].

Case 2.2: Non-small Cell Lung Cancer

History

A 60-year-old female with history of adenocarcinoma involving the right lung. Additional history of left breast cancer in the past.

Findings (Fig. 2.2)

Pretherapy images demonstrate hypermetabolic pulmonary nodule measuring 2.4 × 1.6 cm in the right lung base, SUVmax 3.2.

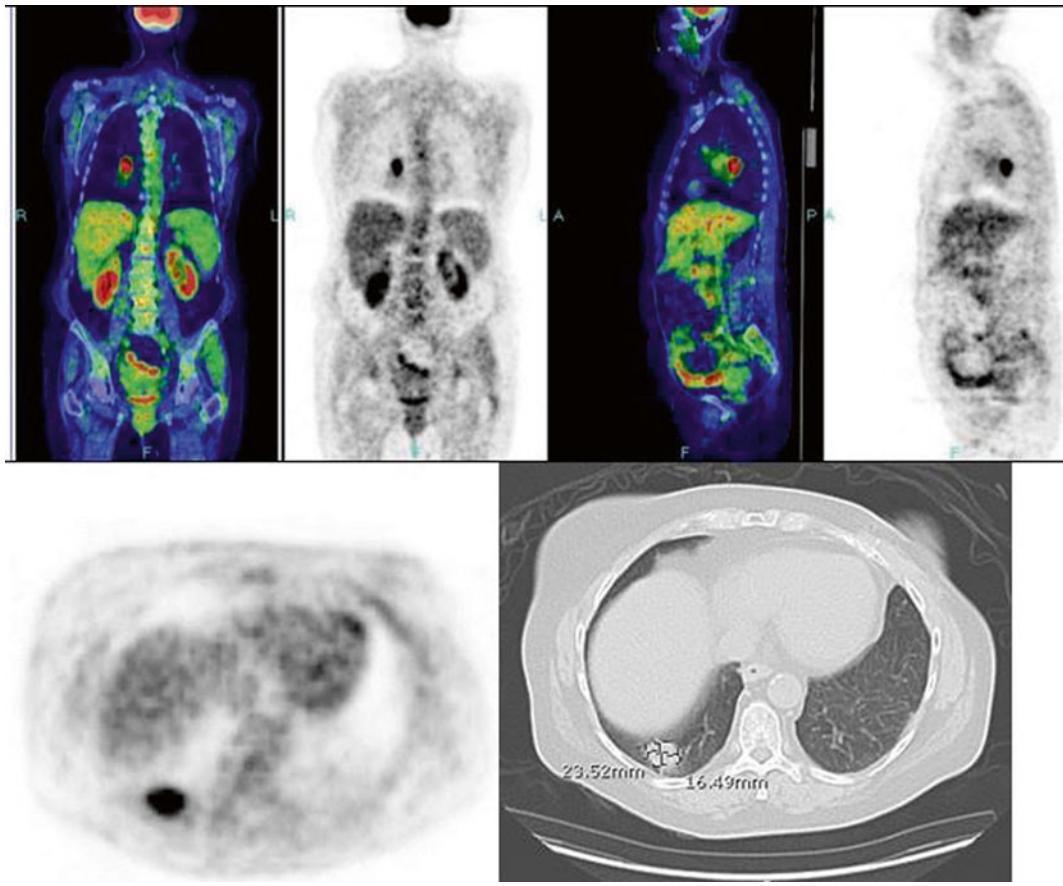

Fig. 2.2 PET/CT (pretreatment)

Impression

Hypermetabolic solitary pulmonary nodule in the right lung base, consistent with malignancy (on biopsy). (The patient later underwent surgical resection of the right lower lobe with nodal dissection.)

Findings (Fig. 2.3)

Posttreatment/follow-up PET/CT demonstrates findings consistent with status post resection of previously noted hypermetabolic pulmonary nodule (seen in Fig. 2.1) at the right lung base. Mild hypermetabolic activity at the lower right costovertebral junction represents inflammation from recent resection. Linear, left chest wall uptake is related to prior breast cancer therapy.

Impression

Post-therapy scan, compatible with treated disease with no scan evidence of local recurrence or distant metastasis.

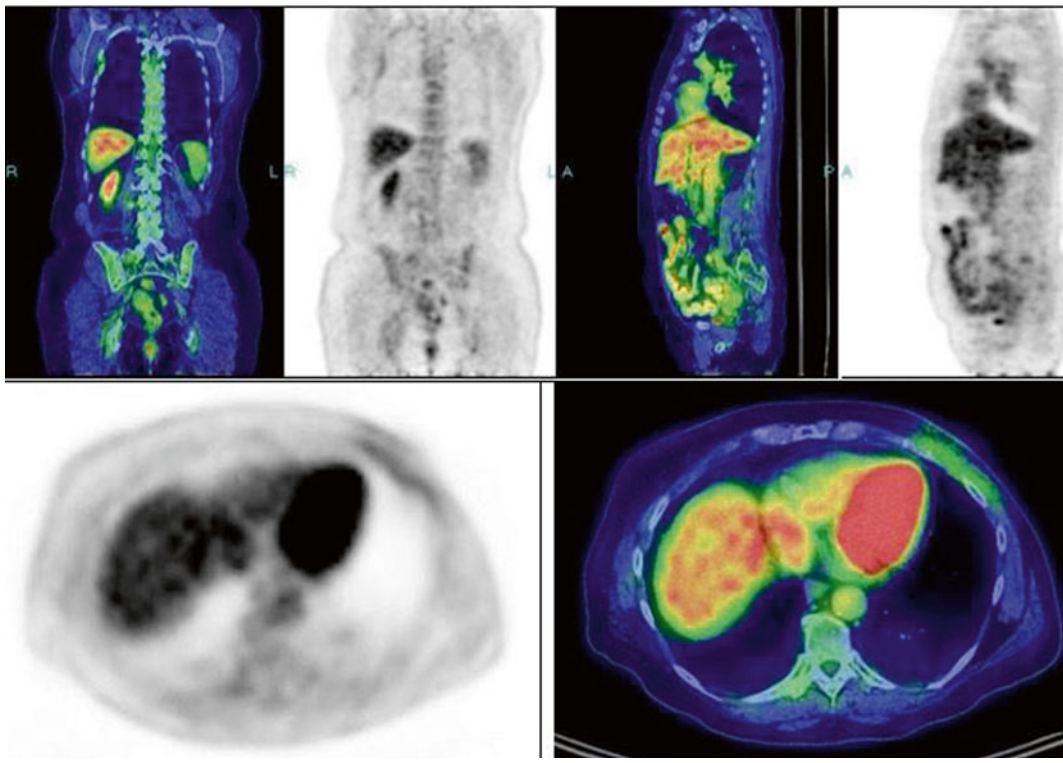

Fig. 2.3 PET/CT (posttreatment/surgery)

