12 Anesthesia for Mediastinoscopy and Mediastinal Surgery

Philip L. Kalarickal and Chai-Lin Winchester

Introduction

Since its introduction in 1959, mediastinoscopy has been a widely-used procedure for the diagnosis and staging of bronchogenic carcinoma and other diseases of the mediastinum [1]. The procedure can be performed as a sole entity or as part of a multi-tiered approach involving video-assisted thoracoscopy or open thoracotomy. Despite advances in noninvasive imaging studies, mediastinoscopy remains essential for the pre-operative staging of bronchogenic carcinoma with a procedural sensitivity of greater than 90% and a specificity of 100%. Other modalities are less predictive: the sensitivity and specificity for computerized tomography (CT) is 55% and 81% compared to positron emission tomography (PET) with 80% and 88%, respectively [2]. A summary of anesthetic considerations for medistinal surgery is presented in Table 12.1.

Anatomy

The mediastinum is the space between the two pleural cavities extending from the thoracic inlet (superior border) to the diaphragm (inferior border). The sternum and the anterior surface of the vertebral bodies comprise the anterior and posterior borders, respectively. The mediastinum is divided into a superior and inferior mediastinum by the transverse thoracic plane, which extends horizontally from the sternal angle to the inferior border of the T4 vertebra. The inferior mediastinum itself is divided into anterior, middle, and posterior compartments by the heart and pericardium.

The anterior compartment of the inferior mediastinum contains the thymus and anterior mediastinal lymph nodes. It is bound by the sternum, pericardium, ascending aorta and great vessels.

The middle compartment of the inferior mediastinum contains the pericardium, heart, ascending and transverse portions of the aorta, trachea, main bronchi, superior and inferior vena cava, phrenic nerve, vagus nerves, brachiocephalic vasculature and the main pulmonary vasculature.

The posterior compartment of the inferior mediastinum lies between the pericardium and the vertebral column. It contains the descending aorta, esophagus, thoracic duct, azygos vein, sympathetic chain and posterior group of lymph nodes.

There are no anatomical or fascial planes that separate the different compartments. Intrathoracic lymphatic drainage is from the pulmonary periphery towards the central lymph nodes (one of the first stations for metastatic

P. L. Kalarickal, M.D., M.P.H. (✉)
C.-L. Winchester, M.D.
Emory University School of Medicine,
Atlanta, GA, USA
e-mail: pkalari@emory.edu;
chai-lin.winchester@emory.edu

B. G. Goudra et al. (eds.), *Anesthesiology*, https://doi.org/10.1007/978-3-319-74766-8_12

Table 12.1 Summary of the anesthesia considerations for mediastinoscopy and mediastinal surgery

Plan/preparation/adverse events	Reasoning/management
Preoperative evaluation	Assessment and optimization of comorbidities Review of imaging and physical exam for the presence of a mediastinal mass and it's secondary effects Laboratory evaluation for comorbid conditions Type and screen
Position	Supine, operating room table may be turned 90 degrees per surgical preference
Access	Large-bore peripheral access is usually sufficient Arterial line—right radial to assess for compression of innominate artery by mediastinoscope. Place NIBP in opposite arm to assess adequacy of systemic perfusion in cases of innominate compression
GETA	Consideration for ventilation effects of anterior mediastinal masses Consider awake intubation or maintenance of spontaneous ventilation if necessary Consideration for judicious use of neuromuscular blockade in setting of Eaton Lambert syndrome or myasthenia gravis with thymoma
Procedural adverse events	
Compression of innominate artery	Pulse oximeter or arterial catheter in right radial artery for monitoring. NIBP in opposite arm
Hemorrhage	Rare, but potentially catastrophic requiring close communication with surgical team
Recurrent laryngeal nerve injury	Monitor closely in post anesthetic care unit for signs of respiratory distress
Postoperative and post-discharge considerations	
Disposition	Following reassuring postoperative chest radiograph and satisfactory respiratory & hemodynamic function discharge to home or standard floor bed

spread), thus making lymph node sampling indispensable to the establishment of diagnosis and staging. Access to the upper and lower paratracheal as well as subcarinal lymph nodes is provided by cervical mediastinoscopy. Access to the aortopulmonary lymph nodes is provided by anterior mediastinoscopy via an incision in the second intercostal space (Chamberlain's procedure). A thorough understanding of the anatomy is essential for understanding the surgeon's perspective on the procedure and to anticipate the anesthetic considerations and potential complications.

Indications

The most common indication for mediastinoscopy is for staging and determination of the resectability of bronchogenic carcinoma. Lymphadenopathy with associated with lymphoma, sarcoidosis, infectious granulomatous diseases, and other diseases of the mediastinum are additional indications.

