

Variable Pulmonary Manifestations in Hemodialysis Patients¹

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A wide variety of pulmonary disorders related to hemodialysis or pre-existing renal disease occurs in hemodialysis patients. The disorders may be classified as 1) pulmonary abnormalities associated with chronic renal failures; 2) pulmonary complications arising during hemodialysis; 3) pulmonary infection; or 4) pulmonary-renal syndrome. An awareness of the various possible pulmonary disorders arising in hemodialysis patients may be helpful for the proper and timely management of such patients. We describe and illustrate various radiographic and CT findings of variable pulmonary disorders in hemodialysis patients.

Index words : Hemodialysis

Lung, edema

Lung, infection

Vasculitis

A wide variety of pulmonary disorders may occur in hemodialysis patients, with variable radiologic manifestations, though the most common abnormality demonstrated at chest radiograph is pulmonary edema due to volume overload. In patients with chronic renal failure, many factors such as uremic toxin, parathyroid hormone, abnormal hemostasis and immunologic dysfunction, may cause various disorders involving the lung, pleura, and pericardium, and hemodialysis also cause

thoracic complications, mainly related to vascular access. In patients with pulmonary-renal syndrome due to systemic vasculitis, pulmonary lesions give rise to chest radiographic abnormalities. The radiologic findings of pulmonary disorders in hemodialysis patients are sometimes complex, and multiple concomitant such disorders are frequently disclosed, making differential diagnosis difficult. An awareness of the various pulmonary disorders which can arise in hemodialysis patients may thus be helpful both for differential diagnosis and timely patient management.

Pulmonary abnormality associated with Chronic Renal Failure

Pulmonary Edema

In uremic patients undergoing dialysis, pulmonary edema is the most frequent complication (Fig. 1). Its common causes are volume-overload and left ventricular failure secondary to systemic hypertension, uremic

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cardiomyopathy, and coronary disease. In most cases differentiation between renal and cardiogenic pulmonary edema at chest radiography is difficult. The typical pattern of renal edema includes batwing central distribution (1) (Fig. 2), but not all cases demonstrate this, and cardiogenic edema may also present with this picture.

Cardiovascular disease is the most frequent cause of death in patients with end-stage renal disease. Atherosclerosis of the coronary artery is accelerated by hypertension and lipid abnormalities and metastatic vascular calcification also promote coronary artery disease. Acute exacerbation of pulmonary edema in patients who have been undergoing hemodialysis may lead to the development of ischemic heart disease (Fig. 3).

Uremic Pericarditis

If present, uremic pericarditis usually appears late in the course of renal failure, though with the advent of dialysis therapy its occurrence has declined dramatically, and it is now most common in patients who have undergone inadequate hemodialysis. It is usually dry, fibrinous, and is associated with fever and chest pain, and in a minority of cases, varying amounts of exudative or hemorrhagic effusion are present. In the majority of cases, uremic pericarditis is cured by dialysis, but at times it evolves into a chronic constrictive form. A triangular shaped "water bottle" heart may be present at chest radiography, and the CT findings include pericardial effusion (Fig. 4) and, in chronic cases pericardial thickening, fibrous adhesions, or pericardial calcification (2).

Uremic Pleuritis

Pleural effusion is a common problem in patients with uremia; its causes include volume overload and cardiac failure, uremic pleuritis, severe hypoproteinemia in nephrotic syndrome, and pulmonary infection. The diagnosis of uremic pleuritis is one of exclusion; clinical signs and symptoms of dry and fibrinous pleuritis, without appreciable effusion, are more common. If pleural effusion is present, it takes the form of an exudates which is at times hemorrhagic, often unilateral, and which disappears with dialysis (Fig. 5) or evolves into a



Fig. 2. A 44-year-old man with end stage renal disease and volume-overload pulmonary edema (renal edema). Chest radiograph shows pulmonary consolidation with "batwing" central distribution.

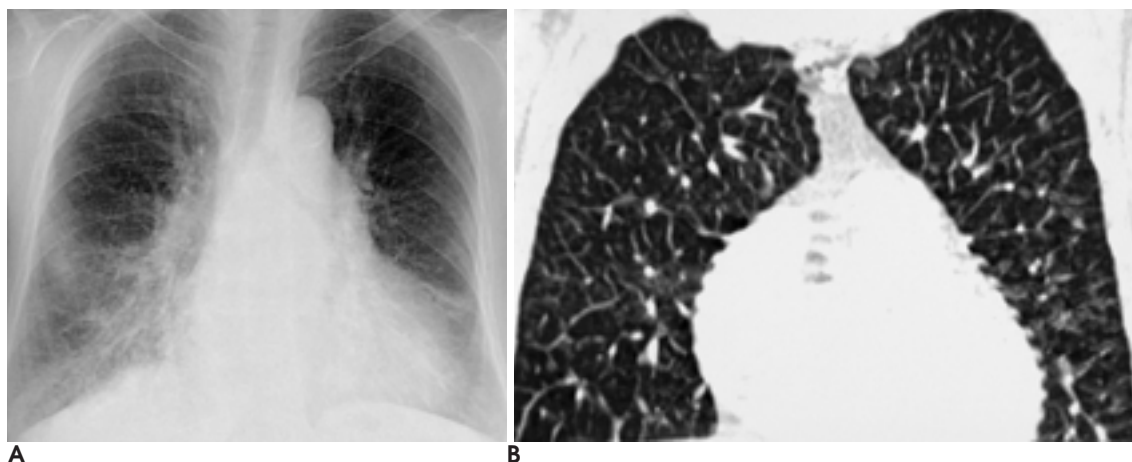


Fig. 1. A 76-year-old woman with end stage renal disease and pulmonary interstitial edema.

