Nuclear Medicine Imaging of Lung Infection

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Learning Objectives

• To become familiar with the pathophysiology and clinical presentation of the most frequent and potentially severe forms of lung infection
• To understand the principles of X-ray-based and radionuclide-based imaging for diagnosing/identifying sites of lung infection
• To learn the role of single-photon emitting agents for imaging lung infection: 67Ga-citrate, 111In-oxine-leukocytes, 99mTc-HMPAO-leukocytes
• To learn the role of the positron emitting agent, [18F] FDG for imaging lung infection
• To learn the most common patterns of radionuclide imaging in patients with different forms of lung infection

13.1 Introductory Background

The definition of lung infection includes acute or chronic infection of the upper or lower respiratory tract caused by microorganisms such as bacteria, viruses, fungi, or parasites. This condition that causes discomfort and affects the day-to-day life of patients can become severely complicated if not properly treated [1]. Bronchitis is most commonly due to viruses rather than bacteria, while pneumonia (either it be community-acquired or a nosocomial infection) is most frequently...
caused by *Streptococcus pneumoniae* [2, 3]. Symptoms, treatment, prevention, and prognosis differ depending on the cause of infection (bacterial, viral, fungal, or parasitic), the type of infection (acquired in a community environment, hospital, or nursing home), and the patient’s status (immunocompetent or immunocompromised) [4]. The main signs and symptoms of lung infections are fever, shortness of breath, dry or productive coughing, fatigue (particularly in case of infection caused by *Candida*), production of mucus, tightness, pressure, and pain in the chest that worsens when breathing in deeply or coughing. In case of infection with methicillin-resistant *Staphylococcus aureus* (MRSA), concomitant skin or urinary infection may also be present [1].

The diagnosis of lung infection is generally based on clinical findings associated with the detection of parenchymal infiltrate at chest X-ray or CT scan [5]. High-resolution CT is the imaging method of choice to evaluate diffuse lung and small airway diseases [6], and it reliably detects infection also in the presence of an underlying chronic lung disease (such as bronchiectasis) [7, 8]. However, in some instances, radiological imaging alone cannot distinguish an acute exacerbation from sequela of a prior infection.

 Cultures of both blood and sputum often identify the microorganism responsible for the infection, so that the most adequate antibiotic therapy can be planned, although false-positive as well as false-negative findings have been reported [9–11]. When infection from *Mycobacterium tuberculosis* (TB) or HIV-associated infection is suspected, specific recommendations and guidelines should be followed for a correct diagnosis [12].

### Key Learning Points

- Acute or chronic infection of the upper or lower respiratory tract due to microorganisms causes discomfort, affects the day-to-day life of patients, and can become severely complicated.
- The diagnosis of lung infection is generally based on clinical findings associated with detection of parenchymal infiltrate at chest X-ray or CT scan.
- However, in some instances, radiological imaging alone cannot distinguish an acute exacerbation from sequela of a prior infection.

### 13.2 Imaging Lung Infection with Single-Photon Emitting Agents

Nuclear medicine imaging techniques have been extensively used in patients with lung infection, mostly for TB-associated or HIV-associated infections [13–16]. Following seminal work by Levenson et al. in patients with *Pneumocystis carinii* pneumonia [17], increased uptake of $^{67}$Ga-citrate has been described in many conditions (besides *Pneumocystis carinii* pneumonia), such as abscess, TB or mycotic lesions, pneumoconiosis, and infection from cytomegalovirus, although false-negative results have been reported [16, 18–21]. One of the most important non-oncologic clinical applications of $^{67}$Ga-citrate scintigraphy of the lungs is early detection of opportunistic infection; this imaging technique enables to detect diffusely increased uptake of the radiopharmaceutical in the lung even when the chest X-ray is normal [17, 22]. In this regard, although $^{67}$Ga-citrate scintigraphy for pulmonary diseases is hampered by several drawbacks (such as its relative lack of specificity, delay between tracer injection and imaging time, and suboptimal imaging characteristics) [23], its sensitivity is higher than that of a chest X-ray in the detection of pulmonary TB [24] and of lung involvement from paracoccidioidomycosis [25]. In patients with TB, the intensity of pulmonary uptake of $^{67}$Ga-citrate is directly related to the inflammation level and to the burden of *Mycobacterium tuberculosis* (assessed by semi-quantitation of sputum acid-fast bacillus) [26]. $^{67}$Ga-citrate scintigraphy and high-resolution CT in sputum smear-negative patients with active TB perform equally well in the noninvasive diagnosis of TB, with high sensitivity (100% versus 93%) and specificity (83% versus 100%) [27].

