

# Mediastinal Mass Syndrome

The Perioperative Management of Patients  
With Mediastinal Mass Syndrome

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# **MEDIASTINAL MASS SYNDROME**

## The Perioperative Management of Patients with Mediastinal Mass Syndrome

### **Introduction**

Mediastinal mass syndrome is associated with an increase in perioperative morbidity and mortality [1]. This group of patients represent a unique set of challenges and remains a key area of interest to the multidisciplinary team managing them.

Depending on the size and location of the mediastinal tumour, symptoms may vary considerably. Patients may present asymptotically or exhibit pronounced features of cardiorespiratory compromise.

In the presence of severe cardiorespiratory symptoms such as positional dyspnoea, stridor, syncope and superior vena cava syndrome, the administration of general anaesthesia may be fatal [2].

Inadequate perioperative evaluation and preparation, coupled with a poor choice in anaesthetic technique may rapidly escalate into a life threatening situation. This review will attempt to cover the major issues surrounding the management of patients with mediastinal masses.

## Anatomy

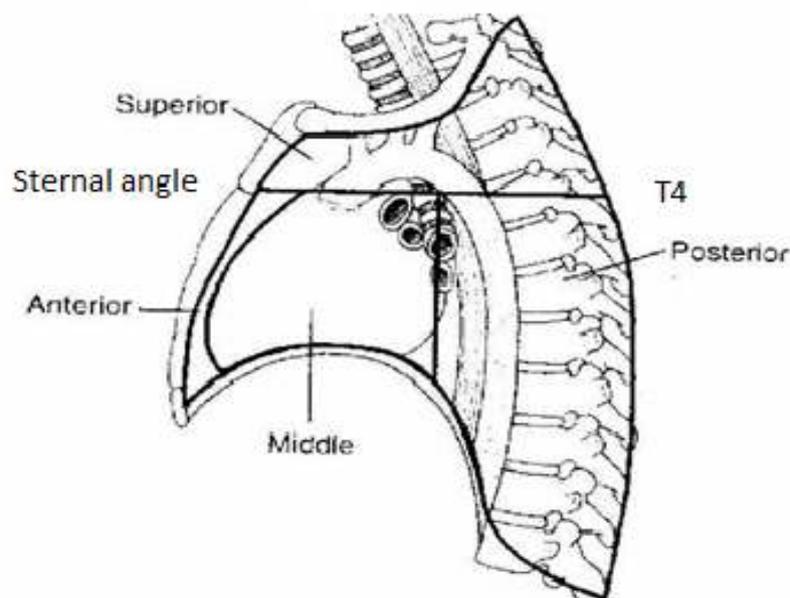
The anatomical location of a mass may explain some of the signs and symptoms patients present with. Due to potential mass compression, deviation or invasion of the adjacent mediastinal structures, a sound understanding of the anatomy of the mediastinum is crucial in the evaluation of these patients.

The mediastinum is located between the right and left pleurae. It extends from the sternum anteriorly to the vertebral column posteriorly. Included are all thoracic viscera with the exception of the lungs. The mediastinum can be divided into the superior and inferior sections by an anatomical plane extending from the sternal angle to the level of the T4 vertebra. The inferior mediastinum is further divided into the anterior, middle and posterior sections.

The anterior mediastinum can be regarded as the space between the sternum and the anterior portion of the pericardium [3]. The anterior mediastinum is also in continuity with the superior mediastinum and collectively they are referred to as the antero-superior mediastinum or the pre-vascular compartment [4]. It contains the trachea, thymus, large veins, arteries, oesophagus, thoracic duct, lymph nodes, sympathetic trunk, ectopic thyroid gland and the parathyroid tissue. Compression of these structures often result in tracheobronchial compression, superior vena cava syndrome and dysphagia.

The middle mediastinum is the area between the anterior pericardium and the anterior aspect of the vertebral body. The middle mediastinum is also known as the visceral compartment and contains the heart, oesophagus, great vessels as well as the phrenic and vagal nerves. A mass occupying the middle mediastinum may lead to airway compression or deviation and cardiac tamponade.