A. Chest radiograph shows cardiomegaly, peribronchovascular cuffing, and Kerley's B lines.

B. High-resolution CT scan coronal reconstruction image shows peribronchial interstitial and interlobular septal thickenings and patch areas of ground-glass attenuation.

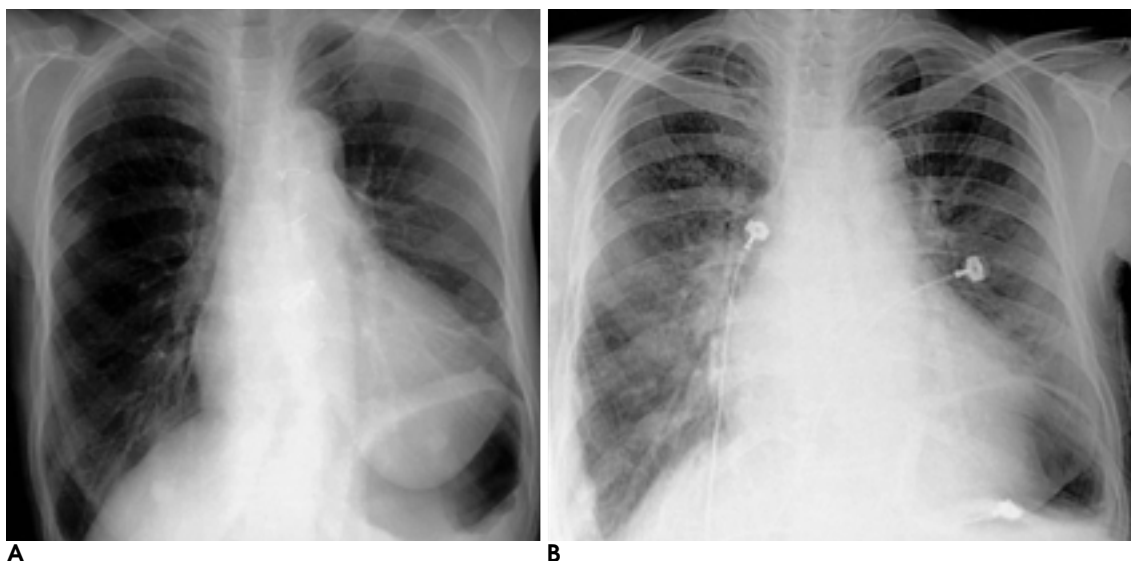


Fig. 3. A 70-year-old woman with end stage renal disease and cardiogenic pulmonary edema induced by acute myocardial infarction.
A. Chest radiograph obtained 1 month ago shows cardiomegaly.
B. Chest radiograph obtained at emergency room shows peribronchovascular cuffings and Kerley's B lines in both lungs with slight interval aggravation of cardiomegaly. He was diagnosed as having acute myocardial infarction.

