Asthma and chronic obstructive pulmonary disease in the intensive care unit

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Abstract

There are many pitfalls in the management of patients with asthma or chronic obstructive pulmonary disease, especially when their condition becomes severe enough to warrant intensive care unit level care. Mortality in both groups remains significant. Standard principles of oxygen and drug administration and mechanical ventilation technique used for typical critically ill patients can all cause problems. Recognition of the presence of airflow obstruction, the potential for dynamic hyperinflation and careful alteration of the principles and targets of therapy are required to avoid complications. In this article we examine the nature and scope of the challenge facing intensivists, highlighting difficulties in management and outlining specific strategies to aid in managing both conditions.

Keywords Asthma; COPD; dynamic hyperinflation; invasive mechanical ventilation; non-invasive ventilation

Learning objectives

After reading this article you should be able to:

- outline the medical management of acute exacerbations of chronic obstructive pulmonary disease (COPD) and asthma
- list the appropriate initial investigations of an exacerbation of asthma or COPD, interpret their results, and initiate appropriate interventions such as non-invasive ventilation (NIV)
- understand the limitations of NIV and describe features in patients who are failing treatment or likely to fail treatment with NIV
- list specific complications associated with intubation and mechanical ventilation in patients with these conditions, and know how to appropriately manage these complications if they arise
- utilize appropriate ventilation strategies to minimize complications commonly associated with the intubated COPD or asthma patient.

Demographics and medical treatment

Asthma and chronic obstructive pulmonary disease (COPD) are conditions characterized by airflow limitation which when sufficiently severe, mandates critical care management. Mortality from COPD is increasing worldwide, exacerbations of COPD are triggered by infection (50%) and episodes of heart failure (25%) but in others no obvious cause is identified. COPD also commonly presents as a co-morbidity of another illness where mechanical ventilation is required, such as major elective or emergency surgery, or trauma.

There is also an increasing prevalence of asthma amongst populations worldwide, with significant morbidity and impact on quality of life.[1] Mortality accounts for approximately 1 in 250 deaths worldwide.[1] The prevalence of asthma is highest amongst first world countries.[1] Mortality remains significant with approximately 1500 (0.3%) deaths per year in England and Wales attributed to acute exacerbations. Acute asthma attacks are attributed to a variety of causes including antigen exposure, non-specific irritants (cold air, smoke, pollution), anxiety and unknown factors (up 25% of acute attacks).

Guidelines written and published by various expert bodies (British Thoracic Society (BTS), National Asthma Council of Australia) have been well implemented in primary care, leading to a diminishing burden on acute hospital services. These guidelines can easily be accessed online and are simple to understand and implement. Their key components include earlier recognition of asthma severity, more widespread use of inhaled steroids, and pre-set plans to ensure prompt treatment of exacerbations.

There are comparable and excellent resources guiding the medical management of COPD (Global Initiative for Chronic Obstructive Lung Disease, BTS). In either case it is important that these medical measures are instituted as soon as an exacerbation of either condition is identified.

Involvement of critical care services and the use of non-invasive ventilation (NIV)

Most referrals to critical care services centre on requests for consideration of ventilatory support in patients with severe presentation or patients who fail to improve despite optimal medical therapy. Non-invasive ventilation (NIV) has become a care standard in the management of acute exacerbations of COPD, with good evidence proving its role.[2] A large Cochrane meta-analysis demonstrated that NIV significantly reduced mortality and invasive ventilation rates and led to a shortened hospital length of stay. NIV improves respiratory physiology with improvements in both PaO_2 and $PaCO_2$.[2] Excellent, concise specific NIV guidelines exist,[3] focusing on the targeted use of NIV in patients with exacerbations of COPD and concomitant respiratory acidosis, which has failed to respond to optimal medical therapy.

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Acute hypercapnic respiratory acidosis may also be triggered or worsened by excess oxygen therapy in a patient subset whose chronic relative hypoxaemia is essential for stable ventilatory function. The majority of patients with severe COPD (FEV_1 <30% predicted), especially those with pre existing hypercapnia are at risk of an increasing $PaCO_2$ when oxygen therapy results in SpO_2 >95%. This is due to a combination of factors (Figure 1). Improvement may occur with titration of FiO_2 to a SpO_2 target of 88–92%. If an oxygen-induced rise in $PaCO_2$ has occurred in a patient with an exacerbation of COPD then hypercapnia may improve but not resolve when FiO_2 is reduced, such that NIV may still be necessary – hence the need for constant monitoring and regular review (Table 1).

The aims of NIV are to unload respiratory muscles, whilst augmenting ventilation and oxygenation, also offsetting the adverse effects of sleep on ventilation and airway resistance (Table 2).

