Reviews

The Role of Invasive Ventilation in Exacerbations of Chronic Obstructive Pulmonary Disease Causing Respiratory Failure.

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Abstract

Acute hypercapnic respiratory failure in chronic obstructive pulmonary disease can usually be managed initially with medical treatment and non- invasive ventilation. In circumstances where non- invasive ventilation cannot be used or has failed, intubation and invasive ventilation may be lifesaving. The outcome of patients with an exacerbation of COPD requiring invasive ventilation is better than often thought, with a hospital survival of 70-89%. Decisions regarding invasive ventilation made by physicians and patients with COPD are unpredictable and vary with the individual. This article reviews the role of invasive ventilation in exacerbations of COPD to assist decision making.

Keywords

Chronic obstructive pulmonary disease, non-invasive ventilation, invasive mechanical ventilation, respiratory failure, decision-making.

Introduction

Chronic obstructive pulmonary disease (COPD) is characterised in its later stages by acute decompensation or exacerbations, typically up to three times a year.[1,2] Mechanical ventilation for respiratory failure during an exacerbation of COPD can be life-saving. A decision to intubate and ventilate must be balanced by patient's wishes if they are known, the discomfort the patient will endure, the chance of survival, the future quality of life of the patient and the availability of resources. COPD is a major global public health problem with numbers of patients predicted to increase.[3] Increasingly, physicians are called upon to decide policy on ventilating patients with COPD.

Respiratory Failure

An exacerbation of COPD is an acute decompensation that can result in respiratory failure. Exacerbations are characterised by increased dyspnoea, often accompanied by increased cough, sputum purulence and sputum volume.[3,4] Common causes of an exacerbation are infections of the tracheobronchial tree and air pollution.[5] In one third of severe exacerbations a cause cannot be identified.[3]

An exacerbation of COPD is associated with airway inflammation, mucous plugging and bronchospasm resulting in worsening airway obstruction. Airway obstruction leads to a prolonged expiratory time constant. This, with an increased ventilatory requirement and a shortened expiratory time results in dynamic pulmonary hyperinflation.[6] The respiratory muscles are at a mechanical disadvantage because of hyperinflation[7] and may be weak from malnutrition or steroid use.[8] In addition, oxygen therapy can blunt hypoxic ventilatory drive and also increase ventilation perfusion mismatch by increasing the flow of blood through poorly ventilated parts of the lung. As respiratory failure develops the consequent acidosis further compromises respiratory muscle function. Acute respiratory failure is reflected in the arterial blood gases with an elevated partial pressure of carbon dioxide (pCO_2>6.0 kPa) and acidosis (pH<7.35).

Medical therapy

Controlled oxygen therapy and medication have important roles in treating respiratory failure from an exacerbation of COPD. Oxygen corrects hypoxia and potentially relieves pulmonary vasoconstriction and right heart strain. Controlled oxygen should be administered by a Venturi mask in low concentration (24% or 28%) to prevent blunting of hypoxic drive and worsening of hypercapnia.[9,10] Inhaled bronchodilators such as beta agonists and anticholinergics show similar FEV1 improvements during exacerbations, but their use in combination has not been found to have added benefit.[11] Although commonly used, aminophylline does not improve FEV1 during COPD exacerbations and has side effects including nausea, vomiting, arrhythmias and seizures. A systematic review did not support the routine use of aminophylline or other methyl-xanthines in COPD exacerbations.[12] Systemic corticosteroids improve lung function during an exacerbation of COPD and reduce the rate of relapse.[13] If hypercapnic acidosis ensues then artificial ventilation should be considered early.

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The Role of Invasive Ventilation in Exacerbations of Chronic Obstructive Pulmonary Disease Causing Respiratory Failure.

Invasive and non-invasive ventilation

Up until the 1980s, invasive mechanical ventilation was commonly used as the main form of ventilatory support for patients with acute hypercapnic respiratory failure due to an exacerbation of COPD. Invasive ventilation requires endotracheal intubation, sedation and ventilation in an intensive care setting. Invasive mechanical ventilation assists patients with hypercapnic respiratory failure in COPD by resting respiratory muscles, reducing the work of breathing, improving alveolar ventilation and gas exchange. It allows time for pharmacological and other interventions to take effect. Reducing dynamic hyperinflation is integral in the strategy to ventilate patients with exacerbations of COPD. Reducing dynamic hyperinflation in patients being ventilated can be achieved by controlled hypoventilation, setting a prolonged expiratory time and adding positive end expiratory pressure (PEEP).[14] Adding PEEP reduces the work of breathing by preventing small airway collapse and overcoming the high elastic threshold load that is imposed on the respiratory muscles at the beginning of inspiration.[15]

