

# PNEUMONIA COMPLICATIONS: A LITERATURE REVIEW

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**Thematic Axis:** Infectious Diseases and Respiratory System

## RESUMO

A pneumonia é uma infecção aguda do parênquima pulmonar que permanece como uma importante causa de morbidade, mortalidade e hospitalização em todo o mundo. Embora muitos casos apresentem evolução clínica favorável, a pneumonia pode evoluir para complicações locais, sistêmicas e cardiovasculares, particularmente em idosos, indivíduos com comorbidades e pacientes com infecção grave. Esta revisão teve como objetivo descrever as principais complicações associadas à pneumonia, enfatizando seus mecanismos fisiopatológicos, manifestações clínicas e relevância prognóstica. Foi realizada uma revisão narrativa da literatura utilizando publicações científicas indexadas no PubMed/MEDLINE, priorizando diretrizes clínicas, revisões sistemáticas, metanálises, estudos observacionais e revisões narrativas recentes. As principais complicações identificadas foram derrame parapneumônico, empiema, abscesso pulmonar, pneumonia necrotizante, insuficiência respiratória aguda, síndrome do desconforto respiratório agudo, sepse, disfunção de múltiplos órgãos e eventos cardiovasculares. As complicações pleurais podem resultar da progressão do processo inflamatório para o espaço pleural e podem exigir drenagem ou intervenção cirúrgica. O comprometimento pulmonar grave pode levar à hipoxemia, insuficiência respiratória e síndrome do desconforto respiratório agudo. A resposta inflamatória sistêmica e a infecção podem resultar em sepse e disfunção de múltiplos órgãos. Além disso, a pneumonia está associada ao aumento do risco de síndrome coronariana aguda, insuficiência cardíaca, arritmias, eventos cerebrovasculares e complicações tromboembólicas. O reconhecimento precoce das complicações e o manejo adequado são essenciais para reduzir a morbidade e a mortalidade. Portanto, a pneumonia deve ser compreendida como uma doença potencialmente sistêmica, cujas complicações podem persistir além do episódio infeccioso agudo..

Palavras-chave: Pneumonia. Complicações. Sepse. Insuficiência Respiratória. Derrame Pleural.

## ABSTRACT

Pneumonia is an acute infection of the lung parenchyma that remains an important cause of morbidity, mortality, and hospitalization worldwide. Although many cases have a favorable clinical course, pneumonia may progress to local, systemic, and cardiovascular complications, particularly among older adults, individuals with comorbidities, and patients with severe infection. This review aimed to describe the main complications associated with pneumonia, emphasizing their pathophysiological mechanisms, clinical manifestations, and prognostic relevance. A narrative literature review was performed using scientific publications indexed in PubMed/MEDLINE, prioritizing clinical guidelines, systematic reviews, meta-analyses, observational studies, and recent narrative reviews. The main complications identified were parapneumonic effusion, empyema, lung abscess, necrotizing pneumonia, acute respiratory failure, acute respiratory distress syndrome, sepsis, multiple organ dysfunction, and cardiovascular events. Pleural complications may result from progression of the inflammatory process into the pleural space and may require drainage or surgical intervention. Severe pulmonary involvement may lead to hypoxemia, respiratory failure, and acute respiratory distress syndrome. Systemic inflammatory response and infection may result in sepsis and multiple organ dysfunction. In addition, pneumonia is associated with an increased risk of acute coronary syndrome, heart failure, arrhythmias, cerebrovascular events, and thromboembolic complications. Early recognition of complications and appropriate management are essential to reduce morbidity and mortality. Therefore, pneumonia should be understood as a potentially systemic disease whose complications may persist beyond the acute infectious episode.

Keywords: Pneumonia. Complications. Sepsis. Respiratory Failure. Pleural Effusion.

## INTRODUCTION

Pneumonia is an acute infection of the lung parenchyma caused by a variety of microorganisms and represents an important public health problem because of its substantial contribution to morbidity, mortality, and healthcare utilization. Community-acquired pneumonia may range from mild disease managed in the outpatient setting to severe infection requiring hospitalization, intensive care, mechanical ventilation, and treatment of sepsis.<sup>1,2</sup> The clinical course depends on the causative microorganism, host characteristics, comorbidities, immune response, and severity at presentation.

Although pneumonia is primarily considered a respiratory infection, its consequences are not restricted to the lungs. Local extension of the infectious process may result in parapneumonic effusion, empyema, lung abscess, and necrotizing pneumonia.<sup>3-5</sup> Severe pulmonary inflammation can compromise gas exchange and progress to acute respiratory failure or acute respiratory distress syndrome.<sup>5</sup> Systemic dissemination and an excessive inflammatory response may result in sepsis, septic shock, and multiple organ dysfunction.