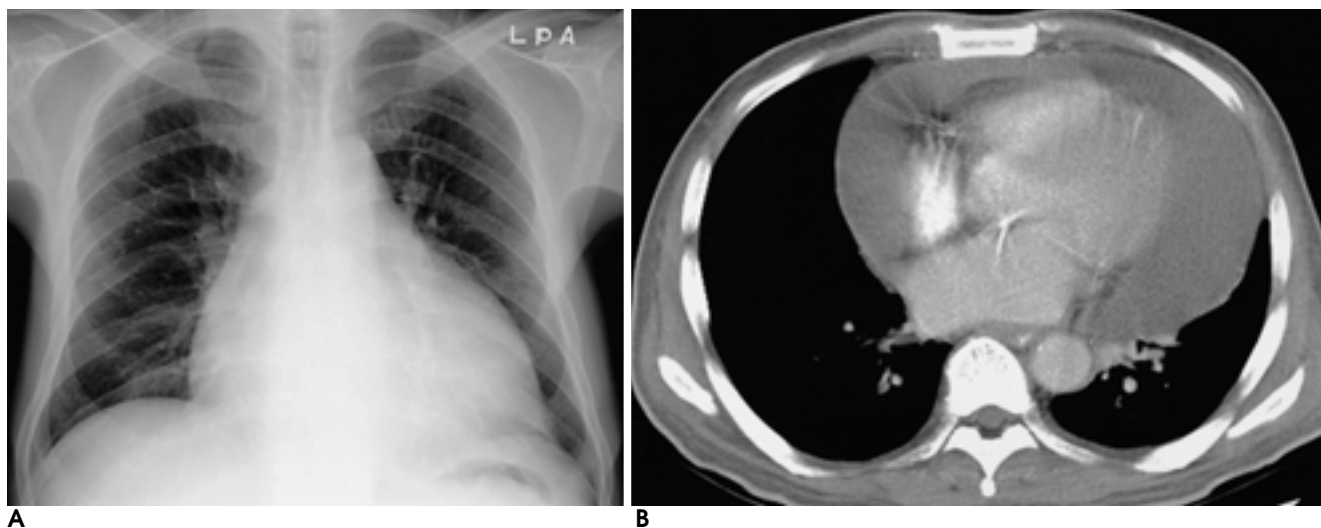


Fig. 4. A 62-year-old man with uremic serositis (uremic pericarditis and peritonitis) induced by inadequate hemodialysis.
A. Chest radiograph shows enlarged heart with "leather bottle appearance".
B, C. CT scan at level of inferior pulmonary vein (**B**) and at level of renal vein (**C**) show pericardial effusion and ascites. Also noted are shrunk both kidneys.



fibrothorax. An ultrasonogram may depict septa, fibrous bands, and debris (2).

Pulmonary Hemorrhage

Abnormal hemostasis is common in chronic renal disease and its most common hemorrhagic manifestations are prolonged bleeding from puncture sites, epistaxis,

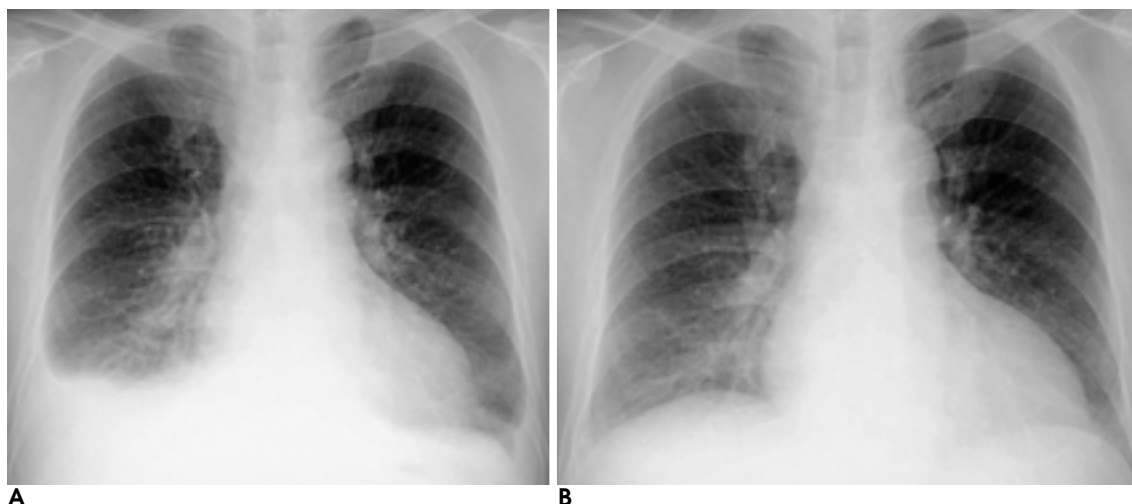


Fig. 5. A 75-year-old man with uremic pleuritis induced by inadequate hemodialysis.
A. Initial chest radiograph shows bilateral pleural effusions and mild cardiomegaly.
B. Follow-up chest radiograph 1 week after adequate hemodialysis shows improvement of pleural effusion.

