Inhaled Anesthetic for Life-Threatening Bronchospasm: Is It Ready for Prime Time?

Despite trends toward lower overall hospitalization rates for pediatric asthma, children requiring admission have an increasing frequency of admission to the ICU.[1,2] Of these children, 6–26% develop respiratory failure requiring mechanical ventilation.[3-5] Though intubation and mechanical ventilation are potentially life-saving, they can exacerbate severe bronchospasm, induce air trapping, and cause ventilator-induced lung injury. In the setting of refractory status asthmaticus not improved with mechanical ventilation, investigators have used rescue therapies, including extracorporeal membrane oxygenation and inhaled anesthetics.

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Do inhaled anesthetics offer a solution for patients refractory to conventional therapy? On one hand, inhaled anesthesia has been used as a rescue therapy for status asthmaticus in the pediatric ICU for more than 20 years. Previous investigators have found that inhaled anesthetics are effective in rapidly lowering CO_2 levels, marginally improving oxygenation, and possibly decreasing ventilator-induced lung injury.[6-8] On the other hand, using inhaled anesthetics may have several adverse effects. Previous investigators describe adverse physiologic effects such as hypotension and cardiac dysrhythmias. In addition, employing inhaled anesthesia in the pediatric ICU is resource-heavy, requiring centers to assume the additional expenses associated with training personnel capable of safely administering and monitoring the therapy, along with the substantial cost of equipment that must be adapted to the ICU environment. Finally, recent epidemiologic studies have noted an association between exposure to intraoperative volatile anesthesia and developmental and behavioral abnormalities in children.[9,10] The effects of longer durations of inhaled anesthetics on the developing brain are unknown. Despite the increasing interest in the use of inhaled anesthetics for life-threatening bronchospasm in the ICU, clinical studies comparing use of inhaled anesthetics with other bronchodilators remain limited.

In this issue of RESPIRATORY CARE, Turner and colleagues[11] present a retrospective review of 31 mechanically ventilated children with severe bronchospasm who were refractory to standard therapy and were treated with isoflurane. This single-center pediatric case series utilized a respiratory therapy database to describe the efficacy and complications associated with the administration of isoflurane. This case series represents the largest review of volatile anesthetics for status asthmaticus in children to date.

Safety and Efficacy

Over the 15-year course of the review, isoflurane was used in the majority of mechanically ventilated children with bronchospasm at the institution. The decision to begin isoflurane was at the discretion of the clinician. The investigators report that isoflurane was associated with a significant and early improvement in surrogates of ventilation, with both blood pH and P_{CO_2} improving within 4 hours of initiation. Though there were no early differences in lung mechanics, patients treated with isoflurane did have a significant decrease in peak inspiratory pressures from 4 to 24 hours after beginning the therapy. The most common adverse effect was hypotension that required treatment with vasoactive agents, which was observed in 77% of the patients. Many of these hypotensive patients were able to be weaned off of inotropic agents during inhaled anesthetic therapy, suggesting an early but non-sustained vasodilatory effect of isoflurane, which may have been compounded by the vasodilatory effects of hypercarbia, β agonist, and sedatives. Other side effects such as arrhythmia (10%), neurologic abnormalities (10%), and pneumothorax (3%) were less common. These observations are consistent with other reports identifying side effects associated with inhaled anesthetics in this patient population.[6]

Modern Anesthesia Ventilators

During the study period, the center utilized the Servo 900C with an attached vaporizer. This ventilator did not have advanced features of recent ventilators, including flow-triggering or calculations of effective tidal volume monitoring. In addition, it was inefficient at conserving anesthetic gas, requiring frequent refilling. Newer generations of anesthesia gas delivery devices have modern critical care ventilators integrated with them. Most provide control (pressure and volume) and support (pressure) modes of ventilation, while maintaining the gas conserving properties of their predecessors. The advanced monitoring and

gas delivery capabilities of the newer generation of anesthesia ventilators offer clinicians more precision in monitoring, delivering, and controlling ventilation. This may lead to better assessment and adaptation to the changing respiratory dynamics associated with bronchodilation.

Isoflurane Versus Sevoflurane

Though isoflurane is the most widely used inhaled anesthetic in patients with refractory status asthmaticus, other agents, such as halothane and sevoflurane, have been used to treat bronchospasm.[12,13] Rooke and colleagues compared the effects of isoflurane, halothane, sevoflurane, and thiopental/nitrous oxide on respiratory resistance in middle-age adults with mild to moderate chronic lung disease.[12] They observed that sevoflurane reduced respiratory resistance 11% more than halothane and 22% more than isoflurane. Other investigators have proposed that sevoflurane may be preferred over other inhaled agents for bronchospasm, because it produces less airway irritation,[14,15] and possesses a theoretical advantage over the others because of its low solubility and rapid onset. Further studies should examine the use of sevoflurane compared with isoflurane for bronchospasm in pediatric status asthmaticus.

Based on the 15 year experience at Children's Hospital Boston, the authors show that administration of inhaled anesthetic in patients with bronchospasm may be safe and effective in improving ventilation when employed shortly after intubation. Hypotension should be an expected effect of initiating therapy with isoflurane. Clinicians should anticipate the need for vasoactive agents to treat this early effect. To minimize associated hypotension, consider prompt weaning of intravenous sedating agents and β agonists. Though Turner et al provide a robust report of their single-center experience, more work remains to be done. Investigators should study the use of newer ventilators capable of gas delivery that may be even more suited to the ICU environment. In addition, given recent concerns of the neurologic and developmental effects of short-term exposure of children to inhaled anesthetics, investigators should examine neurologic effects of longer periods of exposure to these agents. Finally, as the authors note, prospective investigations of volatile anesthetics would provide more clarity on the use of this therapy in children with severe bronchospasm.

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