Sequential $^{67}$Ga-citrate scans are also helpful to monitor the response to treatment in patients with TB, chronic lung disease, or AIDS, in whom radiological findings can be equivocal because of the confounding effects of either chronic pulmonary fibrotic changes or poor inflammatory reaction due to immunodeficiency [28]. $^{67}$Ga-citrate scintigraphy has also been employed to determine the most appropriate duration of treatment with different anti-TB regimens [26]. Pulmonary lesions in active TB compared to nontuberculous mycobacterial infection in acid-fast bacilli smear-positive non-HIV-infected patients have also been successfully evaluated with $^{67}$Ga-citrate scintigraphy, demonstrating the usefulness of this technique in predicting active pulmonary TB in acid-fast bacilli smear-positive patients [29].

Scintigraphy with autologous leukocytes labeled with either $^{111}$In-oxine (most recently reviewed in [30]) or $^{99m}$Tc-HMPAO [31] detects infection with high diagnostic accuracy (sensitivity up to 95% for soft tissue infections). However, there have been only a limited number of investigations on the usefulness of this imaging method for diagnosing lung infections [32]. In patients with focal pulmonary bacterial infections, scintigraphy with labeled leukocytes is more sensitive than $^{67}$Ga-citrate scintigraphy [33], and it is often positive before changes can even be seen on a plain chest X-ray [34]. Equivocal results have instead been reported for radio-labeled leukocyte scintigraphy in patients with bronchiectasis [32, 35].
It should be noted that interpretation of the images obtained with labeled leukocyte scintigraphy of the lungs can be problematic, because of interference from blood pool activity in the heart and great vessels and pulmonary blood background and because of the physiologic leukocyte margination along the walls of small pulmonary vessels early after reinfusion of labeled leukocytes. Furthermore, nonspecific inflammatory changes associated with congestive heart failure or with acute respiratory distress syndrome may mimic diffuse or focal pulmonary uptake in a similar manner as observed in patients with lung infection, making the distinction between infection and inflammation difficult [23, 36]. Nonetheless, if pulmonary accumulation of radiolabeled leukocytes is graded according to soft tissue, rib, and liver activities, specificity increases up to 100% for pulmonary and pleural infections, and a negative scan rules out pulmonary infection with high confidence [37]. Furthermore, in the current clinical practice, these methodological limitations can be largely overcome by SPECT/CT imaging.

A pathophysiologic limitation of radiolabeled leukocyte scintigraphy can be seen in lung infections where leukocyte infiltrations are less significant, as it occurs in granulomatous or nonpyogenic infections [23, 34, 38]. For similar reasons, labeled leukocyte scintigraphy is not routinely used for the characterization of TB patients since variable results (especially in the evaluation of small infectious foci) have been reported, probably due to the predominant type of cells involved (lymphocytes and macrophages, rather than granulocytes) [38]. Finally, in patients with AIDS radiolabeling of autologous leukocytes for scintigraphy can be technically unfeasible because of low white blood cell counts.

