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The Presentation of Respiratory Failure in Elderly Individuals

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Abstract Respiratory failure (RF) is a prevalent condition whose presence in elderly patients may be complex and require specific and specialized intervention. A multidimensional evaluation is necessary to choose the best treatment, taking into consideration functional capacity and frailty. Cardiogenic pulmonary edema, community-acquired pneumonia, pulmonary embolism, bronchitis, and acute asthma are the main causes of RF in this patient population. Despite the limited availability of studies and data, including systematic reviews, regarding RF treatment in elderly patients, in this update, we synthesize data to guide diagnosis, treatment, and health care decision making.

Keywords Respiratory failure · Intensive care · Elderly · Diagnosis · Treatment · Noninvasive ventilation · Invasive ventilation · Oxygen therapy · Pulmonary rehabilitation

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Introduction

The number of elderly adults in the global population is growing rapidly. Medical advances have extended the average human lifespan and increased the ages of patients, contributing to the higher prevalence of chronic disease related to an aging population. According to Global Burden of Disease estimates for 2010, 23.1 % of the total disease burden is attributable to disorders in people aged 60 years and older [1]. The increased number of survivors with chronic diseases has led to more seniors using hospitals [2, 3] and to a higher risk of acute illness [1]. Thus, the number of geriatric patients with acute illness admitted to emergency and intensive care units (ICUs) is expected to grow [4].

Cardiovascular disease, cancer, and respiratory disease are the main causes of mortality worldwide [5•]. Frequently, these diseases result in respiratory failure (RF). In adults, RF is mostly related to complications of respiratory diseases;

however, in the elderly population, it also is a common consequence of chronic heart disease and community-acquired pneumonia (CAP). Up to 16 % of patients with RF are elderly [6••], and independent of gender, RF is a frequent cause of death in the elderly population. The reduced nutritional and functional status of elderly people, especially the oldest and most frail, also contributes to the increased prevalence of sepsis and RF in this population [7••].

The aging process promotes changes in the respiratory system, such as reductions in total lung capacity, forced expiratory volume in 1 s (FEV1), and forced expiratory flow, as well as increases in functional residual capacity, and expiratory reserve volume [8]. These changes are related to a decrease in both lung elastic recoil and thoracic compliance and contribute to the exacerbation of chronic respiratory diseases [8]. Reduced exercise tolerance and cardiovascular fitness also contribute to the increase in vulnerability and the prevalence of respiratory impairment in older people [9]. Sedentary behavior weakens the respiratory muscles (including those involved in inspiration and expiration) [10] and reduces peak cough flow [11], hampering one's ability to generate satisfactory volume ventilation and airflow for coughing, thereby decreasing the efficacy of coughing and increasing the risk of acute respiratory tract infections [12•]. Functional and cognitive decline and polypharmacy also contribute to the higher risk for acute illness [13].

Thus, the assessment and management of elderly patients with RF may be complex and require specialized intervention, such as those proposed for chronic obstructive pulmonary disease (COPD) [14••]. In planning an appropriate management strategy, challenges must be identified clearly; therefore, a comprehensive and multidisciplinary health care approach is important to evaluate and treat this population, taking the patient's level of frailty and/or the presence of comorbidities into consideration, as well as to choose the best place for care: nursing home, ICU, or geriatric unit [14••]. Despite the increased number of elderly patients with RF in the emergency department and ICU settings [15, 16], the model of care may not be adequate for this population.

In this article, we review the presentation of RF in elderly individuals, including diagnosis, causes, consequences, and treatment, taking into consideration a multidimensional approach.

Diagnosis of RF

Definition

RF is a syndrome in which the respiratory system fails to maintain an adequate gas exchange of O_2 and CO_2 to meet metabolic demand, resulting in hypoxemia with or without concomitant hypercarbia [17, 18].

The respiratory system performs the vital function of gas exchange, which is essential to maintain homeostasis. This task is accomplished and controlled by a complex set of structures: the lungs and their conducting airways, the thoracic wall, the respiratory muscles, and the respiratory centers. Pathologic processes may affect the interactions of the cardiopulmonary, nervous, and musculoskeletal systems, leading to RF [19].

