



# A Literature Review on Hospital-Acquired Pneumonia (HAP), Community-Acquired Pneumonia (CAP), and Ventilator-Associated Pneumonia (VAP)

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## Abstract

One of the most dangerous respiratory diseases is pneumonia, one of the ten leading causes of death globally. Hospital-acquired pneumonia (HAP) is a common infection in hospitals, which is the second most common nosocomial infection and causes inflammation parenchyma. In Community-acquired pneumonia (CAP), we have various risk factors, including age and gender, and also some specific risk factors. Ventilator-associated pneumonia (VAP) is one of the deadliest nosocomial infections. According to the Centers for Disease Control and Prevention, VAP is pneumonia that develops about 48 hours of an artificial airway. Bacteria, viruses, parasites, fungi, and other microorganisms can cause these diseases. This review article discusses microbial agents associated with pneumonia. Our goal is to gather information about HAP, CAP, and VAP to give people specific information. In this study, these three issues have been examined together, but in similar studies, each of them has been examined separately, and our type of study will be more helpful in diagnosis and treatment.

**Keywords:** Pneumonia, Hospital-Acquired Pneumonia, Community-Acquired Pneumonia, Ventilator-Associated Pneumonia

## 1. Background

Respiratory diseases are among the most frequent causes of death due to their high diversity of risk factors, and their risk factors originate from various organisms, each of which causes specific clinical features (1). Respiratory diseases are considered diseases of the airways and other parts of the lungs, including obstructive diseases, restrictive diseases, and vascular diseases (1). Each of these diseases can be caused by a wide variety of bacteria, viruses, parasites, fungi, and other microorganisms (1, 2). We discuss bacterial factors. One of the most dangerous respiratory diseases is pneumonia, one in all the ten leading causes of death globally and is the most important infectious killer for children under five (3, 4).

Hospital-acquired pneumonia (HAP) is a common infection in hospitals, which is the second most common nosocomial infection and causes inflammation parenchyma. HAP is usually found in patients who have

been in the intensive care unit (ICU) for at least 48 hours (5, 6). In Community-acquired pneumonia (CAP), there are various risk factors, including age and gender, and some specific risk factors such as autoimmune and heart diseases, which affect the identification of the cause. We can identify these differences using some information such as etiology that we can get from different subjects (7, 8). Ventilator-associated pneumonia (VAP) is one of the deadliest nosocomial infections. According to the Centers for Disease Control and Prevention (CDC), VAP is pneumonia that develops within 48 hours of an artificial airway (9).

One of the characteristics of VAP in most studies is that it occurs within 48 to 72 hours (or more than 48 hours) (10) after the placement of artificial airways for mechanical ventilation (MV) on the patient. The incidence of VAP in patients with MV has been reported to be up to 40%. One of the differences between the definition of VAP and Hospital-acquired pneumonia or HAP is that HAP, unlike VAP, is not

associated with MV (11, 12).

## 2. Etiology

The causative agents of HAP may be *Streptococcus pneumoniae*, *Staphylococcus aureus*, and strains of Gram-negative bacteria (GNB) such as *Pseudomonas aeruginosa* (PA) and *Klebsiella pneumoniae* (5, 13-16). Researchers showed that the type of microorganism that HAP patients are affected by them, can be various in different residential areas (5, 17, 18). As soon as MV and intubation are applied, these artificial airways become a breeding ground for microorganisms (15, 19). VAP is usually caused by a microorganism, which is usually a bacterium; According to studies, the most common causes of VAP are PA, *Acinetobacter baumannii*, *K. pneumoniae*, and *S. aureus* (including MRSA). It has also been suggested that the disease-causing microorganisms observed in respiratory secretions are mainly Gram-negative bacilli. In addition to the above, *Escherichia coli* with high drug resistance has also been observed (9, 11, 20, 21).