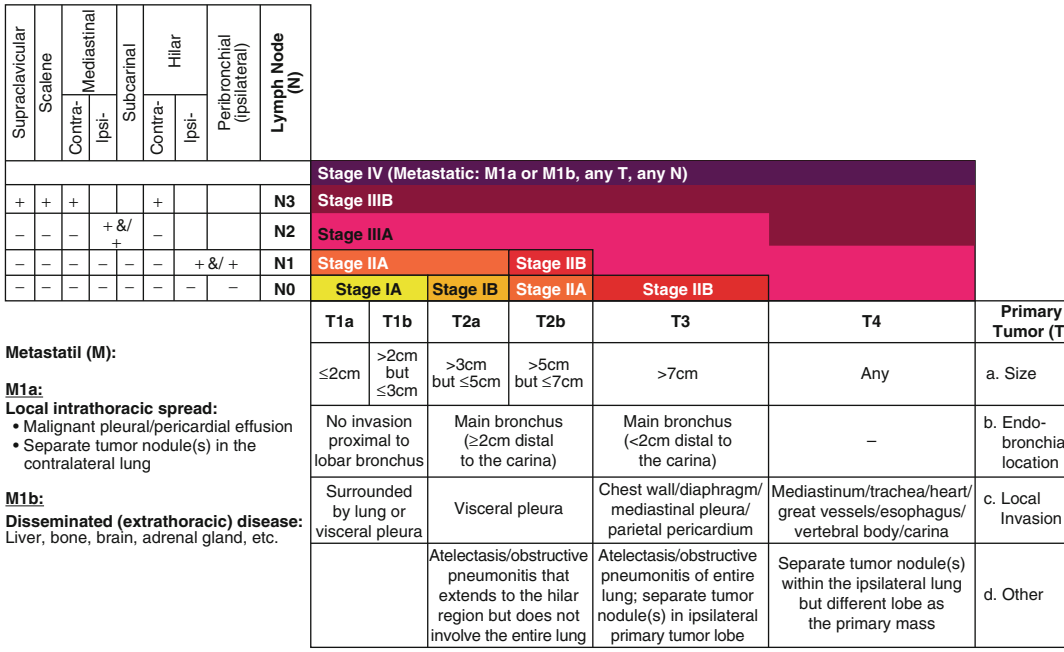

Fig. 2.4

Pearls and Pitfalls

Most solitary pulmonary nodules without increased FDG uptake are highly unlikely to be malignant. However, FDG-PET scans are occasionally falsely negative in cases of well-differentiated adenocarcinoma, bronchoalveolar cell carcinoma, and carcinoid. The spatial resolution of most commercial PET scanners is about 5–6 mm; FDG-PET is less accurate for pulmonary nodules smaller than 1 cm [1].

Discussion

Figure 2.4 illustrates the descriptors from the seventh edition of the TNM staging system for lung cancer [4].

Case 2.3: Squamous Cell Carcinoma of the Lung

History

A 67-year-old female with right lung, pleural-based squamous cell carcinoma (biopsy proven).

Findings (Fig. 2.5)

Large 6.4 cm hypermetabolic, pleural-based mass in the right middle lobe (RML), SUVmax 8.2, with area of central necrosis (yellow arrow) within it. Hypermetabolic focus in the (contralateral) left axillary region (red arrow) corresponds to lymph node on CT.

Impression

Stage III lung cancer. Hypermetabolic pleural-based RML lung malignancy (proven on biopsy as squamous cell carcinoma) with contralateral left axillary lymph node metastasis.

Pearls and Pitfalls

With regard to PET/CT imaging, patient motion (e.g., respiratory motion) can produce significant artifacts on fused images and may cause confusion as to the correct position of the origin of the detected photon [5]. It is recommended to review CT and PET images separately for comparison.

Discussion

National Comprehensive Cancer Network (NCCN) guidelines were reviewed on March 13, 2012 for utilization of F18 fluorodeoxyglucose (FDG) PET and PET/CT.

Practice guidelines from the SNM, NCCN, and other professional groups summarized for lung cancer [6]:

1. Characterization of an indeterminate pulmonary nodule which is at least 8–10 mm in diameter
2. Initial staging in patients with non-small cell lung cancer and selected patients with small cell lung cancer
3. Delineation of gross tumor volume in patients receiving radiation therapy

PET and PET/CT are approved by the Centers for Medicare and Medicaid Services (CMS) for:

a. Characterization of solitary pulmonary nodules.
b. Development of initial treatment strategy and subsequent treatment strategy in patients with NSCLC.
c. Development of initial treatment strategy in patients with SCLC. The use of PET/CT for subsequent treatment strategy falls under "CED" (coverage with evidence of development) category.

