# 19 Anesthesia for Mediastinal Tumors

Ravinder Kumar Pandey, Dalim Kumar Baidya,
and Ankur Sharma

## 19.1 Introduction

The mediastinal masses are increasingly being recognized and scheduled for surgical excision. The perioperative care of these patients poses many challenges to the anesthesiologists. These are related to many concerns including the site of a mediastinal mass, relation to adjoining structures, airway management, perioperative analgesia, etc.

The mediastinum is bounded by important structures. Its superior boundary is formed by the thoracic inlet, inferior boundary is formed by the transverse thoracic plane, lateral boundary is formed by the pleura, anterior boundary is formed by posterior surface of the manubrium sternii and posterior boundary by T1-T4 thoracic vertebra [1]. A hypothetical plane made by the line from the sternal angle anteriorly to the lower border of the fourth thoracic vertebra divides the mediastinum into the superior mediastinum and inferior mediastinum. The inferior mediastinumis divided in to three parts: (Table 19.1) [2].

Anterior mediastinum—It extends from posterior surface of the lower sternum to the anterior surface of the pericardium and great vessels, it lies between pleural cavities and extend from thoracic inlet to the diaphragm.

Middle mediastinum—It lies between the anterior mediastinum and the anterior border of the vertebral bodies.

Posterior mediastinum—It lies posterior to the middle mediastinum.

## 19.2 Overview of Concerns for Mediastinal Tumors

Perioperative management of mediastinal masses has peculiar concerns for perioperative management [3]. The mediastinal masses for surgical intervention may have substantial morbidity and mortality because of the vicinity of vital structures around [4]. The collapse of these mediastinal masses on the trachea, chambers of heart, pulmonary veins, or the superior vena cava could have disastrous cardiovascular and pulmonary outcomes [5]. Primarily prevention of such complications and hence appropriate planning remain paramount. Its early recognition and management are equally important. This requires understanding the anatomical relation and planning of perioperative care accordingly. The collapse of the endobronchial tree is the most dreaded complication, especially when the point

R. K. Pandey (✉) · D. K. Baidya
Department of Anesthesiology, Pain Medicine and Critical Care, All India Institute of Medical Sciences,, New Delhi, India

A. Sharma
Department of Anaesthesia, All India Institute of Medical Sciences, Trauma & Emergency (Anaesthesia), Jodhpur, Rajasthan, India


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**Table 19.1** Division of the mediastinum, its boundaries, and contents

| Mediastinum divisions | | Boundaries | Contents |
|---|---|---|---|
| Superior mediastinum | | Extend superiorly by thoracic inlet, inferiorly transverse thoracic plane, laterally by pleura, anteriorly by the posterior surface of manubrium sterni, and posteriorly by T1-T4 thoracic vertebra | Thymus, trachea, esophagus<br>• Arteries: aortic arch, brachiocephalic trunk, left common carotid artery, left subclavian artery, superior vena cava, brachiocephalic veins, the arch of the azygos, thoracic duct |
| Inferior mediastinum | Anterior | From the posterior surface of the lower sternum to the anterior surface of pericardium and great vessels, lies between pleural cavities, extend from thoracic inlet to the diaphragm | Thymus, trachea, esophagus, large veins, large arteries, thoracic duct, sympathetic trunk, lymph nodes, ectopic thyroid gland, and parathyroid tissues |
| | Middle | Between the anterior mediastinum and the anterior border of the vertebral bodies | Heart and pericardium, great vessels, vagus, and phrenic nerves |
| | Posterior | Posterior to the middle mediastinum | Intercostal nerves, thoracic spinal ganglion, and sympathetic chain |

of tracheobronchial compression or collapse is distal to the tip of the endotracheal tube [6]. Thorough preparation can decrease the risk of significant perioperative complications and post-operative morbidity [7].

## 19.3 Evaluation of the Patient

The patient should be thoroughly assessed including history, signs, symptoms, clinical examination, biochemical parameters, and relevant imaging. Special tests may be required based on the initial assessment outcome.