Scintigraphy with $^{67}$Ga-citrate or with $^{99m}$Tc-HMPAO-labeled leukocytes has been used in patients with occult sepsis in intensive care units. Although $^{67}$Ga-citrate scintigraphy reliably identified extra-site(s) of infection, it did not accurately identify ventilator-associated pneumonia [39]. Instead, $^{99m}$Tc-HMPAO-leukocyte scintigraphy demonstrated good sensitivity (95–96%) and specificity (84–91%) in detecting the occult source of sepsis [40, 41]. It should be noted, however, that in this critical clinical scenario, scintigraphy with $^{67}$Ga-citrate or with labeled leukocytes has definite disadvantages (i.e., either amount of blood needed to harvest leukocytes for labeling or long time span between administration and scintigraphy) with respect to $[^{18}$F]FDG PET/CT (see further below).

Although both $^{201}$Tl-chloride and $^{111}$In-DTPA-octreotide have been employed to distinguish benign lung lesions (i.e., infection) from cancer, their clinical application in infection per se has been very limited [23], except for scanty reports concerning patients with fungal infection [42] or with TB infection [43]. In TB infection, $^{201}$Tl-chloride scintigraphy seems to perform better than $^{67}$Ga-citrate scintigraphy (sensitivity 88% versus 83%, specificity 82% versus 60%, accuracy 85% versus 75%) [44]. Similar results have been reported for $^{99m}$Tc(V)-DMSA, suggesting that scintigraphy with this imaging agent might perform better than $^{67}$Ga-citrate scintigraphy for assessing the overall burden and activity of TB [45]. Good diagnostic performance in patients with pulmonary TB has been reported also for $^{99m}$Tc-sestamibi and $^{99m}$Tc-tetrofosmin, with high sensitivity (96% and 94%, respectively) and specificity (86% and 88%, respectively) [46].

**Key Learning Points**

- Single-photon emitting agents employed for imaging lung infection include $^{67}$Ga-citrate, $^{111}$In-ofoxine-leukocytes, $^{99m}$Tc-HMPAO-leukocytes.
- The preferred imaging modality is currently scintigraphy with $^{99m}$Tc-HMPAO-leukocytes, preferably with SPECT/CT imaging.
- However, in some conditions, the diagnostic performance of $^{99m}$Tc-HMPAO-leukocyte scintigraphy is suboptimal because of the predominant type of cells involved (lymphocytes and macrophages, rather than granulocytes, as in TB infection) or is technically unfeasible because of low white blood cell count, as in HIV-associated infections.
- In such conditions, conventional scintigraphy with $^{67}$Ga-citrate can be usefully employed.
- Less validated agents include $^{201}$Tl-chloride, $^{111}$In-DTPA-octreotide, $^{99m}$Tc(V)-DMSA, $^{99m}$Tc-sestamibi, and $^{99m}$Tc-tetrofosmin.

### 13.3 Imaging Lung Infection with Positron Emitting Agents

Although not specific for infection, PET imaging with $[^{18}$F]FDG can be particularly useful to identify site(s) and extent of infectious disease or to guide biopsy in doubtful cases [22, 47–50], even before the appearance of radiological abnormalities [51].

Different patterns of $[^{18}$F]FDG uptake have been reported in patients with lung infections. Bacterial, viral, fungal, or parasitic pneumonia may present with either a nodular or diffuse pattern of uptake [51–57], while TB may appear as lung or lymphatic patterns [14, 58], and cryptococcosis may present with a solitary pulmonary/scattered nodular or broncho-pneumonic/single mass pattern [59].

A positive $[^{18}$F]FDG PET scan should be interpreted with caution when evaluating pulmonary nodules, especially in patients with predisposing factors for nontuberculous mycobacterial infections [60, 61]. In non-HIV-infected patients suffering from TB, $[^{18}$F]FDG PET and $[^{18}$F]FDG PET/CT
performed better than contrast-enhanced CT, revealing more extensive involvement than CT [14, 62]. In HIV-positive patients, $[^{18}F]$FDG PET and PET/CT consistently demonstrate increased tracer uptake in active pulmonary and extrapulmonary TB; nevertheless, it is difficult to distinguish a malignancy from HIV infection and TB based only on the degree of $[^{18}F]$FDG uptake [63, 64], which is also related to viral load [65]. In this regard, it has been reported that dual-phase $[^{18}F]$FDG PET can distinguish inflammation from malignancy [64].

