10

Gangrenous Lung Disease

Chih-Hao Chen
Department of Thoracic Surgery, Mackay Memorial Hospital, Taipei City, Taiwan

1. Introduction

Normal lung function requires both adequate lung ventilation and adequate perfusion. Adequate lung perfusion means normal blood flow can reach to the lung tissues providing nutrients and oxygen to the lung tissues and the waste can be removed. Perfusion of the lung may be disturbed in numerous settings, including infection, aspiration of foreign body, neoplasm[1], trauma and may be secondary to surgical complications, adverse effects of radiation therapy and chemotherapeutic agents. A variety of causes may lead to gangrenous lung disease.(Table 1) For example, uncontrolled diabetes is a risk factor of severe lung infection, especially caused by *Klebsiella* pneumonia.[4] Inadequate blood flow usually resulted in necrosis, bacterial overgrowth and abscess formation. Gangrenous change indicates tissues necrosis followed by decomposition of tissues into a slough. Compromise of blood flow can be the primary cause and can be the result of other antecedent events. Treatment and outcome were essentially related to its causes and depends on the timing of either medical or surgical intervention. Without prompt intervention, high risks of mortality and morbidity will be encountered.

Primary		
	pneumonia	severe and uncontrolled infection in lung tissues
	pulmonary embolism	hypercoagulable state, deep vein thrombosis
	neoplasm	lung cancer with necrosis and infection, bronchial obliteration by hilar tumor or hilar lymphadenopathy
Secondary		
	trauma	lung contusional hemorrhage
	surgery	Improper ligation of pulmonary artery and vein, lobar torsion
	sepsis	septic emoli, systemic infection
	drug-induced	lung toxicity of chemotherapeutic agents
	radiation effect	radiation pneumonitis
	foreign body aspiration	aspiration pneumonia

Table 1. Etiology of pulmonary gangrene

2. Clinical features

Inflammatory changes can be locally confined in the lung tissues with lobar pneumonia, necrotizing pneumonitis, cystic changes and abscess occurring in any location where the tissues being destroyed. Symptoms of local inflammatory diseases include chest pain, pleurisy, cough, dyspnea, purulent expectorants and reduced tolerance of physical activity. Systemic inflammatory response syndrome (SIRS) causes unstable hemodynamics (dropped blood pressure, tachycardia, tachypnea / dyspnea, and high fever/chills), severe chest pain, malaise, poor appetite and purulent expectorants. In advanced age patients, deterioration of consciousness may be the first presentation. However, these symptoms may be subtle or non-specific and resembled to those symptoms seen in other common diseases. Characteristic features included abundant and putrid sputum in the airway and hemoptysis caused by tissues decomposition. [2] Proper history taking is essential when the patient presented unexpected presentations following surgery (for example improper pulmonary artery ligation after a lung resection). The diagnosis of lung gangrene based on clinical manifestations alone is quite difficult. Established risk factors of community-acquired pneumonia (CAP) are alcoholism, asthma, immunosuppression, advanced age (> 70 years old), dementia, seizure, congestive heart failure, cerebralvascular disease, chronic obstructive pulmonary disease, smoking, end-stage renal disease and others.[3]

3. Diagnostic laboratory blood test

A complete cell count and biochemistry is mandatory. Elevated white blood cells with shift-to-left usually indicates for systemic inflammation or infection. C-reactive protein, erythrocyte sedimentation rate and procalcitonin are also useful infection indicators. When systemic infection is severe and non-pulmonary origins can be reasonably excluded, gangrenous changes, a form of the most severe lung infection and tissues decomposition, should be kept in mind as one of the differential diagnosis.[3, 5] Blood culture is obtained if bacteremia is likely and serology test will be useful in some instances of infection.