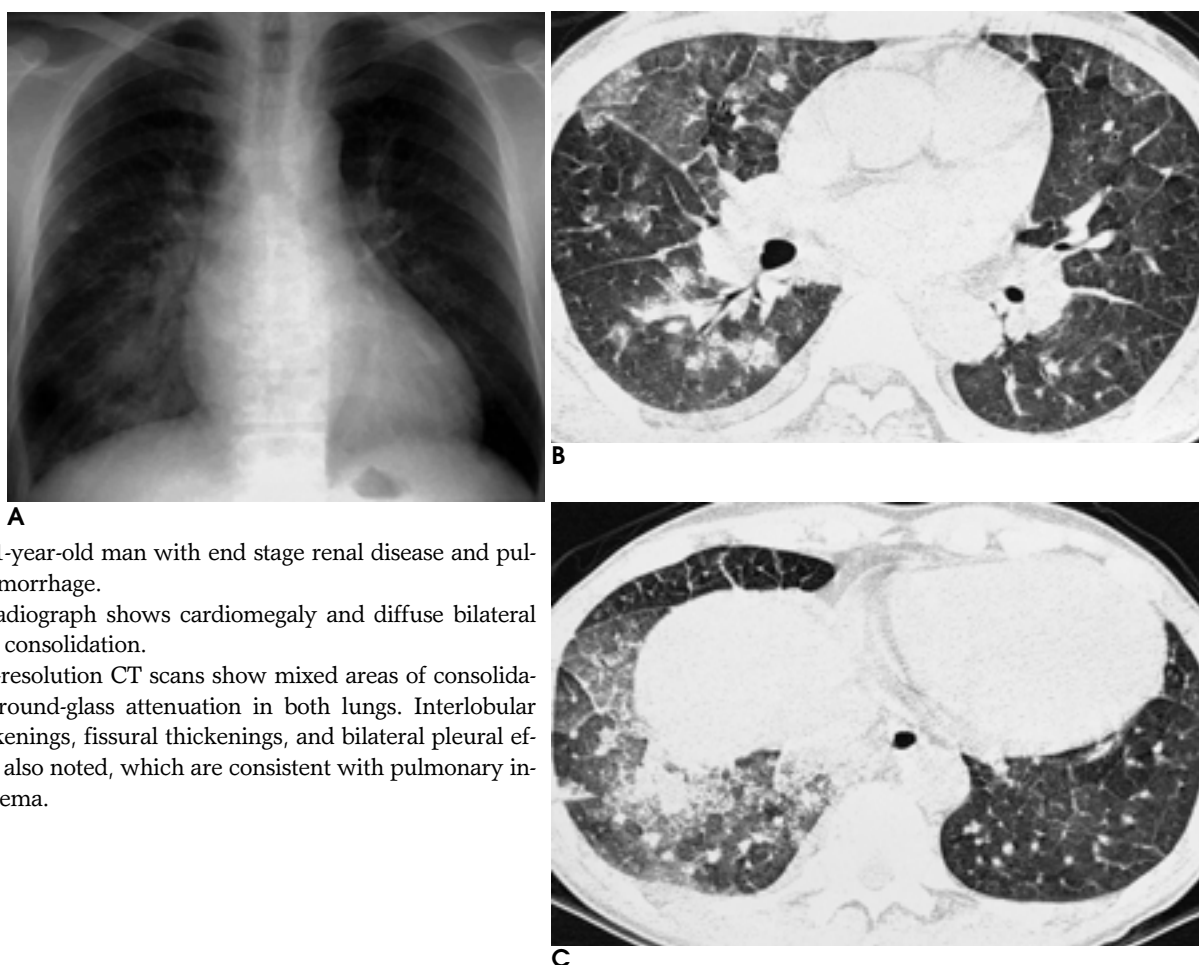


Fig. 6. A 41-year-old man with end stage renal disease and pulmonary hemorrhage.
A. Chest radiograph shows cardiomegaly and diffuse bilateral pulmonary consolidation.
B, C. High-resolution CT scans show mixed areas of consolidation and ground-glass attenuation in both lungs. Interlobular septal thickenings, fissural thickenings, and bilateral pleural effusions are also noted, which are consistent with pulmonary interstitial edema.

and gastrointestinal, retroperitoneal, and intracranial bleeding. Pulmonary hemorrhage can also occur. A chest radiograph demonstrates air space consolidation, which may be widespread or show a perihilar or middle- to lower zone predominance, and tends to be more pronounced centrally. Costophrenic angles and apices are usually spared. The CT findings consist of bilateral areas of ground-glass attenuation or consolidation (3) (Fig. 6).

Metastatic Pulmonary Calcification

Pulmonary calcification associated with chronic renal failure is rare, and regarded as a sign of secondary hy-

perparathyroidism. In most cases, calcification is asymptomatic, but in some patients there may be dyspnea and even severe respiratory distress. Bone scintigraphy is the most sensitive study, and in the correct clinical setting, pulmonary uptake of the radionuclide, even in patients whose chest radiographic findings are negative is sufficient for diagnosis. Chest radiography may reveal diffuse alveolar opacity, reticulation, or calcified nodules (4), while the HRCT findings include ground-glass attenuation nodules in centrilobular regions, with or without macroscopic calcification, a reflection of metastatic calcification in the alveolar septa and walls of the bronchioles and arterioles (5) (Fig. 7).