**Signs and Symptoms** The signs and symptoms related to mediastinal mass lesions vary according to size and nature of the lesion. It can remain asymptomatic as well and is an incidental finding [8]. The anterior and superior mediastinal masses causes following symptoms which can be categorized as: asymptomatic difficulty in swallowing; heaviness in chest with pain; sweating; headache; neck and facial swelling; venous distention in the neck, arms, and upper chest; and posture-related symptoms. The severe symptoms which have associated high risk to the patients' outcome include dyspnea at rest, stridor, orthopnea, syncope, or cough when supine [9].

The severity of a symptom is graded by how it is affected by lying in the supine position [10]. The symptoms due to mediastinal masses at anterior and superior locations may be graded as:

- Asymptomatic – Patient without any symptoms.
- Mild – These patients can lie supine but have a mild cough and/or pressure symptoms due to mediastinal lesion.
- Moderate – These patients can lie supine only for a short duration due to increasing manifestations of symptoms.
- Severe – These patients can not lie supine at all.

In cases wherein the patient cannot lie supine, the inquiry related to head up position using a pillow (number, height) for relief of symptoms should be done. The patient should be enquired for his most comfortable position with minimum symptoms (head up and its degree, sitting upright, forward bending, lateral decubitus) and should be documented. This helps during the positioning for anesthesia induction and airway management to prevent the occurrence of airway compromise or cardiovascular collapse [11].

The patient may experience systemic symptoms from the tumors. These may be related to other medical conditions and the results of previous therapies. Patients with mediastinal mass diagnosed as thymoma may have associated myasthenia gravis in almost 30% of cases [12]. Patients with mediastinal lesions may have received radiation therapy and/or chemotherapy. These may lead to various changes in the chest due to edema, fibrosis leading to distortion of the airway, kinking of vessels, etc. [13]. These may further complicate the conduct of general anesthesia.

**Clinical Examination** Patients with mediastinal examinations not only require general physical examination, but focused assessment for eliciting findings specifically related to mass and its impact on surrounding structures needs to be done. The findings related to any airway, respiratory, and cardiovascular compromise are important to elicit. Cardiovascular examination should focus on evaluating for hemodynamic stability and on a concern for possible pericardial effusion. In addition to the examination of the lungs, respiratory evaluation should assess the patient's most comfortable position without or with minimum symptoms.

## 19.4 Investigations

Preoperative testing should be used to aid in the diagnosis of the mass and the assessment of the severity of the disease. These mediastinal lesions are classified according to location as anterior, middle, or posterior mediastinum tumors [13]. The commoner benign lesions of the anterior mediastinum are thymic cyst, hyperplasia, thymoma, and cystic hygroma. The malignant lesions at this site include lymphomas, germ cell tumors, thyroid cancers, and thymic cancers. The commoner lesions in the middle mediastinum include benign (adenopathies, cysts, hernias, etc.) and malignant (lymphoma, thyroid cancer, esophageal cancer, etc.) lesions. Lesions in the posterior mediastinum are usually neurological lesions and include benign (neurofibroma, schwannoma, etc.) and malignant (neuroblastoma) lesions.

**Imaging** The radiological imaging is done preoperatively for assessing the location of the mass and its relation to the adjacent structures. It is also done to assess the resectability of the tumor if the lesion requires surgical resection. The anesthesiologists should review these imaging modalities before surgery to make a perioperative anesthetic plan. Chest x-ray remains a screening imaging modality, but computed tomography (CT) scan is useful to assess various important findings that are important for perioperative care [14].

The CT scan is a useful to identify compressive effect of the mass on airways or vascular structures including great vessels and the heart. If the pericardial effusion is found, it can be associated with higher chances of perioperative complications [15]. Compression of the main stem bronchi, particularly in combination with tracheal compression, can increase perioperative risk significantly. The extent of tracheobronchial compression signifies not only the symptomatology but also the risk of complete obstruction during airway management under anesthesia [16]. It has been reported that the severity of tracheal compression on CT scans cannot be considered as a good predictor of respiratory complications, as 8% of patients with more than 50% diameter also had respiratory complications under general anesthesia. The cross-sectional area of the trachea is an important parameter to predict airway compromise, and it has been reported that more than 50% reduction of the cross-sectional tracheal area is a predictor of serious anesthetic problems related to the airway.

