Commentary

Helium oxygen mixtures in the intensive care unit

Jean-Claude Chevrolet

University Hospital, Geneva, Switzerland

Correspondence: Jean-Claude Chevrolet, chevrole@cmu.unige.ch

Published online: 13 July 2001
Critical Care 2001, 5:179–181
© 2001 BioMed Central Ltd (Print ISSN 1364-8535; Online ISSN 1466-609X)

Abstract

Heliox, a mixture of helium and oxygen, has a density that is less than that of air. Breathing heliox leads to a reduction in resistance to flow within the airways, and consequently to a decrease in the work of breathing (WOB), particularly in disorders that are characterized by increased airways resistance. Beneficial effects have been observed in patients with asthma, chronic obstructive pulmonary disease (COPD), bronchiolitis, bronchopulmonary dysplasia and upper airways obstruction. Until we have conclusive data that attest to the efficacy of heliox in such conditions, its use will remain controversial. Meanwhile, it appears wise not to incorporate heliox therapy into routine practice because of technical complications and high costs.

Keywords helium, heliox, mechanical ventilation, work of breathing

Human airways are complex tubes, and airflow in a tube may occur in a laminar, a transitional or a turbulent manner [1]. Reynolds number can approximately predict the nature of flow [2]. Flow characteristics are determined by complex interplays between many different factors, including the branching patterns of trachea and bronchi, the diameter of the conduits, the angles of branching, and the degree of roughness of the walls. The flow characteristics in the airways may also vary depending on the inspiratory and expiratory flow rates [2,3].

During quiet breathing in normal humans, a transition from turbulent to laminar flow occurs through the trachea to around the second generation of bronchi. In patients with airways obstruction, however, turbulent flow occurs very frequently, even in low breathing rates and quiet breathing patterns [4]. This leads to increased work of breathing (WOB).

Breathing helium decreases work of breathing

In turbulent flows, the pressure necessary to generate a given flow rate is dependent on the density of the inspired gases [4,5]. Helium has a density that is significantly lower than that of air [4]. Therefore, a mixture of helium and oxygen, termed heliox, has a lower density than does a mixture of nitrogen and oxygen (air, or airox) [6,7]. Breathing heliox leads to a reduction in resistance to flow within the airways, and consequently to a decrease in the WOB, particularly in disorders that are characterized by increased airways resistance [8]. These beneficial effects have been observed in a few patients with asthma, chronic obstructive pulmonary disease (COPD), bronchiolitis, bronchopulmonary dysplasia and upper airways obstruction [9]. Heliox has not only been used in patients breathing spontaneously, but also in the settings of both invasive mechanical ventilation (ie with tracheal intubation) [10] and noninvasive mechanical ventilation (NIV) [11,12]. Nevertheless, the usefulness of heliox in the intensive care unit remains debatable.

The controversy regarding the use of heliox

Upper airways obstruction

In upper airways obstruction, heliox appears to be a reasonable option in severe respiratory distress that results from upper airways obstruction [13]. The gas mixture may allow the intensivist to 'buy time' while awaiting treatment that is aimed at alleviating the obstruction. Of course, helium per se has no curative action [9,14], and COPD = chronic obstructive pulmonary disease; NIV = noninvasive mechanical ventilation; WOB = work of breathing.
in a randomized protocol in children with moderate upper airways obstruction [15] there was no difference between heliox and racemic epinephrine (adrenaline) in alleviating symptoms.

**Acute asthma crisis**

There is controversy regarding the use of heliox in acute asthma crisis. In a meta-analysis of four randomized controlled trials performed in children and adults presenting at the emergency room with moderate to severe asthma [16], there was no evidence favouring the use of heliox. However, there are several studies (randomized protocols) that reported findings in favour of heliox in acute severe asthma [17–19], showing a more rapid decrease in pulsed paradoxus and in airflow obstruction with helium than with air oxygen mixtures in nonintubated patients. As in upper airways obstruction, there is no curative effect of heliox in asthma crisis, and in no circumstances should heliox replace aggressive bronchodilator and corticosteroid therapy [9].

Our present policy is that, in acute severe asthma in spontaneously breathing patients, heliox can be given after failure of the initial bronchodilator therapy. In so doing we aim to avoid intubation, which (as reported by many authors [20,21]) is a dangerous procedure, particularly in asthmatic persons. Heliox has also been used in intubated asthma patients, and an improvement in blood gases with a reduction in inflation pressure was observed [22]. From a practical standpoint, we usually restrict the use of heliox to patients who are difficult to ventilate, with high inflation pressures and haemodynamic instability.

**Chronic obstructive pulmonary disease**

Heliox has been used in both nonintubated and intubated COPD patients. NIV has become the standard initial treatment in the majority of such patients [23]. COPD patients in acute decompensation are at risk for respiratory failure precipitated by an increase in their WOB, leading to inspiratory muscle fatigue. NIV decreases the WOB in these patients [24]. Therefore, it was hypothesized that the WOB associated with NIV could be further reduced by combining that form of ventilation with heliox. Two studies have been reported [11,12] that support this hypothesis. However, the proof that NIV with heliox is superior to NIV with an air–oxygen mixture in avoiding intubation in COPD patients is nevertheless lacking. We are aware of two ongoing multicentre trials in Europe that are attempting to resolve this issue. Until the results of those studies are resolved before we can begin to use this mixture of gas in ventilated patients [31,32].

Finally, even if helium is the second most abundant element in the universe, the extraction and processing costs on Earth are high. In Switzerland, a 60-l tank of 78:22 heliox pressurized at 200 Bars (10,000 l at atmospheric pressure) costs US$275. However, these high costs should be balanced against the benefits, such as improving patient outcome and reducing the duration of intensive care unit stay. Such issues should be addressed in further studies into heliox therapy.

**Competing interests**

None declared.

**References**

1. O’Grady K, Doyle DJ, Irish J, Gullane P: Biophysics of airflow within the airway: a review. J Otolaryngol 1997, 26:123–128.
2. Pedley T, Schroter R, Sudlow M: Gas flow and mixing in the airways. In: Bioengineering Aspects of the Lungs. Edited by West J. New York, Basel: Marcel Dekker; 1977:163–265.
3. Olson D, Dart G, Filley G: Pressure drop and fluid flow regime of air inspired into the human lung. J Appl Physiol 1970, 28:482–494.
4. Otis A, Bembower W: Effect of gas density on resistance to respiratory gas flow in man. J Appl Physiol 1949, 2:300–306.
5. Wood LD, Engel LA, Griffin P, Despas P, Macklem PT: Effect of gas physical properties and flow on lower pulmonary resistance. J Appl Physiol 1976, 41:234–244.
Darioli R, Perret C: 
Kass JE, Terregino CA: 
Kudukis TM, Manthous CA, Schmidt GA, Hall JB, Wylam ME: 
Brochard L, Mancebo J, Wysocki M, Lofaso F, Conti G, Rauss A: 
Mansel JK, Stogner SW, Petrini MF, Norman JR: 
Wolfson MR, Bhutani VK, Shaffer TH, Bowen FW Jr: 
Pingleton SK, Bone RC, Ruth WC: