

Heliox improves pulmonary mechanics in a pediatric porcine model of induced severe bronchospasm and independent lung mechanical ventilation

ABSTRACT

In a pediatric porcine model of acute, severe methacholine-induced bronchospasm and independent lung mechanical ventilation, administration of heliox improves pulmonary mechanics, gas flow, and ventilation. Administration of heliox should be considered for support of pediatric patients with acute, severe bronchospasm requiring mechanical ventilation through small artificial airways.

INTRODUCTION

Introduction In 1935, Barach first advocated helium-oxygen gas mixtures (heliox) as a therapy for obstructive lesions of the airway. Since then, heliox has been shown to be efficacious in the treatment of various disease entities involving narrowed airways. Its safety has been demonstrated in both mechanically ventilated and spontaneously breathing patients. Combining 70% helium and 30% oxygen results in a gas which is much less dense than a nitrogen-oxygen gas mixture (nitrox) and has approximately the same viscosity. The therapeutic effects of heliox gas mixtures are believed to relate to its ability to deliver oxygen and gas flow with less turbulence and resistance through narrowed airways. Since airway resistance is directly proportional to the density of the gas, the administration of heliox is expected to improve ventilation by decreasing resistance, reducing turbulence and promoting laminar gas flow. Although there have been advancements in the treatment of asthma since Barach first studied heliox in 1935, mortality continues to increase. The use of bronchodilators and anti-inflammatory agents have become the standard of care for reactive airway disease and asthma. However, some patients fail to respond to aggressive therapy and require mechanical ventilation. Mechanical ventilation may result in turbulent gas flow secondary to high gas velocity which may cause additional difficulty achieving adequate ventilation. Heliox may, therefore, be most effective in intubated patients with severe bronchospasm and small diameter airways by decreasing turbulent flow, improving ventilation and limiting barotrauma while therapies targeted to the underlying etiology of the bronchospasm are given time to achieve their effect. Several animal and human studies have investigated the effects of heliox on pulmonary function. Although results from these studies have been promising, the wide variation between each patient's biological response to bronchospasm make many of these results difficult to interpret. We have developed a pediatric porcine, independent lung ventilation model of severe bronchospasm which allows one of the animal's lungs to act as a simultaneous control for the contralateral lung. This unique model allows each subject to act as its own control during the same bronchospastic event, thereby minimizing influence from various systemic variable biological responses to acute stress and eliminating the need to compare matched control subjects or different bronchospastic events in the same animal. Our hypothesis is that, during mechanical ventilation, the low density heliox gas mixture will increase flow through constricted airways and improve pulmonary mechanics in the lung receiving heliox compared to the lung receiving nitrox.

CONCLUSION

In a pediatric porcine model of independent lung mechanical ventilation

and severe methacholine-induced bronchospasm, heliox improved pulmonary mechanics when compared to a nitrogen-oxygen gas mixture during mechanical ventilation at identical ventilator settings. This study also indicates that most subjects responded to heliox within the first 4min of therapy and that this response was sustained for at least 20 min. The authors speculate that heliox may be beneficial to critically ill children requiring mechanical ventilation with small endotracheal tubes secondary to severe bronchospasm and high airway resistance with low compliance. In these patients, heliox may be expected to improve tidal volume, lung compliance and resistance and decrease potential ventilator barotrauma while waiting for etiologic targeted therapies to take effect.