

## Lung Nodules and Masses after Cardiac Transplantation<sup>1</sup>

Single or multiple lung nodules or masses were noted at chest radiography in 25 (9.7%) of 257 patients after cardiac transplantation. Two episodes occurred in each of three patients, for a total of 28 (10.9%) episodes in the 257 patients within the first 18 months after transplantation (transplantation performed between July 1987 and December 1990). Bronchoscopy, percutaneous needle biopsy, and open lung biopsy were performed as clinically warranted to establish a diagnosis. Infection was found in 21 instances (8.2%) in 18 patients. The most frequent pathogens were *Aspergillus* ( $n = 9$  [3.5%]) and *Nocardia* ( $n = 7$  [2.7%]). *Aspergillus* was hospital acquired in eight (89%) of nine patients and had a right-sided predominance (20 [74%] of 27 lesions). The nodules or masses appeared a median of 2 months after transplantation for *Aspergillus* (range, 0.5–12 months) and 5 months for *Nocardia* (range, 1–10 months). B cell lymphoma manifested as numerous nodules in two patients (0.8%). Although a variety of causes were found for post-cardiac transplantation nodules or masses, the majority (75%) were infectious.

**Index terms:** Aspergillosis, 60.2056 • Heart, transplantation, 51.459 • Lung, effects of drugs on, 60.469, 60.649 • Lung, infection, 60.2014, 60.2056, 60.2066, 60.2075 • Lung, nodule, 60.458 • Lymphoma, 60.34 • Nocardia, 60.2014

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CARDIAC transplantation is now a widely accepted form of treatment for end-stage heart disease. The most common complications of cardiac transplantation are rejection of the donor heart and infection of the lungs and other organs (1–4). Lymphoma and other cancers occasionally occur (5).

We have noted single or multiple lung nodules or masses on the chest radiographs of a number of patients after cardiac transplantation. In this report, we review the imaging findings and causes of these nodules and masses.

### MATERIALS AND METHODS

Between July 1987 and December 1990, 266 consecutive patients underwent cardiac transplantation at our institution. Nine patients died in the immediate postoperative period (defined as within 48 hours of surgery). The remaining 257 patients form the study population. Two hundred (78%) were men, 57 (22%) were women. The mean age at surgery was 45 years  $\pm$  17 (standard deviation [SD]) (range, 28 days to 69 years). By clinical criteria, no patients were infected at the time of surgery. All patients received antibiotics for 48 hours perioperatively. The standard immune suppression regimen included cyclosporine, azathioprine, and prednisone. A small subset of patients whose serum creatinine levels were elevated received OKT3 induction therapy postoperatively. Prophylaxis (oral trimethoprim-sulfamethoxazole or aerosolized pentamidine) against *Pneumocystis carinii* was administered to all patients after 1988.

Postoperative assessment included at least three in-hospital chest radiographic examinations per week. After initial discharge, physical examination and chest radiography (posteroanterior and left lateral) were performed at a minimum of weekly intervals for 2 months, then biweekly for the next 6 months, then monthly for the next 6 months, and at 2–3-month intervals thereafter. The mean follow-up time for all patients was 21 months  $\pm$  13 (SD). No patients were lost to follow-up. Forty-nine (19%) of the 257 patients died during the study period.

Whenever a chest radiograph revealed a nodular or masslike area or areas of increased opacity (28 episodes in 25 patients), evaluation then included a complete blood cell count and cultures of sputum, blood, and urine. Bronchoscopy ( $n = 26$ ) was performed in 22 patients with use of bronchoalveolar lavage ( $n = 26$ ) and transbronchial biopsy ( $n = 25$ ). Open lung biopsy ( $n = 4$ ) and percutaneous computed tomography (CT)-guided needle aspiration ( $n = 3$ ) were performed as clinically warranted.

Criteria for the diagnosis of pulmonary infection were new radiographic nodule(s) or mass(es) and either (a) culture, cytologic, or histopathologic evidence of a specific organism or organisms or (b) a clinical course in which pulmonary infection appeared highly likely (6). Bacterial infection was diagnosed by means of positive cultures of lavage fluid and positive cultures of blood or pleural fluid. Alternatively, bacterial pneumonitis was diagnosed by means of positive bronchoscopic cultures, a compatible radiographic area of increased opacity, and clinical response to specific antimicrobial therapy. Fungal infection (other than yeast) was diagnosed by observing the organism in lavage fluid or culture medium, a compatible radiographic area of increased opacity, lack of response to usual antibiotic therapy, and response to antifungal therapy. *P. carinii* was diagnosed by means of the presence of silver-stained cysts in lavage fluid or lung tissue. Cytomegalovirus (CMV) infection was diagnosed by demonstrating characteristic haloed "owl eye" intranuclear inclusions in lavage fluid or lung tissue, combined with positive viral cultures (7). Alternatively, CMV pneumonitis was diagnosed in the absence of visible inclusion bodies if there was tissue evidence of interstitial pneumonitis, positive cultures of bronchial aspirate, and absence of other infectious causes of interstitial pneumonitis (7).