$[^{18}F]$FDG PET/CT has a promising role also in the diagnosis and identification of other HIV-associated infections (i.e., Pneumocystis pneumonia) [66, 67], as well as in fever of unknown origin (FUO) [68–70]. However, quite often increased $[^{18}F]$FDG uptake due to infection cannot be distinguished from increased uptake due to malignancy [71].

Similarly, when evaluating bronchiectasis in HIV-positive patients, $[^{18}F]$FDG PET/CT did not reliably predict disease exacerbation [72]. Nonetheless, although $[^{18}F]$FDG PET (currently PET/CT) alone does not have a definite role in identifying the cause of abnormalities, in patients with HIV it can be useful to detect or exclude the presence of abnormal $[^{18}F]$FDG uptake; furthermore, combining the CT anatomic landmarks with the PET findings allows the guidance of biopsy when histopathologic diagnosis is needed and therefore impacts on patient’s management and clinical decision-making [73].

The use of $[^{18}F]$FDG PET can be helpful for assessing response to therapy in a variety of nonmalignant disorders and has therefore been proposed for evaluating the efficacy of therapy also in infectious diseases [74], especially anti-TB therapy [15]. The role of $[^{18}F]$FDG PET in monitoring the efficacy of therapy has been described also for patients with invasive candidiasis [54], cryptococcosis [59], aspergillosis [75], and Pneumocystis carinii pneumonia [66].

In over 85% of the cases, nosocomial pneumonia is associated with the use of respiratory assistance procedures, such as endotracheal tubes, tracheostomy/traechotomy, nasal masks, and nebulization treatment. Ventilator-associated pneumonia (VAP), the most common nosocomial infection in the intensive care unit [76–78], occurs in 8–28% of patients receiving prolonged mechanical ventilation (>48 h) [79]. Also tracheostomy is associated with VAP [80], whereas nasotracheal intubation is more frequently associated with sinusitis [81] and otitis. Infection is caused by continuous tidal movements of air during artificial respiration, which determines some sort of “milking” into the adjacent structures along the nasopharyngeal path of microorganisms that cover the endotracheal tube. When suspecting VAP, endotracheal aspirates or samples collected bronchoscopically should be obtained for microbiological culture [82]. Although sensitive, chest X-ray is typically nonspecific [83], since lobar or subsegmental atelectasis, acute respiratory distress syndrome, alveolar hemorrhage, and/or infarction may be mistaken for pneumonia. Chest CT frequently shows pulmonary abnormalities consistent with atelectasis, pleural effusion, and infiltrates in mechanically ventilated patients. The metabolic information provided by $[^{18}F]$FDG PET has a definite added value in these patients; in fact, detecting increased metabolism in these lesions can be crucial in deciding whether or not the abnormalities found on the CT scan are actually sites of infection causing the symptoms and signs in patients [84]. An overall good diagnostic performance of $[^{18}F]$FDG PET/CT in mechanically ventilated patients with suspected lung infection has been reported, with 100% sensitivity, 79% specificity, and 91% overall accuracy; because of such extremely high sensitivity, a normal $[^{18}F]$FDG PET/CT scan could reliably rule out the presence of a focal active infectious process, thus excluding the need for prolonged antibiotic therapy or drainage [84].

The recent worldwide medical emergency associated with the pandemic caused by the Covid-19 (or SARS-CoV-2) virus has opened new opportunities for the use of $[^{18}F]$FDG PET/CT in patients with either asymptomatic or symptomatic infection with the virus [85–92]. Although in many of the cases reported so far, detection of increased $[^{18}F]$FDG uptake in areas exhibiting the CT pattern of interstitial pneumonia has been purely incidental, and it can reasonably be assumed that the use of $[^{18}F]$FDG PET/CT will provide helpful information to monitor the course of disease—and possibly to assess the efficacy of therapy.