Another parameter that has been used as an assessment tool for perioperative planning of anesthesia includes mediastinal thoracic ratio (MTR) [17]. This parameter compares the mediastinal mass size to the diameter of the thoracic cavity. The perioperative respiratory complications are increased with an increase in MTR >50% [18]. The "mediastinal mass ratio" (MMR) measured by CT scan has been described by King et al. [19] as a maximum mediastinal mass width relative to maximum mediastinum width. They have graded mediastinal masses as small (MMR < 30%), medium (MMR 31% to 41%), and large (MMR > 45%). It has been reported that MMR > 56% correlates with increased perioperative respiratory complications.

**Pulmonary Function Tests (PFT)** These should be performed in an upright and supine position. These provide more objective data in identifying high-risk patients. The Shamberger risk assessment box using two parameters of peak expiratory flow rate (PEFR) and the tracheal area has been proposed to identify patients at risk of respiratory compromise [20]. This risk assessment tool shall be useful to plan perioperative care including airway management (Table 19.2) [20]. The box is divided into four sections (A, B, C, and D). Patients in sections "A" (tracheal area less than 50% and PEFR more than 50% of the predicted values) and "D" (a tracheal area more than 50% and PEFR less than 50% of the predicted values) have moderate risk and therefore should receive local anesthesia (LA), if possible [20]. If general anesthesia (GA) is necessary, it is safe to use spontaneous inhalational anesthesia and avoid the use of muscle relaxants. However, patients in section "B" (tracheal area as well as PEFR more than 50% of the predicted) have "low risk" and can receive GA without any complications. But, patients in section "C" (tracheal area and PEFR, both less than 50% of the predicted) have "high risk" and should receive LA only [20].

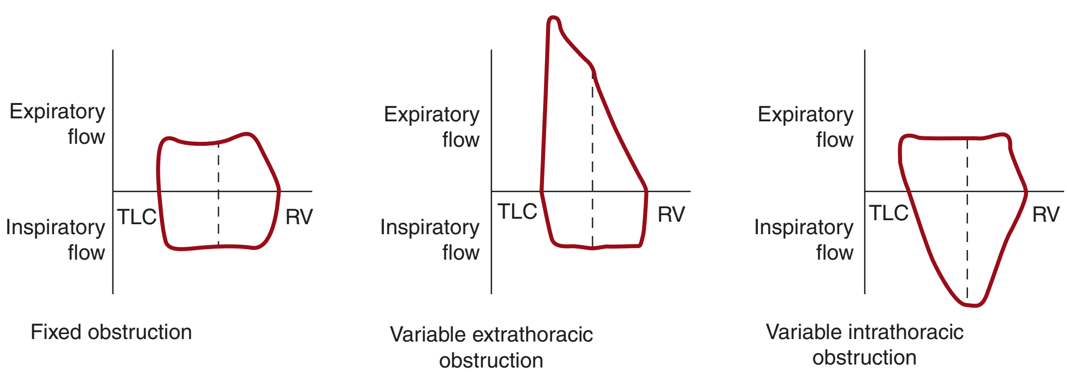
**Flow Volume Loops** This test is thought to aid in the diagnosis of intrathoracic versus extrathoracic masses (Fig. 19.1) [21]. Patients with intrathoracic airway obstruction will present with reduced expiratory flow rate, demonstrated by the appearance of expiratory flow truncation (expiratory limb plateau). The patients having extrathoracic airway obstruction due to the mediastinal masses manifest reduced flow in the inspiratory phase (inspiratory plateau) [22]. Various studies have shown a poor correlation of the flow volume loops with the level of airway obstruction, and this test may not be beneficial for patient management [23, 24].