For the purpose of this study, all chest imaging studies were subsequently reviewed separately by two radiologists specializing in chest disease (L.B.H.,

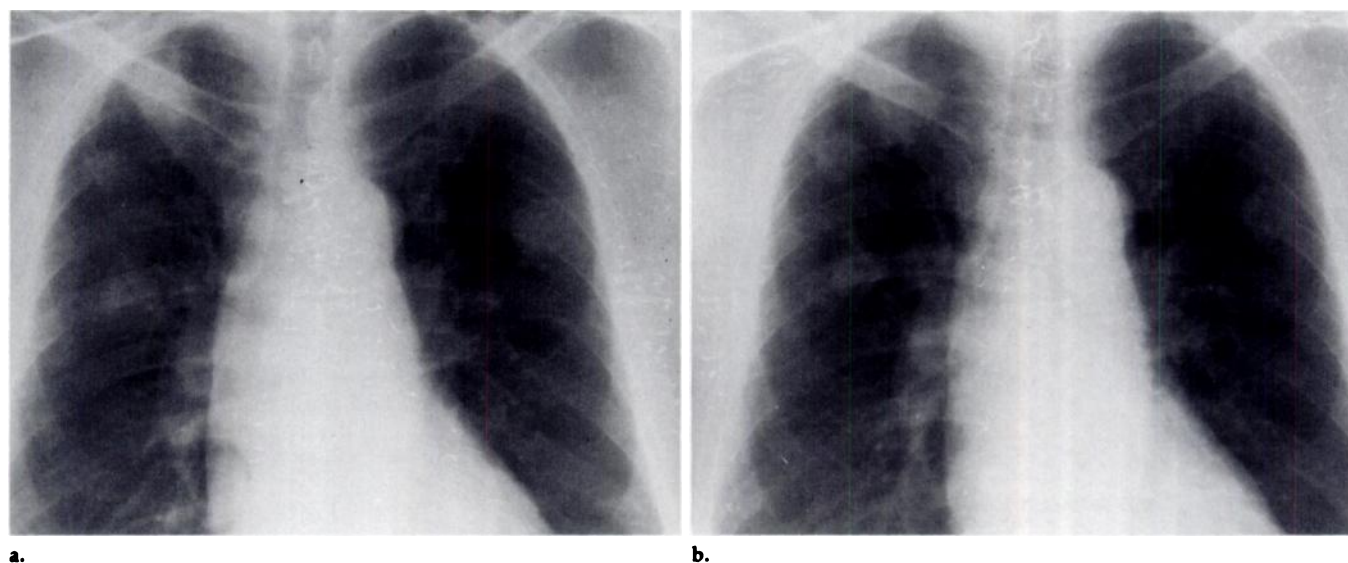
**Abbreviations:** CMV = cytomegalovirus, SD = standard deviation.

