

Anesthetic Considerations for Patients with Anterior Mediastinal Masses

John W.W. Gothard, MBBS, FRCA

*Anaesthetic Department, The Royal Brompton Hospital, Sydney Street,
London SW3 6NP, UK*

Tumors presenting in and around the mediastinal cavity are uncommon. It has been said that a general practitioner in the United Kingdom will see, on average, one case during a professional lifetime, and in the United Kingdom approximately 250 to 300 procedures are performed annually in adults for the open surgical resection of mediastinal tumors [1]. Many more procedures are performed for biopsy of mediastinal masses, and variable but much smaller numbers of resections are undertaken by means of video-assisted thoracic surgery (VATS) (Table 1). It also is likely that thymectomy for myasthenia gravis is not fully represented in these figures, because some of these procedures are undertaken in neurosurgical units.

Mediastinal masses are a heterogeneous collection of benign and malignant tumors [2], and they usually are designated as located in the anterior, middle, or posterior mediastinum (Box 1). This anatomic description is somewhat arbitrary, but, in general, anterior mediastinal tumors cause the most severe and often life-threatening complications relating to compression of the airways and vascular structures. These problems are exacerbated by general anesthesia, as outlined later.

There is considerable overlap in the effect of anterior and middle mediastinal tumors, and anterior masses often encroach on and invade the middle mediastinum. The mortality for surgery and anesthesia in patients who have a mediastinal mass is low (see Table 1). At the extreme end of the disease spectrum, however, anterior mediastinal tumors can be very difficult to manage in the perioperative period, and the literature provides many examples of cardiorespiratory disasters and even death [3–6]. Many of these publications relate to pediatric practice.

There are differences between adult and pediatric populations in the histology, location, and symptomatology in mediastinal tumors [7]. In particular,

E-mail address: j.gothard@rbht.nhs.uk

Table 1
Surgery for mediastinal procedures^a

Procedure	2002–2003		2003–2004		2004–2005	
	Total	Deaths (%)	Total	Deaths (%)	Total	Deaths (%)
Resection mediastinal mass	333	4 (1.2)	269	1 (0.4)	252	1 (0.4)
Mediastinoscopy/ mediastinotomy	2767	9 (0.3)	2525	9 (0.4)	2533	13 (0.5)
Video-assisted thoracic surgery resection of mediastinal mass/tumor	154	0	106	0	43	0

^a United Kingdom data from 36 centers (2002–2005).

Data from Society of Cardiothoracic Surgeons of Great Britain and Ireland (SCTS) (2002–2005) Thoracic surgical register. Available at: www.scts.org. Accessed March 24, 2008.

there is an increased incidence of neurogenic tumors in children [8]. These factors may account for the increased incidence of problems in the pediatric patient, but intuitively one would think the smaller airways and lack of respiratory reserve found in children account for most of the increased difficulty. Slinger and Karsli [9] have recently re-emphasized the risk that general anesthesia poses to children who have an anterior mediastinal mass.

Imaging

CT scanning provides the bulk of information relating to extent of a mediastinal mass, its anatomic location, and the invasion of surrounding structures. A thyroid scan may be helpful if a thyroid mass is suspected and should be undertaken before iodinated contrast is given to enhance a CT scan.

MR imaging is not used routinely, but it may be helpful if a posterior neurogenic tumor is suspected. Positron emission tomography is not used for primary imaging but can be used to follow up germ-cell tumors after initial treatment.

If invasion or obstruction of vascular structures such as the pulmonary arteries or superior vena cava (SVC) is suspected, angiography and/or echocardiography may provide further useful information, but a high-quality CT scan usually is sufficient.

Diagnosis and treatment

The majority of anterior mediastinal masses, including thymomas, require surgical resection, although Hodgkin lymphomas respond well to chemotherapy and/or radiotherapy, with a high cure rate. A biopsy diagnosis is essential to establish a precise diagnosis and guide therapy.