**Table 19.2** Shamberger risk assessment box

| | Tracheal area < 50% | Tracheal area > 50% |
|---|---|---|
| Peak expiratory flow rate (PEFR) > 50% | A (moderate risk) | B (low risk) |
| Peak expiratory flow rate (PEFR <50% | C (high risk) | D (moderate risk) |

**Transthoracic Echocardiography (TTE)** It can aid to detect pericardial effusion and cardiovascular compression [25]. Any patient with cardiac symptoms should have a TTE before the procedure. Identification of a pericardial effusion preoperatively can significantly impact patient management [26].

**Tissue Sampling** Many modalities are utilized to make and confirm the diagnosis of the mediastinal masses. For definitive management strategies, at times, a tissue sample is required for testing. Attempts should be made to obtain a biopsy with the assistance of a CT scan. If it is not technically possible, or the patient is not able to tolerate the procedure, or insufficient samples




Source: J.T. DiPiro, R.L. Talbert, G.C. Yee, G.R. Matzke, B.G. Wells, L.M. Posey: Pharmacotherapy: A pathophysiologic Approach, 10th Edition, www.accesspharmacy.com


**Fig. 19.1** Flow volume loops for thoracic airway obstruction are obtained, the surgical biopsy should be tried next.

## 19.5 Anesthesia Management

An individualized anesthetic plan needs to be formulated for every patient presenting with a mediastinal mass primarily based on the medical and radiological features (Table 19.3) [27]. The plan also needs to be made based on the proposed technique of surgical intervention and extent of surgery.

The various perioperative anesthesia strategies include the following:

**Table 19.3** Anesthesia goals for mediastinal mass

| Strategy | Remarks |
|---|---|
| Multidisciplinary optimization and planning | Optimize medically before the procedure (steroids, radiation, chemotherapy)<br>Perform procedures/biopsies under local anesthesia if possible<br>Guide approach by CT findings (> 50% tracheobronchial obstruction) and positional symptoms (supine dyspnea, presyncope) |
| The cautious approach to general anesthesia, if it is necessary | Maintain spontaneous ventilation and awake during ETT placement distal to the obstruction |
| Planning for an intraoperative crisis | Preoperative cardiopulmonary bypass<br>Invasive monitors and lines, venous access in lower extremities<br>Rigid bronchoscopy and thoracic surgeon immediately available during anesthetic induction<br>Stretcher immediately available for repositioning: prone, decubitus |
| Complications | Complete airway obstruction with dynamic hyperinflation, cardiac arrest from obstructive shock, hemorrhage from superior vena cava (SVC) syndrome, cardiac tamponade |

**Regional/Local Anesthesia** The small minimally invasive procedures like biopsies can be performed under regional anesthesia techniques [28]. The position-related respiratory compromise should be assessed, and care should be taken for such positions during the procedures. Various analgesic and anesthetic techniques include the use of regional blocks like intercostal, paravertebral, and epidural blocks. Local infiltration techniques may also be supplemented. The sedative drugs should be cautiously used; in fact, they should be avoided at most. The emerging use of dexmedetomidine and ketamine may be used in selected patients, if required [ 29].

**General Anesthesia** With the large mediastinal masses, there may be a significant risk of a total or near-total airway obstruction secondary to dynamic airway collapse caused due to various reasons under general anesthesia [30, 31]. The airway compromise may be related to general anesthesia-related decreases in lung volumes and thus the related decrease in tracheobronchial diameters. Also, the general anesthesia reduces the muscular tone including smooth muscles of the airway leading to airway compromise. The impact of general anesthesia on diaphragmatic mobility remains another cause as the caudal movement of the diaphragm is restricted under anesthesia. These cause a reduction in the transpleural pressure gradient which is one of the parameters for keeping the airway dilated [30]. If general anesthesia is required, preserving spontaneous respiration would maintain the normal gradient of transpulmonary pressure that helps to keep the airway stretched and patented, thus preventing the collapse of the airway.

