COMMENTARY

Harms of overoxygenation in patients with exacerbation of chronic obstructive pulmonary disease

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Annual costs related to admissions to hospital for acute exacerbation of chronic obstructive pulmonary disease (COPD) were reported in 2007 at $750 million.[1] Acute exacerbation of COPD is still the primary reason for an adult hospital admission in Canada. A decade later, new data from the Ottawa Hospital, which spent about $20 million on first-time admissions for COPD (n = 1894) over four years, has shed more light on the reasons for this cost burden.[2] The highest costs were for patients with COPD who were admitted to the intensive care unit (ICU), with a substantial association between costs and elevated partial pressure of carbon dioxide in arterial blood ($Paco_2$). Uncompensated elevated $Paco_2$ causes respiratory acidosis, and acidemia can be deadly.[3] It may seem intuitively right to put a "blue" patient on a high concentration of inspired oxygen (Fio_2). However, high Fio_2 has been shown to be dangerous for patients with COPD, and guidelines advise against its use. Yet this dangerous practice continues, putting patients at risk of loss of life and using substantial health system resources.

Dangers of using high Fio_2 for patients with COPD were well-documented 60 to 70 years ago.[4] Two more recent audits of COPD admissions in the United Kingdom that involved 983 and 9716 patients, respectively,[3,5] reported associations between acidosis and the use of high Fio_2. Moreover, the need for ventilatory support (in one in five patients) and high in-hospital mortality (11%) followed use of high-flow oxygen.[3] For patients with COPD, insufficient respiratory effort and/or inadequate alveolar ventilation, in a setting of uncontrolled oxygen delivery (where the precise Fio_2 is unknown) can result in dangerous levels of both oxygen and carbon dioxide.

Physiologic mechanisms linking a raised Fio_2 to hypercapnia are described in Appendix 1, available at www.cmaj.ca/lookup/suppl/doi:10.1503/cmaj.170196/-/DC1. For example, if a patient were to be placed on a 100% oxygen nonrebreather mask for an extended period in response to an episode of distress and hypoxemia, $Paco_2$ might reach more than 150 mm Hg, partial pressure of oxygen in arterial blood (Pao_2) might reach more than 250 mm Hg, and severe acidosis will occur with pH near 7.0. If this situation is present, patients like this can die a preventable iatrogenic death. Nevertheless, potential sources of high concentrations of uncontrolled oxygen (e.g., the 100% nonrebreather mask and nasal prongs) are commonly used during hospital transfers, and treatment within emergency departments and in hospital wards. Nasal prongs provide uncontrolled oxygen by delivering pure oxygen to the nose without controlling the concentration. Partial pressure of oxygen (PAo_2) in the alveoli in a patient will depend on how much air is inspired simultaneously with the oxygen supplied by nasal prongs.

Before the British Thoracic Society guideline for emergency use of oxygen in adults that was published in 2008,[6] professional society guidelines for acute exacerbation of COPD focused little attention on the delivery of oxygen, although a 2003 Canadian Thoracic Society guideline had recommended a Pao_2 of 60 mm Hg during acute exacerbation of bronchitis. Building on the study of the prevalence

KEY POINTS

- Too much oxygen can be dangerous for patients with chronic obstructive pulmonary disease (COPD) with (or at risk of) hypercapnia (partial pressure of carbon dioxide in arterial blood greater than 45 mm Hg).
- Despite existing guidelines and known risk, patients with hypercapnia are often overoxygenated.
- Nasal prongs deliver pure oxygen to the nose, and patient factors (dead space and alveolar ventilation) determine final concentration at the alveolar level, thus use of nasal prongs can be dangerous in the context of acute exacerbation of COPD.
- A "safe sats" strategy (oxygen saturation by pulse oximetry of 88% to 92%) that involves oxygen alert cards for hypercapneic patients, provision of Venturi masks and entering at-risk patients into an emergency health services database may avoid many episodes of iatrogenic acute hypercapnia and reduce overall morbidity, mortality and costs related to respiratory acidosis.

of acidosis in the UK,[5] the British Thoracic Society recommended a target oxygen saturation by pulse oximetry (Spo_2) of 88% to 92% for patients known to be or at risk of becoming hypercapneic. Subsequently, a randomized controlled trial in Australia (involving 405 patients with known or suspected acute exacerbation of COPD), in which ambulance crews were randomly assigned to provide targeted Spo_2 of 88%–92% or usual care with uncontrolled oxygen, reported lower mortality (odds ratio 0.22, 95% confidence interval 0.05–0.91) and near normal pH among patients with COPD who received targeted Spo_2.[7]

A recent retrospective chart review in Halifax found the prevalence of hypercapnia with overoxygenation to be one in five among 89 patients who were subsequently enrolled in the INSPIRED COPD Outreach Program, which rose to one in two among 29 patients transferred to the ICU or intermediate care settings for bilevel positive airway pressure.[8] Currently, hypercapneic patients within the INSPIRED program are issued an oxygen alert card and registered in the Emergency Health Services "at-risk" database, which recommends that paramedics provide a target Spo_2 of 88% to 92% using the patient's own Venturi mask (provided through the INSPIRED program). Venturi masks deliver controlled oxygen at known concentrations via valves that are colour coded for a specific percentage of oxygen (e.g., 24% or 28%). A subsequent audit confirmed high compliance with this strategy within the emergency department at the Halifax Infirmary.[8]

For patients with acute exacerbation of COPD, most hospital journeys begin with transportation by emergency health services. Recently, we conducted telephone interviews with ambulance services in five Canadian provinces (New Brunswick, Prince Edward Island, Saskatchewan, Ontario and Alberta) and determined that, despite awareness of the need for caution with oxygen delivery, none of the services used Venturi masks or had any standards or guidelines for care of hypercapneic patients. Target saturations for four provincial services (New Brunswick, Prince Edward Island, Saskatchewan and Ontario) exceeded the ranges recommended above. Ontario has a COPD-related standard for emergency services within the Basic Life Support Patient Care Standards;[9] however, it is not in alignment with advice from professional societies. The standard for oxygen therapy in general is a target of 92% to 96%. Ontario's standard recommends the following for patients with COPD "… increase oxygen by increments of two litres per minute above starting level approximately every two to three minutes if the patient's status deteriorates or the patient indicates they feel worse; and … be prepared to ventilate."[9] Our emergency health services teams are not to blame. Evidence-based guidance and proper training for emergency health services teams are required. Other health care providers have expressed concerns about lack of training and equipment for safe delivery of oxygen.[10] However, even when guidelines for safe use of oxygen have been introduced, uptake has been slow.[10]

The guideline published in 2004 by the National Institute for Clinical Excellence in the UK affirmed that the aim of oxygen therapy for patients with COPD is to maintain adequate oxygenation without precipitating respiratory acidosis or worsening hypercapnia.[11] Target saturations of 88% to 92% for this patient group are recommended currently by the British Thoracic Society[6] and the 2017 Global Initiative for Chronic Obstructive Lung Disease report for treatment of hypoxia in acute exacerbation of COPD.[12]

The faithful practice of "safe sats" would likely avoid many episodes of iatrogenic acute hypercapnia and reduce overall morbidity, mortality and costs related to respiratory acidosis for patients with COPD. Placing patients with a known elevation of $Paco_2$ on a local ambulance service registry for target Spo_2 of 88% to 92% using an inexpensive ($3.00) Venturi mask and following that advice on arrival in hospital could prove to be a simple and cost-effective strategy.

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