The posterior mediastinum lies between the anterior and posterior vertebral bodies and includes the paravertebral gutters. It contains, intercostal nerves, thoracic spinal ganglion and the sympathetic chain. Posterior mediastinal masses produce effects related to the spinal cord and are rarely associated with airway problems.



**Figure 1. Anatomy of the Mediastinum [5]**

## Mediastinal Masses

Mediastinal masses may either be benign or malignant. Patients with benign tumours are often asymptomatic (54%), compared to malignant tumours (15%) [6]. Malignancy tends to vary with age as lesions are likely to be benign in the first decade of life (73%) and malignant from 2<sup>nd</sup> to 4<sup>th</sup> decade [7].

The commonest mediastinal tumours in order of frequency in adults are lymphomas (Hodgkin's or non- Hodgkin's), thymoma, germ cell tumour, granuloma, bronchogenic carcinoma, thyroid tumours, bronchogenic cysts and cystic hygroma [8]. In children, lymphomas (45%), neurogenic tumour (34%) and germ cell tumour were found to be the most common [9].

**Table1: Classification of mediastinal tumours and masses by location [10]**

<b>Anterior mediastinum</b>	<b>Middle mediastinum</b>	<b>Posterior mediastinum</b>
Lymphoma	Foregut cysts	Neurilemmoma
Thymoma	Lymphoma	Neurofibroma
Germ cell tumour	Pleuropercardial cysts	Schwannoma
Mesenchymal tumour	Granulomatous disease	Ganglio-neroma
Thymic cysts	Mesenchymal cysts	Neuroblastoma
Endocrine tumour	Mesenchymal tumour	

## **Mediastinal Mass Syndrome (MMS)**

Mediastinal mass syndrome refers to the clinical picture caused by the mediastinal mass effect in the anaesthetized patient. This syndrome can result in acute cardio-respiratory decompensation that may present at any time during the intraoperative course and immediate postoperative period. Respiratory decompensation is caused by mechanical compression of the trachea and /or the main bronchi. This is precipitated by a change in the pressure within the respiratory tract, due to positioning, administration of general anaesthesia or the commencement of positive pressure ventilation [11]. A critical increase in airway pressure may make ventilating these patients very difficult and sometimes impossible.

Supine positioning results in a reduction of the transverse diameter of the thorax as well as the cephalad displacement of the diaphragm. The cross sectional area of the thoracic airway is reduced and at the same time there is an increase in external pressure compressing the airway. Interestingly, central blood volume increases which may dramatically expand the size of highly vascular tumours.

On induction of general anaesthesia there is a further reduction in the thoracic transverse diameter as inspiratory muscle tone decreases. Abdominal muscle tone is also reduced and the cephalad displacement of abdominal contents occurs. It is estimated that these changes may result in a reduction of thoracic volume by as much as 1L [12].

In the spontaneously breathing patient, turbulent post stenotic flow across a reduced or narrowed area of the airway results in inefficient gaseous exchange, air trapping and shunt.

The administration of neuromuscular blocking agents results in diaphragmatic relaxation and a reduction in the trans-pleural pressure gradient.

With the commencement of positive pressure ventilation, the poorly perfused anterior lung segments are preferentially ventilated. As a result, dorsal atelectasis occurs. There is V/Q mismatch and increased shunt. Mechanical ventilation increases intrathoracic pressure and causes the tumour to press against adjacent mediastinal structures [13].

Postoperatively, airway obstruction may occur from the formation of tissue oedema at the operative site. Any impediment to thoracic wall movement either from a patient who has not fully recovered from the effects of general anaesthesia or those with inadequate pain management, may precipitate airway obstruction [14].

A mediastinal tumour may compress or infiltrate the heart and great vessels. Haemodynamic instability may occur. Compression of the pulmonary artery produces a reduction in pulmonary blood flow and as a consequence of impaired pulmonary perfusion, hypoxaemia and acute right ventricular failure may result. Patients are often asymptomatic but with the administration of general anaesthesia, symptoms may be unmasked. Another large vessel that may be involved is the superior vena cava, which is particularly susceptible to compression due to its thin vascular wall and low intravascular pressure [15]. Patients with superior vena cava syndrome have reduced venous drainage of the upper body which is often associated with a reduction in right ventricular filling and a decrease in cardiac output. Direct compression of the heart may precipitate arrhythmias and pericardial tamponade [16].