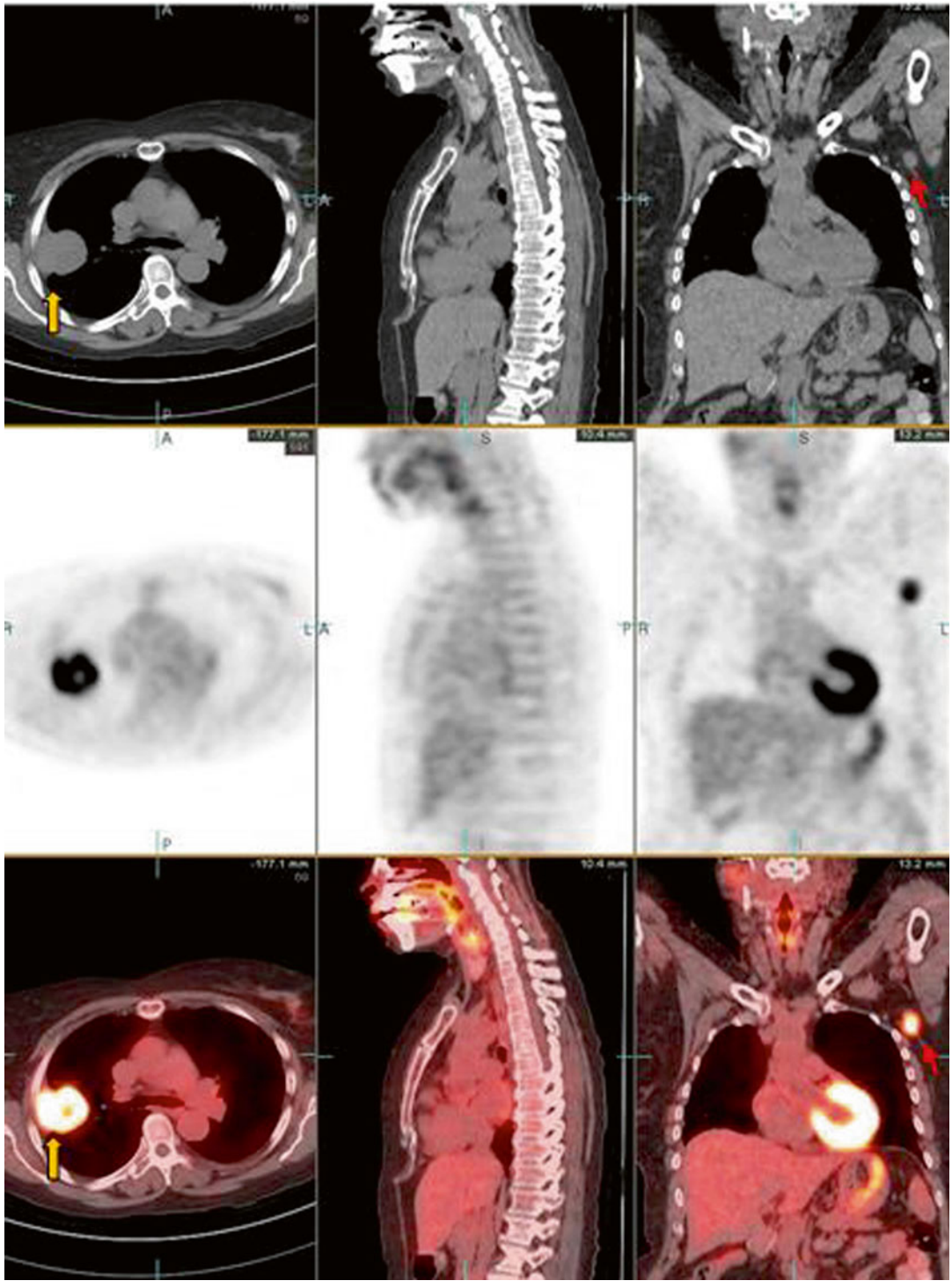

Fig. 2.5

Case 2.4: Stage IIIB Non-small Cell Lung Cancer (NSCLC)

History

A 75-year-old male with right middle lobe non-small cell lung cancer, clinical T4b N2 M0, stage IIIB.

Findings (Fig. 2.6)

Large, irregular, hypermetabolic mass (>7 cm), SUVmax 13.6, in the medial segment of the right middle lobe, with central necrosis (appearing photopenic on PET). There is invasion of the tumor into the right minor fissure and extends superiorly into the right upper lobe. A satellite hypermetabolic nodule, SUVmax 6.6, seen posterior to the dominant mass (yellow arrow).

Impression

Non-small cell lung carcinoma (biopsy proven), in the RML, stage IIIB.

Pearls and Pitfalls

PET is a useful tool for identifying patients at high risk for disease recurrence and restaging following neoadjuvant chemotherapy with or without radiation. PET is particularly useful when posttreatment scarring and pleural thickening limit the role of CT for disease assessment [7].

Discussion

Malignant lung neoplasms arise from respiratory epithelium (bronchi, bronchioles, and alveoli).

Four major cell types make up 90 % of all primary lung neoplasms:

1. Squamous cell or epidermoid carcinoma
2. Small cell (also called oat cell) carcinoma
3. Adenocarcinoma (including bronchoalveolar)
4. Large cell (also called large cell anaplastic) carcinoma

Remainder include:

5. Undifferentiated carcinomas
6. Carcinoids
7. Bronchial gland tumors (including adenoid cystic carcinomas and mucoepidermoid tumors)
8. Other rarer tumor types

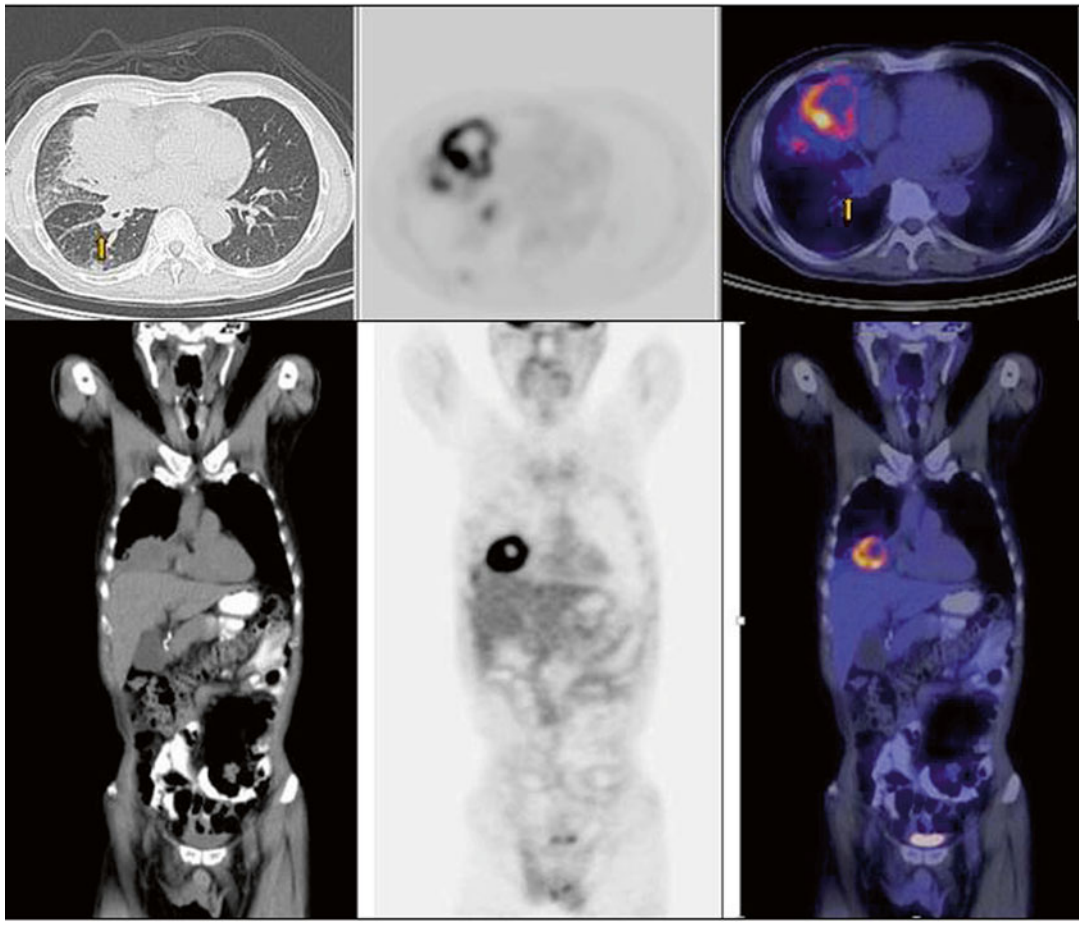

Fig. 2.6

Adenocarcinoma has replaced squamous cell carcinoma as the most frequent histologic subtype for unclear reasons [8].

Case 2.5: Stage IV NSCLC

History

A 79-year-old female with history of locally advanced non-small cell lung cancer in the left upper lobe.

Pretreatment PET CT images and follow-up surveillance PET/CT following cyber knife radiation therapy are shown below.

Findings (Figs. 2.7 and 2.8)

Large, hypermetabolic left posterior apical 4.8 × 4.0 cm mass which abuts the medial pleura and left paravertebral margin, SUVmax of 19.7. In addition, there is subtle erosion of the lateral margin of T3 vertebral body cortex. The mass extends through the left T3/4 neural foramen with epidural involvement at this level. The epidural portion of the mass is inactive on PET, probably related to small size.

Impression

Stage IV lung cancer.

