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## 12.1 Introduction

Pneumonia is a common cause of hospital admission and community-acquired pneumonia (CAP) is a growing health problem in developed country and worldwide. Elderly patients suffer from more severe disease, require intensive care unit (ICU) admission, and exhibit higher mortality compared with their younger counterparts. The immunological changes that occur with age called “immunosenescence” (decreased efficiency of the adaptive and innate immune systems) are known to be responsible for the increased susceptibility of elderly persons to infectious diseases and for their limited response to vaccines [1].

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## 12.2 Epidemiology

Prospective population-based studies reported an annual incidence of CPAP of 5–11 × 1000 adult population. The proportion of patients who required hospital admission varies from 22 to 42% depending upon, above all, in the organization of the health care system. US data demonstrated a constant rise in age-specific incidence of CAP requiring hospitalization from 750,000 to 1,000,000 from 2010 to 2020 [2, 3].

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### 12.3 Risk Factors

Smoking habit, alcohol consumption, alterations of level of consciousness (dementia, cerebrovascular diseases, Parkinson's disease), and an increased burden of chronic diseases (COPD, bronchiectasis, heart failure, uremia) are important risk factors for susceptibility to pneumonia. Impaired nutritional status is an important modifiable risk factor for pneumonia in elderly patient [1].

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### 12.4 Clinical Presentation

CAP can vary from indolent to fulminant in presentation and from mild to fatal in severity. The classic triad of fever, cough, and dyspnea is present only in a minority of elderly patients hospitalized for CPAP. Tachypnea appears to be a sensitive indicator of the presence of lower respiratory tract infection in this subset of patients [3–5].

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### 12.5 Diagnosis

The vast majority of consensus guidelines suggest that all patients with suspected pneumonia should undergo chest X-ray. Radiographic findings, in elderly patients, may include risk factors for increased severity (e.g., cavitations or multilobar involvement). Occasionally, radiological pattern suggests an etiological diagnosis: pneumatoceles suggest infection by *S. Aureus*, and an upper lobe cavitary lesion suggests tuberculosis. Ultrasound examination of the lungs can be performed bedside for the visualization of pulmonary infiltrates. Several studies and meta-analyses support that ultrasound performs well for the diagnosis of pneumonia if performed by an experienced physician. However, ultrasound examinations are difficult to compare over time and the results may vary between performers [1, 6].

All patients should undergo an assessment of disease severity by using validated system of diseases severity (Pneumonia severity index, CURB-65, etc.).

Blood cultures should be obtained for patients with severe disease who are at high risk of bacteremia. The yield of blood cultures in elderly subjects is low: about 11%. Sputum samples for stain and culture are important in subjects with atypical presentation, cavitary lesions, failure of previous treatment, immunodepression, ICU admission, and in all clinical conditions at risk for less common etiologies (Gram-negative organism, *Staphylococcus*, and so on) [6].

Serological testing is not recommended for routine use. Urinary antigen test should be performed for *Legionella pneumophila* (sensitive >80%; specific >95%) and *Streptococcus pneumoniae* (sensitive >70%; specific >95%). The role of PCR technologies is limited and could be crucial for *Mycobacterium* species. If a pleural effusion is present, thoracentesis should be performed, with Gram staining, culture, determination of pH, measurement of leukocyte, and LDH [2, 6].

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## 12.6 Etiology

The distribution of pathogens associated with pneumonia in elderly patients appears to differ from that in younger counterparts. *Streptococcus pneumoniae* the most common etiological agent causing about 50% of infections. *Haemophilus influenzae*, *Moraxella*, *Pseudomonas*, and *Enterobacteriaceae* increase in patients with underlying bronchopulmonary diseases, and *Staphylococcus aureus* are getting more common, above all during influenza outbreaks [7].

Viral pneumonia is frequent in outpatients (>30% of cases); influenza and respiratory syncytial virus remain the predominant viral agents of CPAP in elderly subjects [6, 7].

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## 12.7 Intensive Care Unit Admission and Treatment

Nearly 40% of CAP episodes in seniors will result in a hospitalization with an average length of stay of 5.6 days.

Early recognition and prompt initiation of treatment in severe CAP is associated with reduced mortality. Hypoxemia, confusion, and the onset of respiratory or metabolic acidosis are all signs of disease progression and the need for further interventions [8].