## Clinical Presentation

The pressure effect created by a mediastinal mass on the surrounding tissue determines the presenting features. Symptoms related to airway obstruction could present as cough, stridor, postural dyspnoea and cyanosis. Often symptoms related to postural changes are very subtle (Table 2) and careful enquiry is needed. Compression of the heart and great vessels may lead to syncope, dysrhythmias and cyanosis. Patients may also present with superior vena cava syndrome, characterized by engorged neck veins, facial oedema and mental obtundation [17].

Signs and symptoms of airway and cardiovascular compression should be regarded as predictors of potential anaesthetic problems and should not be taken lightly [18]. However, it is important to realize that patients who show no preoperative symptoms can also develop serious complications perioperatively. Therefore, the clinical assessment of possible cardiorespiratory compromise should be supplemented with additional investigations.

**Table 2. Grading scale for symptoms in patients with mediastinal mass syndrome [19]**

Asymptomatic	Can lie supine without symptoms
Mild	Can lie supine with cough/ pressure sensation
Moderate	Can lie supine for short periods but not indefinitely
Severe	Cannot tolerate supine position

## Investigations

### Radiological evaluation

Radiological evaluation may include the use of a plain chest X-ray and computed tomography. It is important to note that a plain chest X-ray may not clearly delineate the airway and a penetrating view of the neck in both antero-posterior and lateral views should be obtained.

Plain chest X-rays with postero-anterior and lateral views may provide valuable information regarding the relationship of a mass to the tracheobronchial tree [20]. Deviation, compression and lung collapse can be identified on plain X-ray. It may also aid in confirming the density of a lesion. Apart from chest radiographs, computed tomography has become the established standard investigation tool in assessing patients [21]. Modern scans can take as little as twenty seconds and allows for an upper body elevation of thirty degrees without affecting scan quality.

CT and MRI scans are not only used to accurately assess the size and location of a tumour but also airway diameter. Unlike a plain chest X-ray, a CT scan can more reliably and accurately quantify the degree of airway compression. It is especially useful for the evaluation of the lower airway.

### Tracheal diameter

The degree of tracheal compression on CT scan may be used to predict airway difficulty following the induction of general anaesthesia. A 35% reduction in tracheobronchial diameter has been associated with respiratory symptoms, while a 50% decrease has been associated with complete obstruction of the airway following induction or emergence [22]. A 50% reduction in trachea diameter has also been associated with a higher risk of respiratory complications [17].

### Tracheal cross sectional area

The tracheal cross sectional area can be used to predict airway obstruction. The tracheal area in relation to the predicted tracheal area can be calculated as a percentage tracheal area. Reports have indicated that patients with less than 50% of the predicted area have a higher risk of respiratory complications and should not receive a general anaesthetic [23]. Studies have recommended that patients with a 50% or greater reduction should have their femoral vessels cannulated before the start of general anaesthesia in preparation for cardiopulmonary bypass [23].

### Mediastinal thoracic ratio (MTR)

MTR compares the size of the mediastinal mass with the thoracic diameter. Patients with a MTR of greater than 50% have demonstrated a higher risk of pulmonary complications [24].

### Mediastinal mass ratio (MMR)

MMR is the maximum width of the mediastinal mass in relation to the maximal width of the mediastinum, measured by CT scan. Mediastinal masses are regarded as small <30%, medium 30-40% and large >40% [17]. Masses greater than 56% are associated with respiratory complications [17].

### Pulmonary function tests:

The use of dynamic examination techniques may provide an estimation of possible respiratory decompensation under general anaesthesia, based on a change in a patient's position [16]. Pulmonary function studies are quantitative tests and should be performed in both the upright and supine positions.

### Peak expiratory flow rate (PEFR)

PEFR may be used to provide information relating to the central diameter of the airway. A 50% reduction of the predicted PEFR in the supine position has been associated with anaesthetic complications [25]. Samberger et al plotted the PEFR and tracheal area as a percentage of predicted values in 31 patients with anterior mediastinal masses undergoing preoperative assessment. Samberger developed a risk assessment box (table 3) to select the most appropriate anaesthetic for patients based on their risk group [23].

