can be transiently trapped in the right atrium before traveling into the pulmonary arteries where they can result in a fatal cardiopulmonary event. The presentation of right atrial thrombus is usually subtle, and specific manifestations frequently are lacking.1,4 Dyspnea is the most frequent symptom and occurs in two thirds of patients. Chest pain, usually precordial, occurs in one third of patients. Symptoms of reduced cardiac output, like dizziness and fainting, are present in nearly one third of patients. The physical examination usually is nonspecific, and less than one half of patients demonstrate signs of hypotension, elevated jugular venous pressure, or cardiac murmurs. Evidence for venous thrombosis is present in less than one fifth of patients. Two thirds of patients demonstrate evidence of pulmonary embolization, usually within one to three days, but sometimes this occurs within minutes to hours after echocardiographic diagnosis.1,4

The right atrial thrombus, as detected by two-dimensional echocardiography, may take different configurations during the cardiac cycle, reflecting the coiling and uncoiling of the elongated ductile clot as it moves back and forth through the tricuspid valve.1,4,8 Other imaging methods, including computerized tomography,4 digital subtraction angiography,7 and routine angiography,8 may prove useful in the diagnosis of right atrial thrombus. However, because most patients present with cardiac symptoms and because of its simplicity, versatility, and noninvasive nature, two-dimensional echocardiography should be the initial diagnostic procedure.

There are few guidelines for the management of right atrial thrombus. This report would suggest that a mobile nature and prolapse indicate that the mass is at high risk of breaking loose and passing into the pulmonary vasculature. Anticoagulation would not be an appropriate choice for this patient with severe hemodynamic compromise. Thrombolysis for a mobile prolapsing thrombus may increase the risk of the clot breaking loose and of embolization. When a diagnosis is made, immediate surgical therapy should be considered.

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Severe Pneumococcal Pneumonia Complicated by Massive Pulmonary Gangrene

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Massive pulmonary gangrene is a rare complication of pneumonia, particularly in the postantibiotic era. We report two cases of community-acquired Streptococcus pneumoniae pneumonia in young patients with a background of heavy alcohol abuse, but no other preexisting disease, which failed to respond to appropriate antibiotic therapy and intensive care. In both, there was extensive unilateral involvement, with initial dense consolidation followed by cavitation, but the previously reported classic late radiologic feature of coalescence into a large cavity with free-floating slough was not seen. Owing to ongoing sepsis with the development of multiple organ failure and the obvious failure of appropriate medical therapy, both patients underwent pneumonectomy with a successful outcome. These cases serve to emphasize the role of surgery in the management of massive pulmonary gangrene.

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Most patients with community-acquired pneumonia will respond to appropriate antibiotic therapy; however, in 3 to 5 percent of patients, in spite of adequate therapy, the disease process may progress to irreversible respiratory failure and death.1,1 In a small proportion of these cases, frequently those in whom initiation of treatment was delayed, low-grade infection progresses to involve the entire lung in a necrotic process. With ongoing tissue damage, release of cytokines, and persisting infection, bacteremia, septicemia, and multiple organ failure ensue.4 In such cases where adequate and appropriate antibiotic therapy has been given, there may rarely be instances where surgical management is indicated to prevent the progression to multiple organ failure and death.5,6

We have previously reported the successful treatment of pneumonia complicated by lung abscess formation which responded well to surgical drainage,7 and we here describe pneumonecomy in two patients who developed massive pulmonary gangrene secondary to Streptococcus pneumoniae pneumonia which failed to respond to appropriate antibiotics and ICU therapy, including mechanical ventilation with differential lung ventilation.