Contraindications

Prior mediastinoscopy has been touted as a relative contraindication for repeat mediastinoscopy. Scar tissue from the previous procedure will eliminate the plane of dissection, making it difficult to recognize the normal tissue. However, in a group of 101 patients from 1975 to 1989, no mortality was observed [3]. There were a significantly higher number of complications in repeat versus. primary mediastinoscopies (23% vs. 2%), though the authors make note that the higher percentage is partly accounted for by the inclusion of minor complications. In smaller series, no mortality or morbidity has been mentioned. Thus, Veughs et al. conclude that an earlier mediastinoscopy is not necessarily an absolute contraindication for repeat mediastinoscopy.

Other relative contraindications include superior vena cava syndrome (increased risk of bleeding from distended veins), severe tracheal deviation, severe cervical spine disease (poor neck extension may limit adequate surgical exposure), previous chest radiotherapy, and thoracic

aortic aneurysms. All of these entities have the potential to distort anatomy and increases risk of vascular puncture with the mediastinoscope.

Mediastinoscopy Procedure

The patient is typically positioned in the supine position. The head of the bed may be elevated, increasing risk of venous air embolism if the venous vasculature is compromised. A roll may be placed behind the shoulders to maximize neck extension and surgical exposure. For cervical mediastinoscopy, a transverse incision is made above the suprasternal notch. The strap muscles are then dissected and the pre-tracheal fascia is raised and opened to reveal the trachea. Further blunt dissection exposes the mediastinal lymph nodes. For anterior mediastinoscopy, the second or third costal cartilage is resected and the mediastinum is explored without entering the pleural space (limited anterior thoracotomy). For both approaches, visualization is often limited and lymph nodes are often aspirated prior to biopsy.

Preoperative Considerations

As with all surgical procedures, the presence of co-existing disease states should be evaluated preoperatively. In cases of bronchogenic carcinoma, a smoking history may coexist with other morbidities such as hypertension, coronary artery disease, peripheral vascular disease, and pre-existing pulmonary disease. In patients with pre-existing carotid arteriosclerosis or cerebrovascular disease, diminished blood flow to the right carotid artery from compression of the innominate artery by the mediastinoscope may precipitate acute stroke.

Patients with anterior mediastinal masses should have an extensive preoperative evaluation as such pathology has the potential for catastrophic cardiovascular collapse or airway obstruction upon induction of anesthesia [4]. Preoperative imaging, such as a chest X-ray or CT may reveal an incidental mass as most these patients are asymptomatic. CT would give information on the location and extent of the mediastinal mass, as well as possible invasion of surrounding structures. If there is a question of invasion or obstruction of vascular structures, angiography may provide valuable information.

Symptoms of airway compromise include dyspnea, particularly postural dyspnea in the supine position, stridor, cough, unilateral wheeze, or persistent respiratory tract infection. General anesthesia exacerbates the compressibility of large airways by decreasing lung volumes and by relaxing bronchial smooth muscle [5]. Maintenance of spontaneous ventilation may be desired to avoid precipitating complete obstruction in these patients.

Superior vena cava syndrome may result from enlarged lymph nodes or an obstructing mediastinal mass. The clinical manifestations include but are not limited to dyspnea, edema of the face and arms, stridor, engorged and distended veins in the neck, and dysphagia. Edema of the larynx and tongue from poor venous drainage can make intubation challenging, as visualization may be obstructed and the patients are at risk of bleeding from relatively minor trauma secondary to increased venous pressures. Pre-operative interventions in the management of SVC syndrome may include head elevation, steroids, diuretics and even percutaneous vascular interventions.

Paraneoplastic manifestations are well-known complications of lung cancer. Secretion of various substances with significant hormonal activity may mimic hyperparathyroidism and SIADH. Lambert-Eaton Syndrome is a paraneoplastic syndrome most often seen with small cell carcinoma. It is associated with muscle weakness that improves with exercise and is not mitigated by acetyl cholinesterase inhibitor therapy. Patients with Lambert-Eaton Syndrome show an increased sensitivity to both non-depolarizing and depolarizing muscle relaxants. Thirty percent of patients with a thymoma will have myasthenia gravis, an auto-immune condition characterized by weakness and fatigability that worsens with exercise and is treated with acetyl cholinesterase inhibitor therapy [4]. These patients are typically sensitive to non-depolarizing neuromuscular blockers and are often resistant to

depolarizing neuromuscular blockers. Both of these conditions mandate judicious use of these drugs [5]. Although the availability of sugammadex allows for complete reversal of aminosteroid neuromuscular blocking agents, the patient's underlying muscle weakness must still be considered after sugammadex utilization.