Anaerobic bacteria are uncommon causes of VAP. They can be involved in polymicrobial infections, especially in respiratory pneumonia. Also, pneumonia-related to nosocomial fungal and viruses infections are the main causes of mortality in immunocompromised patients (21). Data show that although the major pathogens are similar in both HAP and VAP, antimicrobial susceptibility is lower in VAP. This is especially true about PA. Statistics show that the 30-day mortality rate is about 15 to 20% in HAP and is between 40 and 45% in VAP (12).

## 3. Risk Factor

In addition to the predisposition factors to the disease such as age and gender, there are risk factors such as a history of chest and abdomen surgery and hospitalization, renal and pulmonary disorders, diabetes mellitus, and smoking. They can increase the risk of HAP (18, 22-24). More severe HAP cases have been reported due to the development of drug and antibiotic resistance in HAP-causing microorganisms, including multi-drug resistant PA (MDR\_PA) (17, 23, 25). Prolonged hospitalization, the use of inappropriate broad-spectrum antibiotics, and immunosuppressive drugs likely facilitate the development of drug-resistant microorganisms that cause more deaths in HAP patients (16-18, 22). Evidence suggests a low neutrophil-lymphocyte ratio (NLR) may be a risk factor for MDR\_PA (with low NLR can be expected to get MDR\_PA) (17, 23, 25).

Many risk factors can cause CAP, as mentioned, the general risk factors that can be mentioned are age and gen-

der and some more specific risk factors, including cardiovascular diseases, renal disorders that affect the activity of enzymes and hormones, and the endocrine glands in the body (17, 19, 26, 27). Other specific risk factors consist of neurological diseases such as autoimmune diseases, which are one of the most important risk factors (10, 26, 28). Lung diseases provide the environment for the CAP in a way that is a significant risk factor, and these diseases increase the likelihood of the patient being hospitalized for twenty to thirty days (14, 19, 27, 29, 30).

Some risk factors, such as air pollution, depend on the patient's environment (10, 29). VAP incidence depends on the duration of exposure to the hospital and ICU environment, host factors and characteristics, and therapeutic factors that may lead to VAP (8, 21). Also, risk factors that increase the likelihood of colonization in canals and tubes by bacterial pathogens (such as previous exposure to antibiotics, age over 60, and chronic obstructive pulmonary disease (COPD) as well as secretion respiration. Infections should be considered when sleeping on your back, coma, and head trauma (31). Gender, length of hospital stay, MV, duration of MV, and aspiration and reflux are among the risk factors associated with VAP occurrence in the ICU (9). Possibly, the leading risk factor in creating and developing VAP is MV. Some data suggest that a decrease in antibacterial activity of Th17 in the lung in response to MV prolongation, which is associated with the VAP progression (32). Other risk factors associated with VAP progression include COPD, organ failure, coma, and re-intubation. COPD has been recognized as an independent risk factor for VAP, and statistics show that more than 50% of COPD patients who develop VAP succumb to it (11). Elderly patients with coma and diabetes mellitus require special supervision. Also, comprehensive control and prevention of risk factors in all aspects can control the rate of VAP occurrence and improve its prediction (9).

## 4. Clinical Presentation

After infection, the clinical symptoms of patients manifest with pneumonia, impaired breathing and oxygenation of tissues, and the formation of purulent sputum in the respiratory tract (33). Also, the number of WBCs and markers such as C-reactive protein (CRP) in patients increases, which indicates the presence of inflammation and damage in the body (2, 29). In patients with autoimmune disease associated with CAP, we see kidney failure and difficulty in ventilation, and we see various problems in the respiratory system that expel it in the form of pus (27, 28). Cough, sputum, fever, breathlessness are common clinical features that can be mentioned in patients. Moreover, VAP usually has no specific clinical features and is usually

characterized by the presence or development of new secretions in the lungs and signs of a systemic infection that includes fever, changes in the number of white blood cells (leukopenia, and leukocytosis). Changes in the characteristics of sputum and the presence of pathogens can also be its characteristics. Other clinical findings include pulmonary discharge and worsening gas exchange (21).

