Acute Respiratory Failure in Pneumonia

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Pneumomia is the infection of the pulmonary parenchyma, and it is an important cause of morbidity and mortality [1, 2]. This condition can develop due to specific infectious or noninfectious etiologies, complications of diseases and procedures each with a different epidemiology, pathogenesis, presentation, and clinical course [3].

Hippocrates was first described pneumonia in BC 460–370 [4]. It's clinical and pathological features were described first by Laennec in 1819 [5]. Rokitansky was differentiated lobar and bronchopneumonia in 1842 [6].

Pneumonia is classified.

16.1 According to the Anatomical Placement

Nonsegmental alveolar (lobar) pneumonia is also called non-segmental pneumonia or focal non-segmental pneumonia. There is a homogeneous and fibrinosuppurative consolidation in one or more lobes of a lung in response to bacterial pneumonia. *Streptococcus pneumoniae* is the most common causative organism of lobar pneumonia [7].

Bronchopneumonia (lobular pneumonia) is an acute inflammation of the bronchi with multiple consolidation foci in the pulmonary lobule or lobules [8].

Interstitial pneumonia: idiopathic pulmonary fibrosis is the most common type. Normal lung, interstitial inflammation, fibrosis, and honeycomb replacement areas are the main diagnostic criteria [9].

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Cryptogenic organizing pneumonia (COP) is a noninfectious type of pneumonia with unknown etiology. Inflammation of bronchioles and the surrounding structures are the main diagnostic criteria [10].

16.2 According to the Etiology

16.2.1 Infectious

Bacterial: *Streptococcus pneumoniae* is the most common cause of bacterial pneumonia. *Mycoplasma pneumoniae*, *Haemophilus influenzae*, and *Legionella pneumophila* are the other less common causes [11].

Viral: Respiratory viruses are the common cause of pneumonia. Influenza virus A and B, respiratory syncytial virüs, rhinoviruses, and severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) are the other causative pathogens [12].

Fungal: Fungal pneumonia is the infection of the lungs, which can be caused by either endemic or opportunistic fungi or a combination of both. In immunocompromised patients, mortality of fungal pneumonias can be as high as 90%. *Pneumocystis jirovecii*, *Cryptococcus* species, and histoplasmosis species are the examples of fungi that can cause pneumonia [13].

16.2.2 Noninfectious

Chemical pneumonia: It is rare, may be acute or chronic, is noninfectious, and can be caused by inhalation or aspiration of irritants [14].

16.3 According to the Clinical Picture

Typical pneumonia is distinguished from atypical pneumonia by sudden onset of symptoms and lobar infiltration. Severe weakness, high fever and chills, purulent productive cough, tachypnea, and shortness of breath, and pleuritic chest pain that often accompanies pleural effusion while breathing are the common symptoms [15].

Atypical pneumonia is known as walking pneumonia because of mild symptoms. Intracellular living bacteria are the common causative pathogens [16].

16.4 According to the Empirical Treatment Approach

Community-acquired pneumonia is the most common type of pneumonia that occurs outside of the healthcare facilities. It may be caused by bacteria, bacteria-like organisms, or fungal and viral infections [17].

Hospital-acquired pneumonia (healthcare-associated pneumonia, ventilator-related pneumonia). Pneumonia developing at least 48–72 h after hospitalization is defined as hospital-acquired pneumonia or nosocomial pneumonia. Bacterial infection is the common cause [18].

16.4.1 Pneumonia Developed in Immunocompromised Patients

Immunocompromised patients are vulnerable to infections. Immunodeficiency may be congenital or may develop due to acquired immunodeficiency. Although survival has improved, pneumonia is the most common invasive infection with a high mortality and morbidity rate for immunocompromised patients [19]. ***According to the severity***: Where a patient diagnosed with pneumonia should be treated is one of the most important factors for managing the disease process. This is necessary for patient outcomes and cost. Therefore scoring systems such as PSI, CURB-65 have been developed to determine the pneumonia severity [20].

16.5 Others

Aspiration pneumonia can develop as a part of community and hospital acquired pneumonia [21]. It is estimated that 5–15% of community-acquired pneumonia cases accounts for aspiration pneumonia. Microaspiration of a small amount of oropharyngeal secretion may occur during sleep in the healthy population [22]. However, this situation is the main pathogenetic mechanism in the development of pneumonia [23].

