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REPORTS OF ORIGINAL INVESTIGATIONS

Perioperative complications in adults with a posterior mediastinal mass: a retrospective observational cohort study

Complications périopératoires chez les adultes présentant une masse médiastinale postérieure: une étude de cohorte observationnelle rétrospective

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Abstract

Background *We studied the incidence of perioperative complications in patients presenting with a posterior mediastinal mass and the possible predictors of complications in these patients.*

Methods *We conducted a review of the perioperative records of patients aged over 18 years with a posterior mediastinal mass confirmed by computed tomography (CT) who were admitted for surgical procedures relating to the mass during 2004-2014. Perioperative complications were defined as 1) hypoxemia (pulse oximetry < 90% at a fraction of inspired oxygen of 1.0), 2) difficult ventilation (peak pressure > 40 cm H_2O or respiratory acidosis with P_aCO_2 > 60 mmHg), and 3) hemodynamic instability (systolic pressure < 70 mmHg, pulse rate < 40 beats·min^{-1} and/or > 120 beats·min^{-1} for over five minutes). The review also extended to the first 24 hr postoperatively for cardiovascular and respiratory instability.*

Results *Forty-three patients underwent 44 procedures, and the surgery entailed resection of the mediastinal mass in all but one patient. All patients received general anesthesia following intravenous induction. In 43 of 44 cases, intubation was achieved uneventfully with direct laryngoscopy after neuromuscular blockade. The incidence of perioperative cardiopulmonary complications was seven of 44 (16%) procedures. Four of these involved severe hypoxemia, two concerned hemodynamic instability, and two led to postoperative respiratory distress. No cardiovascular collapse or complete airway occlusion occurred. All occurrences of intraoperative complications transpired mid-surgery — six of the seven with the patient in the lateral position. Patients who developed complications were more likely to have a mass with a larger diameter and evidence of airway compression on the preoperative CT scan.*

Conclusion *The incidence of perioperative complications in patients with a posterior mediastinal mass is not insignificant; however, no catastrophic airway or cardiopulmonary event was encountered in this study.*

Résumé

Contexte *Nous avons étudié l'incidence de complications périopératoires chez les patients ayant une masse médiastinale postérieure et les prédicteurs possibles de complications chez ces patients.*

Méthode *Nous avons passé en revue les dossiers périopératoires des patients âgés de plus de 18 ans ayant une masse médiastinale postérieure confirmée par tomodensitométrie et admis pour des interventions chirurgicales liées à la masse entre 2004 et 2014. Les complications périopératoires ont été définies comme suit : 1) hypoxémie (oxymétrie de pouls < 90 % à une fraction d'oxygène inspiré de 1,0); 2) ventilation difficile (pression maximale > 40 cm H_2O ou acidose respiratoire avec P_aCO_2 > 60 mmHg); et 3) instabilité hémodynamique*

Author contributions *Tao Shen* was involved in data collection and is the archival author. *Xiaodong Bao* and *Paul H. Alfille* were involved in study design. *Tao Shen, Xiaodong Bao,* and *Paul H. Alfille* were involved in the data analysis and manuscript preparation. All authors attest to the integrity of the original data and the analysis reported in this manuscript.

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(pression systolique < 70 mmHg, fréquence du pouls < 40 battements·min^{-1} et/ou >120 battements·min^{-1} pour plus de cinq minutes). Notre analyse s'est également intéressée aux premières 24 h postopératoires pour évaluer l'instabilité cardiovasculaire et respiratoire.