Fig. 2.7 Initial PET/CT, axial view

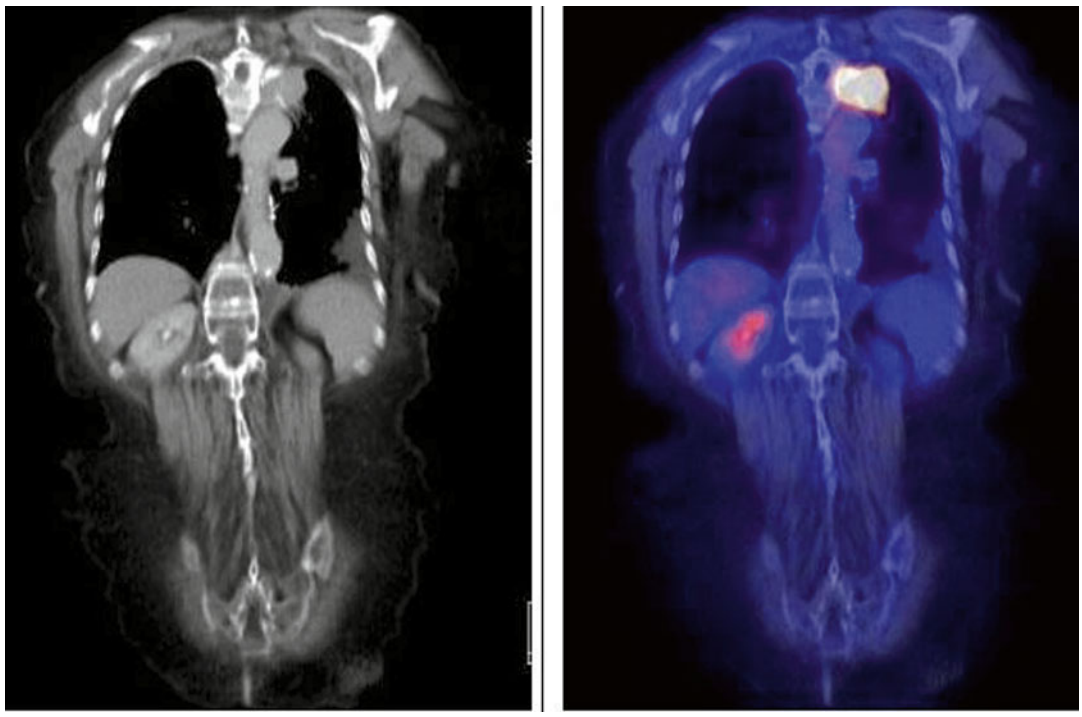

Fig. 2.8 Initial PET/CT, coronal view

Findings (Figs. 2.9 and 2.10)

There is linear hypermetabolic activity associated with fibrotic changes in the left lung apex which appears more confluent and demonstrates SUVmax at 4.4 (compared to pretreatment PET/CT) (which was stable from intermittent post-therapy scan from 6 months prior, not shown).

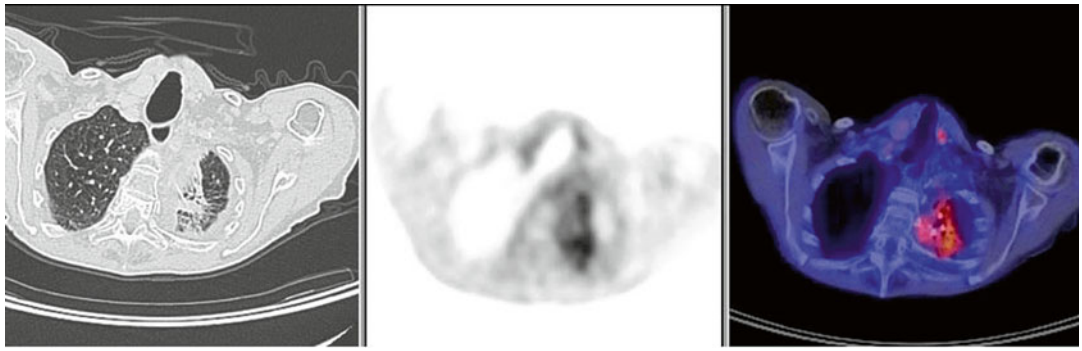

Fig. 2.9 Surveillance PET/CT (2 yrs. following radiation therapy), axial view

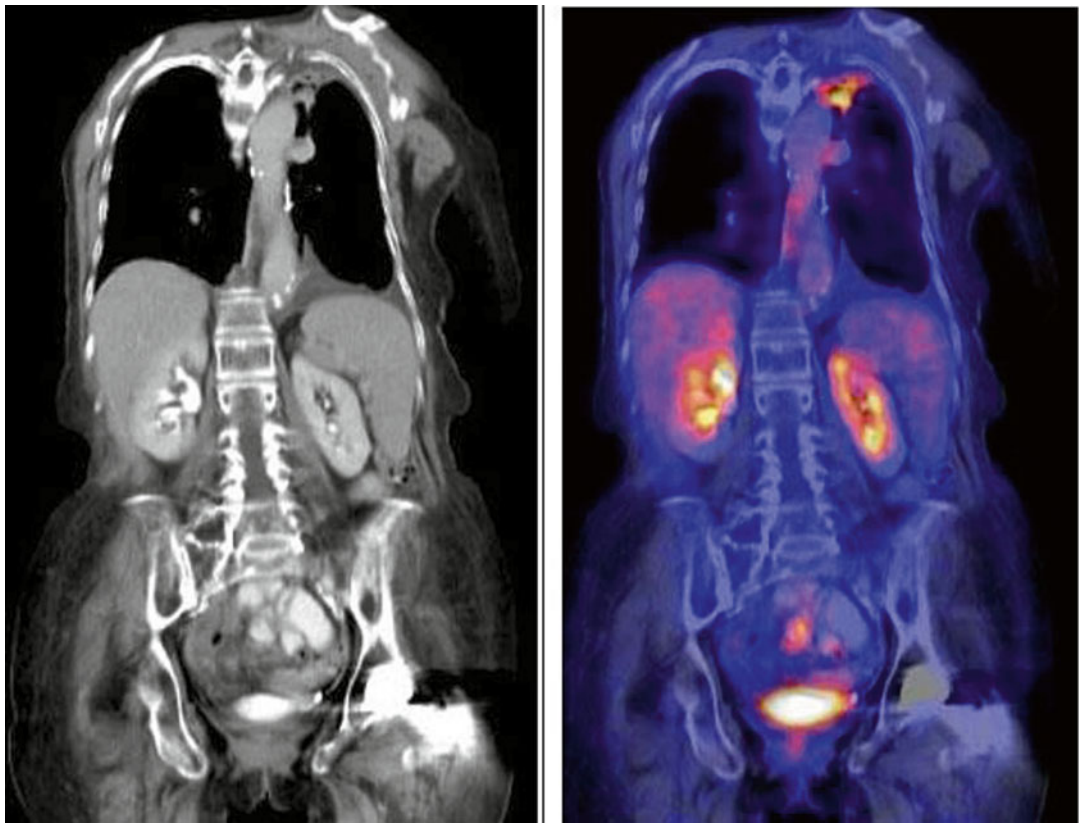

Fig. 2.10 Surveillance PET/CT (2 yrs. following radiation therapy), coronal view

There is associated traction bronchiectasis, left lung volume loss, and mediastinal shift to the left. Findings compatible with postradiation changes. Remainder of the study was unremarkable for metabolically active metastatic disease.

Impression

Stable postradiation-induced inflammation in the left lung apex.

