Acute respiratory failure in the elderly: diagnosis and prognosis

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Abstract

Acute respiratory failure (ARF) in patients over 65 years is common in emergency departments (EDs) and is one of the key symptoms of congestive heart failure (CHF) and respiratory disorders. Searches were conducted in MEDLINE for published studies in the English language between January 1980 and August 2007, using ‘acute dyspnea’, ‘acute respiratory failure (ARF)’, ‘heart failure’, ‘pneumonia’, ‘pulmonary embolism (PE)’ keywords and selecting articles concerning patients aged 65 or over. The age-related structural changes of the respiratory system, their consequences in clinical assessment and the pathophysiology of ARF are reviewed. CHF is the most common cause of ARF in the elderly. Inappropriate diagnosis that is frequent and inappropriate treatments in ED are associated with adverse outcomes. B-type natriuretic peptides (BNPs) help to determine an accurate diagnosis of CHF. We should consider non-invasive ventilation (NIV) in elderly patients hospitalised with CHF or acidotic chronic obstructive pulmonary disease (COPD) who do not improve with medical treatment. Further studies on ARF in elderly patients are warranted.

Keywords: acute respiratory failure, elderly, pulmonary embolism, BNP, congestive heart failure

Introduction

Visits by older adults compose 12–21% of all emergency department (ED) encounters [1]. Furthermore, studies showed a progressive increase in the number of ED attendances and emergency admissions hospital of older patients in the last decade. Between 30 and 50% of all ED visits by older patients result in a hospital admission. Lastly, when admitted, older emergency patients are more likely to require an ICU (intensive care unit) bed [2]. Acute respiratory failure (ARF) is a common complaint of elderly patients in ED, and the key clinical presentation of cardiac (congestive heart failure (CHF)) and respiratory disorders [3].

This article will summarise the age-related structural changes of the respiratory system and their consequences in clinical practice. It will also overview the causes, difficulties in diagnosis, treatment and the prognosis of ARF in elderly patients.

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Physiological changes according to age

Several changes related to ageing need to be taken into account before discussing ARF.

Pulmonary function

Chest wall compliance decreases progressively with age, presumably related to structural changes within the rib cage [4, 5]. Total lung capacity does not change with age, but the functional residual capacity and the residual volume both increase. There is an increased tendency in airway closure at small volumes (senile emphysema) related to the loss of supporting tissues around the airways [4]. Because a significant proportion of peripheral airways do not contribute to gas exchange (low V/Q ratio zones), but also because of a reduced alveolar area, ageing was classically thought to be accompanied by a progressive decline in arterial oxygen tension (PaO₂). Actually, recent studies have found no significant correlation between PaO₂ and age [6]. Because of
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a decline in tests of forced expiration (i.e. increasing airway resistance), an obstructive pattern could exist even in women who are non-smokers. Furthermore, studies suggest that the β-adrenoceptor dysfunction explains a less response to bronchodilation in older asthmatic patients [7].

Other common important changes include loss of diaphragmatic mass and strength with age [8]. Finally, as a consequence of poor nutritional status, decreased T-cell function, decline in mucociliary clearance, poor dentition with oropharyngeal colonisation, and swallowing dysfunction (Parkinson’s disease, Alzheimer’s disease and stroke), community-acquired (CAP) and aspiration pneumonia is exceedingly common in elderly patients [9].

Furthermore, decreased sensitivity of respiratory centres to hypoxaemia, hypercapnia, or added resistive loads will result in a diminished ventilatory response in cases of ARF; and could delay diagnosis because of the poor perception of the respiratory insults [4].

Cardiovascular changes

The physiological cardiovascular changes involve the decrease of myocyte number, intrinsic contractility, coronary flow reserve, ventricular compliance and β-adrenoceptor-mediated modulation of inotropy.

The ageing heart increases cardiac output by increasing stroke volume rather than increasing heart rate. However, this compensatory mechanism is dependent on the effective atrial contribution to late diastolic filling (>30% in the elderly patient) [10]. This explains the frequency of CHF caused by rapid atrial fibrillation in the elderly.