Case Reports

Case 1

A 39-year-old man with a background of heavy smoking and prolonged alcohol abuse was admitted to our emergency unit with a 2-week history of progressive dyspnea, cough, blood-stained sputum, fever, and pleuritic chest pain. On examination, he had a fever of 38.7°C, was hypotensive, and was found to have clinical features of right-sided pneumonia. The white blood cell count was 5,800/mm³, and the platelet count was 28,000/mm³, with an erythrocyte sedimentation rate of 120 mm/h. Arterial blood gas

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levels on room air were as follows: pH 7.41; Po2, 7.4 kPa; and Pco2, 4.0 kPa, with a standard bicarbonate level of 20.6 mmol/L. Sputum culture grew S pneumoniae sensitive to penicillin, and blood cultures were also positive.

The patient was admitted to the ICU, where he was treated with intravenous penicillin and tobramycin and required intubation, ventilation, and inotropic support. Over the next few days the pneumonia was noted to have extended radiologically to involve the entire right lung, and this was associated with the development of a right-sided bronchopleural fistula and worsening of his respiratory function. A chest roentgenogram showed extensive consolidation of the right lung, with loss of volume, a persistent subpulmonic pneumothorax in spite of chest drains, and an area of breakdown in the midzone. The left lung was normal initially (Fig 1). The possibility of the spread of infection to the opposite side prompted the insertion of a double-lumen endotracheal tube and the institution of independent lung ventilation. There was a concomitant deterioration in the patient's renal function with the development of disseminated intravascular coagulation. Following 7 days of intensive supportive therapy, during which the patient showed progressive deterioration with the development of multiple organ failure and a PaO2 of 5.8 kPa, Pco2 of 5.3 kPa, and pH of 7.44 on 35 percent oxygen, it was decided to perform a right pneumonectomy. At surgery the lung was noted to be edematous and frankly necrotic, with breakdown of the anterior segment of the right upper lobe.

After surgery the patient developed right empyema, which was treated with a thoracostomy and then successfully closed. His recovery was otherwise uneventful, and he was able to be discharged from the ICU after 35 days.

Three-month follow-up found the patient well, with some reduction in his lung volumes and moderate airflow limitation (FEV1, 1,030 ml; FVC, 2,050 ml). He was still alive 5 years later.

Case 2

A 33-year-old stable-hand with a long history of alcohol abuse presented to this hospital with a 1-week history of fever, cough, and dyspnea. On examination, he was found to have signs of left-sided consolidation. The chest roentgenogram showed dense homogeneous opacification of the left lung; the right lung was uninvolved (Fig 2). Arterial blood gas levels on room air were as follows: pH 7.14; Po2, 7.6 kPa; and Pco2, 10.1 kPa. The white blood cell count was 12,800/mm³, with a marked leftward shift in the morphology. The patient's serum urea was elevated at 11.7 mmol/L, with a creatinine of 160 mmol/L and normal hepatic function tests.

The patient was admitted to the ICU for ventilation. Antibiotic therapy was commenced on admission with both cefotaxime and cloxacillin. Gram stain of the sputum showed numerous gram-positive diplococci and Gram-negative cocacobacilli, and culture of the tracheal aspirate grew S pneumoniae and Haemophilus influenzae. The patient's course in the ICU was stormy, and he developed evidence of multiple organ failure over the next 6 days. A double-lumen endotracheal tube was inserted on the seventh day because of copious secretions, with the institution of independent lung ventilation; however, the patient's condition remained critical, with ongoing deterioration of his renal function and the need for inotropic support to maintain his blood pressure. On the ninth day, he was taken to surgery for a left pneumonectomy, as he was not responding to conventional therapy.

The findings at thoracotomy were of a nonviable infective process involving the entire left lung. The patient's postoperative course was complicated by a resistant Staphylococcus aureus postpneumonectomy empyema and wound hematoma. Three weeks later, the patient was able to be discharged from the ICU. Eventually, he was discharged from hospital with a thoracostomy tube in situ.

