Pulmonary Disease of Vascular Origin*

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The differential diagnosis of pulmonary disease of vascular origin must include pulmonary edema, uremia, Loeffler's syndrome, periarteritis nodosa, Wegener's granulomatosis, systemic lupus erythematosus, scleroderma, rheumatoid lung, pulmonary hemosiderosis, pulmonary purpura with nephritis, a pulmonary embolism and pulmonary arteriovenous fistula. Pulmonary edema and uremia have been included because of the roentgenographic features (pulmonary vascular congestion, pleural effusion, interlobar collections of fluid) which must be distinguished from those of other vascular disease that cause pulmonary parenchymal infiltrations.

It is the purpose of this paper to review the pulmonary diseases of vascular origin. I have included pulmonary edema and uremia in the discussion because of the roentgenographic features, which can be similar to those of other vascular diseases causing pulmonary parenchymal infiltrations.

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PULMONARY EDEMA AND UREMIA

Classic acute pulmonary edema is one of the most dramatic and potentially serious situations in medicine. It can be recognized clinically by the large volumes of pink frothy sputum, acute difficulty in breathing, distention of neck veins, cyanosis, and tachycardia. Mild pulmonary congestion, on the other hand, is manifested by cough with little ex-

Figure 1. Acute pulmonary edema. A, Cardiomegaly and pulmonary vascular congestion are evident. B, After treatment.
pectoration, and the cough is associated with shortness of breath on exertion or on lying down. The cardinal symptom of pulmonary congestion is breathlessness.

The roentgenographic features are characteristic. The heart is enlarged. The hilar shadows are prominent and the vascular markings increased bilaterally and symmetrically. The characteristic butterfly pattern of the pulmonary venous congestion may be present (Fig 1). Fluid in the right pleural space is one of the earliest roentgenographic signs of heart failure. A minimum of 300 ml of fluid must accumulate within the pleural cavity to cause blunting of the costophrenic angle as seen on the posteroanterior roentgenogram taken with the patient upright.1 It is not understood why pleural fluid develops in the right pleural space with heart failure. A unilateral left-sided effusion would include in the differential diagnosis metastatic carcinoma, tuberculosis, systemic lupus erythematosus, and pulmonary infarction. In advanced pulmonary edema there are large areas of "clouding" particularly at the bases, prominent pulmonary vascular markings, pleural fluid present bilaterally, and cardiomegaly. Interlobar collections of fluid can be seen in patients with chronic pulmonary congestion (Fig 2), the so-called vanishing lung tumor.2

The classic pattern of pulmonary function in congestive failure is a restrictive pattern as shown in the table. Vital capacity and total capacity are markedly decreased.

Treatment consists of restriction of salt and administration of digitalis and diuretics. Right-sided effusions and interlobar collections of fluid disappear on diuresis. In selected cases wherein a low

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**Table 1—Pulmonary Function in Congestive Heart Failure, Showing Restrictive Ventilatory Impairment With Decrease in Vital Capacity and Total Capacity**

<table>
<thead>
<tr>
<th>Pulmonary volumes</th>
<th>Estimated</th>
<th>Normal</th>
<th>Test</th>
<th>After Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vital capacity (expiratory), L</td>
<td>4.2</td>
<td>1.72</td>
<td>1.85</td>
<td></td>
</tr>
<tr>
<td>Inspiratory vital capacity, L</td>
<td>4.2</td>
<td>1.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual volume (RV), L</td>
<td>1.4</td>
<td>1.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total capacity (TC), L</td>
<td>5.6</td>
<td>3.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RV/TC × 100, %</td>
<td>&lt;45</td>
<td>51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Functional residual capacity, L</td>
<td>2.5</td>
<td>2.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expiratory reserve, L</td>
<td>1.1</td>
<td>0.88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximal breathing capacity, L/min</td>
<td>88</td>
<td>38</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>Maximal midexpiratory flow, L/sec</td>
<td>&gt;2.0</td>
<td>0.8</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>Expiratory slowing</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Nitrogen-washout index, % N,</td>
<td>&lt;2.5</td>
<td>1.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arterial O₂ saturation (oximeter), %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting (air)</td>
<td>95–98</td>
<td>89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting (oxygen)</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before exercise (air)</td>
<td>95–98</td>
<td>95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exercise (air)</td>
<td>No fall</td>
<td>93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventilation (at sitting rest, breathing O₂)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L/min</td>
<td>11.96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respirations/min</td>
<td>19.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean tidal volume, ml</td>
<td>617</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO-diffusing capacity (ml/min/mm Hg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exercise</td>
<td>29</td>
<td>7</td>
<td>(16–28)</td>
<td></td>
</tr>
</tbody>
</table>
cardiac output may be associated with pulmonary vascular congestion, thoracentesis may help remove bilateral effusions.