Résultats *Quarante-trois patients ont subi 44 interventions, et la chirurgie comprenait une résection de la masse médiastinale chez tous les patients sauf un. Tous les patients ont reçu une anesthésie générale après induction intraveineuse. Dans 43 des 44 cas, l'intubation s'est déroulée sans incident par laryngoscopie directe après la curarisation. L'incidence de complications cardiopulmonaires périopératoires était de sept sur 44 (16 %) interventions. Quatre de ces complications impliquaient une hypoxémie grave, deux touchaient à une instabilité hémodynamique et deux ont entraîné une détresse respiratoire postopératoire. Aucune défaillance cardiovasculaire ou occlusion complète des voies aériennes n'est survenue. Toutes les occurrences de complications peropératoires sont apparues à la mi-chirurgie – six des sept lorsque le patient était en position latérale. Les patients ayant manifesté des complications avaient le plus souvent une masse de diamètre plus importante et des signes de compression des voies aériennes étaient évidents sur le tomodensitogramme préopératoire.*

Conclusion *L'incidence de complications périopératoires chez les patients ayant une masse médiastinale postérieure n'est pas insignifiante; toutefois, aucune complication catastrophique au niveau des voies aériennes ou cardiopulmonaire n'est apparue dans cette étude.*

Mediastinal masses can present unique challenges to the anesthesiologist. In patients with an *anterior* mediastinal mass, the occurrence of severe cardiovascular compromise and total airway obstruction is well described during a surgical procedure under general anesthesia (GA). Nevertheless, little has been written about the anesthetic implications of patients presenting with a *posterior* mediastinal mass. Several case reports describe the occurrence of cardiopulmonary collapse in these patients,[1-3] which raises the question whether the same level of cautionary approach is recommended in these patients as in those with an anterior mediastinal mass. In this study, we retrospectively evaluated the clinical profiles of patients with a posterior mediastinal mass who underwent surgery at our academic centre. We also assessed the incidence of perioperative complications and studied the possible predictors of complications in these patients. We hypothesized that the incidence of major cardiopulmonary events in patients with a posterior mediastinal mass is low intraoperatively under GA as well as in the immediate postoperative period.

Methods

The Partners Human Research Committee Institutional Review Board (IRB) gave its approval (August 2014) for this study and waived the requirement for written informed consent.

Patient population

We reviewed the records of consecutive patients aged over 18 yr with a posterior mediastinal mass who were admitted to our hospital for surgery relating to the mass during January 2004-October 2014. Potential cases were identified after searching all operative records in this time frame for the keywords "mediastinum" or "mediastinal". Cases prior to 2004 were not reviewed due to the absence of electronic intraoperative records. The presence of a posterior mediastinal mass was confirmed on computed tomography (CT) in all patients. Exclusion criteria included patients with an anterior mediastinal mass and patients who underwent imaging-guided tissue biopsy in the radiology suite under local anesthesia. Hospital records were analyzed in detail for the clinical presentation, pathologic diagnosis, radiographic features, anesthetic management, surgical procedure, and evidence of perioperative complications.

Diagnostic evaluation

The preoperative evaluation was specifically reviewed for signs and symptoms relating to the pressure effects of the posterior mediastinal mass on the surrounding structures, including dyspnea on exertion, orthopnea, stridor, chest pain, arrhythmias, superior vena cava (SVC) syndrome, neural involvement, and dysphagia. All CT scans were analyzed for evidence of compression on the airways, heart, and great vessels, as well as pleural effusion, atelectasis, and diaphragmatic paralysis. Available transthoracic echocardiography was evaluated for pericardial effusion, tumour involvement of the heart, and impaired cardiac function. Existing pulmonary function tests (PFTs) were assessed for evidence of airflow limitations. Obstructive defect was defined as a percent of a forced expiratory volume in one second (FEV_1) < 80% predicted with a ratio of FEV_1 to forced vital capacity (FVC) < 70%. Restrictive defect was defined as total lung

capacity < 85% predicted or FVC < 80% predicted combined with a FEV_1: FVC ratio > 70%.