In the 1980s and 1990s non invasive intermittent positive pressure ventilation (NIPPV) was proven to be an effective first line treatment for respiratory failure in COPD and a means of avoiding invasive mechanical ventilation. NIPPV is delivered by a face or nasal mask attached by tubing to a ventilator, which is often small and portable. The patient usually triggers a ventilated breath. NIPPV has the advantage of being used without the requirement for sedation and endotracheal intubation and can be used on wards outside an intensive care unit. A meta analysis of studies of patients with exacerbations of COPD, compared NIPPV to usual medical care.[16] It found treatment with NIPPV improved arterial blood gases and pH, decreased the need for invasive mechanical ventilation and intubation, reduced complication rates, decreased the length of hospital stay and reduced in-hospital mortality. The lower mortality rate of patients with exacerbations of COPD treated with NIPPV compared to usual medical care appears to be due to improved care over traditional medical management and from the avoidance of complications associated with invasive ventilation. Invasive ventilation can be complicated by pneumonia,[17] gastric insufflation, gastrointestinal bleeding,[18,19] deep vein thrombosis and barotrauma.[20,21] Failure to wean from invasive mechanical to spontaneous ventilation can also be a clinical challenge.[22]

There have been few studies comparing invasive mechanical ventilation and NIPPV head to head. Patients requiring immediate invasive mechanical ventilation were excluded in most trials using NIPPV for respiratory failure. Conti and colleagues[23] reported a prospective randomised control trial of NIPPV versus endotracheal intubation and mechanical ventilation of 49 patients with COPD who had failed medical treatment and required ventilatory support. The two groups were matched in age, degree and cause of respiratory failure. In the 48% that could be managed successfully with NIPPV there was improved hospital survival, reduced complication rate and shorter hospital stay compared to the group invasively ventilated. However, it is likely the better result in those using NIPPV was partly due to the more severe patients in the NIPPV group being intubated.

In those patients treated with NIPPV, there is at least a 20% failure rate.[8,24] NIPPV is less likely to be successful in patients who are severely acidotic (pH<7.26), tolerate it poorly, have an associated complication or poor premorbid condition.[24,25,26,27] Late application of NIPPV reduces the likelihood of success by allowing acidosis and encephalopathy to develop. In the early hours of NIPPV use, an improvement in the patient's arterial blood gases and respiratory rate and tolerance of NIPPV predict a good outcome. Patients failing NIPPV usually require invasive mechanical ventilation in order to survive. Late failure, defined as worsening respiratory failure occurring after 48 hours of initiating NIPPV, has been found to have a poor prognosis with more than half of patients dying despite subsequent intubation and mechanical ventilation.[24] Elliot reasons that a distinction needs to be made between failure of the non-invasive interface and failure of ventilation.[28] Failure of ventilation implies a change of interface from non-invasive mask to endotracheal tube is less likely to be successful.

Indications for Invasive Mechanical ventilation

Patients with acute respiratory failure due to COPD and hemodynamic instability, life threatening acid base disturbance or altered mental status usually require invasive mechanical ventilation.[3,29] Hypercapnea may cause confusion and make NIPPV poorly tolerated by the patient. As hypercapnia worsens a patient's reduced level of consciousness may necessitate airway protection with an endotracheal tube. **Figure 1** summarises indications for invasive mechanical ventilation and exclusion criteria for NIPPV.[3]

Prognosis and Factors Predicting Survival.

It is commonly believed patients with COPD requiring intubation and invasive ventilation have poor survival. In fact, the hospital mortality for patients requiring invasive ventilation for an exacerbation of COPD is between 11% and 30%.[30-35] This is approximately the same or better than other diseases such as pneumonia and congestive cardiac failure requiring intubation.[32,36] Median time of intubation was 2-10 days. This misconception may lead to inappropriately conservative clinical decision making. However clinicians should take full account of severe co-morbidity and social dependence.

Patient survival in these trials is dependent largely on the severity of COPD in patients selected for invasive ventilation and prior use of NIPPV. In the 3 most recent studies, the mean forced expiratory volume in one second (FEV1) was 0.74, 0.96 and 0.74 litres respectively.[32, 33, 35] The mean acute physiology and chronic health evaluation (APACHE II) scores were between 19-22. All included

The Role of Invasive Ventilation in Exacerbations of Chronic Obstructive Pulmonary Disease Causing Respiratory Failure.