**Discussion**

Severe community-acquired pneumonia still has a mortality of between 29 and 54 percent, despite intensive care and appropriate antibiotic therapy. A number of factors, including age over 65 years, preexisting disease, renal impairment, raised hepatic enzyme levels, hypoalbuminemia, confusion, and hypoxemia, have been recognized as markers of more severe disease, while septic shock, a white blood cell count less than 4,000/mm³ and Gram-negative organisms are recognized as indicators of increased mortality, with death usually occurring in the first few days after admission. The cause of these deaths is usually due to overwhelming infection and endotoxemia leading to the
adult respiratory distress syndrome, septic shock, and multiple organ failure.\textsuperscript{4} Massive pulmonary gangrene resulting from both \textit{Klebsiella pneumoniae} and \textit{S pneumoniae} pneumonia was recognized as a rare complication in the preantibiotic era, and successful outcome often relied on surgical management of such cases.\textsuperscript{5,6,10} Whereas there is usually rapid spread of pneumonia with bilateral involvement, these two case reports differ substantially from the usual pattern of severe overwhelming pneumonia in that the process remained confined to one lung for some days before spread to the opposite uninvolved lung occurred. It was thought that this unusual course was due to the development of massive necrosis of the underlying lung, with subsequent spillover to the opposite side. In both of these cases, the development of the typical late radiologic features of pulmonary gangrene,\textsuperscript{11} including the presence of a lobar sized cavity containing movable tissue, was not seen, probably because its development was anticipated and treated with early surgery. Many cases of pneumonia which have been thought radiologically to have unilateral involvement are shown at autopsy to have involvement of both lungs, especially in those where the progression to death is rapid; this makes the decision as to when to proceed to pneumonectomy difficult. Special investigations, including computed tomography of the chest and perfusion scans, may contribute to the clinical decision to proceed to surgery, but these have not yet been adequately evaluated. Evaluation of the pulmonary reserve using pulmonary function testing is impossible in this situation, and a clinical assessment of pulmonary function needs to be made, taking the history of previous effort tolerance and coexisting lung disease into consideration.

Serotype 3 pneumococci are recognized to cause more severe necrosis than other types; the mechanism is multifactorial, including both host and microbial factors. The phagocytic activity of the alveolar macrophages and polymorphonuclear leukocytes may be overwhelmed by the rapid accumulation of capsular polysaccharides often seen with type 3 infections. This mechanism, as well as a large antigenic load of capsular polysaccharide, leads to reduced humoral and mechanical defenses. This, together with toxin production, including leukocidin, hemolysin, pneumolysins, and hyaluronidase, may predispose to lung necrosis.\textsuperscript{4,10} The pathology of the lung frequently shows significant vascular thrombosis, which undoubtly is particularly important in the pathogenesis of massive pulmonary gangrene. Numerous host factors have been implicated; however, in our patients, alcoholism and smoking were the only common factors, although aspiration may well have played a role. Both were young (aged 33 and 39 years, respectively), and the white blood cell counts (5,800/mm$^3$ and 12,800/mm$^3$) were inappropriately normal.

Massive pulmonary gangrene frequently occurs in patients who are at risk of aspiration, as in our two patients; however, anaerobic bacteria have only occasionally been cultured in this setting. The association of both \textit{S pneumoniae} and \textit{K pneumoniae} with aspiration is well recognized, as is the synergistic tissue necrosing effect of a combined aerobic/anaerobic infection. It is therefore likely that aspiration is a factor in some cases of massive pulmonary gangrene.\textsuperscript{10} Although successful medical management has been described in three cases of massive pulmonary gangrene,\textsuperscript{12} the majority have been treated surgically, either by drainage or resection. In both of our cases, medical therapy had already failed, making surgery the only option. Surgery in these circumstances has a high morbidity and mortality,\textsuperscript{13} and both patients developed a postpneumonectomy empyema, a distressing, difficult problem to treat; one also had a wound hematoma. It is uncertain whether earlier surgical drainage would have modified the outcome. This late complication of massive pulmonary gangrene is rare and has only been seen in these 2 cases, while over the same 9-year period, 446 patients have been admitted to our ICU with severe community-acquired pneumonia. The successful outcome in these 2 cases, where there was ongoing clinical deterioration with extension of their disease after 7 days of full therapy, suggests that surgery should be considered in patients with a similar pattern of disease.

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