Finally, PET imaging with other agents other than $[^{18}F]$FDG, such as $[^{11}C]$choline and $[^{18}F]$-fluoroethyltyrosine, has also been explored in patients with lung infections [93]; in this regard, in patients with pulmonary TB and atypical lung mycobacterial infection, the uptake of $[^{18}F]$FDG at the infections sites has been reported to be higher than uptake of $[^{11}C]$ choline [94].
Key Learning Points

- Although not specific for infection, PET imaging with $[^{18}\text{F}]$FDG can be particularly useful to identify site(s) and extent of infectious disease or to guide biopsy in doubtful cases.
- A positive $[^{18}\text{F}]$FDG PET scan should be interpreted with caution when evaluating pulmonary nodules, especially in patients with predisposing factors for nontuberculous mycobacterial infections.
- In HIV-positive patients, $[^{18}\text{F}]$FDG PET and PET/CT consistently demonstrate increased tracer uptake in active pulmonary and extrapulmonary TB.
- Increased $[^{18}\text{F}]$FDG uptake due to infection cannot be distinguished from increased uptake due to malignancy.
- By combining the CT anatomic landmarks with the PET findings, PET/CT imaging allows the guidance of biopsy when histopathologic diagnosis is needed and therefore impacts on patient’s management and clinical decision making.

Examples of Lung Infection Imaging

Cholesterol $^{99m}\text{Tc}$-HMPAO-Leukocyte Scintigraphy in Patient with Lung Infection
(Figs. 13.1, 13.2, and 13.3)

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Fig. 13.2. \(^{99m}\)Tc-HMPAO-leukocyte scintigraphy: planar anterior (right) and posterior (left) images at 4 h (upper) and 24 h (lower), showing a mild accumulation of labeled leukocytes in the inferior lobe of right lung.
Fig. 13.3  $^{99m}$Tc-HMPAO-leukocyte scintigraphy: transaxial SPECT (upper), CT (middle), and fused SPECT/CT sections (lower) allow the identification of the exact site of leukocyte accumulation

$^{[18F]}$FDG PET/CT in Patient with Tuberculosis Infection of Left Pleura (Figs. 13.4, 13.5, 13.6, and 13.7)

Fig. 13.4  $^{[18F]}$FDG PET/CT: maximum intensity projection (MIP), showing diffusely increased $^{[18F]}$FDG uptake in left chest and in mediastinum
Fig. 13.5  $^{[18}F]FDG$ PET/CT: PET (upper), CT (middle), and fused PET/CT (lower) transaxial sections of chest, showing increased $^{[18}F]FDG$ uptake in left lung and pleural tissues
Fig. 13.6 $[^{18}F]FDG$ PET/CT: PET (left), CT (middle), and fused PET/CT (right) coronal sections of chest, showing increased $[^{18}F]FDG$ uptake in left lung and pleural tissues; $[^{18}F]FDG$ uptake is localized at left lung and at all left pleural tissues (a) while pleural effusion does not exhibit increased tracer uptake (b).
Fig. 13.7  $[^{18}F]$FDG PET/CT: PET (left), CT (middle), and fused PET/CT (right) sagittal sections of chest, showing increased $[^{18}F]$FDG uptake in left lung and pleural tissues; $[^{18}F]$FDG uptake is localized at left lung and at all left pleural tissues (a) while pleural effusion does not exhibit increased tracer uptake (b)
[¹⁸F]FDG PET/CT in Patient with “Ab Ingestis” Pneumonia (Fig. 13.8)

**Fig. 13.8** [¹⁸F]FDG PET: (left) Maximum intensity projection (MIP) image and (right) transaxial section of PET (upper), CT (middle), and fused PET/CT (lower), showing increased tracer uptake in posterior fields of both lungs.
[\textsuperscript{18}F]FDG PET/CT in Patient with Hypereosinophilic Syndrome (Fig. 13.9)

Fig. 13.9 Transaxial [\textsuperscript{18}F]FDG PET/CT sections (PET, upper; CT, middle; fused PET/CT, lower) in a patient with pleuroperticarditis and multiple pulmonary opacities, showing intense [\textsuperscript{18}F]FDG uptake at both lungs; biopsy demonstrated hypereosinophilic syndrome.
[\textsuperscript{18}F]FDG PET/CT in Patient with Atypical Mycobacteria Pneumonia (Fig. 13.10)