Pearls and Pitfalls

Radiation pneumonitis (RP) has a characteristic linear border and diffuse intense uptake [7]. Uptake on PET can be seen before radiation changes are seen radiographically. Tumor recurrence is usually more focal and can be differentiated from radiation pneumonitis. However, sometimes RP can occasionally have heterogeneous uptake in the early treatment stages. PET imaging should be delayed by 3–6 months following radiation therapy.

Discussion

See Fig. 2.11.

Treatment Recommendations and Future Research Directions in the Management of Non-Small Cell Lung Cancer

Stage	Standard Management	Future Directions
Stage I	Surgical resection	Adjuvant therapy (chemotherapy/radiation or a combination of the two) Chemoprevention
Stage II	Surgical resection	Same as stage I
Stage IIIA	Chemoradiotherapy Surgical resection in selected patients	Neoadjuvant combined-modality therapy to downstage primary tumor
Stage IIIB	Chemoradiotherapy	Neoadjuvant combined-modality therapy to downstage primary tumor
Stage IV	Cisplatin-based chemotherapy* Surgical resection if solitary metastatic lesion with resectable primary tumor	More efficacious single-agent and combination chemotherapy

*Chemotherapy beneficial only in patients with good performance status and weight loss less than 10% of their body weight

Fig. 2.11

Case 2.6: Small Cell Lung CA (SCLC)

History

A 65-year-old female with history of limited stage small cell lung carcinoma.

Findings (Fig. 2.12)

Initial scan shows hypermetabolic pulmonary nodule in the left lower lobe (adjacent to the left hilum), measuring 1.9 × 2.9 cm, SUVmax 34.3, most consistent with malignant tumor.

Impression

Left lower lobe hypermetabolic pulmonary nodule consistent with neoplasm (primary versus secondary).

Pathology on biopsy: Small cell lung carcinoma.

The patient underwent chemoradiation and prophylactic cranial radiation. Follow-up PET/CT, 1 year since initial diagnosis was obtained. (fig 2.13)

Findings (Fig. 2.13)

Posttreatment scan shows traction bronchiectasis, peribronchial thickening, and fibrotic changes related to radiation therapy in the left lower lobe, demonstrating low-grade activity, SUVmax 3.8. There is volume loss within the left lung with shift of mediastinum to the left.

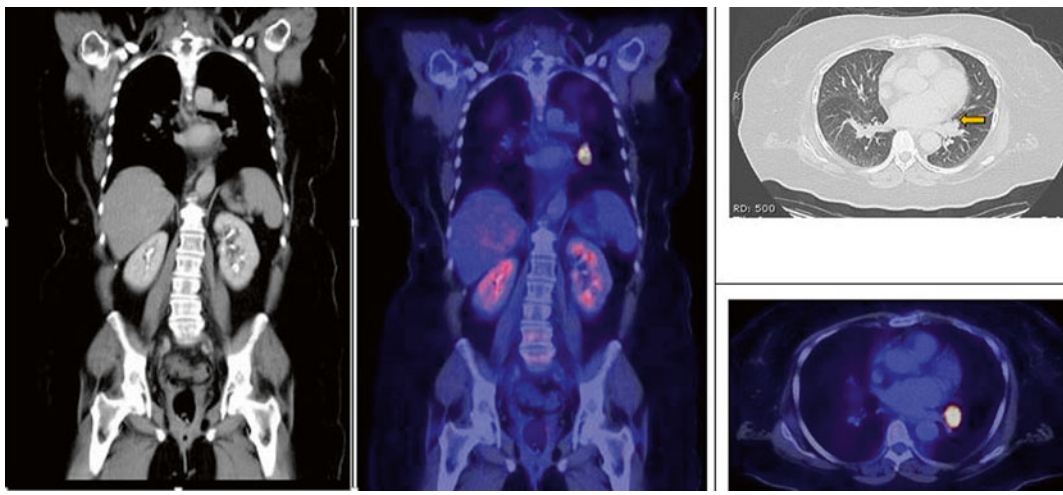

Fig. 2.12

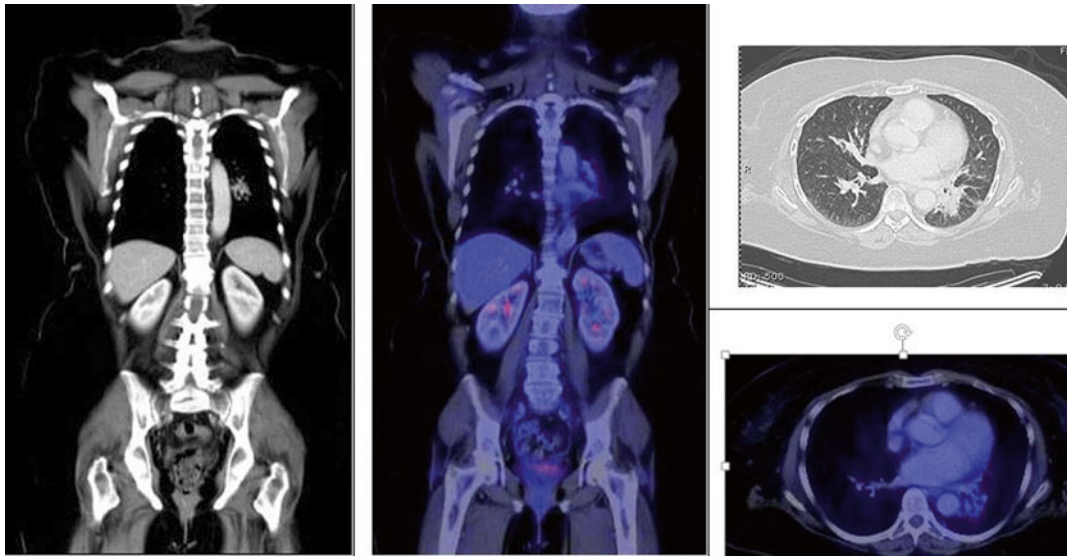

Fig. 2.13

Impression

Findings consistent with radiation-related changes in the left lower lobe.

Pearls and Pitfalls

Limited data indicate that PET and PET/CT are more accurate than conventional imaging in the staging and follow-up of SCLC with superior accuracy for mediastinal, hilar, and extra thoracic lymph nodes, distant metastases, and bone marrow metastases [9]. Compared to conventional imaging, PET/CT can result in a change in stage in 10–17 % of patients.

Discussion

SCLC is considered a systemic disease. The clinical course, prognosis, and treatment options are clearly different from those of other lung cancers. Clinically, lung cancers are often categorized into SCLC and non-SCLC (NSCLC) [10].

SCLC is categorized into two stages: limited disease and extensive disease. The disease is termed limited when it is confined to an area of the chest that can be encompassed by a single irradiation port; supraclavicular nodes may be included. The disease is called extensive when metastasis outside the thorax is present or when intrathoracic disease cannot be contained in a single irradiation port.

Patients with SCLC are rarely surgical candidates, and they are usually treated with irradiation and/or chemotherapy.

Case 2.7: Neuroendocrine Tumor Favoring Small Cell Lung Cancer

History

A 49-year-old male presents with anterior mediastinal mass.