**Table 1**  
**Lung Nodules or Masses after Cardiac Transplantation: *Aspergillus* (n = 9)**

| Patient/<br>Age (y)/<br>Sex | Time to<br>Radiographic<br>Detection (mo) | Location          | Diameter<br>(cm)*       | Radiographic<br>Appearance        | Associated<br>Findings   | Source of<br>Diagnosis     | Follow-up<br>Results   |
|-----------------------------|---|-------------------|-------------------------|-----------------------------------|--|----------------------------|--|
| 1/43/M                      | 0.5                                       | RUL               | 4                       | Lobulated, fuzzy, one<br>cavitary | Small, bilateral pleural<br>effusions                                    | Bronchoscopy               | Developed diffuse areas<br>of increased opacity,<br>died at 2 mo   |
| 2/44/F                      | 1.5                                       | RUL               | 2                       | Irregular, ill defined            | ...  | Bronchoscopy               | Marked decrease at 2<br>wk, later complete<br>resolution           |
| 3/63/M                      | 1.7                                       | RUL<br>LUL<br>RML | 3, 2, 1<br>2.5<br>2 (2) | Ill defined                       | ...  | Bronchoscopy               | Cavitated at 2 wk, re-<br>solved at 3 mo                           |
| 4/59/M                      | 2.0                                       | RLL               | 6                       | Lobulated                         | ...  | Bronchoscopy               | Marked clearing at 1<br>mo, then slow resolu-<br>tion              |
| 5/61/M                      | 2.0                                       | RML<br>RLL<br>LUL | 5<br>3.5<br>2.5         | Ill defined, cavitary             | ...  | Bronchoscopy               | Decrease at 3 wk, re-<br>solved at 5 mo                            |
| 6/57/M                      | 2.0                                       | RUL<br>RLL        | 3, 1, 0.7<br>1.5 (2)    | Irregular, well margin-<br>ated   | ...  | Percutaneous<br>aspiration | Cavitated and de-<br>creased size, died at 3<br>mo of other causes |
| 7/46/F                      | 3.0                                       | RUL<br>RML        | 0.8 (2)<br>0.8          | Well defined                      | Mediastinal<br>adenopathy  | Bronchoscopy               | Improved at 6 wk, re-<br>solved at 5 mo                            |
| 8/60/M                      | 6.5                                       | LUL               | 2.5, 1 (3)              | Irregular, well margin-<br>ated   | Patchy areas of in-<br>creased opacity in<br>LUL and RLL                 | Bronchoscopy               | Resolved at 2 mo   |
| 9/55/M                      | 12.0                                      | RML               | 3                       | Irregular, cavitary               | Diffuse areas of in-<br>creased opacity, small<br>right pleural effusion | Bronchoscopy               | Gradual resolution at 7<br>mo                                      |

Note.—LUL = left upper lobe, RLL = right lower lobe, RML = right middle lobe, RUL = right upper lobe.

\* Numbers in parentheses indicate number of lesions.



**Figure 1. Patient 3.** *Aspergillus* appearing as multiple pulmonary nodules on a radiograph in a 63-year-old man (a) 7 weeks after cardiac transplantation. Treatment with amphotericin B was instituted. (b) Two weeks later, several of the nodules have cavitated.

J.H.M.A.). Differences of interpretation, which were minor, were resolved by means of consensus. Complete clinical information was available at the time of review.

In the setting of probable community-acquired infectious illness in which all microbiologic studies were unrevealing, each patient was treated empirically with antimicrobial therapy specific for *Nocardia* (8). If radiographic abnormalities resolved subsequently, they were assumed to have been due to *Nocardia*.

The Fisher Exact Test was used to compare proportions between two groups. The Mann-Whitney test was used to compare median times of onset between the two groups. A *P* value of less than .05 was accepted as statistically significant.

## RESULTS

Single or multiple lung nodules or masses were noted at chest radiogra-

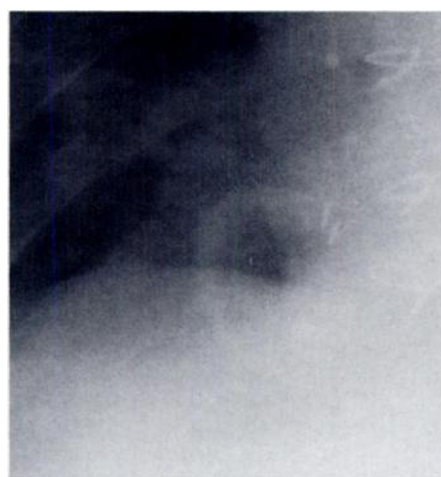
phy in 25 (9.7%) of the 257 patients surviving the immediate posttransplantation period. Two episodes occurred in each of three patients, for a total of 28 (10.9%) episodes in the 257 patients. The mean age of the 25 patients at the time of transplantation was 51 years  $\pm$  11 (range, 30–65 years). Twenty (80%) of the 25 patients were men, five (20%) were women. The mean duration from the