Cardiac and respiratory systems are dependent. For example, (1) a bout of pneumonia is sufficient to trigger an acute exacerbation of heart failure, (2) a reduction in cardiac output accompanying septic shock is a cause of ARF caused by diaphragm hypoperfusion leading to alveolar hypoventilation, and respiratory arrest.

Other relevant changes

Decrease in glomerular filtration rate (approximately 45% by the age of 80) with ageing has important implications in terms of drug dosing, as most drugs are renally excreted [2].

Most studies have shown an imbalance between procoagulant/antifibrinolytic and anticoagulant factors, which could contribute to an increased incidence of PE.

Definition and pathophysiology of acute respiratory failure

The respiratory system consists of two parts: the lung, i.e. the gas-exchanging organ, and the pump [11]. The pump consists of the chest wall, including the respiratory muscles (essentially the diaphragm), the respiratory controllers in the central nervous system and the pathways that connect the central controllers with the respiratory muscles (spinal and peripheral nerves). ARF is a condition in which the respiratory system fails in one or both of its gas exchange functions, i.e. oxygenation (\(\text{PaO}_2 < 60 \text{ mmHg}\)) of and/or elimination of carbon dioxide (arterial carbon dioxide tension (\(\text{PaCO}_2 > 45 \text{ mmHg}\)) [11]). Both cut-off values simply serve as a general guide in combination with the history and clinical assessment of the patient. Thus, ARF could also be suspected by ‘simple’ clinical criteria: polypnea > 30 per min, contraction of the accessory inspiratory muscles, abdominal respiration, orthopnea cyanosis, and asterixis. Orthopnea is frequently associated with all causes of ARF, and is neither a sensible nor specific predictor of CHF [3].

The four pathophysiological mechanisms related to hypoxaemic ARF (1) ventilation/perfusion inequality which is the main mechanisms in an emergency setting (CHF or pneumonia), (2) increased shunt (acute respiratory distress syndrome), (3) alveolar hypoventilation [chronic obstructive pulmonary disease (COPD)], and (4) diffusion impairment (pulmonary fibrosis) [11].

Failure of the pump (or ventilatory failure) results in alveolar hypoventilation with an increase in \(\text{PaCO}_2\) (Table 1). Mechanisms responsible are decreasing minute ventilation and increasing dead space. In elderly patients, the major cause is severe hypoperfusion, with flattened diaphragm and reduced mechanical action of the inspiratory muscles (COPD exacerbation) [4].

Actually, hypoxaemic ARF is a situation accompanied by increased work of breathing. However, energy availability is reduced due to hypoxaemia, resulting in muscle fatigue and

<table>
<thead>
<tr>
<th>Table 1. Principal causes of acute respiratory failure (adapted from [11])</th>
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<tr>
<td><strong>Decreased central drive</strong></td>
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<tr>
<td>Morphone (or other drugs: sedatives)</td>
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<tr>
<td>Central nervous system diseases (encephalitis, stroke, trauma)</td>
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<tr>
<td>Altered neural and neuromuscular transmission</td>
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<tr>
<td>Spinal cord trauma, transverse myelitis, tetanus, amyotrophic lateral sclerosis, poliomyelitis, Guillain–Barre’ syndrome</td>
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<tr>
<td>Myasthenia gravis, botulism</td>
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<td><strong>Muscle abnormalities</strong></td>
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<td><strong>Kyphoscoliosis</strong></td>
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<tr>
<td>Chest wall trauma (80% of cases, diaphragmatic rupture)</td>
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<td>Lung and airways diseases</td>
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<td><strong>Acute exacerbation of chronic obstructive pulmonary disease</strong></td>
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<td>Congestive heart failure and non-cardiogenic pulmonary oedema (acute respiratory distress syndrome)</td>
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<tr>
<td><strong>Pneumonia</strong>, tuberculosi</td>
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<td>Upper airways obstruction</td>
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<td>Lung cancer, pulmonary fibrosis</td>
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<td>Pneumothorax, plural effusion</td>
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<td>Bronchiectasis</td>
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<td>Vascular diseases</td>
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<td><strong>Pulmonary embolism</strong></td>
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<td>Severe haemoptysis</td>
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<tr>
<td>Other</td>
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<td><strong>Severe sepsis</strong> or septic shock, other shock</td>
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The many causes of ARF in elderly patients are in bold.
ventilatory failure through imbalance between demand and supply [11].