Box 1. Mediastinal tumors*Anterior mediastinum*

Benign

- Thymoma
- Thymic cyst
- Thymic hyperplasia
- Thyroid
- Cystic hygroma

Malignant

- Thymic carcinoma
- Thyroid carcinoma
- Seminoma
- Mixed germ cell
- Lymphoma

Middle mediastinum

Benign

- Benign adenopathy
- Cysts
- Esophageal mass
- Hiatus hernia
- Cardiac/vascular structure

Malignant

- Lymphoma
- Metastases
- Esophageal cancer
- Thyroid cancer

Posterior mediastinum

Benign

- Neurofibroma
- Schwannoma
- Chemodectoma
- Foramen of Bochdalek hernia

Malignant

- Neuroblastoma

Data from Yoneda KY, Louie S, Shelton DK. Mediastinal tumors. Curr Opin Pulm Med 2001;7:226-33.

Biopsy

A needle biopsy or a “Tru-cut” type biopsy performed under CT guidance often provides sufficient tissue for diagnosis. This procedure can be performed under local anesthesia in adults but may be difficult in children. In some circumstances insufficient tissue is obtained, or the tumor may be adjacent to vascular structures such as the aorta, making this approach inadvisable. In these situations patients may be referred for a surgical biopsy under general anesthesia, possibly via mediastinoscopy, mediastinotomy, or thoracoscopy. In this circumstance symptomatic patients who have airway obstruction are exposed to the risks of anesthesia discussed later.

Tracheobronchial stenting

Developments in airway stenting have revolutionized the treatment of adult patients who have lymphoma and severe airway obstruction. In the past it often was very difficult, even following anesthesia for a biopsy procedure, to extubate patients who had a large tumor mass causing severe extrinsic tracheobronchial compression. On occasions the author and colleagues have ventilated patients using a double-lumen endobronchial tube in the postoperative period to maintain some degree of airway patency during chemotherapy. Now, stenting of the trachea and bronchi is used to maintain an adequate airway and allow spontaneous respiration [10]. As chemotherapy/radiotherapy progresses, assuming the tumor responds, the stents can be removed. Anesthesia for tracheobronchial stent insertion has been reviewed by both Brodsky and Conacher [11,12] and is not considered further here. It is worth noting, however, that stenting is less practical in small children.

The controversy over blind pretreatment

Patients at high risk of airway obstruction intraoperatively may benefit from pretreatment of the mediastinal mass with steroids, empiric chemotherapy, and/or radiotherapy. This approach is advocated in some treatment algorithms for children [13]. This treatment can cause rapid tumor lysis and alleviate airway obstruction but also may adversely affect the accuracy of tissue diagnosis once a biopsy is taken. Robie’s group [13] found tissue diagnosis was not affected if biopsies were taken within 72 hours of starting treatment. Other groups, however, believe that an accurate tissue diagnosis can be compromised by pretreatment. Ferrari and Bedford [14] reported a series of children requiring surgery for an anterior mediastinal mass. None of the 44 children undergoing an anesthetic procedure died or sustained permanent injury as a result of the procedure. Two patients, however, required airway management with a rigid bronchoscope intraoperatively (see later discussion), two patients needed a change in position to alleviate airway

obstruction, and four patients could not be extubated at the end of surgery. The authors conclude that, except in extreme circumstances, it is preferable to acquire a tissue diagnosis before starting treatment, even if doing so necessitates the use of general anesthesia.

Anesthesia for resection of anterior mediastinal tumors

Evaluation of risk factors

Patients who have marked symptoms of airway compromise such as dyspnea at rest, postural dyspnea, orthopnea, or even stridor are at high risk of intraoperative airway problems. Compression of the heart, SVC, and pulmonary arteries also can cause syncope, arrhythmias, head and neck edema, and even a degree of cyanosis, particularly in children [13]. These symptoms usually correlate with the CT findings, which delineate airway obstruction and vascular and pericardial involvement.

Lung function tests, including arterial blood gas analysis, usually are performed as a baseline but in the author and colleagues' experience do not play a large part in evaluating the risk of surgery. It is important to realize that the symptoms described can be much worse in the postoperative period, particularly following a biopsy procedure; hence difficulty in extubating these patients sometimes is experienced. After a biopsy under general anesthesia, the patient is exposed to the deleterious effects of anesthesia, with diminished lung volumes and other effects, without the benefits of tumor excision [5].