**Table 2**  
**Lung Nodules or Masses after Cardiac Transplantation: *Nocardia* (n = 7)**

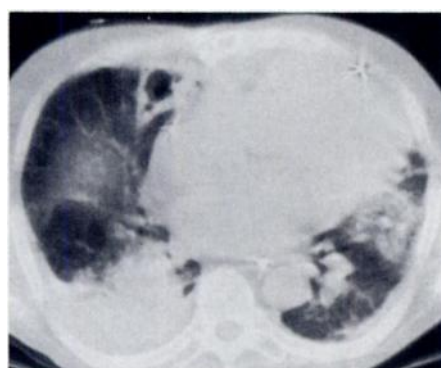
| Patient/<br>Age (y)/<br>Sex | Time to<br>Radiographic<br>Detection (mo) | Location | Diameter<br>(cm)* | Radiographic<br>Appearance                        | Associated<br>Findings  | Source of<br>Diagnosis | Follow-up<br>Results  |
|-----------------------------|---|----------|-------------------|---|---|------------------------|---|
| 5/61/M                      | 1.0                                       | RLL      | 1.5               | Round, ill defined                                | ...   | Bronchoscopy           | Decrease at 1 wk  |
| 10/30/M                     | 1.5                                       | LUL      | 1.5               | Ovoid, well defined                               | ...   | Clinical               | Gradual resolution by 5 mo  |
| 11/42/M                     | 2.0                                       | RUL      | 2.5               | Lobulated, possible small cavitation, ill defined | ...   | Bronchoscopy           | Decrease at 1 mo, ultimately resolved   |
| 12/45/M                     | 5.0                                       | RUL      | 0.4 (2)           | Well defined, round and ovoid                     | 2-cm-diameter subcarinal lymph node                                   | Clinical               | Resolved at 1.5 mo; new 3-cm-diameter nodule in LLL after therapy stopped, resolved after further therapy   |
|                             |   | RML      | 0.3–0.6 (3)       |   |   |                        |   |
|                             |   | RLL      | 0.4–0.9 (5)       |   |   |                        |   |
|                             |   | LUL      | 0.8–1.5 (12)      |   |   |                        |   |
|                             |   | LLL      | 0.4–1.2 (3)       |   |   |                        |   |
| 13/53/F                     | 6.0                                       | RUL      | 1.7               | Well defined                                      | Lingular area of increased opacity, small bilateral pleural effusions | Clinical               | Decrease at 1 wk, resolved at 1 mo; new nodule in RUL after therapy stopped, resolved after further therapy |
| 14/62/M                     | 9.0                                       | LUL      | 6                 | Cavitary, ill defined                             | ...   | Sputum                 | Marked decrease at 1 mo, scar at 4 mo   |
| 4/60/M                      | 10.0                                      | RUL      | 5                 | Well defined                                      | ...   | Clinical               | Decrease to 3 cm in diameter at 3 wk, further decrease at 6 mo  |

Note.—LLL = left lower lobe, LUL = left upper lobe, RLL = right lower lobe, RML = right middle lobe, RUL = right upper lobe.

\* Numbers in parentheses indicate number of lesions.

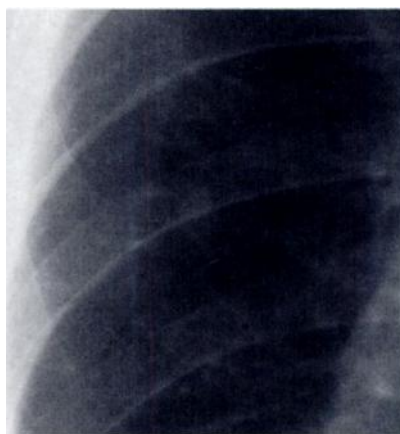


a.

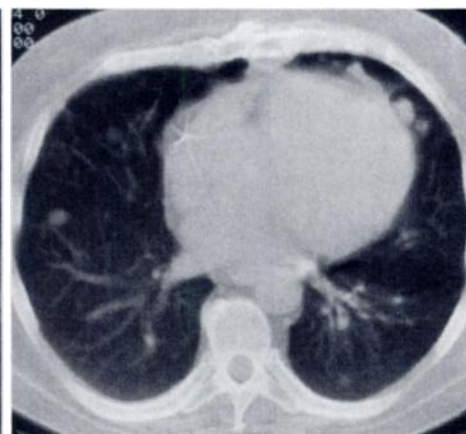


b.

**Figure 2. Patient 9.** *Aspergillus* appearing as a cavitary mass in the right middle lobe in a 55-year-old man 12 months after cardiac transplantation. (a) Detail view of anteroposterior chest radiograph. (b) CT scan.



a.



b.

**Figure 3.** *Nocardia asteroides* appearing as nodular disease after cardiac transplantation. (a) Patient 5. Solitary nodule, 1.5 cm in diameter, on a radiograph in a 61-year-old man 1 month after transplantation. (b) Patient 12. Multiple nodules on a CT scan in a 45-year-old man 5 months after transplantation.

time of transplantation to the time of detection of the radiographic abnormality was 4.7 months  $\pm$  4.3 (range, 0.5–18 months; median, 3.0 months). The mean follow-up time for the 25 patients was 22.9 months  $\pm$  12.9 (range, 2.3–49 months) after transplantation. Diagnosis was definitive in 22 (79%), presumptive in five (18%), and unknown in one (4%) of the 28 episodes.