**ARF in elderly patients**

**Etiology of ARF**

The EPIDASA study prospectively evaluated ARF in 514 patients (mean age of 80 years), presenting to the ED. CHF (43%), pneumonia (35%), COPD exacerbation (32%), and PE (18%) were the main causes [3]. Half of the patients had more than two diagnoses (CHF and CAP in 17%). Pneumothorax, lung cancer, severe sepsis and acute asthma were less frequent (<5%). An autopsy study of 234 elderly patients confirmed that the most common causes of death were CAP and CHF, both frequently underestimated [12]. Ely et al. reported the causes of being mechanically ventilated: CHF (16%), CAP (16%), COPD (14%), and sepsis (10%) [13].

**Difficult diagnosis of ARF in the elderly**

Ray et al. found that the sensitivity of the emergency physician was 86% for pneumonia, 75% for PE, and 71% for CHF [3]. In this study, the variables associated to a missed diagnosis were a final diagnosis of CHF, CAP or PE, highlighting the fact that frequent causes of ARF are very challenging to diagnose in the ED. Riquelme et al. demonstrated that the definite diagnosis of CAP was delayed for more than 72 h in 62% of patients [14]. The association of dyspnea, cough, and fever, was observed in only 32% of patients with CAP, and delirium at admission was very common (45%) [9, 14]. Atypical signs of CHF are frequent (confusion or leg swelling, or wheezing), and confusing [15, 16, 17]. Unfortunately, an inappropriate diagnosis is associated with an increased mortality (Figure 1a and b) [3, 18]. The difficulties of diagnosing CHF and PE [19, 20, 21, 22, 23, 24] are reported in Appendix 1 and Appendix 2 in the supplementary data on the journal’s website http://www.ageing.oxfordjournals.org (Figure 2 and see Appendix 4 in the supplementary data on the journal’s website http://www.ageing.oxfordjournals.org).

**Outcomes**

The mortality rate associated with ARF in the elderly varies according to the etiology. In a study, the crude mortality of CAP requiring hospitalisation was 26%, and age by itself was not a significant factor related to prognosis [14]. CHF has an in-hospital mortality, ranging from 13 to 29%, with a rate of early re-hospitalisation from 29 to 47% within 3–6 months of the initial discharge, and a 1 year survival of 50% [3, 16, 25, 26]. In the EPIDASA study, 29% of patients were admitted to an ICU, and 16% died in hospital. The five variables associated to death were: inappropriate initial treatment, hypercapnia >45 mmHg, creatinine clearance <50 ml/min, elevated B-type natriuretic peptides (BNP and NT-proBNP), and clinical signs of ARF. Age was not significantly associated with mortality.

**Prognosis of elderly admitted in an ICU**

Age is included in several scores of severity such as the APACHE II, Fine’s score for CAP [27], and Aujesky’s score for PE [2, 28]. However, the large majority of the studies indicate that acute physiology disturbances and diagnosis have larger relative contributions to prognosis than age [2]. Kaarlola et al. reported that the cumulative 3-year mortality rate among the elderly patients was lower than that among the controls (40% versus 57%). However, 88% of the elderly survivors assessed their present health state as satisfactory [29].

**Ethical considerations**

The decision to admit a patient to the ICU from the ED is challenging, as physicians must decide in a short time. When a patient potentially requiring ICU care is admitted to the ED, emergency physicians take the first decision as to whether to propose the patient to the ICU. Thus, intensivists are involved only if an ICU admission is requested for the patient. Age over 85 years seems to be an independent predictor of ICU refusal [30]. Actually, the decision to admit...
Figure 2. Diagnostic strategy based on B-type natriuretic peptide levels in elderly patients admitted for ARF in the emergency department. 1In the grey zone (BNP between 100 and 500 pg/ml), which represents less than a quarter of patients, further investigations are needed, and ER physicians should consider massive PE, CHE, severe exacerbation of COPD or severe pneumonia as possible diagnoses. 2Physicians should keep in mind that half of elderly patients with ARF has more than one diagnosis, i.e. a BNP greater than 500 pg/ml strongly suggests CHF, but other diagnosis that could have precipitated CHF. CXR: chest X-ray; EKG: electrocardiogram; ABG: arterial blood gas analysis; CHF: congestive heart failure; ACS: acute coronary syndrome; CT: computed tomography; IV: intravenous; NIV: non-invasive ventilation including continuous positive airway pressure; ACEi: angiotensin converting enzyme inhibitor; EC: echocardiography.