**Table 3. Samberger risk assessment box [23]**

<b>Group</b>	<b>PEFR and Tracheal cross sectional area (% of predicted)</b>	<b>Anaesthetic Technique</b>
A (moderate risk)	>50%, <50%,	Local/ GA spontaneous respiration, avoid muscle relaxation
B (low risk)	>50%, >50%	GA
C (high risk)	<50%, < 50%	LA only
D (moderate risk)	<50%,>50%	Local/ GA spontaneous respiration, avoid muscle relaxation

### Flow volume loop

Flow volume loops are often ordered as part of the perioperative work up for patients with anterior mediastinal masses. Variable intrathoracic airway obstruction can be identified by an increased expiratory plateau, when changing from the upright to supine position. This is often regarded as pathognomonic and places patients at risk of airway collapse on induction of anaesthesia [26]. Unfortunately, flow volume loops have shown a poor correlation with the degree of airway obstruction and its usefulness in managing these patients is currently under evaluation [27].

One study of 25 patients with intrathoracic masses due to Hodgkin's disease found that no patient showed the pathognomonic pattern of variable intrathoracic obstruction on flow volume loop, despite 9 out of 25 patients having moderate to severe intrathoracic tracheal compression on CT scan [28]. Interestingly, 7 of the 25 patients also demonstrated an inspiratory plateau on the flow volume loop, typical of extrathoracic airway obstruction. Of note, none of the CT scans were able to identify an extrathoracic mass in this group of patients [28].

### Awake fiberoptic bronchoscopy

Awake fiberoptic bronchoscopy should be considered in symptomatic patients with anterior mediastinal masses to assess the degree of obstruction and mass invasion. It allows for the direct visual assessment of the obstructed zone as well as the proximal and distal airways [29]. A fiberoptic bronchoscope can be used to secure an airway by facilitating the passage of an armoured endotracheal tube through the obstructed zone, into the distal airway [30].

### Echocardiography

If haemodynamic instability or cardiovascular involvement is suspected from clinical examination and/or CT scan findings, transthoracic and transoesophageal echocardiography is indicated [31]. To assess compression and possible changes in ventricular filling, associated with changes in position, the echocardiogram should be performed in both the supine and lateral positions.

**Table 4: Risk classification, possible anaesthetic mediastinal mass syndrome [16]**

Safe	Asymptomatic adults (CT and dynamic evaluation with negative results)
Unsafe	Symptomatic adults (clinical signs present and positive diagnostic evaluation)
Uncertain	Adults with moderate clinical symptoms Asymptomatic adults obstruction of the tracheobronchial tree (CT tracheal/bronchial diameter <50% of normal) Asymptomatic adults with abnormal dynamic evaluation Adults without the possibility of diagnostic evaluation

## **Preoperative Management of Mediastinal Mass Syndrome**

Patients with mediastinal mass syndrome should be presented to the interdisciplinary team as soon as possible to determine the optimal diagnostic and therapeutic approach. Close cooperation and good communication between various departments including anaesthesia, surgery, radiology, ENT and pathology is required. The possibility of irradiation and chemotherapy should be considered [4]. This may help reduce the size of the tumour and decrease perioperative complications [3]. Therefore, histological confirmation of a mediastinal mass using CT or ultrasound guided biopsy should be performed under local anaesthesia, especially in high risk patients [15].

The role of the anaesthesiologist prior to surgery should be to carry out a careful clinical examination as well as review CT and cardiorespiratory dynamic test findings. Before the commencement of anaesthesia, the size and location of the mass needs to be clearly determined as well as any airway, superior vena cava or pulmonary artery compression [16]. Following clinical and diagnostic evaluation, patients should be assigned an MMS risk class (safe, unsafe, uncertain) in order to standardize perioperative management [19].

Patients who have been classified as being unsafe or uncertain may require additional staff members to be available, should an emergency arise. Therefore, in addition to the surgical team, a second anaesthetist, nursing staff and perfusionist are required.