A single case (patient 10) was included in a previous series from our institution (2).

*Aspergillus* was the causative organism (Table 1) on nine occasions, occur-

ring as a single episode in each of nine (3.5%) of the 257 patients (Figs 1, 2). The radiographic changes appeared at a mean of 3.5 months  $\pm$  3.4 (range, 0.5–12 months; median, 2.0 months) after transplantation. Four (44%) of the nine patients were asymptomatic. Cough was present in four (44%), fever in one (11%), and dyspnea and rales in one (11%).

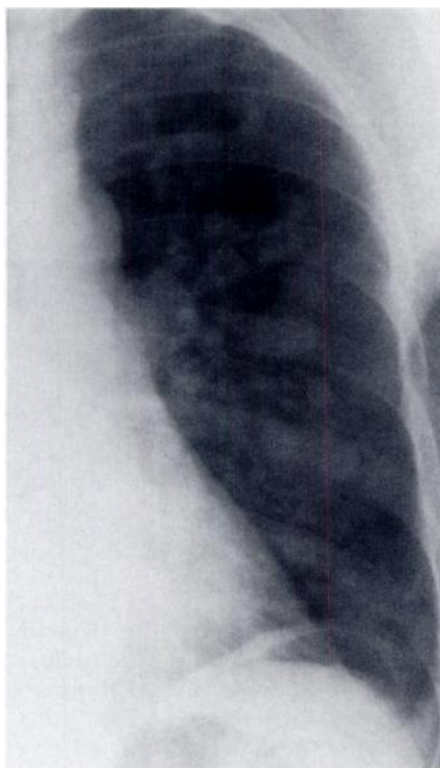
*Nocardia* was the proved causative organism on three occasions and the presumed cause on four occasions, occurring as a single episode in each of seven (2.7%) of the 257 patients (Table 2) (Fig 3). The radiographic

**Table 3**  
**Lung Nodules or Masses after Cardiac Transplantation: Miscellaneous Causes (n = 12)**

| Patient/<br>Age (y)/<br>Sex | Cause                             | Time to<br>Radiographic<br>Detection (mo) | Location                     | Diameter<br>(cm)*  | Radiographic<br>Appearance            | Associated<br>Findings   | Source of<br>Diagnosis | Follow-up<br>Results  |
|-----------------------------|-----------------------------------|---|------------------------------|--------------------|---------------------------------------|--|------------------------|---|
| 15/32/M                     | B cell lymphoma                   | 6.0                                       | Lower lung predomi-<br>nance | ≤7 (~20)           | Well defined                          | Left hilar and mediasti-<br>nal adenopathy   | Open lung biopsy       | Decreased with immu-<br>notherapy, resolved at<br>7 mo  |
| 16/60/M                     | B cell lymphoma                   | 10.0                                      | Bilateral                    | Varied (~50)       | Well defined                          | Confluent mass in right<br>base, right hilar and<br>mediastinal adenopa-<br>thy, right pleural effu-<br>sion | Open lung biopsy       | Chemotherapy, resolved<br>at 2 mo   |
| 17/56/M                     | <i>P carinii</i> and CMV          | 3.5                                       | LUL<br>LLL                   | 2<br>5             | Well defined<br>Ill defined, cavitory | Diffuse haziness in right<br>lung  | Bronchoscopy           | Haziness and LLL nod-<br>ule decreased after 1<br>wk of therapy, re-<br>solved at 4 mo; LUL<br>nodule persisted |
| 3/63/M                      | <i>P carinii</i> and CMV          | 5.5                                       | LUL                          | 2                  | Ill defined                           | Hazy areas of increased<br>opacity   | Bronchoscopy           | Areas of increased opac-<br>ity resolved with ther-<br>apy, nodule decreased                                    |
| 18/62/M                     | <i>A actinomycetemcomitans</i>    | 3.0                                       | RUL                          | 5                  | Ovoid, ill defined                    | ...  | Open lung biopsy       | Slowly resolved over 7<br>mo of therapy   |
| 19/66/M                     | Mycobacterial                     | 12.0                                      | RLL                          | 3                  | Ill defined                           | ...  | Open lung biopsy       | Necrotizing granuloma,<br>positive acid-fast ba-<br>cilli stain, culture neg-<br>ative                          |
| 20/51/M                     | <i>Lactobacillus</i> endocarditis | 1.5                                       | Right<br>Left                | 1<br>1 (5)         | Ill defined, some cavit-<br>ation     | Surrounding increased<br>opacity, positive blood<br>cultures, right atrial<br>mass at echocardiogra-<br>phy  | Blood culture          | Resolved with therapy   |
| 21/31/M                     | Pulmonary varix                   | 3.0                                       | Right retrocardiac           | 2.5                | Well defined                          | Acute rejection  | Radiography            | Decreased as rejection<br>waned   |
| 22/45/F                     | Rounded atelectasis               | 2.0                                       | LLL                          | 8                  | Ill defined                           | Pleural thickening, bron-<br>chovascular structures<br>converging on mass at<br>CT                           | CT                     | ...   |
| 23/60/F                     | Infarcts                          | 0.5                                       | Right midlung                | 2 (multiple at CT) | Peripheral, irregular,<br>small       | Resolved congestive<br>heart failure, pulmo-<br>nary embolism 2 mo<br>before in same distri-<br>bution       | Clinical               | ...   |
| 24/64/M                     | Healing fracture                  | 18.0                                      | RUL                          | 1.2                | Fuzziness over second<br>anterior rib | Rib fracture and callus at<br>CT   | CT                     | ...   |
| 25/38/F                     | Unknown                           | 1.0                                       | RLL<br>LLL                   | 1 (3)<br>1         | Irregular, peripheral                 | ...  | None                   | Resolved with antiimi-<br>crobial therapy   |