Pneumonia developing in the elderly: Pneumonia is common and severe problem in the elderly. Disease severity is strongly associated with age and age-related comorbidities. While *Streptococcus pneumoniae* is the main pathogen responsible for pneumonia in the elderly, anaerobic pathogens should be considered as causative [24].

Respiratory support should be required in patients who cannot be adequately respond to etiology-oriented pneumonia treatment. In this case, respiratory support can be applied with noninvasive and invasive methods.

The physiological effects of positive pressure mechanical ventilation should also be taken into account in patients who will undergo respiratory support.

16.6 Effect of Positive Airway Pressure on Circulatory System

Effects of Continuous Positive Airway Pressure (CPAP) on the cardiovascular system in patients with pneumonia are less known.

Positive End Expiratory Pressure (PEEP) increases intrathoracic pressure, decreases venous return especially in those patients with reduced ejection fraction and heart failure. Increase of intrathoracic pressure, decreases ventricular afterload.

If CPAP is to be used to treat a patient with ARF secondary to pneumonia, physicians should be careful in monitoring the hemodynamic effects and the patient's volume status. If necessary, fluid replacement should be assessed prior to CPAP administration [25, 26].

16.7 Effects of Continuous Positive Airway Pressure on the Respiratory System

CPAP, recruits collapsed alveoli and improves gas exchange with healing intrathoracic shunt and ventilation/perfusion rate. PEEP opens the collapsed alveoli during expiration. In this way functional residual capacity and compliance increases and work of breathing decreases.

In a study that is evaluated the effect of CPAP (10 cmH_2O) and CPAP with PSV (10–10), PSV (15-5) in patients with acute lung injury and pneumonia it was indicated that respiratuar frequency decreased with high inspiratory support; arterial oxygenation improved with 10 cmH_2O PEEP; work of breathing decreased with both PSV modalities except CPAP.

Multiple complications may develop in patients in case of invasive mechanical ventilation (IMV). However noninvasive positive pressure ventilation (NPPV), provides respiratory support without invasive intervention and ratio of complication decreases with NPPV. Increase in patient comfort, maintaining airway defense mechanisms, protecting speech, swallowing without inhibiting effective cough and sputum production, enabling effective removal of increased respiratory secretions, and providing air flow to obstructed lung areas can be stated as the superior aspects of NPPV to IMV [27].

16.8 Respiratory Support to the Special Conditions with Pneumonia

Chronic Obstructive Pulmonary Disease (COPD): Patients with respiratory failure due to COPD and pneumonia have a higher success rate and NPPV generally preferred as the first line treatment option [28].

Cardiogenic Pulmonary Edema: The success rate of NPPV was found to be higher in patients with respiratory failure due to pneumonia with cardiogenic pulmonary edema. It is generally preferred as one of the main treatment options for this patients [28].

Interstitial Pneumonia: Patients with interstitial pneumonia and associated acute respiratory failure under invasive mechanical ventilation have an increased risk of ventilator-associated lung injury and ventilator-associated pneumonia. Early administration of NPPV is expected to improve prognosis and reduce short-term mortality in these patients. However there is insufficient evidence regarding the use of NPPV [29].

Immunocompromised Patients: NPPV is recommended as first-line therapy in the treatment of patients with immunodeficiency and acute respiratory failure due to pneumonia [19].

Elderly Patients: Patients older than 75 years of age with acute hypercapnic respiratory failure due to pneumomia, NPPV has been shown to reduce the need for intubation and mortality by improving arterial blood gases, shortness of breath and NPPV has been recommended as an alternative therapy for elderly patients [24].

Palliative Care: Pneumonia is often the leading cause of death for end-stage elderly patients. For palliative care, NPPV has been found to be more effective than oxygen therapy in reducing shortness of breath, so NPPV may play a role in the treatment of moderate to severe acute respiratory failure with pneumonia [24].

Adult respiratory distress syndrome, community acquired pneumonia, persistence of impaired arterial oxygenation are the significant and independent predictors of NPPV failure in patients with pneumonia [25].

NPPV may be a clinically useful tool in reducing the risk of intubation and mortality. Mortality will be significantly reduced with clinical protocols that define patients who are more likely to benefit from NPPV. Early detection of patients who will fail in NPPV and immediately switch to invasive mechanical ventilation will improve the prognosis and reduce the mortality rate of patients with ARF and pneumonia [30].

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