Findings (Fig. 2.14)

(Red arrow) hypermetabolic, heterogeneous, left anterior mediastinal mass centered in the prevascular space/AP window, SUVmax 9.7.

Impression

Hypermetabolic anterior mediastinal mass corresponding to biopsy-proven diagnosis of neuroendocrine tumor favoring small cell carcinoma.

Pearls and Pitfalls

The maximum SUVs of neuroendocrine tumors are significantly different for carcinoid tumors, large cell neuroendocrine carcinomas (LCNEC), and small cell lung cancers (SCLC). A high maximum SUV suggests short survival of patients with (LCNEC) or (SCLC).

Discussion

Neuroendocrine tumors of the lung arise from Kulchitsky cells of the bronchial mucosa and comprise typical carcinoid, atypical carcinoid, large cell neuroendocrine carcinoma (LCNEC), and small cell lung cancer (SCLC) [11]. Pulmonary or bronchial carcinoid tumors account for over 25 % of all carcinoid tumors and for 1–2 % of all pulmonary neoplasms.

National Comprehensive Cancer Network (NCCN) guidelines were reviewed on March 13, 2012 for utilization of F18 fluorodeoxyglucose (FDG) PET and PET/CT.

Specific indications for PET and PET/CT in (SCLC) [12]:

For initial staging of small cell lung carcinoma and high-grade/large cell neuroendocrine carcinoma: PET/CT is recommended if limited stage is suspected (staging). PET/CT has replaced bone scan in NCCN guidelines; bone scan is now only recommended if PET/CT is not available.

PET/CT is not recommended for routine follow-up after initial therapy (restaging).

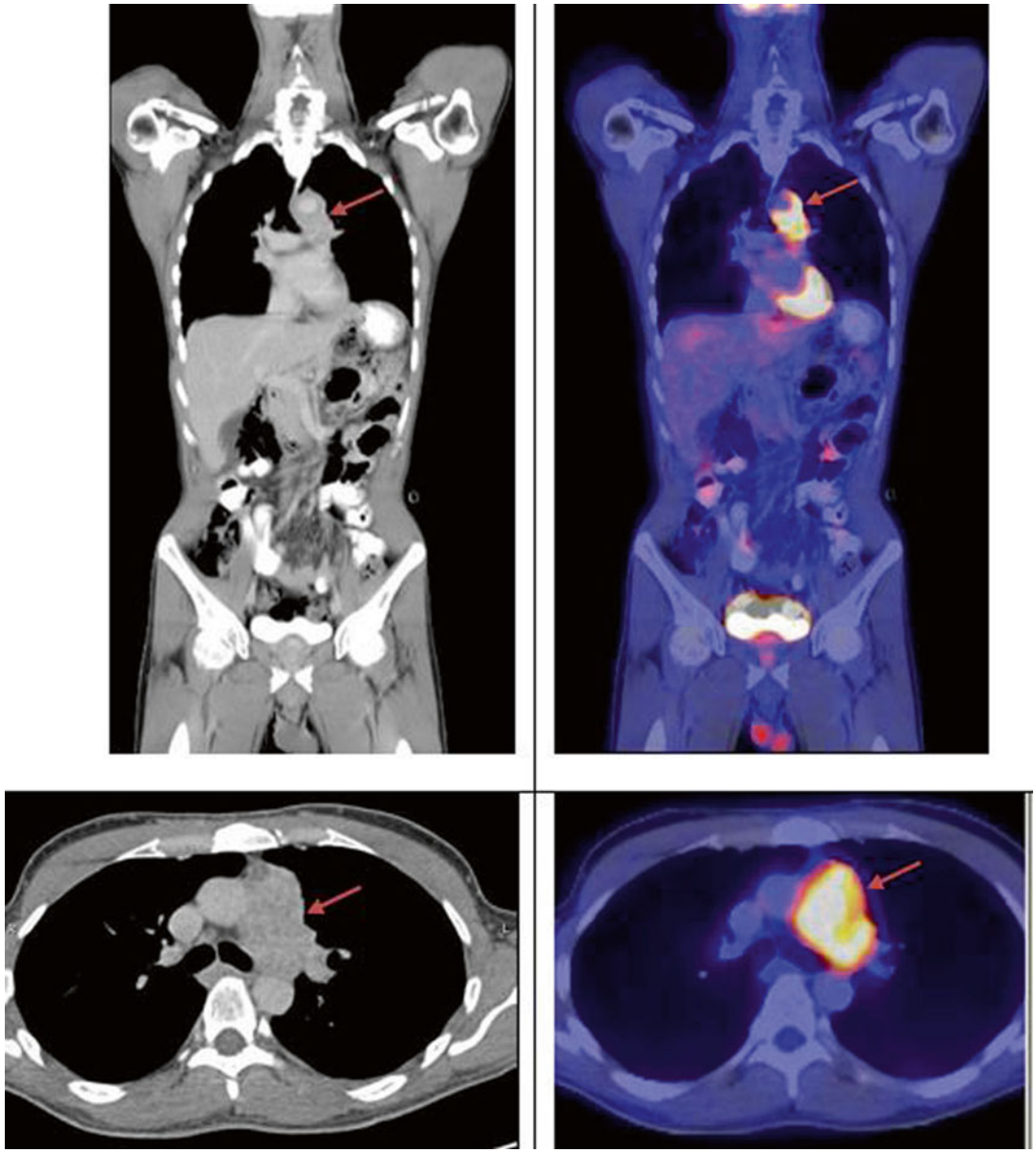

Fig. 2.14

PET/CT is also suggested for radiation treatment planning purposes.

For low- and intermediate-grade neuroendocrine carcinomas (e.g., carcinoid tumor): PET scan is considered optional (staging). Currently, PET is undergoing evaluation in clinical trials and should only be considered as a supplement and not a replacement to other studies in such cases [12].

Case 2.8: Mesothelioma

History

An 80-year-old male with history of unresectable left malignant pleural mesothelioma.

Findings (Fig. 2.15)

Multiple hypermetabolic pleural-based nodules in the left hemithorax demonstrating circumferential distribution causing encasement of the left lower lobe with loss of lung volume (yellow arrow). Pleural-based

