Endotracheal Tube Management and Obstructed Airway

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KEYWORDS

• Anesthesia • Lung isolation • Airway obstruction • One-lung ventilation • Rigid bronchoscopy

KEY POINTS

- While managing the surgical procedure, the surgeon should be constantly aware of the respiratory mechanics and control of the airway via the endotracheal tube.
- Operations in the pleural cavity usually necessitate lung isolation.
- The surgeon and anesthesiologist should have a clear plan in terms of a strategy for intubation, a management algorithm for respiratory problems, and an established crisis protocol.
- Proper management of an acute central airway obstruction requires a thorough knowledge of anatomy and techniques, rapid decision making, and an intimate communication with a skilled anesthesiologist.
- The surgeon must be aware of multiple ventilation strategies including standard ventilation, jet ventilation, and, if necessary, extracorporeal membrane oxygenation (ECMO) if intubation is not possible.
- Surgeons must also be aware of multiple intubation strategies including standard intubation, double-lumen tube intubation, laryngeal mask airway, cross-field ventilation, and rigid bronchoscopy.
- Rigid bronchoscopic management is the most efficient initial step in the management of a central airway obstruction.

INTRODUCTION

The scope of general thoracic surgery encompasses a wide array of procedures and corresponding anesthetic techniques. Thoracic anesthesia is a field requiring mastery of pulmonary anatomy and physiology, as well as technical prowess in the stabilization of an adequate airway through various modalities. In addition, in most cases, patients undergoing thoracic surgery include those with difficult airways and significant respiratory pathologies, thus increasing the complexity of the anesthesiologist's role. Finally, the thoracic surgical procedure usually involves entry into the pleural cavity, thereby necessitating lung isolation techniques.

The general thoracic surgeon is not spared from these complexities. While managing the surgical procedure, the surgeon should be constantly aware of the respiratory mechanics and control of the airway via the endotracheal tube. The surgeon should be familiar with the various

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techniques of airway management and lung isolation. Also, the surgeon and anesthesiologist should have knowledge of the potential catastrophes and be able to communicate proper crisis protocol plans. The following sections detail the surgeon's role in managing the airway and endotracheal tube by explaining intraoperative respiratory monitoring, techniques of lung isolation, and potential complications therein.

MONITORING

Accurate respiratory monitoring is vital to good outcomes. Modern anesthesia ventilators provide real-time data regarding pressure-volume relationships in the ventilated lungs. Changes in pressure may be issues related to the anesthesia circuit or the lung parenchyma and airway itself, such as an obstructed airway or auto–positive end-expiratory pressure. Similarly, changes in tidal volume (inspiratory and expiratory) can relate to the patient's baseline pulmonary function or be secondary to the operative procedure, that is, air leaks. The intricacies of ventilation strategies are beyond the scope of this article; however, it is important to understand that a working knowledge of these details is necessary.

In the diseased lungs that are often managed in thoracic surgery, gas exchange is an important variable to closely monitor. Hypoxemia (arterial saturation <90%) is especially prevalent in lung isolation techniques. Fortunately, with improved modalities in the past 25 years, the incidence of intraoperative hypoxemia has dropped from 25% to 1% in thoracic surgery.[1] The intraoperative measurement of oxygenation is done by pulse oximetry and arterial blood gases. Advances in technology have yielded reliable pulse oximeters so that ventilation management decisions can be made based on their measurements; this permits decreased arterial blood gas requirements without a sacrifice in outcomes.[2] However, it has been shown that pulse oximetry has a slower rate of change when compared with arterial saturation. Also, pulse oximetry measurement usually provides a lower reading than a simultaneous arterial blood gas.[3] Continuous blood gas monitoring devices have been developed but are not yet in widespread use.[4] Therefore, it is recommended to use continuous pulse oximetry with intermittent arterial blood gas measurements as an adjunct. Finally, the measurement of cerebral oximetry may have utility; however, the usefulness of the data in thoracic surgery has yet to be defined.[5]

Carbon dioxide monitoring in patients undergoing thoracic surgery is as important as oxygenation. Hypocarbia or hypercarbia are signs of significant ventilation dysfunction. Similar to oxygenation monitoring, different modalities are available with different advantages and disadvantages. Arterial blood gas measurements usually provide the most accurate result, but require more time and frequent blood draws; their usefulness seems to be best in an intermittent role. At the time of intubation, end-tidal CO_2 has been shown to be an excellent determinant of successful endotracheal intubation.[6] In terms of continuous monitoring, both transcutaneous and end-tidal carbon dioxide monitoring are currently used. Studies have shown that in thoracic surgery procedures, especially those requiring 1-lung ventilation, transcutaneous carbon dioxide monitoring provides more accurate results than end-tidal carbon dioxide.[7]

LUNG ISOLATION

A unique aspect of operations in the pleural cavity is the necessity for lung isolation and 1-lung ventilation. One-lung ventilation permits the following:

- Improved surgical exposure
- Prevention of contamination of contralateral lung
- Airway control in bronchopleural fistula, sleeve resection, or pneumonectomy
- Differential lung ventilation

Successful methods to perform lung isolation and 1-lung ventilation have been available since the introduction of red rubber double-lumen endotracheal tube (DLT) by Björk and Carlens[8] in 1950. Although other techniques do exist for certain circumstances, the primary methods used to provide lung isolation include the DLT and bronchial blockade. Advantages of both modalities are listed in **Table 1**. Although each method has its own pros and cons, the general consensus remains that the thoracic anesthesiologist and surgeon should be facile in the use of a variety of techniques based on the patient's specific situation.[9]

Double-Lumen Endotracheal Tube

A DLT consists of tubes bonded together side by side, with an endotracheal component and an endobronchial component and each lumen intended to ventilate 1 lung. DLTs are made as left- and right-sided tubes. Left-sided tubes are more commonly used because of the relative ease of positioning the bronchial tube component in the longer left main bronchus. Right-sided DLTs must be precisely placed into the right main stem bronchus so that the ventilation opening for the right upper lobe is placed over the upper lobe