4. Sputum analysis

Obtaining adequate sputum for possible pathogens is essential to guide the use of antibiotics. Prior to identifying the definite culprit pathogen, empiric antibiotics of broad-spectrum should be started as soon as possible. Four common pathogens encountered in community-acquired pneumonia are Streptococcus pneumonia, *Haemophilus* influenzae, *Staphylococcus* aureus and *Mycoplasma* pneumoniae. Among the common pathogens, Streptococcus pneumonia occupied more than 50% of all cases. Gram stain, Acid-fast stain and rapid antigen test can assist differential diagnosis. A positive gram stain for diplococci has near 100% sensitivity for pneumococcal infection but the specificity is poor (less than 5%). [5] Recently, polymerase chain reaction (PCR) becomes more and more popular in detection of some pathogens, from throat swab or sputum, yielding rapid result to guide our treatment strategy. A multiplex PCR allows us to detect tuberculosis, *Legionella* spp, *Mycoplasma* pneumoniae and C. Pneumonia. However, due to higher costs, such test is not routinely applicable.

5. Bronchoscopy

Bronchoscopy is a useful tool to help evaluate the condition of trachea and bronchus. Lobar torsion, most commonly encountered in right middle lobe following resection of right upper lobe, and subsequent lobar gangrene can be diagnosed under bronchoscopic findings of total obliteration of bronchial orifice.[6] Ischemic bronchial wall can also be demonstrated under bronchoscope. With brushing, lavage with saline (BAL) and punch biopsy of suspected endobronchial lesion may also assist proper diagnosis prior to definitive treatment.

6. Images

6.1 Chest radiograph

Chest radiograph can demonstrate disease progression from a smaller pneumonia patch, lobar pneumonia, lung abscess, parapneumonic effusion and then to diffuse necrotic and gangrenous changes of the lung. Consolidation of lung, cavitation and interstitial infiltrates are possible changes. (Figure 1)When clinical suspicion of lung infection is high but chest radiograph is normal, interval follow-up of chest radiograph is mandatory. Many other disease may have similar image findings. As a result, diagnostic value of these findings is quite low.(Figure 1)

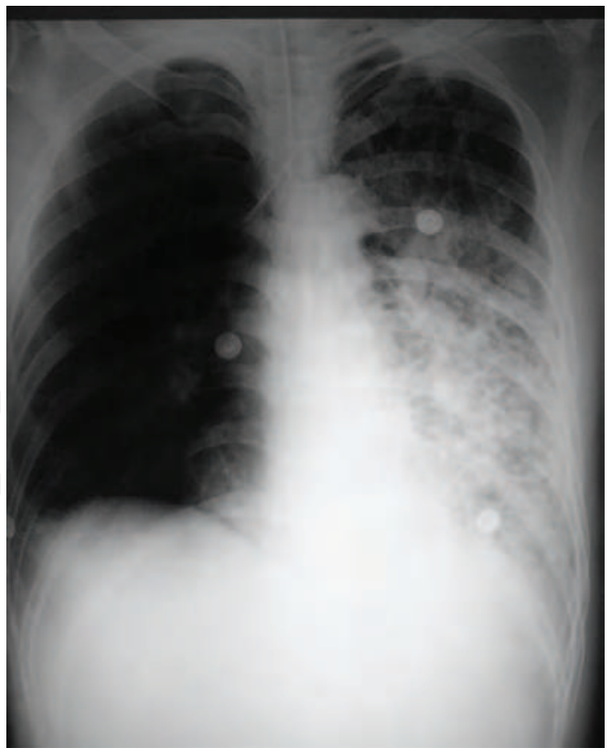

Fig. 1. Chest radiograph showed unilateral involvement of the lung with increased infiltrates and patchy consolidation with apical lung spared.

6.2 Angniography

When normal blood flow to the infected lung had been disturbed, angiography is an adequate methods to evaluate the vascular structure and help differentiate from other diseases. [7] However, pulmonary angiography is an invasive procedure carrying higher risks of vascular injury. In most circumstances, the role of diagnosis has been replaced by CTA (computed-tomography angiography), which is a relatively less invasive approach. [8]

6.3 Computed tomography

Computed tomography (CT) can clearly define gangrenous lung disease into localized form and diffuse form. With and without contrast enhancement can help identify the involved regions, preoperative evaluation for the extent of lung resection, and whether pulmonary vessels are occluded or not. Gangrenous changes of lung on CT scan have features of multiple low-density areas, consolidations, air-trapping, loculated effusion and possibly hydropneumothorax due to broncho-pleural fistula. Figure 2 is an example of the patterns of both consolidation, necrosis and parapneumonic effusion.