RF is classified according to which gas exchange function it impairs: oxygenation, CO_2 removal, or both. In this way, it is classified as type I, or oxygenation failure; type II, or ventilatory failure; or type III, or combined oxygenation and ventilatory failure [19].

Type I failure is characterized by low partial pressure of O_2 in the arterial blood (PaO_2 <60 mm Hg while breathing room air) with normal or low partial pressure of CO_2 ($PaCO_2$) and an increase in alveolar–arterial O_2 partial pressure difference (PAO_2-PaO_2), venous admixture, and dead space effect (Vd/VT) [18, 19]. It may be caused by any disorder that produces low inspired oxygen partial pressure, alveolar hypoventilation, diffusion impairment, ventilation/perfusion (V/Q) mismatch, and right-to-left shunt [17, 19]. On the other hand, type II failure is characterized by an abnormal increase in $PaCO_2$ (>45 mm Hg) [18] and is accompanied by simultaneous decreases in PAO_2 and PaO_2. It may be caused by disorders affecting central ventilatory drive, disorders affecting signal transmission to the respiratory system, or disorders of the respiratory muscles or chest wall [19].

Moreover, type I and type II RF may occur together. In these cases, pulmonary parenchymal disease initially causes acute hypoxemic RF due to V/Q mismatch and shunt. Because of the increased work of breathing (due to reduced pulmonary compliance), the respiratory muscles become fatigued and ventilatory failure develops, increasing arterial $PaCO_2$ [17].

RF also is classified as acute, developing in minutes or hours, or chronic, evolving over several days or a longer period. Moreover, the term *acute-on-chronic RF* is applied when acute deterioration occurs in a patient with chronic RF. Acute hypercarbic RF occurs in patients with little or no evidence of preexisting respiratory disease and with arterial blood gas tensions showing high $PaCO_2$, low pH, and normal bicarbonate. Chronic hypercarbic RF is characterized by evidence of chronic respiratory disease, high $PaCO_2$, normal pH, and high bicarbonate. Acute-on-chronic hypercarbic RF is characterized by acute deterioration in an individual with significant preexisting hypercarbic RF, high $PaCO_2$, low pH, and high bicarbonate [18].

Type I is considered the most common form of RF [17], including among the elderly population. Acute RF in elderly adults usually is related to symptoms of congestive heart failure (CHF) or respiratory disorders [6••, 20••]. Ray et al. (2006) evaluated 514 elderly patients (80±9 years old) presenting to the emergency department of a teaching hospital.

They showed that cardiogenic pulmonary edema (CPE; 43 %), CAP (35 %), exacerbation of COPD (32 %), pulmonary embolism (PE; 18 %), bronchitis (4 %), and acute asthma (3 %) were the main causes of RF in this patient population. They also demonstrated that half the patients presented with more than two causes of RF [6••].

Regarding type II failure, the major cause in elderly patients is severe hyperinflation due to COPD exacerbation. The flattened diaphragm and reduced mechanical action of the inspiratory muscles result in alveolar hypoventilation with an increase in $PaCO_2$ [6••, 20••]. Table 1 presents the principal causes of acute RF.

Diagnosis

An RF diagnosis is established when the patient cannot ventilate adequately or provide sufficient oxygen to the blood and systemic organs, resulting in hypoxemia (PaO_2 <60 mm Hg) with or without concomitant hypercarbia ($PaCO_2$>45 mm Hg). The mainstay of RF diagnosis is arterial blood gas analysis [18]; however, this must be considered in combination with history, clinical assessment, and investigations to identify the underlying disease process [17].

Causes of acute RF in elderly patients often are difficult to identify. Atypical signs of the main causes of RF in this patient population contribute to misdiagnosis, resulting in increased morbidity and mortality [6••, 20••]. Ray et al. (2006) found that 20 % of elderly patients in an emergency department were misdiagnosed. The accuracy of the diagnosis was 0.76 for CPE, 0.79 for CAP, and 0.78 for PE. In this study, the variables associated with a missed diagnosis were a final diagnosis of CPE, CAP, or PE, emphasizing the fact that it frequently is very challenging to determine the causes of acute RF in the elderly population [6••].

