Postoperative Noninvasive Ventilation

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KEYWORDS

• Postanesthesia care unit • Noninvasive ventilation
• Noninvasive positive pressure ventilation • Bilevel positive airway pressure
• Continuous positive airway pressure • Boussignac

KEY POINTS

- General anesthesia and surgery are associated with changes in the shape of the chest that result in atelectasis, a major factor in the development of postoperative respiratory failure.
- Postoperative noninvasive positive pressure ventilation (NIPPV) has been shown to improve oxygenation and ventilation for high-risk patients.
- NIPPV has been used as rescue therapy for patients developing acute respiratory distress postoperatively, and appears to be most frequently successful in patients whose problem is atelectasis or obesity.
- The use of continuous positive airway pressure (CPAP) helmets may improve patient comfort and compliance, and may result in fewer reintubations.
- Prophylactic NIPPV is usually preplanned. Rescue NIPPV is used in situations of central respiratory depression (pressure support ventilation), or for airway obstruction or low lung volumes (V/Q mismatch) (CPAP). Failure to respond to NIPPV after 20 minutes is usually an indication of intubation, mechanical ventilation, and transfer to the intensive care unit.

INTRODUCTION

General anesthesia is associated with significant changes in the shape of the chest, the orientation of the diaphragm, and alveolar gas content. This process results in significant loss of lung volume, airway closure, mucus trapping, ventilation-perfusion mismatch, and shunt, further compounded by surgeries of the upper abdomen and chest.[1] The major impact of these changes is atelectasis and increased work of breathing, which elevates the risk for reintubation, mechanical ventilation, and nosocomial pneumonia, all resulting in prolonged hospital stay.

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Noninvasive positive pressure ventilation (NIPPV **Box 1**), a term that covers continuous positive airway pressure (CPAP) and noninvasive pressure support ventilation (NIV/bilevel positive airway pressure [BiPAP]), is widely used in the postanesthesia care unit (PACU), intensive care unit (ICU), and high-dependency care unit (HDU) to both treat and prevent postoperative respiratory failure. This review initially addresses the basic physiology of gas-exchange abnormalities under anesthesia, and looks at NIPPV delivery systems and the evidence to support their use in the postoperative setting. Finally, a stepwise clinical approach to the patient with acute respiratory distress in the PACU is discussed.

GAS-EXCHANGE ABNORMALITIES UNDER ANESTHESIA

Anesthesia: Atelectasis and Ventilation-Perfusion Mismatch

Ventilation-perfusion mismatch occurs in all patients who undergo general anesthesia and major surgery,[2] and occurs whether or not the patient breathes spontaneously or whether the patient is maintained on volatile or intravenous anesthetic.[3] Immediately following induction of anesthesia there is a 16% to 20% reduction in functional residual capacity (FRC),[4] and this continues to decrease over the next 5 or 10 minutes.[5,6] The reduction in FRC is correlated with age and chest-wall elastance,[7] and leads to airway closure, reduced compliance, and ventilation-perfusion mismatch. The shape of the chest cavity changes: there is cephalad displacement of the diaphragm.[8] Complete or partial collapse of lung segments is known as atelectasis. Atelectasis occurs in 90% of anesthetized patients,[9] and is the most common cause of shunt (**Fig. 1**A). Up to 20% of lung bases are collapsed soon after induction of anesthesia.[6] Certain types of patients, namely the elderly and the obese, are at elevated risk for profound atelectasis, and certain types of surgery enhance risk: upper abdominal surgery, cardiac surgery, and thoracic surgery.

Oxygen and Atelectasis

Preoxygenation is known to increase the safe duration between apnea and hypoxemia; it involves breathing a high fractional inspired oxygen tension (FiO_2).[10,11] The vital capacity becomes a reservoir for apneic oxygenation, and depending on the shape and size of the patient there may be between 2 and 10 minutes of apnea-hypoxemia safety time.[12] However, this high FiO_2 causes atelectasis (absorption atelectasis; **Fig. 2**).[13] Atelectasis results from the presence of a large oxygen gradient between the alveolus and mixed venous blood: nitrogen washout removes the normal

Box 1
Delivery systems for noninvasive ventilation in the PACU

CPAP

CPAP face mask with positive end-expiratory pressure valve and high-flow system

Home BiPAP machine

Stand-alone noninvasive ventilator (such as BiPAP Vision)

Boussignac CPAP system

NIV

Home BiPAP machine

Stand-alone noninvasive ventilator (such as BiPAP Vision)

Intensive-care ventilator on "NIV" setting