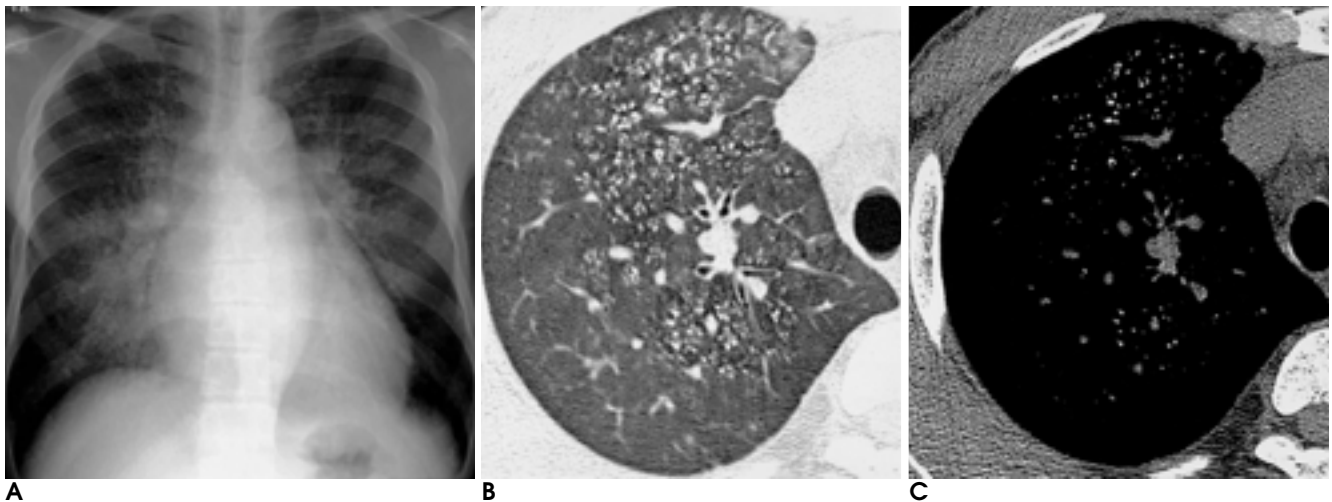


Fig. 7. A 45-year-old man with end stage renal disease and metastatic pulmonary calcification.
A. Chest radiograph shows ill-defined haziness and small nodules in both lungs.
B. High-resolution CT scan of lung window setting shows multiple small nodules and areas of ground-glass attenuation.
C. High-resolution CT scan of mediastinal window setting shows calcification in small nodules.

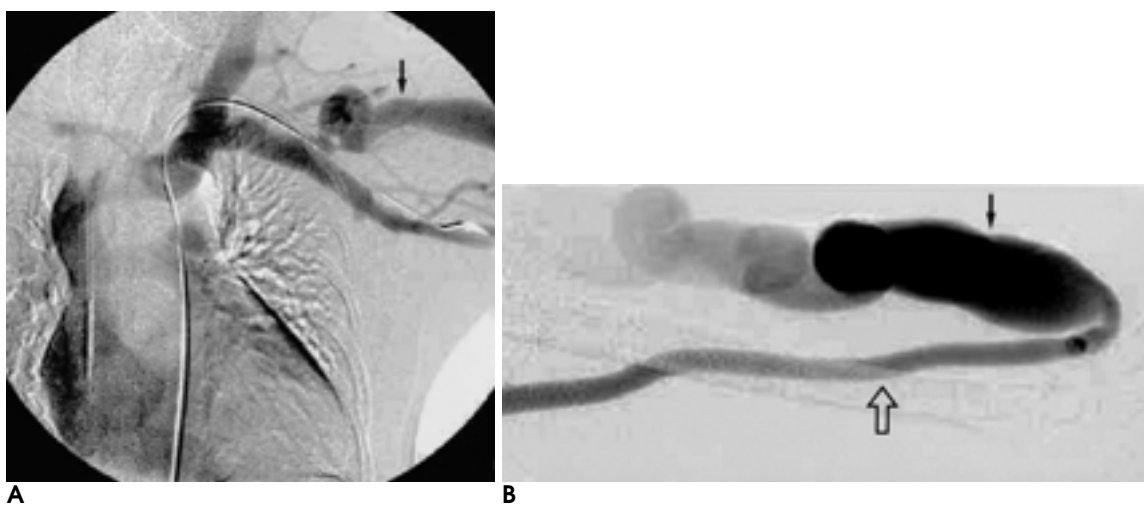


Fig. 8. A 60-year-old woman with high-output cardiac failure induced by arteriovenous fistula.
A, B. Angiograph obtained with contrast injection into the left axillary artery shows arteriovenous fistula between radial artery (open arrow) and vein. Markedly dilated draining vein from fistula is noted (arrow).

Pulmonary Complications accruing during Hemodialysis

Thoracic complications in patients undergoing hemodialysis are commonly related to the malpositioning or malfunctioning of the vascular catheters used, or arise iatrogenically for other reasons. Other complications related to these maneuvers are common to all central venous catheterizations, and include pneumothorax,

hemothorax, mediastinal hemorrhage, sepsis, and stenosis of the subclavian vein. Other rare complications include pulmonary, air, and septic embolism, high-output cardiac failure due to the arteriovenous fistula (Fig. 8), and pulmonary hemorrhage or hemothorax due to systemic heparinization and platelet dysfunction (6).