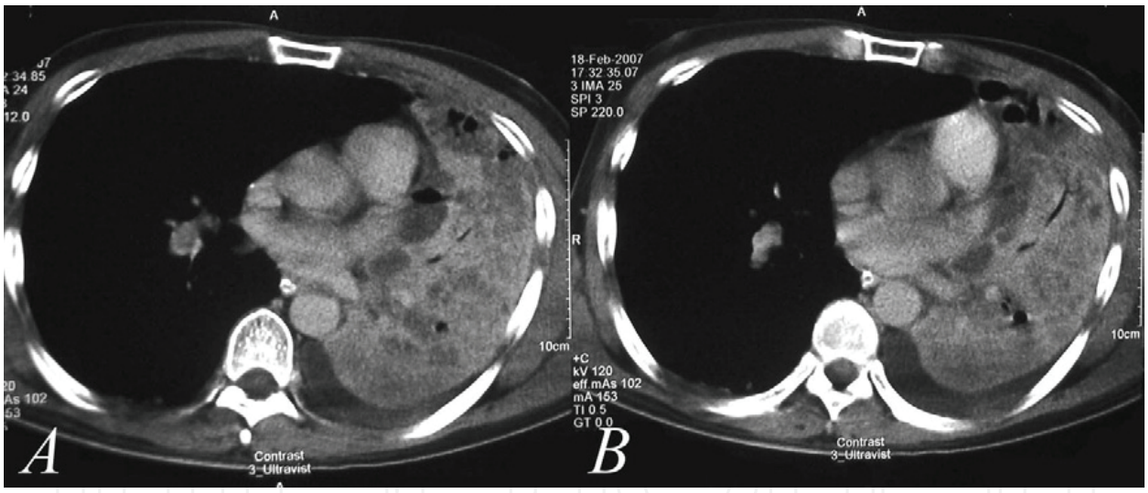

Fig. 2. Computed tomography scan of the lung showed multiple low-density regions with marked consolidation as well as some parapneumonic effusions. The contralateral lung is spared. The involved hemithorax is smaller in volume while the spared hemithorax expands normally.

6.4 Lung function test

Lung function test is not for definite diagnosis but for evaluation the possibility of lung resection and determine the extent of resection. However, the infected lung usually has impaired lung function. Nuclear scan maybe more useful to determine the percentage of

lung function of each lobe. Such test can differentiate restrictive lung disease from obstructive lung disease.

6.5 Nuclear imaging

Nuclear scan helps little in establishment of definite diagnosis. However, both perfusion and ventilation scan help a lot in evaluation of the extent of lung resection and estimated post-operative lung function. Lung function test alone can determine the patient's overall lung function but can not predict the function, perfusion and ventilation, of individual lobe and gives us more reliable reading than lung function test alone. However, due to the limitation of resolution of nuclear scan, interpretation of the results should be careful and may discuss with the specialists.

7. Treatment

7.1 Medical treatment

Medical treatment is still the mainstay of treatment of gangrenous lung disease. The goals of medical treatment is to control both local and systemic infection, preventing occurrence of SIRS and septic shock. Administration of broad-spectrum of antibiotics, proper fluid replacement therapy, steroid therapy, secure airway are useful strategies. Emperic antibiotics should be modified according to culture results. When patient's response is poor despite of aggressive medical treatment, surgical evaluation ought to be considered. The most appropriate timing of surgery is to be defined. According to the experience of our institute, after aggressive medical treatment for 48 hrs, surgical evaluation is to be expected to prevent bilateral involvement of necrotizing pneumonia and unavoidable lethal outcome. If patient's condition become stablized and the infected lung was only confined locally. Resection of the local infection can be either delayed or unnecessary depending on infection control.