A recent study of adults who had a mediastinal mass looked at the cardiorespiratory complications in the perioperative period [15]. This group found that intraoperative complications were associated with a pericardial effusion seen on the CT scan. Postoperative respiratory complications were related significantly to tracheal compression of more than 50% on CT scan and a mixed (obstructive/restrictive) picture of abnormal pulmonary function preoperatively. A similar study of 63 children (1964–2002) found that the presence of at least three respiratory symptoms/signs, tracheal and vascular compression, and infection significantly increased the risk of general anesthesia [6]. Of these features, tracheal compression, which led to two deaths, was the strongest predictive factor for complications. Findings from a similar but more recent study by Lam and colleagues [16] are listed in **Box 2**.

Angelescu and colleagues [17] recently have reported a larger series of 117 children who had malignant mediastinal masses. Risk factors associated with anesthesia-related complications were similar to those reported by Lam and colleagues [16], but the severity of complications was low. The authors attribute this reduced severity to a number of factors, including the use of interventional radiology to obtain tissue diagnosis, thorough preoperative evaluation, and minimal anesthetic intervention.

Box 2. Mediastinal tumors in children**Factors associated with acute airway compromise**

- Airway narrowing/displacement on imaging
- Anterior location of tumor
- Histologic diagnosis of lymphoma
- Symptoms/signs of superior vena cava obstruction
- Radiologic evidence of vessel compression
- Pericardial effusion
- Pleural effusion

Data from Lam JCM, Chui CH, Jacobsen AS, et al. When is a mediastinal mass critical in a child? An analysis of 29 patients. *Pediatr Surg Int* 2004;20:180–4.

Systemic effects of the tumor

Patients who have an intrathoracic goiter may have abnormalities of thyroid function that require monitoring and treatment before surgery. Up to 30% of patients who have a thymoma have symptomatic myasthenia gravis, which obviously has significant anesthetic implications [18,19].

Management of airway obstruction

Management of the airway in patients who have a large anterior mediastinal mass causing airway compression remains controversial. Treatment modalities that can (or have been) used to minimize risk are listed in **Box 3**.

During anesthesia lung volume is reduced, and bronchial smooth muscle relaxes, thereby increasing the compressibility of large airways [20]. Partially obstructed respiration, which can occur during an inhalational induction, generates large negative pressures that tend to flatten further a trachea weakened by extrinsic compression. Muscular relaxation, on the other hand, causes loss of chest wall tone and disrupts the forces of active airway inspiration, thereby further reducing external support of the narrowed airway. Abnormal patterns of spontaneous breathing on emergence also can cause partial obstruction of breathing on inspiration.

Maintenance of spontaneous respiration

Maintenance of spontaneous respiration and avoidance of muscular relaxation during anesthesia has been advocated by several authors and is a major part of some management algorithms. This approach is based on local experience in individual centers and on case-report evidence in the literature. There are inconsistencies in the use of this technique, however.

**Box 3. Airway management during anesthesia:
anterior mediastinal masses****Posture**

- Induce in sitting position
- Change supine position to lateral or prone position (access ?)

Maintain spontaneous respiration

- Awake fiberoptic intubation
- Inhalational induction
- Intravenous induction (ketamine?)

Airway stenting: conventional intravenous induction

- Long endotracheal tube
- Double-lumen endobronchial tube
- Rigid bronchoscope
- Insertion of tracheobronchial stents

Cardiopulmonary bypass

- Commenced under local anesthesia before induction
- Vessels prepared under local anesthesia, then general anesthesia

Goh and colleagues [21], for example, describe the use of awake intubation but follow this intubation with intravenous thiopentone and a muscle relaxant. Pullerits and Holzman [5] advocate the use of spontaneous ventilation intraoperatively but then state, “After diagnostic procedures such as mediastinoscopy, bronchoscopy and thoracoscopy, severe respiratory failure requiring re-intubation and ventilation may occur when the SVC obstruction has not been relieved.” John and Narang [22] reported the use of an inhalational induction in a 12-year-old child who had an anterior mediastinal mass that precipitated immediate severe airway obstruction. The case reports of Victory et al [3] include a death where an inhalational induction led to respiratory obstruction in a child, which could not be relieved with either an endotracheal tube or a bronchoscope.