Patients with MMS should not receive preoperative sedation to avoid respiratory depression and muscle relaxation [16]. The anaesthesiologist must be present to transport patients with position dependent MMS to theatre. Intravenous injection in the upper limbs cannot be used for effective drug administration in patients with superior vena cava syndrome. Reduced superior vena cava blood flow may alter the pharmacokinetics of drug administration, delaying the onset of anaesthetic and resuscitation drugs.

It is therefore recommended that large bore intravenous access be established in the lower extremities. The pulse oximeter should be attached to the right hand in order to monitor the brachiocephalic trunk which may be injured during intrathoracic procedures. Preoperative documentation of the patient's most comfortable position in terms of haemodynamic and respiratory symptoms should be established [16]. The induction of general anaesthesia should be carried out on an operating table that allows for rapid changes in patient position should cardiorespiratory decompensation occur.

It is important, before the induction of general anaesthesia, to discuss alternative airway and circulatory management plans with the entire team. All necessary equipment must be gathered and checked. Long endotracheal tubes of various sizes, reinforced endotracheal tubes, a flexible fiberoptic and rigid bronchoscope should be immediately available. Patients who have been classified as being unsafe should also have a cardiopulmonary bypass machine prepared and a perfusionist present.

### **Anaesthesia for biopsy**

An important part of any anaesthetic assessment of these patients should be to determine if the proposed procedure is therapeutic or diagnostic. Tissue biopsy should be performed under local or regional anaesthesia in symptomatic or unsafe patients to avoid the risk associated with general anaesthesia.

CT guided needle biopsies have demonstrated a diagnostic accuracy of over 90% and are often carried out under local anaesthesia or sedation [32]. Another useful, well described option in adults, is an awake anterior mediastinoscopy carried out under local anaesthesia. Diagnostic thoracentesis can be done with ultrasound guidance in the sitting position with minimal or no sedation. Cytometric and immunocytochemical studies of pleural fluid can be diagnostic, especially in patients with lymphoblastic lymphoma [33].

Young symptomatic children under going superficial lymph node biopsy should receive EMLA cream locally so as to improve patient cooperation [9]. Lymph node and tissue biopsies have been safely carried out with the use of ketamine sedation or anaesthesia. Ketamine has many desirable properties as it maintains spontaneous ventilation and preserves the normal transpleural pressure gradient and airway patency. Its sympatomimetic properties are also useful in maintaining haemodynamic stability in patients with large mediastinal masses, causing cardiovascular compression [34]. Antisialagogue agents should be used prior to the administration of ketamine.

## Management of Mediastinal Mass Syndrome

Induction of general anaesthesia should be gradual and the constant monitoring of respiratory and haemodynamic parameters during this process are essential. The use of short acting agents to facilitate general anaesthesia while maintaining spontaneous ventilation and preserving muscle tone is recommended [19]. Possible agents for induction include sevoflurane and etomidate. Remifentanyl appears to be a good choice of opioid due to its short half- time [35]. Airway management is ideally established in unsafe patients by an awake fiberoptic intubation with the patient fully conscious and breathing spontaneously [16]. The endotracheal tube selection, should be based on the largest internal diameter able to facilitate intubation and resist external compression such as a reinforced spiral endotracheal tube. Once the endotracheal tube has been inserted, the fiberoptic scope is used to confirm tube position. The fiberoptic bronchoscope can then be used to rule out collapse and intraluminal obstruction of the trachea and bronchi. The patient's position may then be changed and airway obstruction further evaluated.

Having induced the patient, temporary- assisted breathing may often be necessary. The use of muscle relaxation should be avoided unless the surgeon requests paralysis. Succinylcholine should be injected slowly and if mechanical ventilation is achieved without a significant increase in airway pressure, then only can longer acting agents be used [16]. Should oxygenation become a problem, a change in the patient's position may be required and tube position reconfirmed.

### Management of intraoperative complications

Airway obstruction is one of the most common and feared complications. It may occur on induction or at any time during anaesthesia and may result in significant morbidity and mortality. Involvement of the lower airways poses a special problem as emergency tracheostomy may not alleviate the obstruction [5]. In the event of cardiorespiratory compromise, first reaction should be to reverse the effects of general anaesthesia (positive airway pressure) and change the patient's position [5].