Pulmonary Infection

Infection is the second-leading cause of death among

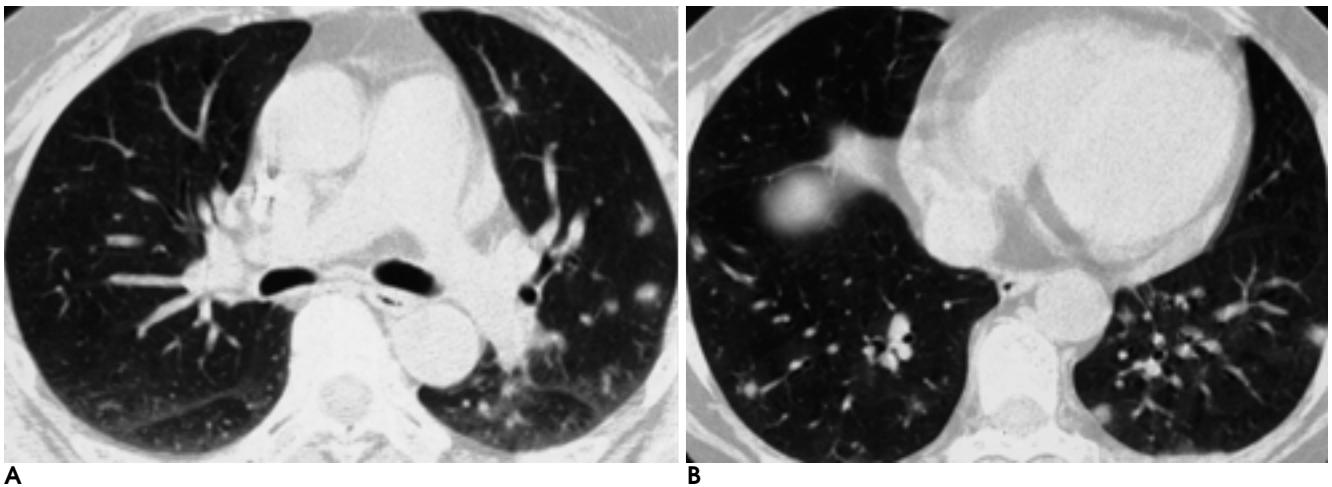


Fig. 9. A 31-year-old woman undergoing hemodialysis with candidiasis.

A, B. High-resolution CT scans show multiple small nodules with surrounding ground-glass attenuation halo scattered through both lungs, predominantly in peripheral lung.

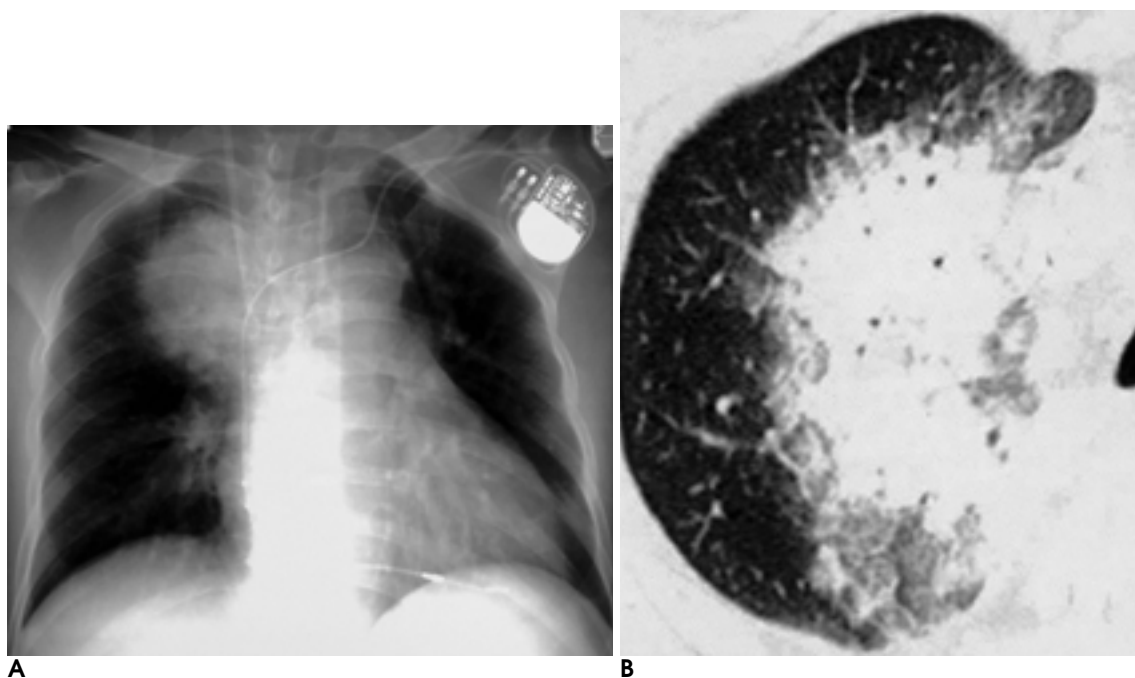


Fig. 10. A 59-year-old man with end stage renal disease and *Legionella* pneumonia.

A. Chest radiograph shows round areas of consolidation in right upper lobe.
B. Chest CT scan shows ill-defined round consolidation in right upper lobe.

patients with chronic renal failure, following cardiovascular disease, and sepsis (Fig. 9) and pulmonary infections account for 75% and 20% of such deaths, respectively. Exposure to infectious agents can occur in a hemodialytic setting, but in a uremic patient, fundamental abnormalities of the phagocytic system, including defective cellular immunity, neutrophil function, and complement activation, also exist. Infections are usually due to common bacterial pathogens, and the radiologic manifestations are indistinguishable from the usual patterns of pulmonary infection (7) (Fig. 10).