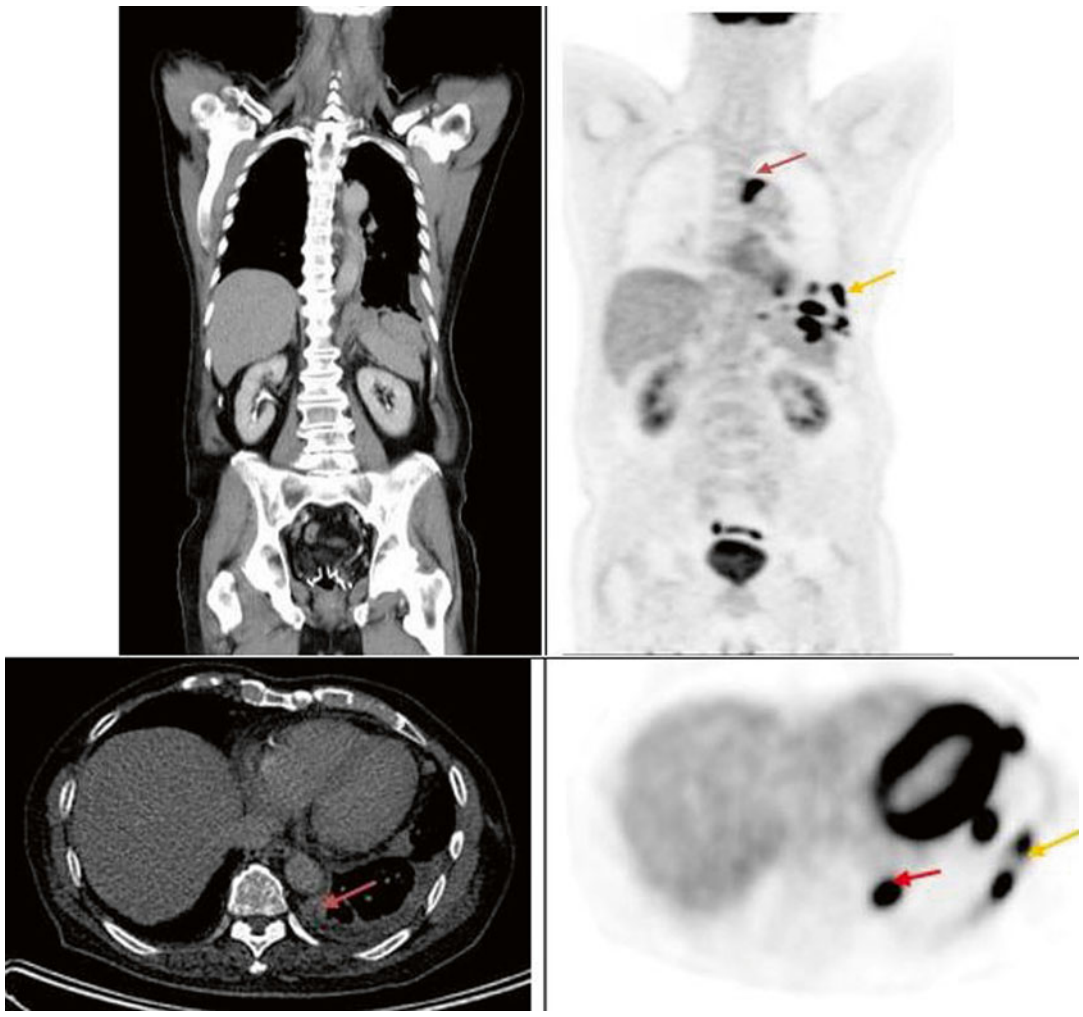

Fig. 2.15

lesions seen at the medial aspect of left lung apex, between the trachea and posterior arch of aorta and in the left costovertebral region shows SUVmax in the range of 25.0–26.0 (red arrow). No FDG avid pleural plaques in the right hemithorax. Left pleural effusion.

Impression

Findings compatible with biopsy-proven diagnosis of left hemithorax mesothelioma.

Pearls and Pitfalls

The findings in talc pleurodesis are very similar to mesothelioma and pleural metastasis. In patients with mesothelioma, talc pleurodesis is used in treating recurrent pleural effusions, which also limits future PET/CT evaluation as they both show similar scan patterns. The activity of both pleural implants and talc-induced inflammation will be high. Careful evaluation of the PET/CT images in the pleural reflections adjacent to diaphragm is important to allow confident identification of loculated talc (radiodense material on CT) at these sites [13].

Discussion

Malignant pleural mesothelioma (MPM) is an uncommon neoplasm that arises from the pleura or, rarely, the pericardium or peritoneum. There are approximately 2000–3000 new cases diagnosed in the United States every year, the majority of which are associated with prior asbestos exposure. Patients frequently present with dyspnea, chest pain, cough, and weight loss. The tumor can invade both visceral and parietal pleura and frequently extends to adjacent structures [14]. The prognosis is poor, with a median survival time of 12 months after diagnosis.

Case 2.9: Mesothelioma (with low SUV)

History

A 65-year-old male with biopsy-proven right pleural mesothelioma.

Findings (Fig. 2.16)

Circumferential pleural thickening with associated hypermetabolism, SUVmax up to 7.2, with presence of calcified pleural plaques in the right hemithorax. Large right pleural effusion.

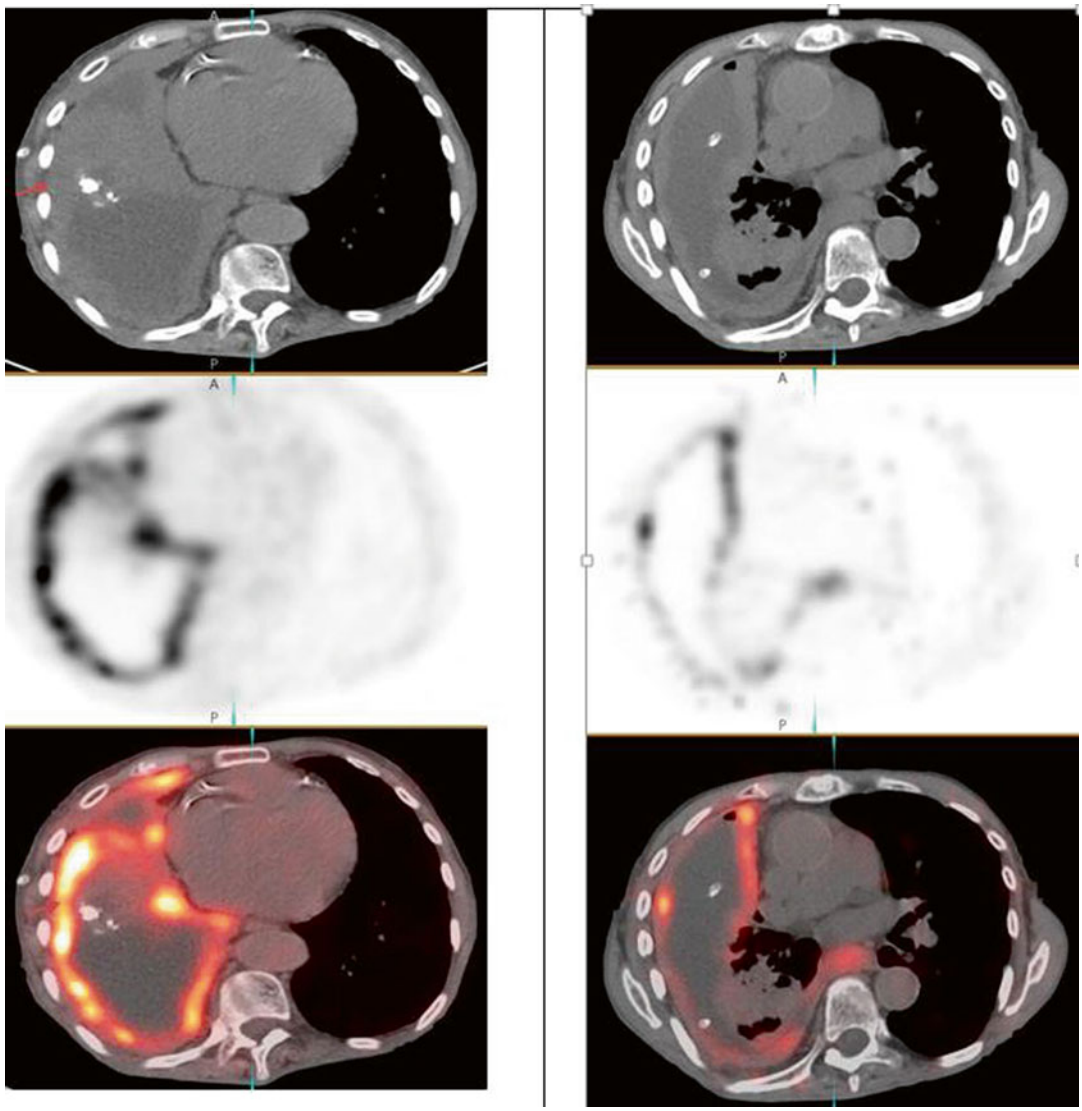

Fig. 2.16

Impression

Findings compatible with known mesothelioma in the right hemithorax.

