Mechanical Ventilation of the Anesthetized Patient

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KEYWORDS

• Atelectasis • Perioperative • Anesthetized • Continuous mandatory ventilation
• Volume-controlled ventilation • Pressure-controlled ventilation

KEY POINTS

- General anesthesia compromises pulmonary function during the perioperative period.
- A variety of modes and features are now available on the anesthesia ventilator.
- No specific mode or strategy is most effective for all patients and procedures.

INTRODUCTION

Patients who require general anesthesia to undergo a surgical procedure often require mechanical ventilation during the perioperative period. Ventilators incorporated into modern anesthesia machines offer various options for patient management. The unique effects of general anesthesia and surgery on pulmonary physiology must be considered when selecting an individualized plan for mechanical ventilation during the perioperative period. In this article, the pulmonary effects of general anesthesia are reviewed and available options for mechanical ventilation of the anesthetized patient during the perioperative period are presented.

PULMONARY EFFECTS OF GENERAL ANESTHESIA

On assuming care of the patient scheduled for surgery, the anesthesia provider initiates interventions that have unintended negative consequences on pulmonary physiology. Before transferring the patient to the operating room, sedative doses of benzodiazepines in combination with opioids may be given. At low doses, benzodiazepines alone do not cause significant respiratory depression; however, when administered concurrently with opioids, this is more likely.[1] On entering the operating room, the patient is transferred to the operating table in a supine position, with the head of bed flat. The simple act of moving from the upright to a supine position results in a 0.7-L to 0.8-L reduction in functional residual capacity, even in the awake state.[2]

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In anticipation of the period of apnea that often ensues immediately after induction of general anesthesia, it is recommended that patients breathe 100% oxygen by face mask for several minutes or more beforehand. Although preoxygenation extends the period that a patient maintains arterial oxygen saturation in case of prolonged apnea during airway placement,[3] it is also associated with development of absorption atelectasis.[4,5]

The period during which general anesthesia is induced is marked by additional interventions that compromise pulmonary status. Relatively large bolus doses of intravenous sedative/hypnotic agents and narcotics are administered. In combination and at the doses required for this indication, these drugs exert a synergistic effect on pulmonary function, such that induction of general anesthesia frequently results in profound respiratory depression or even periods of apnea.[1] Neuromuscular blockers may also be often given during this period, which induce a state of temporary muscle weakness or complete paralysis. Full support of ventilation is required at the onset of effect of induction drugs. Most often, this support consists of manual positive pressure ventilation by face mask with 100% oxygen via the anesthesia machine breathing circuit and reservoir bag. Assuming the airway is patent, oxygenation and ventilation are effectively supported in the short-term, but can contribute to further development of absorption atelectasis.

Many general anesthetics in the United States are now performed with a laryngeal mask airway (LMA) instead of an endotracheal tube. Muscle relaxation is not required for general anesthetics involving use of an LMA.[6] As a result, increased use of the LMA has resulted in a trend toward allowing patients to breath spontaneously during general anesthesia.[7] Work of breathing during spontaneous ventilation is still significantly increased during spontaneous ventilation through the LMA, albeit less so than during spontaneous ventilation with an endotracheal tube in place.[8]

Whenever muscle relaxant drugs are either not required or their clinical effect has diminished over time, patients breathe spontaneously while under general anesthesia. However, at a level sufficient to permit surgical stimulation, general anesthesia is associated with significant respiratory depression, characterized by irregular respiratory rate and breathing pattern. Pharmacologic agents commonly administered during the maintenance phase of general anesthesia are also associated with a decreased central response to hypercapnia and hypoxia.[4] The effects of anesthetic agents combined with increased work of breathing favor development of atelectasis during extended periods of spontaneous breathing through an artificial airway in the absence of any ventilatory assistance.[7]

PERIOPERATIVE MECHANICAL VENTILATION OPTIONS

The specific modes of mechanical ventilation available on a given anesthesia machine vary by manufacturer, model, and software package installed. In the United States, Dräger (Telford, PA, USA) and GE Healthcare (Wauwatosa, WI) manufacture most anesthesia machines used in clinical practice.[9] It is recommended that anesthesia providers familiarize themselves with the settings and options on the anesthesia machine present at the anesthetizing location before assuming care of the patient. Regardless of manufacturer, anesthesia ventilators are designed and function differently from intensive care unit (ICU) ventilators. These differences are primarily a consequence of the need to contain and properly dispose of respiratory gases, because the anesthesia ventilator serves the dual functions of providing positive pressure support and delivering volatile anesthetic agents. A detailed discussion of anesthesia machine design is beyond the scope of this article. The reader is directed to consult a textbook