Table 1 Diagnosis of acute respiratory failure in the elderly [6••, 20••]

Principal causes
Cardiogenic pulmonary edema
Community-acquired pneumonia
Acute exacerbation of chronic respiratory disease
Pulmonary embolism
Bronchitis
Acute asthma
Use of morphine or sedatives
Common missed diagnosis of the emergency physicians
Cardiogenic pulmonary edema
Community-acquired pneumonia
Pulmonary edema
Variables associated with in-hospital death
Initial Inappropriate treatment in the emergency department (double mortality)
Hypercapnia: at least 45 mm Hg
Clearance of creatinine 50 ml min^{-1} or less
Clinical signs of acute ventilator failure
Elevated BNP or NT-proBNP levels

BNP brain-type natriuretic peptide, *NT* N-terminal

The clinical diagnosis of CHF is challenging; physicians miss this diagnosis in at least 30 % of cases [21]. Atypical signs of CHF (confusion, leg swelling, wheezing) are observed frequently in elderly patients [20••]. On the other hand, PE may simulate many cardiopulmonary diseases in this population. Dyspnea, tachycardia, chest pain, syncope, and cough are the main symptoms in elderly patients with PE. Because of the nonspecificity of the clinical signs and symptoms, as well as the instruments and laboratory tests, PE is one of the most misdiagnosed diseases in this patient population [20••, 22].

CAP is a common and serious condition in elderly patients, in whom the clinical presentation may differ from that in younger patients. Older patients with pneumonia report significantly fewer symptoms, and confusion, alterations in functional physical capacity, and decompensation of underlying illnesses may appear as unique manifestations [23, 24]. Riquelme et al. [24] showed that definitive diagnosis of pneumonia was delayed for more than 72 h in 62 % of the elderly patients included in their study. The combination of cough, fever, and dyspnea was absent in 69 % of the patients, and 36 % had no fever. Delirium at admission was very common (45 %) and significantly more frequent than in controls.

Because the standard tools used to determine the major underlying causes of acute RF are not very accurate in elderly patients, other diagnostic strategies are proposed to improve outcomes of acute RF in this population.

Echocardiography is considered a valid instrument for diagnosing CHF, and its use should be encouraged in emergency departments. In cases of nonsystolic CHF, Doppler and myocardial tissue imaging are recommended. Moreover, it has been demonstrated that adding natriuretic peptides, namely B-type natriuretic peptide (BNP) and amino-terminal fragment of the precursor protein (NT-proBNP), to clinical evaluation for CHF improves diagnostic accuracy [25•]. BNP, a polypeptide released by ventricular myocytes in direct proportion to wall tension, lowers renin–angiotensin–aldosterone activation. In the blood, the cleavage of a precursor protein produces BNP and the biologically inactive NT-proBNP [20••]. In the study by Ray et al. [6••], elevated NT-proBNP or BNP was one of the variables predicting death in elderly patients in an emergency department (odds ratio, 2.06; $P<0.046$). A flow chart showing BNP or NT-proBNP cutoff values to aid CHF diagnosis in older patients may be found in Delerme and Ray (2008) [20••].

Regarding PE, thoracic CT is considered a first-line investigation and is useful in determining alternate diagnoses, such as pneumonia or CHF missed on chest radiography. Concerning CAP, which also is difficult to diagnose in elderly

patients, the use of biologic markers such as C-reactive protein and procalcitonin may be useful in identifying bacterial infection and guiding antibiotic therapy [20••].