The patients with mediastinal masses can be stratified for perioperative risk based on symptoms and tracheal diameter as “safe, unsafe, and uncertain” [10]. Such risk stratification shall aid in appropriate perioperative care planning, especially during the induction of anesthesia. Adult patients who are asymptomatic with a tracheal diameter of >50% may be considered “safe”; with severe symptoms irrespective of tracheal diameter as “unsafe”; and mild or moderate symptoms with tracheal diameter < 50% or with an uncertain history of tracheal diameter not known as "uncertain".

The concern for cardiovascular collapse after induction or bleeding due to mass invasion mandates the presence of wide-bore venous access in a patient with a mediastinal mass. It is prudent to secure two large-bore peripheral venous accesses before the induction of anesthesia. An arterial line may also be secured for blood pressure monitoring. The use of cardiac stable drugs like etomidate is preferred for the induction of anesthesia. The choice between propofol-based intravenous versus sevoflurane-based inhalational induction techniques needs to be individualized as per patient assessment. The shorter-acting neuromuscular blocking drugs are desirable for an optimal surgical field; however, its need may be discussed along with surgeons based on surgical interventions. If a patient has dyspnea while lying supine, a semi-recumbent or a lateral decubitus position should be used during anesthesia induction and airway management to alleviate the patient's symptoms. At times, turning the patient laterally or use of rigid bronchoscope is required if airway compromise occurs during anesthesia induction. Awake tracheal intubation under topicalization should be planned in patients with tracheal compression. The endotracheal tube should be negotiated beyond the compression [32]. Microlaryngeal surgery tube (MLS) can be handy in such a situation as it has more length with the narrow diameter and adult size cuff. The rigid bronchoscope can be used for the rescue oxygenation even if it is crossed into only one main stem bronchus to negotiate the compressed obstructed trachea. In such a situation, the endotracheal tube can be placed either by inserting an airway exchange catheter through the rigid bronchoscope or railroading the endotracheal tube over it after removal of the rigid bronchoscope. A double-lumen tube is the other option in cases of distal tracheal compression [33].

In patients with features suggestive of superior vena cava (SVC) syndrome, the peripheral venous access should be secured in lower limbs [34]. In patients with significant cardiovascular compromise, the arrangement of cardiopulmonary bypass (CPB) or extracorporeal membrane oxygenation (ECMO) is suggested [35, 36]. If it is impossible to place an endotracheal tube (ETT) or to do an awake tracheostomy due to the location of the mass, then CPB may be a useful alternative. The initiation of ECMO in individuals with low-lying mediastinal tumors should be considered as a component of the airway management strategy [35].

The postoperative concerns include lung atelectasis, infections, and airway edema with associated airway compromise. The postoperative mechanical ventilation and care in the critical care unit are desirable if the resection is lengthy, complicated, or technical hard or if the patient has undergone major fluid shifts or blood loss.

## 19.6 Anesthetic Concerns for Thoracic Robotic Surgery

Robotic surgery for mediastinal tumors has peculiar perioperative anesthetic concerns. It usually requires patient positioning in such a manner that the robot can be docked, its arms optimally aligned, and freely moved (Fig. 19.2). Such a position has the concern of airway and neurovascular compression of the upper limb. The pressure points need to be properly padded to prevent such neurovascular injuries [36]. The surgical procedure of robotic thymectomy requires dissection of major vascular and neural structures in the thorax [37]. This may lead to hemodynamic compromise and arrhythmias. Recurrent nerve palsy has been observed after surgical removal of ectopic thymus from the aortopulmonary window [38].