7.2 Surgical treatment

Adequate timing of surgical intervention isn't easy to determine because gangrenous changes of lung often accompany with pleural infection including empyema thoracis and chest wall infection. Resection of lung, division of pulmonary vessels and bronchus in an infected pleural space is risky for postoperative bleeding, prolonged air leaks due to bronchial rupture and persistent pleural infection. A two-stage approach had been proposed a reasonable strategy.[9] With concomitant pleural space infection, tube thoracostomy to allow drainage of purulent pleural effusion or thoracoscopic deloculation and decortication to help cleaning of pleural space and prepare for subsequent lung resection. However, infection may be overwhelming in some situations and surgical intervention is emergent. The most appropriate timing should be judged individually because such information in the literature is very limited. If tube thoracostomy failed to alleviate systemic infection, prompt surgical intervention should be started. If bronchial or vascular structure is fragile and necrotic, pleural or muscle flap may be considered during operation. Extent of resection is according to the involved lung tissues with normal lung spared. [4] Gross appearance of gangrenous lung may be from densely fibrotic (Figure 3) to very fragile with foul smell. (Figure 4)

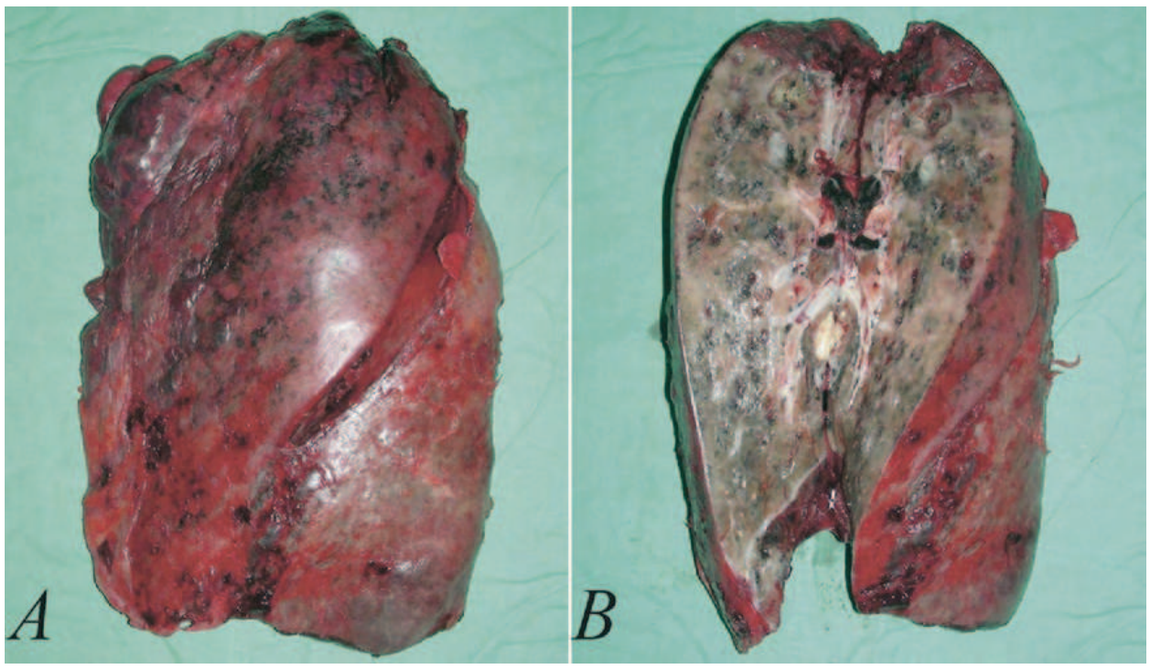

Fig. 3. This is a specimen after left side pneumonectomy. Repeated infection with regeneration will result in consolidation(hepatization) and may cause pulmonary artery occlusion. Such interruption of blood flow further aggravates infection because the antibiotics may not reach to necrotic tissues.