Note.—LLL = left lower lobe; LUL = left upper lobe; RLL = right lower lobe; RUL = right upper lobe.  
 \* Numbers in parentheses indicate number of fusions.





a.



b.

**Figure 4. Patient 16.** B cell lymphoma appearing as numerous nodules 10 months after cardiac transplantation in a 60-year-old man. (a) Posteroanterior radiograph of left lung. (b) CT scan.

changes appeared at a mean of 4.9 months  $\pm$  3.4 (range, 1–10 months; median, 5 months) after transplantation. Six (86%) of the seven patients were symptomatic (weakness,  $n = 2$ ; cough,  $n = 1$ ; green phlegm,  $n = 1$ ; sweats,  $n = 1$ ; chills and fever,  $n = 1$ ). Two (29%) of the seven patients developed recurrence of their *Nocardia* nodules when treatment was stopped. The nodules resolved after resumption of therapy.

Comparison of *Aspergillus* and *Nocardia* cases revealed that *Aspergillus* lesions were multiple (six [67%] of nine patients) more frequently than *Nocardia* lesions (two [29%] of seven patients), but the difference was not

statistically significant (Fisher Exact Test) (Tables 1, 2). Although the median duration from transplantation to onset of infection was only 2 months for the patients infected with *Aspergillus* and 5 months for the patients infected with *Nocardia*, the difference in median time of onset between these two groups was not statistically significant (Mann-Whitney test).

B-cell lymphoma manifested as multiple nodules in two (0.8%) of the 257 patients 6 and 10 months after cardiac transplantation (Table 3) (Fig 4). Both of these patients were asymptomatic.

Combined *P carinii* and CMV pneumonia formed a nodular or masslike area of increased opacity in two (0.8%) of the 257 patients 3.5 and 5.5 months after transplantation (Table 3) (Fig 5). One patient was symptomatic, with fever, cough, and dyspnea; the other was asymptomatic.

A wide variety of other processes ( $n = 8$ ) also resulted in lung nodules or masses on a single occasion (Table 3). Among these, the cause was infectious in three of the patients. *Actinobacillus actinomycescomitans*, an unusual pulmonary pathogen (9), manifested as a 5-cm-diameter mass. An untyped mycobacterial infection manifested as a 3-cm-diameter area of increased opacity. It was resected and stained positive for acid-fast bacilli, but no organism grew in culture. Septic emboli in a patient with *Lactobacillus* endocarditis manifested as ill-defined bilateral areas of increased opacity, some with cavitation.

One patient had severe congestive heart failure and pulmonary emboli before transplantation. As the pulmonary edema cleared after the transplantation, multiple peripheral areas of increased opacity were noted without evidence of infection, consistent with pulmonary infarcts.

Rounded atelectasis was another cause of a pulmonary mass. At CT, the bronchovascular structures converged on the mass in the classic manner described for rounded atelectasis (10). Pleural thickening was associated with the mass.

Two cases mimicked true pulmonary nodules. One was a pulmonary venous varix, which markedly enlarged during a period of acute rejection related to elevated left atrial filling and waned as rejection resolved. Another was a healing second anterior rib fracture. After oblique views did not allow definitive localization of the lesion, CT was required to establish the diagnosis.