Fig. 13.10  Transaxial [\textsuperscript{18}F]FDG PET/CT sections (PET, top; CT, middle; fused PET/CT, bottom) in a woman with several episodes of pneumonia; biopsy performed after [\textsuperscript{18}F]FDG PET/CT revealed pneumonia sustained by atypical mycobacteria
[\textsuperscript{18}F]FDG PET/CT in Patients with Incidentally Detected Interstitial Pneumonia Associated with the Covid-19 Virus (SARS-CoV-2) (Figs. 13.11 and 13.12)

Fig. 13.11  [\textsuperscript{18}F]FDG PET/CT performed in a 45-year-old woman for restaging after chemotherapy for recurring colorectal cancer. The patient did not complain of fever, cough, or dyspnea, but lived in an area with very high incidence of Covid-19 infection. MIP image on the left. On the right: selected coronal (above) and transaxial slices (below) for CT, PET, and fused PET/CT images (from left to right). Multiple areas with increased [\textsuperscript{18}F]FDG uptake corresponding to bilateral interstitial alveolar infiltrates. (Images provided by courtesy of Drs. L. Setti, M. Kirienko, SC Dalto, M. Bonacina, and E. Bombardieri, Nuclear Medicine Department, Humanitas Gavazzeni, Bergamo, Italy)

Fig. 13.12  [\textsuperscript{18}F]FDG PET/CT performed in a 70-year-old man for staging after the discovery of metastasis in cervical lymph nodes from a squamocellular cancer with unknown primary. The patient did not complain of fever cough or dyspnea but lived in an area with very high incidence of Covid-19 infection. MIP image on the left. On the right: selected coronal (above) and transaxial slices (below) for CT PET and fused PET/CT images (from left to right). Multiple areas with increased [\textsuperscript{18}F]FDG uptake consistent with viral pneumonia. (Images provided by courtesy of Drs. L. Setti, M. Kirienko, SC Dalto, M. Bonacina, and E. Bombardieri, Nuclear Medicine Department, Humanitas Gavazzeni, Bergamo, Italy)
Clinical Cases

Case 13.1

Josep Martin-Comin

Background
A 20-year-old man without previous history of illness or allergies was stabbed in the back. No signs or symptoms of TB were present. Chest X-ray and CT findings were: lung wound due to stab on the back and areas with opacification of air spaces within the lung parenchyma (in the left inferior lobe) associated with pleural effusion (bleeding) and left hilar and mediastinal lymphadenopathy. Passive atelectasis.

Differential Diagnosis
Lung neoplasm and granulomatous/infectious process.

Radiopharmaceutical Activity
[18F]FDG 3.7 MBq/kg.

Imaging
PET/CT protocol acquisition: scan was performed for 60–120 min p.i. Acquisition of the scan included: (1) scout view (120 kV, 10 mA) in order to define the limits of body to explore, (2) whole-body CT scan (from skull base to proximal femur: 140 kV, 80 mA), and (3) craniocaudal whole-body PET (2D, 3–5 min/field of view, FOV). Images were reconstructed with soft tissue and lung filters using iterative OSEM, with and without attenuation correction using the low-dose transmission CT scan (Figs. 13.13, 13.14, and 13.15).

Conclusion/Teaching Point
The conclusion of these findings is based on analyzing the characteristics of the morphometabolic changes, considering the young age of the patient. PET without CT cannot distinguish between tuberculosis and lung neoplasm, but CT findings of the hybrid PET/CT acquisition support the diagnosis of tuberculosis. The cutaneous purified protein derivative (PPD) test was positive (18 mm), and sputum smears were positive for *Mycobacterium tuberculosis*. The patient was treated with tuberculostatics.
**Fig. 13.14** (a) Transaxial CT slice shows opacification of airspaces within the lung parenchyma (in the left inferior lobe) associated with pleural effusion (bleeding) and left hilar and mediastinal lymphadenopathy. Passive atelectasis. (b) Transaxial slice from $[^{18}F]$FDG PET/CT fusion in lung window shows increased and heterogeneous $[^{18}F]$FDG uptake in the left inferior lung corresponding to multiple consolidation areas with cavity lesion, and subpleural nodules with poorly defined margins, associated with pleural effusion and stab wound.