Uremia is sometimes associated with roentgenographic pulmonary opacities distributed in a distinctive manner on a posteroanterior view. The typical pattern (Fig 3) consists of symmetric densities extending from each hilum into the pulmonary fields, leaving clear peripheral zones, apices, and costophrenic angles. Terms that have been used to describe the pattern include "butterfly shadow" and "batswing shadow." Uremic pneumonia is the result of single or repeated episodes of left ventricular failure in uremia in the presence of factors modifying pulmonary capillary permeability. The incidence does not appear to be
determined by the degree or duration of azotemia. Treatment aims at correction of underlying renal disease along with diuresis. If obstructive uropathy exists, the obstruction should be relieved by catheter drainage and diuresis carried out prior to corrective operation.

Aspiration pneumonitis (Mendelson's syndrome)\(^6\) should be mentioned in the differential diagnosis of acute pulmonary edema since its clinical appearance is the same, with acute dyspnea, tachypnea, perspiration, tachycardia, cyanosis, and cough productive of frothy pink sputum. Aspiration pneumonitis is usually encountered postoperatively. It was originally described in the obstetric patient post partum. Rales, wheezes, and rhonchi are heard throughout both lungs. The roentgenographic picture differs from acute pulmonary edema in that there is diffuse mottling throughout both upper lobes without cardiomegaly (Fig 4). Mendelson's syndrome results from chemical pneumonitis caused by aspiration of fluid gastric contents into the lungs. Treatment of aspiration pneumonitis consists of giving hydrocortisone sodium succinate (Solu-Cortef) intravenously, aminophylline for bronchospasm, antibiotics to prevent secondary infection, oxygen, and, in selected cases, hydrocortisone by instillation into the tracheobronchial tree.\(^7\)

The differential diagnosis of pulmonary alveolar infiltrates has been well described by Goodman.\(^8\) The discussion herein will consider only the pulmonary infiltrates of vascular origin.

**Loeffler's Syndrome**

Loeffler's syndrome should be included in the vascular disease group. It most likely represents an allergic reaction in the lung to a foreign antigen.\(^9\) It is more common in asthmatics. It is characterized by migrating infiltrates in the lung and by eosinophilia. The pulmonary infiltrates may be unilateral or bilateral and located in any part of the lung (Fig 5). The percentage of eosinophils in the blood may range from 10 per cent to 80 per cent. The disease is treated with steroids, which in many cases must be administered for as long as a year to prevent a relapse. Loeffler's syndrome is a benign disease, and it should be differentiated from periarteritis nodosa because of the different prognosis.

**Periarteritis Nodosa**

Periarteritis nodosa is a progressive and often fatal disease presenting the typical picture of multisystem involvement. There are often fever, polyneuritis, and renal, dermal, and pulmonary involvement. The features that differentiated Loeffler's syndrome from periarteritis nodosa include a
shorter duration of pulmonary signs in the former, an absence of profound anemia and or renal disease, a lower incidence of hemoptysis and pleural effusion, and an absence of multisystem involvement. Pulmonary lesions are due to vasculitis; periarteritis nodosa is a necrotizing inflammatory reaction involving the small arteries and arterioles.\textsuperscript{10} Pulmonary involvement is manifested by chest pain, dyspnea, cough, and hemoptysis.