The other issues are docking the robot from one side and covering the patient's torso and face from the other side, limiting access to the airway of the patient (Fig. 19.3). Thus, double lumen tube (DLT) should be properly secured and in cephalad direction as the migration of DLT after the creation of capnomediastinum has been reported (Fig. 19.4). Surgical injury can cause pleural rent on the opposite side with a risk of


**Fig. 19.2** Patient's position during thoracic robotic surgery

**Fig. 19.3** The robot docking covers the patient's torso and head, limiting access to the airways of the patient

tension capnothorax. This is manifested by a sudden increase of end-tidal carbon dioxide ($EtCO_2$) and a rise in airway pressures (Paw). This can be treated by increasing the size of the rent surgically for the escape of the collected gases. Neuromuscular blockade is needed to adequately ventilate and maintain normocarbia. Besides care for patients with myasthenia gravis, thorough observation is needed for blood loss and postoperative nerve injury.

**Postoperative Pain Management** Postoperative analgesia is not only important for patient satisfaction but also for minimizing pulmonary complications, enabling the patient to breathe deeply, cough effectively, and ambulate. Opioids can be titrated during emergence from anesthesia to achieve adequate analgesia, avoiding respiratory depression. This can be continued postoperatively by patient-controlled analgesia (PCA), often in conjunction with nonsteroidal anti-inflammatory drugs (NSAIDs). For video-assisted or robotic-assisted thoracoscopic surgery, postoperative PCA in combination with NSAIDs or paracetamol should be sufficient. However, for sternotomy or thoracotomy, con-


**Fig. 19.4** Cephalad fixation of DLT to avoid any obstacle in the field of robotic arms

gruent thoracic epidural infusion or paravertebral infusion of local anesthetic will provide suitable postoperative analgesia. Other techniques of pain management are intrathecal opiates, intercostal nerve block, cryoanalgesia, and intrapleural regional analgesia. As robotic surgeries are minimally invasive, neuraxial analgesia should be avoided, and the use of multimodal analgesia techniques including short-acting opioids and NSAIDs is sufficient for pain control.

## 19.7 Anesthetic Concerns in Pediatric Patients with a Mediastinal Mass

As children have the compressible cartilaginous structure of the airway [39] and it is difficult to obtain a history of positional symptoms, deaths are mainly been reported in children with mediastinal mass during anesthesia induction. Anesthetic management of such children is challenging because of the risk of compression of the airway and great vessels after induction of anesthesia [40]. Moreover, signs/symptoms may not correlate with the size of the tumor, and it is difficult to find out from history as they cannot express symptoms. Pre-biopsy steroid treatment is justifiable in high-risk children without extrathoracic lymphadenopathy or pleural effusion. Coordinating the timing for the biopsy is essential in these situations, with the oncology, surgery, and anesthesia team. Another option to preoperative steroids is to irradiate the tumor while leaving a tiny region covered by lead for subsequent biopsy in the cooperative high-risk person.

Inhalational induction with spontaneous ventilation is advisable as children may not be cooperative under local/topical anesthesia. For thoracotomy of VATS, lung isolation with one-lung ventilation may be achieved with an appropriate size DLT or bronchial blockers. The smallest size DLT available is 26Fr which can be used only in children >8 years. In children below 8 years, the other option is to use univent tube with a bronchial blocker. The smallest univent tube available is size 3.5 mm ID which can be used in children >6 years. However, fiber-optic bronchoscopy is required to place bronchial blockers in the appropriate place, and univent has a high resistance to gas flow due to small internal diameter. Other bronchial blockers like Arndt, Cohen, and EZ blockers can be used in children if appropriate sizes are available. Fogarty embolectomy catheter has been used for lung isolation in small children and infants [41]. This also requires fiber-optic bronchoscopy for the appropriate placement of the Fogarty catheter. Moreover, the high-pressure, low-volume cuff can cause bronchial mucosal injury, and there is a risk of displacement of Fogarty intraoperatively.

Appropriate analgesia is of paramount importance for thoracotomy or sternotomy. Inserting a thoracic epidural catheter in an anesthetized child may not be considered safe. The epidural catheter can be inserted via lumber or caudal route and advanced till thoracic dermatome under ultrasound guidance [42]. Alternate modes of analgesia are paravertebral block or intravenous opioid analgesia supplemented by paracetamol/NSAIDs.

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