**Fig. 13.15** Sequential transaxial slices from $[^{18}F]$FDG PET/CT fusion in mediastinum window demonstrate increased uptake of $[^{18}F]$FDG in the bilateral hilar and mediastinal nodes.
Case 13.2
Paola A. Erba

Background
An 80-year-old man previously submitted to axillo-bifemoral vascular prosthesis presented with fever and cough. Abnormalities in the chest X-ray and CT: opacity in the superior lobe of the right lung of equivocal interpretation. Bronchoscopy with bronchoalveolar washing was inconclusive.

Due to persistence of fever associated with suspected vascular periprosthetic infection, $^{18}$F-FDG PET/CT was performed (Fig. 13.16). Since the PET/CT findings were inconclusive, $^{99m}$Tc-HMPAO-leukocyte scintigraphy was performed (Figs. 13.17, 13.18 and 13.19). $^{99m}$Tc-HMPAO-leukocyte scintigraphy ruled out ongoing active infection.

**Fig. 13.16** $^{18}$F-FDG PET/CT. Transaxial CT, PET, and fused PET/CT sections of chest (a) show increased $^{18}$F-FDG uptake in the right lung. Transaxial CT, PET, and fused PET/CT sections of abdomen (b) show a mildly increased $^{18}$F-FDG uptake in aortic region, site of previous surgery.
Fig. 13.16 (continued)
Differential Diagnosis
Lung neoplasm and infectious process.

Radiopharmaceutical Activity
$[^{18}F]$FDG, 3.7 MBq/kg; $^{99m}$Tc-HMPAO-leukocytes, 640 MBq.

Imaging
PET/CT acquisition protocol: the scan was performed at 60–120 min p.i. Acquisition of the scan included: (1) scout view (120 kV, 10 mA) in order to define the limits of the body to explore, (2) whole-body CT scan (from skull base to proximal femur: 140 kV, 80 mA), and (3) whole-body PET (3D, 3 min/FOV).

$^{99m}$Tc-HMPAO-leukocyte scintigraphy: whole-body scan was performed 30 min p.i. Planar anterior and posterior acquisitions of the chest were acquired at 30 min, 4 h, and 24 h p.i. and SPECT/CT imaging of the abdomen was acquired 3 h, whereas SPECT/CT imaging of the chest was acquired at 24 h.

Conclusion/Teaching Point
This clinical case highlights the different specificity of $[^{18}F]$FDG PET/CT and of scintigraphy with radiolabeled leukocytes. $[^{18}F]$FDG allows the identification of inflammatory processes as well as infection; radiolabeled leukocytes allow the identification of only neutrophil-mediated processes, which are present in the majority of infections.

Fig. 13.17 $^{99m}$Tc-HMPAO-leukocyte scintigraphy. Whole-body scan, anterior (a) and posterior (b) views, 30 min p.i.
Fig. 13.18 $^{99}$mTc-HMPAO-leukocyte scintigraphy. Planar anterior (left) and posterior (right) images of chest, 30 min (upper), 4 h (middle), and 24 h (lower) p.i. The images show no pathologic accumulation in the lung region. The focal uptake of radiopharmaceutical in the axillary right region corresponds to the external portion of the central venous catheter.
Fig. 13.19 \(^{99m}\text{Tc}-\text{HMPAO}-\text{leukocyte scintigraphy. SPECT/CT acquisitions of chest (a) and abdomen (b) do not show pathologic accumulation of labeled leukocytes (CT, upper left; SPECT, upper right; fused, bottom left).} \)
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