Treatment

Acute RF in the Elderly and Its Reflection in Intensive Care

Healthy aging no longer is defined as the absence of disease but as success in overcoming disease through selective, adaptive, and compensatory mechanisms to maintain the highest level of functional capacity possible, thus increasing life expectancy with freedom from disabilities [26]. In many cases, admission to an ICU results in functional decline with worsening of quality of life and institutionalization after hospital discharge. Therefore, it is not an easy task to indicate or deny intensive care to patients in this age group, especially the very elderly. In fact, the decision to admit elderly patients to the ICU should be based on the presence of chronic disease, prehospital functional status, severity of acute illness, and patient preference [20••, 27, 28••]. Once ICU support is indicated, treatment should be offered with respect to the pharmacokinetics and pharmacodynamics of drugs, with dosages adjusted according to renal function, especially given the possibility of drug interactions, thus avoiding iatrogenic effects [29•].

The clinical diagnosis of CHF in elderly patients with RF often is difficult because of comorbidities. Therefore, as discussed earlier, it may be necessary to perform basic echocardiography and measurement of BNP, which have demonstrated a positive impact on prognosis and cost–benefit ratio. In the epidemiologic studies ADHERE [30], EHFR (Euro Heart Failure) [31], and OPTIMIZE [32], the participants were elderly (mean age 75, 71, and 73 years) and about 50 % had preserved left ventricular ejection fraction (<40 % in 59, 46, and 52 % of patients, respectively), which should always be considered in choosing the best treatment. Most patients with acute decompensation present with signs and symptoms of pulmonary congestion due to the accumulation and redistribution of fluids, suggesting treatment with diuretics known to increase renin expression [33]. However, the treatment of choice is aimed at reorganizing body fluids and includes nitrates targeted toward venous and arterial vasodilator action. In patients with low cardiac output, inotropes such as dobutamine and levosimendan may be used, although progressive worsening was observed after the use of adrenergic inotropic agents [34]. In patients already receiving ACE inhibitors or AT1-receptor or β-blockers, dosages should be kept to a minimum. However, after clinical stabilization, these drugs must be optimized or instituted as quickly as possible [35, 36].

Pulmonary infection, the second most common cause of RF, has a significant impact on morbidity and mortality in the elderly. Several features related to microbiology patterns among elderly patients differ from those of adults with pneumonia, including higher rates of pneumococcal pneumonia and influenza viruses and lower rates of atypical pathogens. *Streptococcus pneumoniae* is the most common pathogen found in immunosuppressed and nonimmunocompromised elderly patients, whereas Gram-negative bacilli, particularly *Pseudomonas aeruginosa* and *Nocardia* spp., are more frequent among those who are immunocompromised [37]. Moreover, many elderly patients live in long-term care facilities, where they may be colonized by resistant microbial strains. These are important considerations when selecting empirical antimicrobial agents; according to the recommendations of evidence-based guidelines, the choice of an antimicrobial should be based on the risk of infection with multidrug-resistant bacteria, the severity of comorbidities, and the clinical situation presented. Thus, although each case is different, for outpatients or those hospitalized outside the ICU, a respiratory fluoroquinolone alone or a β-lactam combined with a macrolide generally is indicated. However, in seriously ill patients in the ICU, the combination of a β-lactam and a respiratory fluoroquinolone or macrolide may be considered as a first choice. It should be noted that prognosis is directly related to the appropriate choice and how soon antimicrobial treatment begins [37].

COPD also is associated with high morbidity and mortality rates and is the third leading cause of RF in elderly patients. Pharmacologic treatment of COPD in the elderly is based on the guidelines of the Global Initiative for Lung Disease (GOLD) [38••]. An anticholinergic bronchodilator and a long-acting β-agonist must be used regularly, as up to 40 % of patients have reversible airway resistance [39]. In addition, during the acute phase, intravenous corticosteroids should be given to shorten this period, after which inhaled corticosteroids may be introduced [39].

PE is the cause of acute RF in 18 % of patients with this disease, but it is difficult to recognize and often is overlooked because of its generally nonspecific and atypical presentation. Management of PE in elderly patients generally is the same as that in nonelderly people, because thrombolytic therapy carries no significant additional risk in older people and the indications and contraindications are the same regardless of age [40]. However, one should consider that sensitivity to the anticoagulant effect of a given dose, along with drug interactions and associated comorbidities, increases with age.