How could we improve outcomes of ARF in elderly patients?

Studies suggested that an inappropriate diagnosis and treatment were associated with an increased mortality rate [Figure 1(b)] [3, 18]. Usual tools used to differentiate CHF from respiratory disorders are not very accurate, even the chest X-ray (CXR) in CHF [31] or the classical hypocapnia in PE [32]. Thus valid diagnostic tools for differentiating CHF from other etiologies of ARF could aid clinicians.

Usefulness of transthoracic echocardiography

Echocardiography (EC) should be encouraged because the diagnosis of systolic CHF can be easily confirmed by the emergency physician [33, 34]. However non-systolic CHF is more difficult to evaluate by EC, and needs Doppler and myocardial tissue imaging (see Appendix 1 in the supplementary data on the journal’s website http://www.ageing.oxfordjournals.org) [35].

Role of B-type natriuretic peptides

BNP is a polypeptide, released by ventricular myocytes directly proportional to wall tension, for lowering renin-angiotensin-aldosterone activation. In the blood, the cleavage of a precursor protein produces BNP and the biologically inactive NT-proBNP. For diagnosing CHF, both BNP and NT-proBNP have similar accuracy [36, 37] (see Appendix 1 in the supplementary data on the journal’s website http://www.ageing.oxfordjournals.org). However, threshold values are higher than in middle-aged population. A study demonstrated that the use of BNP in patients >70 years early in the ED reduced the time to discharge, total treatment cost, and 30-day mortality. Figure 2 shows a diagnostic strategy based on BNP in elderly patients admitted for ARF in the ED [38, 39].
Inflammatory markers

Diagnosing CAP is difficult and urgent because it requires prompt antibiotics [40]. Thus, biological markers such as C-reactive protein (CRP) and procalcitonin (PCT) may be useful to suggest bacterial infection [41]. PCT seems to be more sensitive and specific than CRP, with an additional prognostic value [42]. Several studies suggested that, in a middle-aged population with suspected CAP or COPD exacerbation, PCT guidance of antibiotic use had no adverse effect [43]. However, in elderly patients Strucker et al. have found that it had a low sensitivity (24%) for infection [44].

Potential usefulness of thoracic imaging

When PE is suspected, thoracic computed tomography (CT) is now one of the first line investigations (see Appendix 2 in the supplementary data on the journal’s website http://www.ageing.oxfordjournals.org, Figure 2) [45]. Furthermore, thoracic CT is useful in determining alternate diagnoses (pneumonia or CHF missed on CXR). In case of unknown ARF, we recommend to begin with parenchymal windows to diagnose obvious CHF or pneumonia, following by contrast injection to rule in PE; if the parenchymal windows do not explain the clinical picture [46, 47]. However, physicians should be aware of the risks taken in performing helical CT scan [48].

Lung ultrasound could also be useful, but needs further evaluation [49, 50].

Treatment of ARF

Medical and social aspect

Most emergency physicians do not have the expertise to comprehensively address the myriad of needs of elderly patients with complex chronic illnesses (for example, in the EPIDASA study, 45% of the patients had previous cardiac disease and 26% chronic respiratory disease [3]) and daily treatments (in one study, the average number of drugs taken by elderly patient was 4.2 [51]). Furthermore, polypharmacy may affect the respiratory and cardiac systems (for example, β-blockers prescribed for hypertension have an effect on lung function). A multi-disciplinary care model, involving emergency physicians, gerontologist physicians, nurses, clinical pharmacist, social worker, family doctor should be encouraged [26].

Oxygen therapy

Hypoxaemic patients with ARF need oxygen supplementation as the first stage of treatment. However, studies suggested that injudicious use of oxygen therapy is associated with increased hypercapnia in COPD patients [52]. Thus, it is important that, emergency physicians aim at providing an oxygen saturation >90%, and check blood gases 30 min after starting oxygen in COPD patients [53].