Pulmonary-renal Syndrome

The term 'pulmonary-renal syndrome' is used to describe disorders associated with pulmonary hemorrhage and glomerulonephritis, and includes Wegener's granu-

lomatosis (or related systemic vasculitides such as microscopic polyangiitis and Churg-Strauss syndrome), Goodpasture disease, Henoch-Schonlein purpura, and systemic lupus erythematosus (8). Diagnostic markers can be used and include 1) anti-glomerular basement membrane antibodies, which are essentially diagnostic of Goodpasture disease; 2) anti-neutrophil cytoplasmic antibodies (ANCA), which are suggestive of Wegener's granulomatosis, Churg-Strauss syndrome (C-ANCA) or microscopic polyangiitis (P-ANCA); 3) anti-nuclear antibodies in patients in whom lupus is suspected.

The radiologic manifestations of pulmonary disease in systemic vasculitis are varied. In the angitis-granulomatosis group, including Wegener's granulomatosis and Churg-Strauss syndrome, multiple nodules or masses that may demonstrate cavitation are usually seen, while diffuse multifocal air space opacities with or without

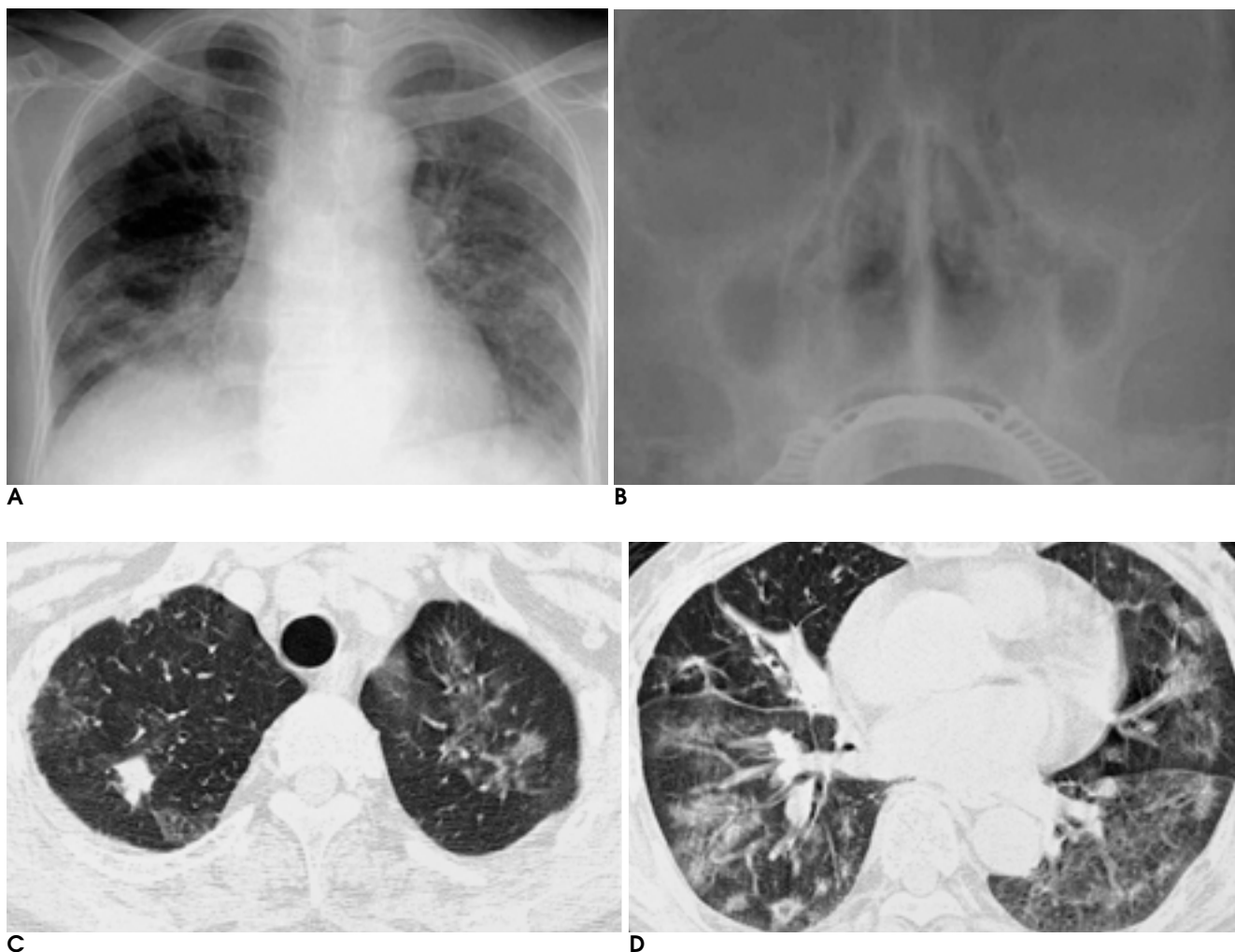


Fig. 11. A 68-year-old woman with progressive renal failure and Wegener's granulomatosis.