The presence of respiratory frequency > 30 breaths/min, diastolic blood pressure < 60 mmHg, and BUN > 7 mM induced a 21-fold increased risk of death. Severe CAP was defined according to the 2007 Infectious Disease Society of America/American Thoracic Society guidelines. These guidelines revised the criteria, retain the major criteria as absolute indications for intensive care, and combine the ATS major criteria (hypotension requiring aggressive fluid resuscitation, multilobar infiltrates, and PaO<sub>2</sub>/FiO<sub>2</sub> ratio < 250), the CURB variables, and three additional minor criteria (white blood cells < 4000/mm<sup>3</sup>, platelets < 100,000, and temperature < 36 °C) [2, 8, 9].

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## 12.8 Respiratory Management

In CAP patients, the inflammatory process causes a leakage of edema fluid into the lung and inflammatory cellular infiltrates cause diffusion abnormalities and mismatch between ventilation and perfusion. Thus, the mechanism of respiratory failure is based on several factors, that is, alveolar flooding, intrapulmonary shunting, and bacterial cytotoxic effects on the epithelial barrier [10, 11].

All patients with CAP should receive oxygen treatment as needed with the aim of maintaining an arterial oxygen saturation (SpO<sub>2</sub>) of 92% corresponding to a partial pressure of oxygen in the blood of about 60 mmHg. Lower values are accepted in cases of underlying severe pulmonary disease with a risk of carbon dioxide retention. Oxygen can be delivered via nasal cannula up to 5 L/min or by mask 0–15 L depending on the type of mask, alternatively via a high-flow system. The SpO<sub>2</sub>

value should always be interpreted in relation to the respiratory rate and the oxygen fraction in the inspiratory air. Blood gas analysis should be performed liberally in patients with severe CAP. Oxygen treatment of COPD patients should be monitored with repeated blood gas analysis. Hypercapnia indicates the need for more intensive ventilatory support. Noninvasive positive pressure ventilation (NPPV), which is the primary treatment for exacerbation of COPD, may be a good tool for patients with severe CAP [12]. While the clinical practice guidelines on evidence-based application of NIV for community-acquired pneumonia did not provide a recommendation for its use, the Infectious Disease Society of America/American Thoracic Society guidelines on management of CAP did suggest a cautious trial of NIV [2, 12]. Most studies on NIV and treatment of acute hypoxemic respiratory failure, including CAP, have been carried out in the critical care setting and have reported controversial results with varying failure rates for NIV use. Nevertheless, NIV continues to be commonly used for the treatment of severe CAP, especially in the Emergency Department [12, 13].

A recently published retrospective cohort study involving 163 subjects with severe CAP treated with NIV demonstrated that most patients who presented to the ED with CAP and respiratory failure received NIV as first-line ventilatory therapy. The NIV failed in 50% of cases. Risk factors that predicted NIV failure at baseline was: no history of chronic obstructive pulmonary disease, APACHE II score, need for hemodynamic support and number of CXR quadrants involved. Risk factors for failure after 2 h of therapy were respiratory rate, serum PH, and hemodynamic support. Hemodynamic support was the most strongly associated with failure of NIV [14]. A recent study by Carreaux et al. demonstrated differences in expired tidal volume in patients with hypoxemic respiratory failure who failed and succeeded NIV [15]. Higher tidal volume was a significant risk factor for NIV failure on multivariable analysis. A paper by Paolini et al. proposed a protocol to evaluate CPAP responsiveness in patients with acute respiratory failure due to CAP. The responders were defined as patients hemodynamically stable with a  $\text{PaCO}_2 < 45$  mmHg, those with partial pressure of arterial oxygen to the fraction of inspired oxygen ( $\text{PaO}_2/\text{FiO}_2$ ) increase  $>20\%$  and/or reduction of respiratory distress. In this setting, 66% of subjects benefit from CPAP application. CPAP-responders were less likely to present comorbidities compared to CPAP-non-responders, and responsiveness does not seem to be associated with better outcomes, with the exception of a shorter length of hospital stay [16].

High-flow nasal cannula oxygen therapy (HFNC), which delivers high flow (up to 60 L/min) of blended, humidified oxygen through a nasal cannula, is a promising tool for respiratory support. The key mechanisms of action of HFNC are effective delivery of up to 100% oxygen, washout of the pharyngeal dead space, decreased inspiratory resistance, airway hydration, and positive end-expiratory pressure effect (PEEP range from 3 to 5  $\text{cmH}_2\text{O}$ ). Several clinical trials have demonstrated the effectiveness of HFNC in a variety of clinical situations, such as acute hypoxemic respiratory failure, post-cardiac surgery, post-extubation, and during invasive procedures [17–20].

Kim SE designed a retrospective study involving patients with acute respiratory failure with hypercapnia. Pneumonia (36.4%) and acute exacerbation of chronic obstructive pulmonary disease (33.4%) were the most common reasons for oxygen therapy.