Indications for invasive mechanical ventilation

- Severe dyspnoea with use of accessory muscles and paradoxical abdominal motion.
- Respiratory frequency > 35 breaths per minute.
- Life-threatening hypoxemia (PaO2 < 5.3kPa, 40mm Hg or PaO2/FiO2 < 200mmHg.)
- Severe acidosis (pH > 7.25) and hypercapnia (PaCO2 > 8.0 kPa, 60mm Hg).
- Respiratory arrest.
- Somnolence / impaired mental status.
- Cardiovascular complications (hypotension, shock, heart failure).
- Other complications (metabolic abnormalities, sepsis, pneumonia, pulmonary embolism, barotrauma, massive pleural effusion).
- NIPPV failure or exclusion criteria (see below).

Exclusion criteria for NIPPV (any may be present)

- Respiratory arrest.
- Cardiovascular instability (hypotension, arrhythmias, myocardial infarction).
- Somnolence / impaired mental status / uncooperative patient.
- High aspiration risk: viscous or copious secretions.
- Recent facial or gastroesophageal surgery.
- Craniofacial trauma, fixed nasopharyngeal abnormalities.
- Burns.
- Extreme obesity.
- Untreated pneumothorax

Table 1. Indications for invasive mechanical ventilation and exclusion criteria for non-invasive intermittent positive pressure ventilation. (modified from GOLD).[3]

varying numbers of patients on home oxygen and who were housebound. In one study, approximately two thirds of patients had very severe COPD and used home oxygen, with 70% surviving to be discharged from hospital after a mean intubation time of 10 days.[35] Patients in earlier studies of invasive ventilation in COPD, performed before the of use NIPPV[31, 34] had a better prognosis compared to those studies which included patients that had failed NIPPV.[32, 33, 35]

Long term survival of patients with COPD is not affected by an episode of respiratory failure requiring invasive ventilation. The long term mortality rate for these survivors returns to the background rate for patients with equivalent severity of COPD. Overall about two thirds will be dead at 3 years.[32, 33]

Reliable outcome predictors have been difficult to identify. Recurring independent variables found in more than one study predicting increased hospital mortality are increased age, low serum albumin and high APACHE score.[31-34] Long term survival cannot currently be predicted at the time of intubation.[34, 35]

Attitudes of physicians and patients

Decisions regarding survival and ventilation for acute respiratory failure in COPD vary between physicians. A simulation study found consultants differ markedly in their decisions about admitting identical patients with COPD to intensive care.[37] Another survey comparing the attitudes of respiratory physicians, general physicians and intensivists towards ventilation in an exacerbation of COPD found no significant difference between these specialities[38] though there was great variation between individual physicians. The degree of inconsistency is cause for concern.

Patients with COPD also have varied attitudes towards ventilation and their views cannot be predicted. In a survey of 100 outpatients with stable COPD, 48 wanted all additional treatment, including NIPPV, invasive ventilation and cardiopulmonary resuscitation if needed.[39] There was no statistical difference between age, sex, spirometry, hospital admissions, quality of life scores, use of long term oxygen therapy (LTOT) or antidepressants. In a survey of 101 patients with severe COPD on long term oxygen, a preference for ventilation was not influenced significantly by health related quality of life or depression.[40] Refusal of resuscitation was significantly higher in the depressed group compared to the non-depressed group.

The majority of patients with stable COPD thought the issue of ventilation and cardiopulmonary resuscitation should be discussed in outpatient clinics.[36] This mirrors attitudes of elderly patients studied, the majority supporting the routine discussion of resuscitation.[41,42] In a group of 40 outpatients with stable COPD patients 14% had discussed the issue of resuscitation and ventilation with their doctor.[43] However, an advanced directive regarding ventilation written in outpatients becomes problematic if, during an exacerbation, a patient wishes to change their mind or if the treating physicians or close relatives have different views to those of the patient.

Summary

The majority of patients with an exacerbation COPD causing respiratory failure will be adequately treated with medical therapy and NIPPV. NIPPV should be started early to avoid higher failure rate associated with worsening acidoisis. There is usually a rapid improvement in the first hours of NIPPV use. A decision should be made when

The Role of Invasive Ventilation in Exacerbations of Chronic Obstructive Pulmonary Disease Causing Respiratory Failure.

initiating NIPPV as to whether intubation would be considered if NIPPV fails. The decision needs to account for the patient's wishes, quality of life and prognosis. Patients who have had a respiratory arrest, are haemodynamically unstable, agitated or unconscious will usually need intubation at the outset if they are to survive. The hospital outcome for NIPPV is better than that of invasive ventilation. However, the outcomes following intubation and invasive ventilation for an exacerbation of COPD are much better than many clinicians believe. The long term outcome of COPD is reflected by the severity of COPD and does not appear effected by an episode of respiratory failure requiring invasive ventilation.

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