The roentgenographic findings in periarteritis nodosa are not diagnostic. They consist of parenchymal patchy infiltrates (Fig 6). In later stages, pleural and pericardial effusions may occur and thrombotic changes in the patchy infiltrates may

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure7}
\caption{A, Cavitating pulmonary nodule in a patient with Wegener's granulomatosis. B, Tomogram of nodule.}
\end{figure}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure8}
\caption{A, Pleural involvement, areas of atelectasis, and patchy parenchymal infiltration in a patient with systemic lupus erythematosus. B, View with patient in right lateral decubitus, showing free fluid present.}
\end{figure}
Honeycombing and spontaneous pneumothorax in a patient with scleroderma. The typical pathologic picture is that of an ulcerating granuloma of the upper or lower respiratory tract and a necrotizing angitis and glomerulitis. The combination of granulomatous disease and vasculitis in the lungs may give rise to pneumonitis, necrosis, cavitation, and infarction. Hemoptysis occurs frequently. The roentgenographic picture is that of multiple, frequently cavitated nodules (Fig 7). Steroids are the drugs of choice, but prognosis is poor and death results from progressive renal failure in most cases.

**THE LUNG IN SYSTEMIC LUPUS ERYTHEMATOSUS**

Systemic lupus is characterized by widespread involvement of almost all the organs in the body,

and pulmonary involvement is frequent. The most common pulmonary lesions are interstitial inflammatory lesions with atelectasis. Interstitial pneumonitis is encountered often. Pleural involvement is a well-recognized part of the clinical syndrome, causing pleuritic pain, friction sound, and unilateral or bilateral effusions. The chest roentgenogram shows infiltrates, areas of linear collapse, and pleural involvement (Fig 8). Steroids can be lifesaving, and often patients with systemic lupus erythematosus can be maintained on steroid therapy for many years.

**SCLERODERMA**

Scleroderma (progressive systemic sclerosis) is characterized by widespread involvement of connective tissue; in the lungs the principal change

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**FIGURE 9.** Honeycombing and spontaneous pneumothorax in a patient with scleroderma.

**FIGURE 10.** Pleural effusion and diffuse interstitial pneuomonitis in a patient with rheumatoid lung.

**FIGURE 11.** Nodular fibrosis throughout both lungs in a patient with Caplan's syndrome.
and causing spontaneous pneumothorax (Fig 9). Pulmonary vascular changes are common. Pulmonary scleroderma physiologically produces a restrictive ventilatory impairment with an alveolar-capillary block. Steroids are of no benefit in the treatment of the parenchymal pulmonary involvement from scleroderma.

**THE LUNG IN RHEUMATOID ARTHRITIS**

“Rheumatoid lung” is the term for the pulmonary lesions encountered in rheumatoid arthritis. The pulmonary manifestations of rheumatoid disease consist mainly of pleuritis, interstitial pneumonitis, and diffuse fibrosis. The interstitial pneumonitis and diffuse fibrosis are not specific for rheumatoid arthritis. A rare but more specific lesion is the pulmonary rheumatoid nodule, first recognized in coal miners with pneumoconiosis.15 Cavitation is common in the pneumoconiotic nodule, but rare in the nonpneumoconiotic nodule.16 The x-ray appearance of the chest of patients with rheumatoid disease of the lung is not pathognomonic (Fig 10); usually a pleural effusion or pleural reaction, diffuse interstitial pneumonitis, and rarely a rheumatoid nodule are seen. Treatment is directed toward the rheumatoid arthritis and the diffuse pneumonitis and fibrosis, the same as if they occurred separately. Steroids can prevent irreversible fibrosis if used early in the disease.

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**Figure 12.** Section of pneumoconiotic nodule obtained on biopsy of lung (hematoxylin and eosin, ×30).

Takes place in the alveoli.13 The elastic tissue of the alveolar wall is replaced by collagen. Cysts develop from degenerated alveolar walls, giving the roentgenographic picture of “honeycomb lungs”14.

CAPLAN'S SYNDROME

In 1953, Caplan called attention to an association of nodular fibrosis of the lungs with rheumatoid arthritis in coal miners. Since Caplan's original description, the syndrome has been reported in foundry workers, carbon electrode workers, boiler scalers, and workers exposed to brass, sand blasting, and asbestos. The necessary factor for the production of these lesions seems to be the presence of collagen necrosis resulting from the reaction of sensitized pulmonary tissue to dust particles. The syndrome may be a hypersensitization reaction to irritating dust particles in the lung in rheumatoid patients who already have a hyperimmune state. The chest roentgenogram shows nodular fibrosis (Fig 11), and the pneumoconiotic nodule has a central area of necrotic collagen surrounded by an inflammatory cellular layer and a zone of fibroblasts containing multinucleated giant cells (Fig 12). Treatment is the same as for the joint or pulmonary manifestations when they exist alone.