Oxygen Therapy

Hypoxemic patients with acute RF need oxygen supplementation as the first stage of treatment, as delayed and inadequate

treatment of hypoxemia leads to cerebral damage and organ dysfunction [17, 20••].

Oxygen generally is supplied via a facemask, nasal cannula, or nasal prongs and is indicated in acute RF if the patient's PaO_2 is lower than 60 mm Hg or oxygen saturation in arterial blood (SaO_2) is less than 90 % [17]. In this case, sufficient supplemental O_2 should be provided to maintain a PaO_2 above 60 mm Hg with the lowest fraction of inspired oxygen (FiO_2), aiming to avoid oxygen toxicity, which usually occurs with an FiO_2 >50 % used for long periods. It is important to highlight that PaO_2 is only one of the determinants of O_2 delivery to the tissues; therefore, other determinants, such as cardiac output and hemoglobin concentration, should be considered when treating hypoxemia [18]. Moreover, the expected PaO_2 in room air falls with age, leading to a great deal of individual variation [17].

In patients with chronic obstructive airway diseases and chronic type II RF who have lost their hypercapnic drive and rely on hypoxic drive to stimulate ventilation, FiO_2 should be limited to 24 to 28 % by using a Venturi-type fixed performance oxygen mask whenever possible. Injudicious use of oxygen therapy in these patients may be associated with increased hypercapnia and neurologic disorders such as drowsiness and coma, characteristic of narcosis [17, 19].

Patients with hypoxemia due to intrapulmonary shunt-producing lesions (pneumonia, acute respiratory distress syndrome, pulmonary edema, etc.) should be managed with administration of high concentrations of O_2. The usual practice of beginning treatment with a low concentration of O_2 is not recommended in these cases; endotracheal intubation and controlled ventilation with high-concentration O_2 usually are necessary [19].

More recently, the impact of high-flow nasal cannula (HFNC) oxygen therapy was assessed in ICU patients with acute RF not requiring intubation [41, 42]. In HFNC therapy, air and oxygen are mixed in a blender to achieve the desired FiO_2 and flow. The gas mixture enters a humidification chamber, where it is heated and humidified. It is delivered to the patient via a heated circuit to avoid heat loss and condensation and then via wide-bore nasal prongs or a cannula [41]. In two studies assessing adult and elderly ICU patients, HFNC therapy was superior to conventional high-flow oxygen via facemask in increasing SaO_2 and PaO_2 and reducing breathing frequency [41, 42]. Moreover, HFNC therapy was associated with less dyspnea and mouth dryness and was more comfortable for the patient.

Correction of arterial hypoxemia is one of the cornerstones of RF management. The use of oxygen is associated with risks such as increased $PaCO_2$ in patients with COPD. Therefore, if hypoxemia does not improve with oxygen therapy or if the patient becomes exhausted from a rising $PaCO_2$, he or she should be transferred to the ICU and mechanical ventilation (MV) should be considered [17, 19], especially for a patient with pulmonary congestion and exacerbated COPD. MV may reduce the frequency of intubation significantly, reducing the length of stay in the ICU as well as mortality.

Ventilatory Support: Invasive and Noninvasive

Some older patients who have severe disease, with reduction in compliance, hypoxemia, and infection, require intubation and MV. During MV, the pressure and volume may lead to ventilator-induced lung injury, particularly in elderly patients. Although there are new methods of MV that theoretically are safer than conventional modes, the literature has not yet shown them to be superior in older patients [29•, 43]. Therefore, noninvasive ventilation (NIV) was developed as an alternative to intubation and invasive MV in elderly patients. NIV avoids endotracheal intubation, reduces the risk of nosocomial pneumonia, and decreases the incidence of mortality and ICU use, as well as the length of hospital stay [44]. However, there are disadvantages, such as a delay in providing endotracheal intubation in severe cases of acute RF and the risk of aspiration pneumonia in patients without an adequate level of consciousness [45•, 46••, 47–49].