The mean fraction of inspired oxygen and HFNC flow rate were  $0.45 \pm 0.2$  and  $41.1 \pm 7.1$  L/min, respectively; mean duration of application was  $3.6 \pm 4.1$  days. The partial pressure of arterial carbon dioxide ( $\text{PaCO}_2$ ) was  $55.0 \pm 12.2$  mmHg at admission and increased by approximately  $1.0 \pm 7.7$  mmHg with conventional oxygen therapy. In contrast, with HFNC therapy,  $\text{PaCO}_2$  decreased by  $4.2 \pm 5.5$  and  $3.7 \pm 10.8$  mmHg in 1 and 24 h, respectively, resulting in significant improvement in hypercapnia ( $P = 0.006$  and  $0.062$ , respectively). They suggest that HFNC can improve hypercapnia in some patients through clearance of anatomical dead space, which improves alveolar ventilation, thus leading to reduction of  $\text{PaCO}_2$  and an increase of  $\text{PaO}_2$  [21].

Itō J et al. performed a retrospective cross-sectional multicenter survey evaluating adult patients receiving HFNC in 33 participating hospitals in Japan. They included 312 patients with acute respiratory failure due to various clinical situations: cardiogenic pulmonary edema, ARDS, AECOPD, interstitial lung disease, and pneumonia (54 patients, 16.8% of cases). Median duration of HFNC was 4 days; median total flow rate, 40 L/min; and median  $\text{FIO}_2$ , 50%. HFNC significantly improved  $\text{PaO}_2$ ,  $\text{PaCO}_2$ ,  $\text{SpO}_2$ , and respiratory rate from baseline. Two-thirds of patients finally survived to be discharged [22].

A systematic review of five randomized clinical trials was recently published by Leong BL and colleagues. The studies compare at least NIV with HFNC or NIV + HFNC with NIV in acute respiratory failure. Primary outcomes included intubation/re-intubation rates; secondary outcomes were ICU mortality and morbidities.

Patients were post-cardiothoracic surgery, mixed medical/surgical patients, and those with pneumonia. Two trials were conducted after extubation, two before intubation, and one during intubation. Three trials reported intubation/re-intubation rates as the primary outcomes.

The results were conflicting because of differences in patient populations, primary outcomes, trial design (superiority vs. noninferiority) as well as comparison arms. Despite these differences, HFNC is a viable option in patients with less severe hypoxemic respiratory failure from pneumonia and ARDS as well as patients at risk of post-extubation respiratory failure [23].

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## 12.9 Conclusions

Pneumonia is a common cause of hospital admission in elderly patients. The classic triad of fever, cough, and dyspnea is present only in a minority of elderly patients hospitalized for CPAP. Tachypnea appears to be a sensitive indicator of the presence of lower respiratory tract infection in this subset of patients. Streptococcus pneumoniae is the most common etiological agent causing about 50% of infections.

Haemophilus influenzae, Moraxella, Pseudomonas, and Enterobacteriaceae increase in patients with underlying bronchopulmonary diseases, and Staphylococcus aureus are getting more common, above all during influenza outbreaks. Nearly 40% of CAP episodes in seniors will result in a hospitalization with an average length of stay of 5.6 days.

Early recognition and prompt initiation of treatment in severe CAP is associated with reduced mortality. The presence of respiratory frequency > 30 breaths/min, diastolic blood pressure < 60 mmHg, and BUN > 7 mM, induced a 21-fold increased risk of death.

All patients with CAP should receive oxygen treatment as needed with the aim of maintaining an arterial oxygen saturation (SpO<sub>2</sub>) of 92% corresponding to a partial pressure of oxygen in the blood of about 60 mmHg. Oxygen treatment of COPD patients should be monitored with repeated blood gas analysis. Hypercapnia indicates the need for more intensive ventilatory support. Noninvasive positive pressure ventilation (NPPV), which is the primary treatment for exacerbation of COPD, may be a good tool for patients with severe CAP. High-flow nasal cannula oxygen therapy (HFNC), which delivers high flow (up to 60 L/min) of blended, humidified oxygen through a nasal cannula, is a promising tool for respiratory support in these patients.

### Key Recommendations

1. Tachypnea appears to be a sensitive indicator of the presence of lower respiratory tract infection in elderly subjects.
2. Early recognition and prompt initiation of treatment in severe CAP is associated with reduced mortality.
3. All patients with CAP should receive oxygen treatment as needed with the aim of maintaining an arterial oxygen saturation (SpO<sub>2</sub>) of 92% corresponding to a partial pressure of oxygen in the blood of about 60 mmHg.
4. High-flow nasal cannula oxygen therapy is a promising tool for respiratory support in these patients.

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