Management of pneumonia in the elderly

Previous studies showed the important role of silent aspiration and the low prevalence of Legionella sp., Chlamydia and Mycoplasma pneumoniae in CAP [9]. Strepococcus pneumoniae is the most common cause of CAP in the elderly. Conversely, gram-negative bacilli (Klebiella, Pseudomonas sp, Escherichia coli, and others) account for half of all the culture-diagnosed pneumonias in nursing-home acquired pneumonia. Recommendations for anti-microbial drug use depend on the suspected specific organism, and guidelines [54, 55]. The main objective is to start antibiotics as early as possible since antibiotic administration within 4 h of hospital arrival is associated with a lower 30-day mortality [56]. Recently, it was suggested that the SOAR score (based on systolic blood pressure, oxygenation, age and respiratory rate) was an alternative criteria for a better identification of severe CAP in advanced age where both raised urea level above 7 mmol/l and confusion are common [57].

Pharmalogical treatment of CHF

Classically, medical treatments of CHF consisted of diuretics, and morphine, based on the ‘inappropriate’ concept that CHF is caused by fluid accumulation rather than fluid redistribution. Nitrate conveys both venodilatation (reducing right and left ventricular preload and reducing pulmonary venous pressure directly) and arterioldilatation (reducing the afterload mismatch and therefore increasing cardiac index). Cotter et al. [58] demonstrated that boluses of high-dose isosorbid dinitrate improved outcome compared to repeated high-doses furosemide [58]. Sacchetti et al. [59] demonstrated that morphine sulfate use in the ED was associated with an increased ICU admission and endotracheal intubation, whereas captopril sublingual use was associated with a decreased ICU admissions, and a decreased need for endotracheal intubation. Considering the fact that 50% of the elderly with CHF have preserved systolic function [60] and that nearly two thirds present with hypertension, nitrate should be preferred [61]. Rapid determination of whether there is a systolic or non-systolic CHF is important because the etiologies and pharmalogical treatment are different (see Appendix 1 in the supplementary data on the journal’s website http://www.ageing.oxfordjournals.org) [62].

Potential role of non-invasive ventilation by a face mask

In acute COPD exacerbations, non-invasive positive-pressure ventilation (NPPV) decreases PaCO2 by unloading the respiratory muscles and supplementing alveolar ventilation. Several trials and meta-analysis support the use of NPPV by reducing ventilator associated pneumonia, intubation, duration of ICU stay, and mortality [13]. The few studies on NPPV suggest that the response of middle-aged patients with acidic COPD exacerbations to NPPV may extend to the geriatric population. In CHF, NPPV improves oxygenation, reduces work of breathing, and may prevent intubation,
and decrease mortality [63]. One study demonstrated that, compared to medical treatment, continuous positive airway pressure (CPAP) decreased respiratory rate, decreased PaCO₂, and improved oxygenation compared with baseline in elderly patients with hypoxaemic CHF [64]. However, the in-hospital mortality (28% versus 30%) was not different. There is no difference in outcome between NPPV and CPAP for CHF [65].

**Conclusion**

CHF is the most common cause of ARF in the elderly but half of the patients had more than two diagnoses. As inappropriate treatment is associated with increased morbidity and mortality, accurate diagnostic tools, such as BNP, should be available in an ED 24 h a day. We should consider non-invasive ventilation (NIV) in elderly patients hospitalised with acidic COPD exacerbations or CHF who do not improve with medical treatment. ICU admission decisions should not be based on age alone but on factors such as the patient’s baseline level of function and co-morbidities, severity of illness, and preferences for life support.

**Key points**

- Causes of ARF in the elderly are often difficult to diagnose.
- A misdiagnosis in the ED is associated with increased morbidity and mortality.
- Use of BNP or NT-proBNP for suspected CHF improves diagnostic accuracy and outcome.
- NIV should be an option for severe CHF or COPD exacerbation.

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**Conflict of interest**

None

**Supplementary data**

Supplementary data for this article are available online at http://ageing.oxfordjournals.org.

**References**

(Due to the large number of references, only 40 are listed below and are represented by bold type throughout the text. The full list can be found in the supplementary data online, on the journal website http://www.ageing.oxfordjournals.org as Appendix 3.)


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