Cardiovascular complications are also clinically relevant. Acute inflammation, hypoxemia, increased myocardial demand, endothelial dysfunction, and prothrombotic mechanisms may contribute to acute coronary syndromes, heart failure, arrhythmias, and cerebrovascular or thromboembolic events.<sup>7,8</sup> Recent evidence further indicates that the risk of cardiovascular and vascular events may remain elevated after the acute episode of community-acquired pneumonia, demonstrating that its consequences can extend beyond hospitalization.<sup>8</sup>

Because complications substantially influence prognosis and may require specific interventions, their early recognition is essential in clinical practice. Therefore, this review aimed to describe the principal complications of pneumonia, emphasizing their clinical characteristics, pathophysiological mechanisms, and prognostic implications.

## **METHOD**

A narrative literature review was conducted using scientific publications indexed in the PubMed/MEDLINE database. The search strategy included combinations of the terms *pneumonia*, *complications*, *community-acquired pneumonia*, *parapneumonic effusion*, *empyema*, *lung abscess*, *necrotizing pneumonia*, *respiratory failure*, *acute respiratory distress syndrome*, *sepsis*, *cardiovascular complications*, and *thromboembolic events*, using the Boolean operators AND and OR.

Clinical guidelines, systematic reviews, meta-analyses, observational studies, and narrative reviews were prioritized, with emphasis on publications from 2015 to 2026. Classical studies were also considered when they provided relevant evidence regarding specific complications. Publications addressing adult pneumonia and its pulmonary, pleural, systemic, or cardiovascular complications were included. Studies without a direct relationship to the proposed topic were excluded.

The selected evidence was organized according to the main categories of complications identified: pulmonary and pleural complications, systemic complications, and cardiovascular and thromboembolic complications. The findings were subsequently synthesized qualitatively.

## **RESULTS**

As evidências analisadas indicam que as complicações da pneumonia podem ser organizadas em três grandes grupos: pulmonares/pleurais, sistêmicas e cardiovasculares. Sua ocorrência está relacionada à gravidade da infecção, às características do agente etiológico, às condições do hospedeiro e à presença de comorbidades.<sup>3,5</sup>

### **Pulmonary and Pleural Complications**

Pulmonary and pleural complications represent some of the most directly recognizable consequences of pneumonia. Among them, parapneumonic effusion and empyema are particularly important because they may require additional diagnostic and therapeutic procedures and are associated with prolonged hospitalization.

Parapneumonic effusion develops as a consequence of inflammation associated with pulmonary infection and may progress through different stages. Initially, the effusion may be free-flowing and relatively uncomplicated. With progression of infection and inflammation, fibrin deposition, bacterial

invasion, septation, and loculation may occur, leading to a complicated parapneumonic effusion or empyema.<sup>3,9</sup> The presence of pleural infection is associated with increased morbidity and may require antibiotics combined with chest drainage. In selected cases, intrapleural enzyme therapy or surgical management may be necessary.<sup>9</sup> Current approaches emphasize early risk stratification and individualized management according to clinical, biochemical, microbiological, and radiological findings.<sup>9</sup>

Empyema is characterized by infection of the pleural space and may develop as a complication of bacterial pneumonia. Clinical manifestations may include persistent fever, pleuritic chest pain, dyspnea, cough, and continued systemic inflammatory response despite appropriate antimicrobial therapy. Imaging, particularly chest ultrasonography and computed tomography when indicated, can assist in identifying loculations and pleural abnormalities.<sup>9</sup> The timely recognition of empyema is essential because delayed drainage may contribute to organization of the pleural space and prolonged disease.

Another important complication is lung abscess, characterized by localized pulmonary tissue necrosis with formation of a cavity containing purulent material.<sup>4</sup> It may occur following aspiration, severe bacterial infection, or infection caused by microorganisms with necrotizing potential. Patients may present with persistent fever, productive cough, malaise, and occasionally foul-smelling sputum. Radiological evaluation is essential when clinical improvement does not occur as expected.<sup>4</sup>

Necrotizing pneumonia represents a severe form of pulmonary infection characterized by progressive tissue destruction and parenchymal necrosis. It may occur in association with severe bacterial pneumonia and can overlap clinically with lung abscess formation. The condition is associated with prolonged fever, persistent respiratory compromise, extensive pulmonary infiltrates, and increased risk of respiratory failure.<sup>5</sup>

Acute respiratory failure is one of the most severe complications of pneumonia. Extensive alveolar consolidation, inflammatory edema, impaired ventilation-perfusion matching, and alveolar-capillary membrane injury can substantially reduce oxygenation. In severe cases, these mechanisms may progress to acute respiratory distress syndrome, characterized by acute hypoxemia and diffuse pulmonary involvement.<sup>5</sup> The need for invasive mechanical ventilation is considered a major criterion of severe community-acquired pneumonia and is associated with increased mortality.<sup>2</sup>

### **Systemic Complications**

The systemic inflammatory response to pneumonia may lead to complications beyond the respiratory system. Sepsis is one of the most important systemic consequences and occurs when the host response to infection becomes dysregulated, resulting in life-threatening organ dysfunction.<sup>6</sup> Pneumonia is a major infectious source of sepsis, particularly among hospitalized and critically ill patients.