A. Chest radiograph shows ill-defined opacity and poorly-defined nodules in both lungs.

B. Water's view shows diffuse haziness in both maxillary sinuses.

C, D. High-resolution CT scans show multiple nodules and large areas of ground-glass attenuation in both lungs.

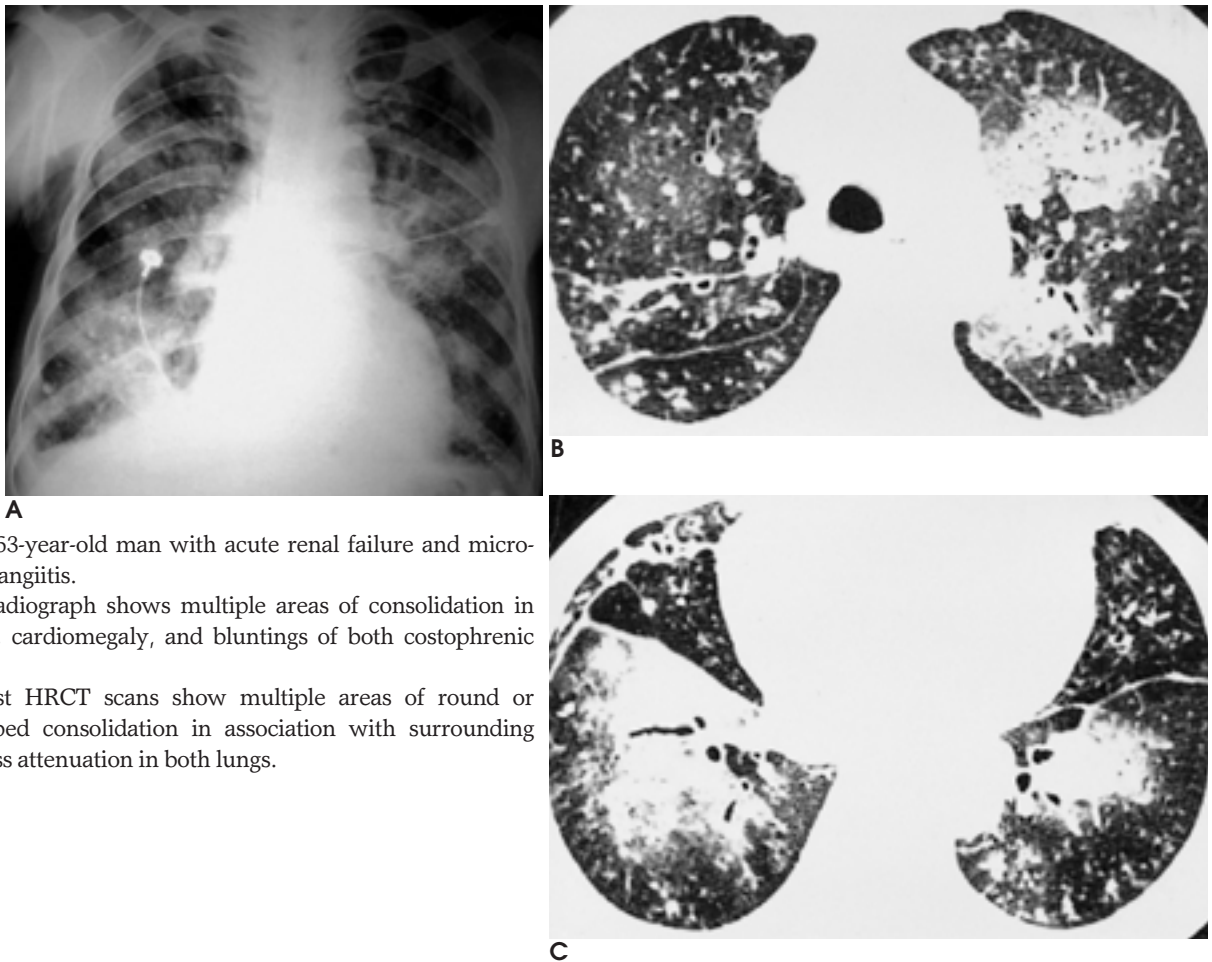


Fig. 12. A 63-year-old man with acute renal failure and microscopic polyangiitis.

A. Chest radiograph shows multiple areas of consolidation in both lungs, cardiomegaly, and bluntings of both costophrenic angles.

B, C. Chest HRCT scans show multiple areas of round or wedge-shaped consolidation in association with surrounding ground-glass attenuation in both lungs.

cavitation are less frequent (9) (Fig. 11). The diffuse pulmonary hemorrhage with capillaritis group, including microscopic polyangiitis and Goodpasture disease, shows focal or diffuse air-space consolidation (10) (Fig. 12).

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