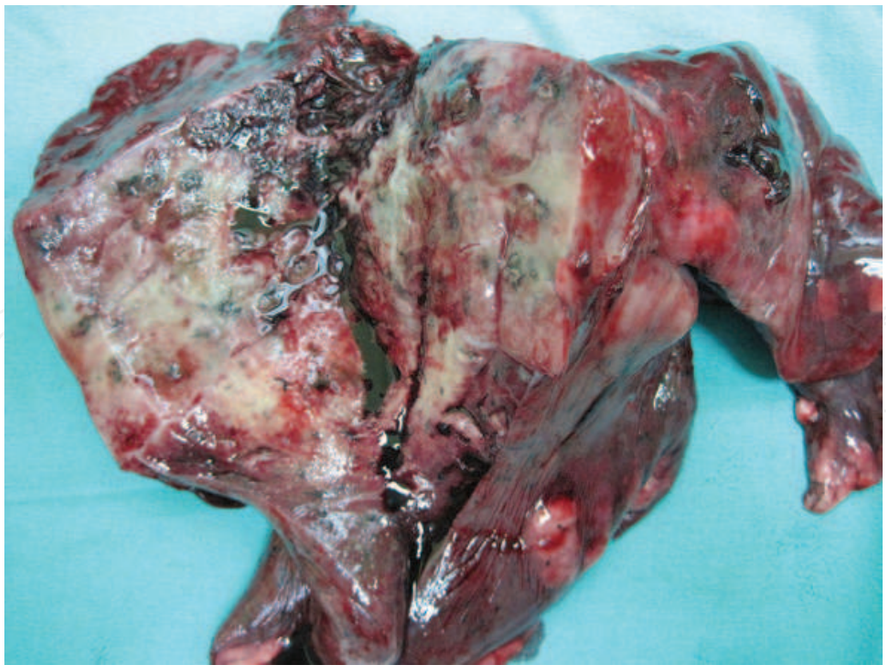

Fig. 4. This is a specimen of right middle and right lower lobe after bilobectomy. On cut, there was foul smell and the lung was very fragile in some regions admixed with some fibrotic regions.

8. ECMO

Extracorporeal membrane oxygenation is a strategy when lung fails to provide adequate level of oxygenation.[10] Whether a patient's condition is operable or can be treated medically, ECMO can maintain adequate oxygenation (V-V mode) and circulation (A-V mode) when lung condition is potentially reversible. Currently, more and more evidences support the role of ECMO in non-cardiac circulatory failure. The exact timing and place of such treatment in lung infection management remains to be determined

8.1 Outcome

Outcome depends mostly on the timing of detection of the gangrenous changes and prompt intervention, either medical or surgical. Currently, there is still no reliable statistical results about the mortality rate and complication rate. In some instances, auto-pneumonectomy may occur after severe infection in hemi-lung without resection. This condition is termed as " dry gangrene" and the involved lung becomes functionless and does not cause further systemic infection. This is only rarely occurred. In most conditions, prompt surgical intervention is mandatory if medical treatment failed to alleviate sepsis within days. When involvement of pulmonary gangrene extends more than one lobe, extent of lung resection need to be carefully evaluated. After complete resection of the necrotic tissues, infection control will be easier. Chest tube can be removed days after operation. Long-term follow-up is mandatory because most patients with pulmonary infections, to the extent of necrosis and gangrene, have obvious predisposing factors and these factors must be monitored carefully in outpatient department. Pulmonary rehabilitation is strongly recommended 3 months after lung resection.

9. Conclusion

In most circumstances, lung infection is a medical disease and rarely requires lung resection. However, surgical intervention should be carefully evaluated when a patient's condition rapidly deteriorates despite aggressive medical treatment.

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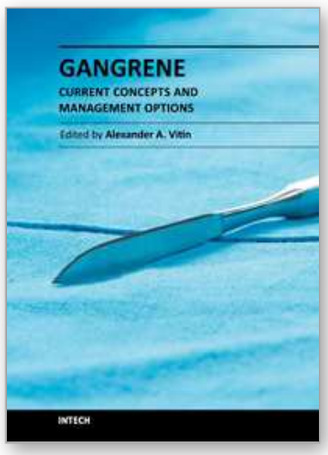

Gangrene - Current Concepts and Management Options

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Gangrene is the term used to describe the necrosis or death of soft tissue due to obstructed circulation, usually followed by decomposition and putrefaction, a serious, potentially fatal complication. The presented book discusses different aspects of this condition, such as etiology, predisposing factors, demography, pathologic anatomy and mechanisms of development, molecular biology, immunology, microbiology and more. A variety of management strategies, including pharmacological treatment options, surgical and non-surgical solutions and auxiliary methods, are also extensively discussed in the bookâ€™s chapters. The purpose of the book is not only to provide a reader with an updated information on the discussed problem, but also to give an opportunity for expert opinions exchange and experience sharing. The book contains a collection of 13 articles, contributed by experts, who have conducted a research in the selected area, and also possesses a vast experience in practical management of gangrene and necrosis of different locations.

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