A single case remained without diagnosis, for which the clinical sce-

nario was not appropriate for *Nocardia*; the lesions resolved during antimicrobial therapy.

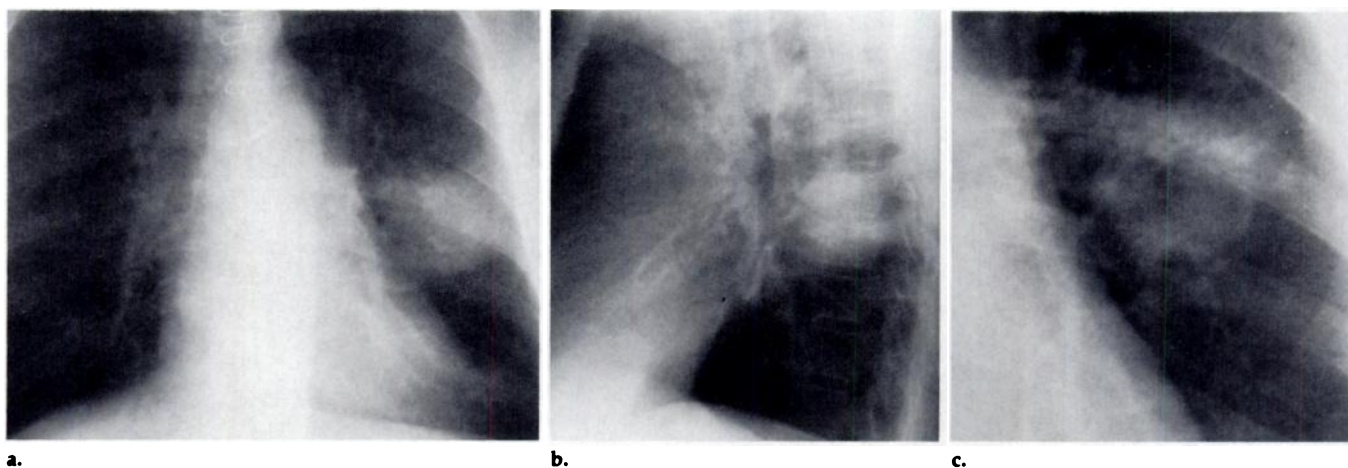
Among the three patients in whom nodules or masses were seen on two occasions, *Aspergillus* was a causative organism in each patient on one of the occasions. The other episode was caused by *Nocardia* in two of the patients and by combined *P carinii* and CMV in the remaining instance.

## DISCUSSION

The main finding of the present study is that nodular or mass lesions are not uncommon (25 [9.7%] of 257 patients) plain chest radiographic abnormalities in recipients of a cardiac transplant. To our knowledge, no previous series of major organ (heart, lung, liver, or kidney) transplant recipients has addressed this specific question. Infection was the leading cause of the radiographic abnormalities (21 [75%] of 28 episodes), whereas pulmonary lymphoma developed in two subjects (0.8% of 257 patients) and one each of various miscellaneous causes accounted for the remaining five episodes (Tables 1–3). In all but one patient, the initial radiographic abnormality became evident during the 1st year after transplantation, which is generally the period of greatest iatrogenic postoperative immune suppression (11).

The leading pathogens causing the nodular or masslike changes were *Aspergillus* (nine [32%] of 28 episodes) (Table 1) and *Nocardia* (seven [25%] of 28 episodes) (Table 2).

*Aspergillus* is ubiquitous in water and soil and has been reported in nosocomial outbreaks contaminating respirators, as well as in parenteral medication (12). Eight (89%) of the nine episodes of *Aspergillus* in the present series are believed to have been acquired in the hospital. The radiologic abnormalities developed within at most 6 weeks after discharge from the hospital. A clustering of three of the *Aspergillus* cases was related to transient contamination of two intensive care unit rooms. One patient acquired *Aspergillus* 12 months after transplantation. He had been in the hospital 1 month prior; his infection is believed to be related to that hospitalization. Only one episode of *Aspergillus* developed remote from hospitalization (6.5 months after transplantation). This patient had been doing construction in his home, and that is the presumed source of his infection.



**Figure 5. Patient 17.** Combined infection with *P carinii* and CMV appearing as an ill-defined mass in a 56-year-old man 3.5 months after transplantation. (a) Posteroanterior radiograph. There is a mass in the left midlung area plus mild, diffuse haziness in the right lung. (b) Lateral radiograph. The mass is in the superior segment of the left lower lobe. (c) Nine days later, radiograph shows the mass has decreased in size and cavitated.