There is a growing consensus, but no strong supporting evidence, that the judicious use of NIV in a critical care setting for severe acute asthma can obviate the need for invasive ventilation.[4]

NIV services will vary between hospitals, with emergency departments and respiratory physicians increasingly implementing treatment outside intensive care unit (ICU) settings. The application of NIV is a significant intervention, patients may deteriorate in spite of its institution, the evidence suggests it is best delivered in a dedicated critical care environment, where experienced staff can easily escalate care as required. In high-risk groups (Table 2) this type of setting is mandated.

Despite optimal medical management and the correct usage of NIV, a proportion of patients with COPD and acute asthma will still require endotracheal intubation for their respiratory failure (increasing respiratory acidosis, patient exhaustion, hypoxia, reduced conscious level or respiratory arrest). The life expectancy in patients with COPD falls with deteriorating FEV_1 and episodes of acute respiratory failure. Of all patients with COPD, those admitted to ICU for invasive ventilatory support have the highest mortality, even those patients who survive to discharge from ICU have a decreased life expectancy in comparison to the general COPD population. Careful consideration of any course of invasive treatment needs to be undertaken in patients who have severe COPD and end-stage lung disease (often in association with significant co-morbidity). This assessment should include age, severity of COPD, the presence of a reversible component and functional status. Functional status prior to the exacerbation is perhaps the most important factor; this often-omitted information should be carefully collected. Patients with severely limited mobility (housebound or worse) and compromised self-care (e.g. showering, dressing) may require limitation of full intensive care management. This limitation is most commonly to provide active non-invasive care including NIV, all drug, fluid, nutritional and physical therapies but not invasive ventilation. It may also include limitations on other life supports systems such as renal replacement therapy and inotropic support.

Ventilation and dynamic hyperinflation

The primary challenge in the ventilation of patients with COPD or severe asthma is that of dynamic hyperinflation (DHI). Incomplete expiration of inspired gas (gas trapping), due to slow expiratory airflow and airway closure, leads to increased end-expiratory lung volume.[5] When DHI is excessive, this can lead to compromise of cardiac output, circulatory collapse and increase the risk of pneumothorax.[5,6] The three primary determinants of DHI are (i) the severity of airflow obstruction (the expiratory

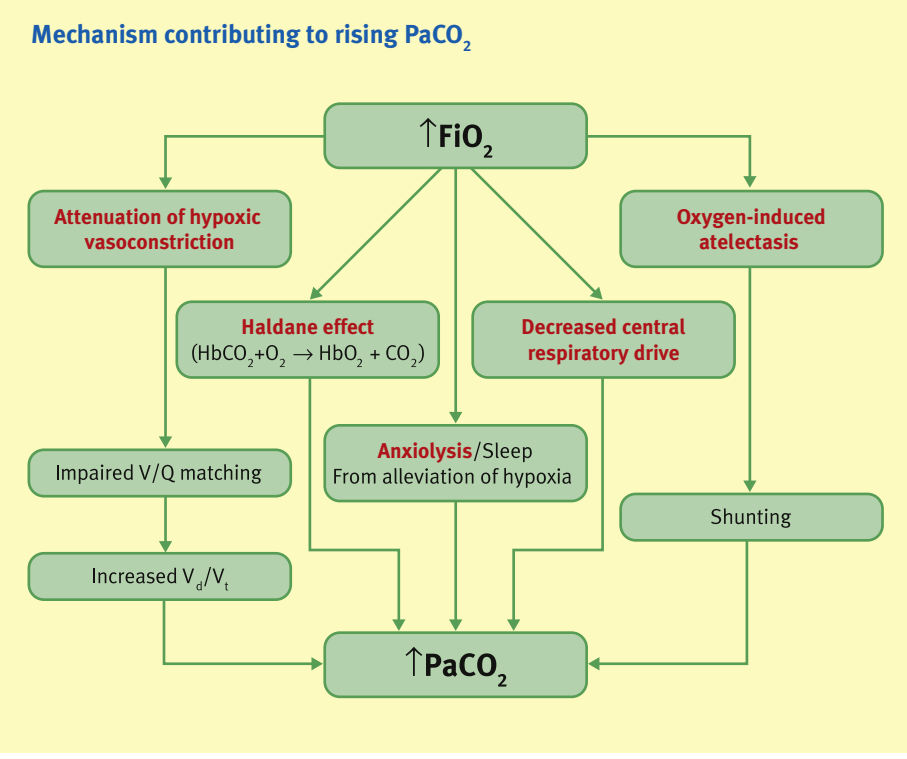

Figure 1 Mechanisms contributing to rising $PaCO_2$ as a result of excessive oxygen therapy, five major causes in red.