PULMONARY HEMOSIDEROSIS

Idiopathic pulmonary hemosiderosis is a disease of unknown cause characterized by repeated episodes of pulmonary hemorrhage with hemoptysis. In a series of 112 patients, 91 were children less than 16 years of age and distributed about equally by sex. Of the 21 adults, most were less than 30 years of age and the ratio of males to females was 2:1. The clinical course is variable, but death usually occurs from massive pulmonary hemorrhage. Repeated episodes of bleeding cause hemosiderin deposition, pulmonary fibrosis, and pulmonary hypertension with cor pulmonale in a few. The diagnosis depends on the roentgenographic changes

FIGURE 15. Typical appearance of pulmonary infarction in a postoperative cardiac patient.
(Fig 13) (lower lobe poorly defined, confluent pulmonary infiltrates, and subsequent fibrosis) associated with repeated pulmonary hemorrhage and microcytic anemia. Hemosiderin deposition can be demonstrated by biopsy of the lung and by finding hemosiderin-laden macrophages in sputum. There is no effective treatment.

**PULMONARY PURPURA WITH NEPHRITIS**

Pulmonary purpura with nephritis (Goodpasture’s syndrome) presents also with repeated episodes of hemoptysis. The disease differs from idiopathic pulmonary hemosiderosis in that the patients are more than 16 years of age and are usually men.

Initially, patients present with hemoptysis, but without roentgenographic abnormality except in the acute stage of hemoptysis. A diffuse infiltrate with an alveolar pattern is seen on the roentgenogram (Fig 14). The patient becomes mildly anemic, but rarely requires blood replacement. The second stage develops several months later, with fulminating glomerulonephritis which usually terminates in irreversible renal failure and death. At necropsy, acute and chronic glomerulonephritis are found in addition to pulmonary hemosiderosis. There is destruction of both the alveolar and the glomerular capillary basement membrane, which suggests the preferential localization of a hypersensitivity state at these two sites. Treatment consists of giving steroids, but few patients do well and usually death occurs from renal failure.

**PULMONARY EMBOLISM AND INFARCTION**

Pulmonary embolism with infarction (Fig 15) must be considered in any discussion of pulmonary disease of vascular origin. A characteristic of pulmonary embolic disease is the changing nature of the lesions. The history, physical examination, and suspicion of embolus combined with the roentgenographic examination and macroaggregated-albumin scan of the lungs will usually reveal the diagnosis. Scanning and arteriography of the lungs are complementary, not competitive. Arteriography is indicated only if surgical intervention becomes mandatory. Pleural effusion commonly accompanies pulmonary infarction. Infarction occurs in only half the instances of pulmonary embolism recognized clinically. There are cough, hemoptysis, and pleuritic pain. The development of bloody pleural fluid is to be expected in infarction. Few disturbances can deceive the experienced physician as often as pulmonary embolism. It can mimic most acute pulmonary conditions. Pulmonary emboli can

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appear as multiple cannon-ball metastases. Early diagnosis and adequate treatment depend on constant awareness, particularly if the pulmonary lesion is of a changing nature.

**HEREDITARY TELANGIECTASIA AND PULMONARY FISTULA**

Pulmonary arteriovenous fistula occurs in 5 per cent to 6 per cent of patients with hereditary hemorrhagic telangiectasia (Rendu-Osler-Weber syndrome). This condition is inherited as a dominant trait and its cause is unknown. The telangiectatic spots are actually tiny arteriovenous fistulas. The lesions are frequently not recognized until the second decade of life. A bruit is present if the fistula is large. Complications include rupture of the fistula and cerebral embolism with brain abscess. The presence of a fistula is suspected from the appearance of the thoracic roentgenogram (Fig 16A), but angiographic examination is the only definitive procedure (Fig 16B and C). Treatment is surgical excision for the larger arteriovenous fistulas to prevent rupture and brain abscess.

**REFERENCES**


15 Caplan, A.: Certain unusual radiological appearances in the chest of coal-miners suffering from rheumatoid arthritis, Thorax, 8:29, 1933.

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