Airway stenting—conventional intravenous induction

The most experienced surgeons consistently have used rigid bronchoscopy to establish an airway in adult patients who have an anterior mediastinal mass, following conventional intravenous anesthesia in the semi-upright position (P. Goldstraw, personal communication, 2007). The variable narrowing of the tracheobronchial tree usually is caused by extrinsic compression and will have been assessed fully from a preoperative CT scan. In experienced hands a rigid bronchoscope therefore can be advanced to stent the airway. After initial assessment of the anatomy/pathology, it may be possible to stent the airway for resection surgery with an endotracheal

tube or a double-lumen endobronchial tube placed under direct vision into the most patent main bronchus. If this technique is not possible, ventilation can be maintained down the rigid bronchoscope via a Venturi injector, in the usual way, and anesthesia can be maintained intravenously. Once surgery has commenced and the tumor has been lifted anteriorly, the degree of airway obstruction tends to lessen, and it may be possible to replace the bronchoscope with an endotracheal tube at some stage.

Gas exchange relies on ventilation and perfusion. When possible, therefore, the state of the pulmonary arteries should be evaluated on the CT scan. The author and colleagues have had least one case in which the pulmonary artery blood supply to the lung with “most patent” main bronchus was severely compromised. Fortunately, endobronchial intubation of the contralateral lung, which had a patent pulmonary artery, proved feasible.

Cardiopulmonary bypass

A number of authors have advocated the use of cardiopulmonary bypass to overcome the problems of intraoperative gas exchange in patients who have severe airway narrowing and pulmonary artery involvement [23–26]. These reports include the use of femorofemoral bypass instituted using local anesthesia before induction [24] and the use of venoarterial extracorporeal membrane oxygenation in a child [25] to facilitate initial diagnosis and subsequent chemotherapy treatment over a number of days.

The author and colleagues have not used cardiopulmonary bypass in relation to airway problems but have had the facility on stand-by on occasions. One of the surgeons at The Royal Brompton Hospital institutes cardiopulmonary bypass when tumor is invading the SVC to facilitate resection and, if necessary, replacement of the SVC with a graft.

Vascular involvement/intraoperative bleeding

As discussed previously, mediastinal tumors may invade or compress many of the intrathoracic vascular structures. SVC obstruction is a common presenting sign of large anterior mediastinal tumors, and bleeding from the SVC is a relatively common problem intraoperatively. If tumor involvement of this structure is suspected, it is prudent to place a large intravenous cannula in the lower half of the body, preferably in the femoral vein, to facilitate transfusion if the vessel is breached surgically. Occasionally, it may be necessary to clamp or resect the SVC. The anesthetic considerations for this surgical maneuver have been reviewed by Galatoudis and colleagues [27].

Effects of chemotherapy

Patients presenting for surgery and anesthesia may have undergone chemotherapy previously. This setting has many implications for anesthesiologists, which have recently been reviewed by Heuttemann and Sakka [28].

Bleomycin, in particular, is used in the treatment of a variety of tumors, including primary and secondary teratomas, that can occur in the mediastinum. The pulmonary toxicity of bleomycin has been well documented, and it is important to have baseline pulmonary function tests in these patients. The provocation of further lung injury in these patients who have high inspired oxygen concentrations is controversial. It is probable that this effect occurs only if the bleomycin has been administered relatively recently. This problem is complex, however, and it is prudent to keep the inspired oxygen concentration as low as possible but compatible with reasonable arterial oxygen saturation.

Nerve section

Anterior mediastinal tumors may advance to surround or invade the phrenic and/or recurrent laryngeal nerves. Surgical division of these nerves may affect the postoperative course and in the case of the phrenic nerve is an indication for postoperative ventilation.

Resection of a complex tumor is often a long procedure, however. The author and colleagues electively ventilate most patients postoperatively because of the long procedure times and the associated comorbidities.

Summary

Anterior mediastinal tumors can cause severe airway and vascular compression, and these effects are exacerbated by general anesthesia, particularly in children. Tumor biopsy using a local anesthetic technique is preferable, if possible. General anesthesia for a biopsy procedure or resection of an anterior mediastinal mass should be undertaken only after a thorough preoperative assessment. Treatment protocols for surgery and anesthesia vary from institution to institution, and management remains operator dependent.

Maintenance of spontaneous respiration during anesthesia is considered optimal by some clinicians, particularly for biopsy procedures. Airway stenting, with a rigid bronchoscope in the first instance, is advocated by others. Cardiopulmonary bypass, instituted at the outset of surgery under local anesthetic, is rarely indicated but may be used as a fall-back technique in extreme circumstances.

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