Anesthetic Management

Access and Monitoring

The proximity to vital structures such as the aorta, superior vena cava, azygous vein, pulmonary arteries and veins makes surgical complications, though rare, potentially devastating. Large-bore peripheral venous access should be obtained given the possibility of massive hemorrhage. A type and screen for possible transfusion should be performed. Pulse oximetry should be obtained on the right upper extremity to provide information of compression of the innominate artery by the mediastinoscope leading to cerebral and extremity ischemia. Invasive arterial blood pressure monitoring in the right extremity is preferred for more rapid detection of hemodynamic compromise and compression of major vessels with the mediastinoscope. Pulse oximetry may be unable to detect innominate artery compression until ischemia is already present [6]. Noninvasive blood pressure cuffs should be on the left arm to avoid inappropriately treating hypotension from vessel compression.

Induction

Mediastinoscopy is usually done under general endotracheal anesthesia (GETA). Induction for GETA is dependent upon the patient's symptoms and degree of airway obstruction, if any. If no evidence of obstruction is present, intravenous induction can be performed after adequate preoxygenation. If there is concern for airway obstruction during induction of general anesthesia, awake fiberoptic intubation in the supine or sitting position depending on symptomatology should be considered. A reinforced endotracheal tube should be considered in cases of possible airway obstruction. Inhalational induction may also be pursued to maintain spontaneous ventilation to prevent airway collapse on induction. If ventilation becomes difficult, a rigid bronchoscope should be available. Given the possibility of intraoperative gas exchange impairment in patients with severe airway compromise and pulmonary vasculature involvement, it may be prudent to have cardiopulmonary bypass standby in the operating room on very select patients.

Another option, however uncommon, is to perform the procedure under local anesthesia. Local anesthesia would be used for the cervical incision. With this option, spontaneous ventilation is preserved. The level of consciousness can also be continuously monitored in patients with impaired cerebral circulation. There are risks of patient movement leading to vascular damage and excessive sedation leading to airway compromise. This would necessitate emergent conversion to general anesthesia and the possibility of immediate surgical exploration.

Maintenance

Muscle relaxation may be advantageous to aid in ventilation and prevent coughing and other sudden movements, thereby decreasing the risk of complications. However, in patients with thymoma, Lambert-Eaton syndrome and possibly pre-existing neuromuscular disease, the use of neuromuscular blockade should be judicious. For maintenance of anesthesia, either inhaled volatile anesthetics or intravenous anesthetics may be utilized.

Management of Intraoperative Complications

Major Hemorrhage

One of the most feared complications of mediastinoscopy is major hemorrhage. Major hemorrhage, defined as that requiring surgical exploration for definitive control, is an uncommon

but potentially fatal event, with a reported incidence of 0.4% [7]. Other series report rates between 0 and 0.6%. The most common site of biopsy resulting in major hemorrhage is that of the lower right paratracheal region. The most frequently injured vessels are the innominate vein, azygos vein, and pulmonary arteries. Bleeding encountered intra-operatively is initially treated with compression. Factors that may increase the risk of a major bleeding complication include induction chemotherapy agents, prior radiation to the mediastinum, prior surgical procedure, and repeat mediastinoscopy [7]. Packing is used initially to control bleeding. If the patient demonstrates persistent hemodynamic instability, surgical exploration is required either through median sternotomy or thoracotomy. Large bore venous access should be obtained in the lower extremities, as bleeding may be from vessels that drain into the SVC. If thoracotomy is necessary, one-lung ventilation may be required. In a recent case series, mortality for major hemorrhage was 7% [7].

Venous Air Embolism

Venous air embolism may occur once venous bleeding develops. If patients are spontaneously breathing, the risk is higher given the development of negative intrathoracic pressure during inspiration. Positioning of the patient with the patient's head above the level of the heart also increases risk of venous air embolism. Manifestations include arrhythmias, reduced lung compliance, hypoxemia, hypercarbia, sudden decrease in end-tidal carbon dioxide, and cardiovascular collapse. Although various monitoring devices can help detect the presence of venous air embolism, such as transesophageal echocardiography, end-tidal nitrogen, and precordial Doppler, these are often not feasible with mediastinoscopy. Treatment involves prevention of further entrainment of air by covering the field with saline soaked gauze, tilting the table if possible, administering 100% oxygen to reduce embolus volume by eliminating nitrogen, and treating right sided heart failure while maintaining hemodynamic support as possible. Mortality of VAE ranges from 48 to 80% [8].