Pearls and Pitfalls

Patients with highly active mesotheliomas on FDG-PET imaging have a poor prognosis. High FDG uptake in these tumors indicates shorter patient survival [15].

Discussion

Several factors have been shown to correlate with reduced survival time: intrathoracic lymph node metastases, distant metastatic disease, and extensive pleural involvement [14].

Case 2.10: Solitary Fibrous Tumor (SFT) in the Lung

History

A 65-year-old male with right lower lobe mass on the CT chest, status post biopsy of tumor.

Findings (Fig. 2.17)

Mild-to-moderately active, pleural-based soft tissue mass in the right costophrenic angle (yellow arrow), measuring approximately 7.1 cm × 5.0 cm × 8.2 cm (TR XAP X CC), SUVmax 2.9.

Impression

Pleural-based right lower lobe mass with low-grade FDG activity, consistent with biopsy-proven diagnosis of benign solitary fibrous tumor.

Pearls and Pitfalls

Benign SFT exhibits low-grade activity in PET, whereas malignant SFT tends to be strongly hypermetabolic. In addition to FDG activity on PET scans, lesion multiplicity is a helpful feature in identifying malignant disease [16]. However, benign pleural SFT sometimes causes adjacent rib destruction, mimicking an aggressive or malignant lesion. Ultimately, benign SFT has a local recurrence rate of 8 %, and malignant lesions recur within 2 years in as many as 63 % of cases.

Discussion

Solitary fibrous tumors (SFTs) are uncommon neoplasms of mesenchymal origin that can be benign or malignant. Although SFTs most commonly occur in the pleura, numerous extra pleural sites of involvement have been reported. SFTs most commonly present during the fifth and sixth decades of life, and there is no significant sex predilection. SFT can be associated with hypoglycemia secondary to production of insulin-like

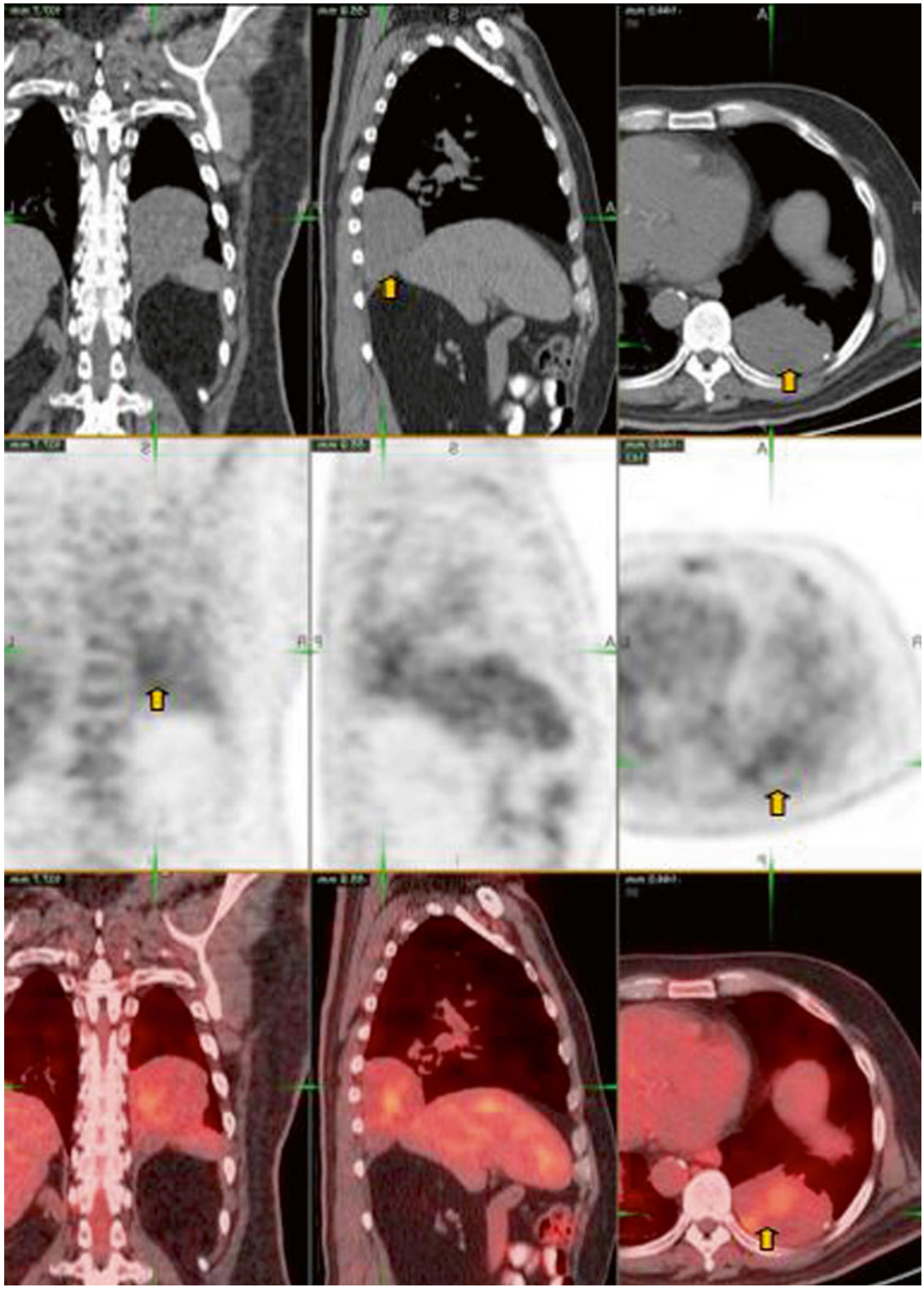

Fig. 2.17

growth factor, osteoarthropathy, arthralgia, and clubbing. Histologically, SFTs are composed of spindle cells within a background of collagen stroma, often in a whorled pattern or patternless. These tumors are highly vascular and have a propensity to undergo myxoid degeneration [16]. The diagnosis is confirmed by characteristic positive immunohistochemical staining for CD34 and negative staining for S-100. Overall, approximately 15–20 % of SFTs are malignant, and even benign SFTs have indeterminate malignant potential. Therefore, complete resection is the treatment of choice.

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