According to reports, the predictors of success in NIV use are a good level of consciousness, a Glasgow Coma Scale score between 6 and 9, and a lower Acute Physiology and Chronic Health Evaluation (APACHE II) score [45•, 47]. Another important determinant of successful NIV is the best choice of ventilator and interfaces, as many factors, including economic and social support, must be considered. Ideally, the ventilator and interface for providing NIV should be selected based on patient adaptation and compliance as well as regularization of gas exchange and the number of hours of ventilation [50].

The spontaneous ventilation modes are used most frequently in NIV. In pressure support mode, the inspiratory assistance is around 16–20 cm H_2O, with a positive expiratory end pressure between 4 and 5 cm H_2O, respiratory frequency of 10–12 breaths/min, and tidal volume between 6 and 8 mL/kg [29•, 46••]. In bilevel mode, the inspiratory positive airway pressure varies from 8 to 12 cm H_2O and increases gradually to 20 cm H_2O, with increments of 2 cm H_2O in the initial hours; the expiratory positive airway pressure is 4–5 cm H_2O, increasing gradually to 8 cm H_2O; and the tidal volume is around 7 mL/kg [44, 47]. Regarding the interface to be used in this mode, it also should be selected according to what is best suited to the patient. The most useful is the facemask because it prevents leakage from the mouth; however, other possibilities include a full face mask, which reduces the risk of skin injury; a nasal mask; nasal pillows; and helmets [29•, 44, 47, 49, 50). During NIV, the patient must be monitored at the bedside in case the ventilator needs to be adjusted and to ensure he or she is adapting to the interface [49].

There is NO consensus regarding the best mode of MV for elderly patients admitted to the ICU because of an acute RF episode; therefore, more studies are needed to evaluate this therapy in this population [46••].

Multidimensional Approach

In elderly patients, deterioration in health is exacerbated by physiologic aging effects and the frequency of nonrespiratory diseases. Thus, treatment also should focus on preserving functional capability and quality of life. Therefore, the use of multidimensional tools to improve assessment and treatment is required to evaluate quality of life and depression, cognition and physical function, and social and nutritional status, as proposed and fully described by Antonelli Incalzi et al. (2009) [14••] in COPD patients. Clinical and scientific interest has led to support for safe and early mobilization of patients with RF in the ICU [51••].

After an acute RF episode, it is important to adhere to a multidisciplinary approach to prevent further exacerbations. Pulmonary rehabilitation (PR) is a complete intervention for managing pulmonary diseases that includes but is not limited to physicians, geriatricians, respiratory nurses, physiotherapists, occupational therapists, dietitians, and social workers [52••]. Most PR programs and publications are targeted to COPD patients, but there is increased evidence for their use in other respiratory diseases. PR is associated with a reduction in subsequent hospital admissions. The participation of patients and their families and caregivers in an educational program is emphasized to promote self-care and self-efficacy [52••].

Following ICU discharge, elderly patients with RF often have general deconditioning and functional impairment limited by dyspnea. Deep breathing exercises, directed coughing and huffing, and early mobilization are techniques to improve mucus clearance and pulmonary ventilation, as are resources such as incentive spirometry, positive expiratory pressure, and respiratory muscle training devices. Several programs have been proposed to enhance physical activity [53, 54]. However, there is a lack of studies on the use of specific respiratory techniques and exercise programs in elderly patients after discharge [55••]. Because sleep disorders are common in elderly people, they also should be considered and may justify additional interventions [56]. Therefore, a multidisciplinary team is required to promote the multidimensional approach in caring for critically ill older patients [57].

Conclusions

The most important aspects of RF management in the elderly population are to individualize evaluation, treatment, and interventions and to integrate care to prevent injuries, preserve functional status, and prolong a disability-free life.

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Compliance with Ethics Guidelines

Conflict of Interest Raquel R. Britto, Danielle S. R. Vieira, Fernando A. Botoni, Adriana L. A. S. Botoni, and Marcelo Velloso declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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