Other Complications

1. Stroke is a rare complication of mediastinoscopy. Strokes are usually located in the right hemisphere and occur because of compression of the innominate artery, resulting in diminished flow through the right carotid and subclavian arteries. Invasive arterial blood pressure monitoring in the right extremity enables continuous monitoring for vascular compression to prevent this complication.
2. Autonomic reflexes may occur as a result of compression or stretching of the great vessels or the vagus nerve. Bradycardia may be profound and may necessitate pharmacologic treatment and temporary cessation of surgical manipulation [9].
3. Entry into the pleural cavity can result in a pneumothorax which is often not apparent until the postoperative period where chest radiograph should be routinely performed. Tension pneumothorax is a rare but significant complication that may manifest acutely as increased peak inspiratory pressures, tracheal shift, and hypotension.
4. Phrenic or recurrent laryngeal nerve injuries are also possible complications. The rate of vocal cord palsies is <1%. In a study evaluating the use of recurrent laryngeal nerve monitoring during mediastinoscopy, 14 out of 15 patients demonstrated intense recurrent nerve stimulation during digital dissection along the anterior trachea. This suggests that the recurrent laryngeal nerve injuries occur more from traction than direct stimulation [10]. In a series of patients undergoing mediastinoscopy, a 6% rate of at least temporary vocal cord paralysis was noted when all patients underwent preoperative and postoperative laryngoscopy [11].
5. Esophageal injury and chylothorax are rare complications following mediastinoscopy.

Postoperative Care

Postoperatively, the patient should be monitored for hemodynamic stability and dyspnea. Unilateral recurrent laryngeal nerve injury often

presents with hoarseness, raspy voice and dyspnea though may not be present immediately following extubation. Though rare, bilateral nerve damage would present with stridor, increasing respiratory insufficiency and patient discomfort including significant use of accessory muscle for respiration. This condition demands rapid diagnosis and often necessitates emergent reintubation. Pneumothorax may often present postoperatively and a chest radiograph should be routinely performed. Most patients with a small asymptomatic pneumothorax can be managed conservatively without the need for a chest tube. Pain management can be managed with intravenous or oral opioids as thoracic neuraxial anesthesia is rarely performed for mediastinoscopy. Other nerve blocks, such as intercostal injections can provide analgesia [9]. Depending on preexisting morbidity and course of surgery, patients are often able to be discharged the same day [12].

References

1. Carlens EL. Mediastinoscopy: a method for inspection and tissue biopsy in the superior mediastinum. Dis Chest. 1959;36:343–52.
2. Hammoud ZT, Anderson RC, Meyers BF, Guthrie TJ, Roper CL, Cooper JD, Patterson GA. The current role of mediastinoscopy in the evaluation of thoracic disease. J Thorac Cardiovasc Surg. 1999;118:894–9.
3. Vueghs PJM, Schurink GA, Vaes L, Langemeyer JJM. Anesthesia in repeat mediastinoscopy: a retrospective study of 101 patients. J Cardiothorac Vasc Anesth. 1992;6(2):193–5.
4. Gothard JW. Anesthetic considerations for patients with anterior mediastinal masses. Anesthesiol Clin. 2008;26:305–14.
5. Attar AS, Taghaddomi RJ, Bagheri R. Anesthetic management of patients with anterior mediastinal masses undergoing chamberlain procedure (anterior mediastionostomy). Iran Red Crescent Med J. 2013;15(4):373–4.
6. Ahmed-Nusrath A, Swanevelder J. Anesthesia for mediastinoscopy. Continuing education in anaesthesia. Critical Care Pain. 2007;7:6–9.
7. Park BJ, Flores R, Downey RJ, Bains MS, Rusch VW. Management of major hemorrhage during mediastinoscopy. J Thorac Cardiovasc Surg. 2003;126:726–31.
8. Shaikh N, Ummunisa F. Acute management of vascular air embolism. J Emerg Trauma Shock. 2009;2(3):180–5.
9. Thomsen RW. Mediastinoscopy and video-assisted thoracoscopic surgery: anesthetic pitfalls and complications. Semin Cardiothorac Vasc Anesth. 2008;12(2):128–32.
10. Roberts JR, Wadsworth J. Recurrent laryngeal nerve monitoring during mediastinoscopy: predictors of injury. Ann Thorac Surg. 2007;80:288–92.
11. Sayar A, Çitak N, Büyükkale S, Metin M, Kök A, Çelikten A, Gürses A. The incidence of hoarseness after mediastinoscopy and outcome of video-assisted versus conventional mediastinoscopy in lung cancer staging. Acta Chir Belg. 2016;116(1):23–9.
12. Vallières E, Pagé A, Verdant A. Ambulatory mediastinoscopy and anterior mediastinotomy. Ann Thorac Surg. 1991;51:1122–6.