## 5. Diagnostics

Non-invasive diagnosis of HAP is made by methods such as using the patient's respiratory secretions for polymerase chain reaction (PCR), sputum and blood culture, and invasive methods such as bronchoalveolar lavage (BAL) (33-37). Using methods such as X-ray imaging or newer methods such as lung ultrasound can detect the appearance of infection in the lung tissue (30). The most common treatments for patients are strong antibiotics. According to the findings, the use of appropriate antibiotics before the disease progresses, along with ensuring the accuracy of HAP in the patient is a factor that contributes to the progression and effectiveness of the treatment (33, 38).

It is very important to diagnose the patient's medical history and physical examination, and some clinical manifestations can be non-specific, and a device such as a chest X-ray (CXR) and Computed tomography (CT) can help make a definitive diagnosis (31). However, these also have some limitations. Recently, the use of ultrasound is also increasing because it does not have some limitations of CXR and CT. Ultrasound is introduced as an alternative method and must be accompanied by the patient's history, clinical examination, and laboratory analysis. Ultrasound also needs experienced staff (31). Gold standard VAP diagnostic tests are still incomplete in some places, and there is no clear and reference evidence for the order of diagnostic tests and their exact effects on the clinical condition (39).

According to the criteria, the clinical diagnosis of VAP, CAP, and HAP is based on the observation of new or advanced pulmonary leakage on radiography without any previous cause and at least two cases of fever more than 38 degrees, leukocytosis more than 12,000 per deciliter, less leukopenia from 4,000 per deciliter, pulmonary secretion, isolate pathogenic pathogens and increase oxygen demand (11). Markers used for diagnosis include WBC and CRP and sequential organ failure assessment scores. Patients diagnosed with VAP have been found to have higher levels of CRP and procalcitonin (PCT) (11, 39, 40). Procalcitonin is also one of the measured indicators, but in VAP, unlike CAP, PCT level measurement alone cannot be a good biomarker for VAP diagnosis. Also, the combination of lung ultrasound with PCT in diagnosis is accurate and use-

ful. Lavage (BAL) is another common tool used for VAP detection (34).

According to a study conducted in collaboration with a panel of European experts, a classification of diagnostic tools has been obtained. In this study, CXR was introduced as the most significant imaging technique. Apart from blood culture, endotracheal aspirate culture was introduced as the main collection method in microbiological tests. Also, Mini-BAL was introduced as the most accepted invasive technique and Gram stain as the most accepted laboratory technique. The top three biomarkers in this category were CRP, PCT, and WBC, respectively. The study suggested combining imaging, culture of clinical specimens, and using biomarkers to diagnose VAP (39). Timing of diagnosis and prognosis is a serious challenge in hospitals, especially in the ICU. Due to the high mortality rate due to VAP, as well as other cases, early detection with high accuracy can be crucial. Low-specificity diagnostic tests can lead to misdiagnosis, severe nosocomial infections, and increased mortality. Therefore, updating cases and diagnostic methods and providing new solutions with high accuracy have been studied by many researchers (40). For example, one study found that measuring trigeminal receptor expression expressed on myeloid cells 1 (sTERM-1) in serum plus clinical pulmonary infection score (CPIS) is useful in diagnosing and measuring PCT plus CPIS in prognostics assessment (40).

## 6. Limitations

Due to the limited database, many issues are not mentioned or subheadlines are not fully explained and are summarized, which increases the likelihood of inaccuracy. Some of the information could not be accessed, and due to the widespread of the selected topic, it was not possible to use accurate statistics.

## 7. Conclusion

By collecting information about pneumonia, we can increase awareness about the disease. By knowing the characteristics of hospital-acquired pneumonia (HAP), community-acquired pneumonia (CAP), and ventilator-associated pneumonia (VAP), we can prevent or treat them. The simplicity of the information and the type of writing also helps to understand better the public, which makes this information not specific to a particular group, and everyone can use and understand it. In this study, these three issues have been examined together, but in similar studies, each of them has been examined separately, and our type of study will be more helpful in diagnosis and treatment.

## Footnotes

**Authors' Contribution:** PB, SM, and AF designed the study, carried out the search, study selection, collected data. PB, MR, AL, AS, and SM wrote the manuscript and final approval of the version to be published.

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