Severe sepsis may progress to septic shock, characterized by persistent circulatory and metabolic abnormalities despite adequate initial management. Hypotension, tissue hypoperfusion, altered mental status, oliguria, elevated lactate levels, and progressive organ dysfunction may indicate deterioration.<sup>6</sup> Early identification and appropriate treatment are essential because the prognosis is strongly influenced by the duration and severity of organ dysfunction.

Multiple organ dysfunction may occur in severe pneumonia as a consequence of systemic inflammation, endothelial injury, altered coagulation, tissue hypoxia, and impaired perfusion. The kidneys, cardiovascular system, nervous system, liver, and hematological system may be affected.<sup>6</sup> Acute kidney injury, thrombocytopenia, altered consciousness, metabolic abnormalities, and hemodynamic instability may therefore accompany severe respiratory disease.

Bacteremia can also occur, particularly in severe infections, allowing microorganisms or inflammatory mediators to affect distant organs. However, systemic complications are not necessarily dependent on proven bloodstream infection, as inflammatory and immunological mechanisms may produce organ dysfunction even when bacteremia is not demonstrated.

The development of systemic complications is associated with worse prognosis and greater healthcare utilization. Patients with severe pneumonia should therefore undergo continuous clinical assessment,

including monitoring of respiratory status, hemodynamics, renal function, neurological status, and other indicators of organ dysfunction.

### **Cardiovascular and Thromboembolic Complications**

Pneumonia is associated with a clinically significant risk of cardiovascular complications. Acute systemic inflammation, hypoxemia, fever, tachycardia, increased myocardial oxygen demand, endothelial dysfunction, platelet activation, and prothrombotic changes may contribute to cardiovascular injury.<sup>7,8</sup>

Heart failure, acute coronary syndrome, and cardiac arrhythmias are among the most frequently described cardiovascular complications. A systematic review and meta-analysis demonstrated that cardiac complications occur in a substantial proportion of hospitalized patients with community-acquired pneumonia, with heart failure, acute coronary syndromes, and arrhythmias representing important clinical outcomes.<sup>7</sup> These events are particularly relevant in older patients and individuals with pre-existing cardiovascular disease.

Acute coronary syndromes may result from increased myocardial oxygen demand combined with reduced oxygen delivery and systemic inflammatory activation. In susceptible patients, the physiological stress imposed by pneumonia may destabilize pre-existing atherosclerotic disease. Similarly, inflammation and hypoxemia may precipitate or worsen heart failure.

More recent evidence suggests that the cardiovascular consequences of pneumonia may persist beyond the acute infectious episode. A systematic review published in 2025 found that community-acquired pneumonia was associated with increased risks of cardiovascular and cerebrovascular events, as well as deep-vein thrombosis and pulmonary embolism. The risk was highest shortly after the pneumonia episode but remained elevated during longer follow-up periods.<sup>8</sup>

These findings reinforce the concept that pneumonia may act as a systemic inflammatory trigger rather than an isolated pulmonary event. Cardiovascular surveillance may therefore be particularly important in patients with advanced age, cardiovascular comorbidities, severe pneumonia, or signs of cardiac dysfunction.

### **Prognostic Relevance of Pneumonia Complications**

The development of complications is closely associated with disease severity, prolonged hospitalization, intensive care admission, and mortality. Respiratory failure, septic shock, multiple organ dysfunction, and complicated pleural infection are particularly important markers of poor prognosis.<sup>2,6,9</sup>

Several factors may increase the likelihood of complicated disease, including advanced age, immunosuppression, chronic cardiopulmonary diseases, aspiration risk, delayed treatment, and severe infection at presentation.<sup>2</sup> The early identification of these factors allows clinicians to intensify monitoring and consider additional diagnostic investigations when the expected clinical response is not achieved.

The recognition of complications should therefore be incorporated into the longitudinal assessment of patients with pneumonia. Persistent fever, worsening dyspnea, increasing oxygen requirements, hemodynamic instability, altered mental status, or failure of radiological improvement may indicate treatment failure or the development of a complication.

### **CONCLUSION**

Pneumonia is not restricted to infection of the lung parenchyma and may evolve into a multisystem disease with significant clinical consequences. Pulmonary and pleural complications, including parapneumonic effusion, empyema, lung abscess, necrotizing pneumonia, acute respiratory failure, and acute respiratory distress syndrome, represent important causes of morbidity and may require invasive interventions. Systemic complications, particularly sepsis and multiple organ dysfunction, are strongly associated with severe disease and increased mortality.

Cardiovascular and thromboembolic complications further demonstrate the systemic impact of pneumonia. The association between pneumonia and acute coronary syndromes, heart failure, arrhythmias, cerebrovascular events, and thromboembolic disease may persist beyond the acute phase.

Therefore, early recognition of complications, appropriate severity assessment, timely treatment, and follow-up of high-risk patients are essential to improve outcomes. Future research should focus on strategies for early identification of patients at risk for complications and on interventions capable of reducing both short- and long-term consequences of pneumonia.

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