*Nocardia* is a soil inhabitant. Cardiac transplantation recipients have been shown to be susceptible to infection with *Nocardia* (2,3,13,14). However, epidemiologic evidence does not support an in-hospital point source of nocardial contamination (3,13). The present series confirms the results of prior studies in that a clustering of nocardial infection did not occur.

*Aspergillus* pulmonary infection in the present series was characterized by findings both of timing and of location. Nodules or masses caused by *Aspergillus* tended to develop earlier (a median of 2 months after transplantation) than those caused by *Nocardia* (a median of 5 months after transplantation), but the time of onset for each organism's radiographic changes covered virtually the entire 1st year. The difference was not statistically significant. However, we believe that the trend toward *Aspergillus* occurring earlier than *Nocardia* relates to more frequent in-hospital acquisition of *Aspergillus* compared with *Nocardia*.

An unanticipated finding in the present series was that the locations of the *Aspergillus* pulmonary lesions were strikingly right sided: 20 (74%) of 27 lesions (Table 1). Moreover, the left upper lobe accounted for all seven left-sided *Aspergillus* lesions. An upper lobe predilection was noted in an earlier series from our institution (2), but to our knowledge, predominance of *Aspergillus* infection in the right lung after cardiac transplantation has not been previously described (3). The *Nocardia* lesions had an upper lobe location in six (86%) of the seven involved patients (Table 2). No right- or left-sided predilection was present.

An upper lobe predominance for nocardial lesions has not been noted previously, to our knowledge (8,13). An upper lobe predilection for pulmonary infection can be hypothesized to relate to the relative lymph stasis, hyperoxia, or hypocarbia of upper compared with lower lung zones (15), but the right-sided predominance of *Aspergillus* lesions in the present series is an observation for which we are unable to offer a plausible explanation, beyond the comparison with the modest right-sided predominance of pulmonary tuberculosis in the immune-competent general population (16) and the fact that inhalation of the organism is the accepted route of entry for most cases of infection with *Aspergillus* and *Nocardia* (1). Deposition of inhaled particles preferentially occurs in the upper lobes, and more in the right upper lung than in the left, a phenomenon possibly related to the short, straight right main bronchus compared with the long, curved left main bronchus (17).

Cavitation developed in five (56%) of the nine cases of *Aspergillus* lesions and in two (29%) of the seven cases of *Nocardia* lesions. Each of these organisms has been reported previously in association with cavitary lung lesions (2,12,18), and this feature is not a helpful point in differentiating these two causes of pulmonary infection. Similarly, diameters of the individual lesions did not appear to be a differentiating feature (*Aspergillus* lesions ranged up to 8 cm in diameter, *Nocardia* lesions up to 6 cm in diameter). Cavitation also occurred in one patient with combined *P carinii* and CMV pneumonitis and in another

with septic emboli from *Lactobacillus* endocarditis (Table 3). Cavitation in the present series was therefore found in nine (36%) of the 25 patients, and only in association with pulmonary infection.

Non-Hodgkin lymphoma is increased in frequency after cardiac transplantation, especially in patients receiving cyclosporine immunosuppression (5,19). The frequency varies depending on the time after transplantation, from a low of 0.7% in one series (5) to a high of nearly 12% 2 years after transplantation (4). Starzl et al reported a 6% frequency of non-Hodgkin lymphoma after heart transplantation in a series of patients with heart, kidney, or liver transplants (19).

Among patients who receive solid organ transplants, patients with heart transplants have a relatively high frequency of lymphoproliferative disorders, probably related to their high degree of immunosuppression (19). Treatment remains controversial, although reduced immunosuppression is frequently helpful (5,18,20,21). In the present series, one patient responded to reduced immunosuppression and one responded to combination chemotherapy.

There is strong evidence that transplantation-associated lymphoma is frequently related to uninhibited proliferation of B lymphocytes that are infected with the Epstein-Barr virus (19,20). The main immunosuppressive target of cyclosporine is the T lymphocyte, and the cell-mediated T cell response to viral infection is correspondingly diminished (19,20). Two patients in the present series developed pulmonary B cell lymphoma (Table 3). The radiographic features

were typical in that there was extensive extranodal parenchymal disease in addition to less dramatic hilar and mediastinal adenopathy (21,22).

Among the miscellaneous causes of pulmonary nodules or masses in the present series (Table 3), it is of interest that carcinoma of the lung was not represented, despite the fact that many of the patients with ischemic cardiomyopathy were cigarette smokers who then became immunosuppressed. However, lung carcinoma after heart transplantation has been described by others (two patients [0.7%] in two series comprising a total of 303 patients) (5). ■

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