### Changing the patient's position

The operating table should be tilted into the comfort position as described preoperatively by the patient. In this position airway compression and circulatory decompensation can be alleviated following a reduction in tumour related compression [18].

### Emergency median sternotomy and tumour debulking

Emergency surgical decompression may be lifesaving in refractory cases. A median sternotomy and manual elevation of the mass may be required to relieve extrinsic compression on the airway [36].

### Splinting the trachea and bronchi

Respiratory compression can also be managed by attempting to splint the trachea by advancing a long endotracheal or armoured tube [37]. This can also be facilitated by the use of a rigid bronchoscope when a normal endotracheal tube fails to pass through the affected area [18]. Double lumen tubes have also been used to splint the trachea and main bronchi and can maintain airway patency by independently ventilating each lung [38]. Inverted Y stents have been used to splint the airway when the obstruction extends to the main bronchi [39]. Patients with severe tracheal and left bronchial compression have also been managed by placing a single lumen endobronchial tube into the right main bronchus and ventilating the right lung [40]. Interestingly, microlaryngeal tubes are often used and are best suited as they have a smaller diameter (5mm) and a longer length (31cm) allowing them to be placed endobronchially, beyond the area of obstruction [41].

### Femoro-femoral cardiopulmonary bypass

Haemodynamic instability may be managed by volume expansion and inotropic support. Surgical bleeding should also be considered as a differential in an unstable patient. Unsafe patients should not be induced unless alternative methods of maintaining oxygenation and circulation have been instituted. Femoro-femoral cardiopulmonary bypass has been successfully used to restore oxygenation in patients with severe airway obstruction and those with pulmonary artery compression [42]. Femoral vessel cannulation should occur prior to induction of anaesthesia. Once cardiorespiratory decompensation occurs it may take between 5-10 minutes to cannulate and provide adequate circulation and oxygenation even if the team is prepared and the pump primed [43].

### Helium- oxygen mixture

A helium- oxygen mixture can be used to maintain oxygenation by reducing airflow resistance in spontaneously breathing anaesthetized patients who encounter severe airway compression [44].

### Postoperative management of mediastinal mass syndrome

Patients who have been identified as being unsafe should be transferred to an intensive care unit postoperatively, with the aim of early extubation [16]. Patients who are of the uncertain risk category should be transferred appropriately depending on the level of monitoring and nursing care required. This is often based on the preoperative findings as well as the intraoperative course.

Mediastinal tumours that have been completely removed are rarely associated with cardiorespiratory instability post operatively [16]. However, patients who have undergone diagnostic procedures or surgery unrelated to the mass are still at risk and may decompensate at any time during the postoperative period. Therefore, provision should be made to acutely manage these patients should the need arise.

Patients who have been extubated and who are cardiopulmonary and neurologically stable should be transferred to high care, where ECG, blood pressure and saturation monitoring must continue for the next 24 hours.

## **Conclusion**

Cardiorespiratory decompensation can only in part, be attributed to the underlying pathophysiological process. Most of the life-threatening complications occur as a result of ignorance and the lack of proper perioperative management. Over the past two decades our awareness of the potential cardiorespiratory complications in patients with MMS under general anaesthesia has grown. This has led to improved management of these patients as many institutions have developed their own standardized protocols that represent a logical pathway for colleagues to follow in managing patients with MMS.

New imaging modalities have made it possible to avoid general anaesthesia and its associated complications for diagnostic purposes in high risk patients. We have also identified a subset of patients who may benefit from chemotherapy and radiotherapy in an attempt to shrink tumour size and decrease perioperative complications.

The most useful information relating to the management of these patients can be elicited by careful clinical evaluation and the review of CT scan findings. Interestingly, flow- volume loops have not been able to add any additional benefit in managing these patients, but are still ordered as part of the standard perioperative work up.

Femoro- femoral cardiopulmonary bypass has been used to restore oxygenation and circulation in high risk patients. It is recommended that the femoral vessels be cannulated under local anaesthetic prior to the induction of general anaesthesia to save time in the event of acute decompensation.

Finally, much of the success in managing these patients depends on a high level of cooperation and communication among members of a multidisciplinary team.

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