Perioperative complication

Perioperative complications were divided into intraoperative and immediate postoperative complications. Intraoperative complications were defined as 1) severe hypoxemia (pulse oximetry [SpO_2] < 90% at a fraction of inspired oxygen [F_iO_2] of 1.0), 2) difficulty with ventilation (peak pressure > 40 cm H_2O or respiratory acidosis with $P_aCO_2 > 60$ mmHg on arterial blood gas), and 3) hemodynamic instability (systolic pressure < 70 mmHg, pulse rate < 40 beats·min^{-1} and/or > 120 beats·min^{-1} for over five minutes). The first 24 hr in the postoperative period were reviewed for cardiovascular and respiratory instability that necessitated medical treatment, e.g., bronchoscopy, racemic epinephrine and helium-oxygen inhalation therapy, noninvasive mechanical ventilation, or reintubation.

Statistics

Statistical analysis was performed using Stata® 12.0 for Windows (StataCorp, TX, USA). The Wilcoxon rank-sum and Pearson's Chi square tests were used for continuous and categorical variables, respectively. Univariable logistic regression was performed to identify potential predictors of perioperative complications, with results expressed as odds ratio (OR) and associated 95% confidence intervals (CI). All reported *P* values are two sided.

Results

Demographics

Forty-three patients underwent 44 procedures. Their mean (range) age was 44 (20-85) years. There were 22 males and 21 females. Most patients (73%) were categorized as American Society of Anesthesiologists (ASA) physical status class II, while 25% and 2% were ASA class III and IV, respectively.

Clinical features and mass characteristics

The most common pathologic diagnosis in this series was schwannoma (37%), followed by neurofibroma (14%), and bronchogenic cyst (14%) (Table 1). The median (range) maximum diameter was 5 (2-18) cm. Twenty of 43 patients were symptomatic from their posterior mediastinal mass. Six patients presented with dyspnea on exertion, while seven presented with chest and back pain, three with Horner's syndrome and three with dysphagia. No patient presented with orthopnea, stridor, or cyanosis. Preoperative PFTs (measured in the upright position) were available in 19 of 43 patients. Five PFTs showed an obstructive pattern; two showed a restrictive pattern, and 12 were within normal limits. Extrinsic airway compression was evident in six patients (14%), and compression of major vasculature was seen in four patients (9%), two with SVC compression and two with compression of one of the pulmonary veins. There was no sign of either pericardial effusion or tamponade physiology in any patient.

Table 1 Pathologic diagnosis

Pathologic diagnosis	Patients (n = 43)
• Schwannoma	16
• Neurofibroma	6
• Bronchogenic cyst	6
• Ganglioneuroma	4
• Enteric cyst	4
• Sarcoma	2
• Germ cell tumour	2
• Metastatic thyroid cancer	1
• Thoracic chordoma	1
• Extra-adrenal pheochromocytoma	1

Anesthetic and surgical management

All surgeries except one involved resection of the posterior mediastinal mass. The exception was an embolization of the tumour's vasculature prior to definitive resection. There were 41 thoracotomies performed with the patient in the lateral decubitus position and two median sternotomies with the patient in the supine position. All cases were performed under GA. A thoracic epidural catheter was inserted in 30 of 44 cases for postoperative pain relief. Patients with SVC compression had lower extremity venous access. General anesthesia was induced intravenously with an opioid and hypnotic (usually propofol) in all cases. Intubation was achieved with direct laryngoscopy after neuromuscular blockade in all patients except one who was kept spontaneously breathing during induction (described below). Deliberate bronchial intubation with a small-sized endotracheal tube was performed in two cases with significant tracheal compression; otherwise, lung isolation was achieved using double-lumen tubes.

Perioperative complications

There were seven perioperative complications identified in 44 cases (16%), the most common being hypoxemia. The complications are summarized in Table 2.

Table 2 Perioperative complications

Diagnosis	Age (yr)	Symptoms	Mass diameter	PFT pattern	Airway compression	Vascular Compression	Complication
1. Bronchogenic cyst	58	Dyspnea on exertion	13 cm	Obstructive	None	None	Hypoxemia during OLV (SpO_2 70%) treated with CPAP to operative lung; improved after cyst drainage
2. Neurofibroma	41	Dyspnea at rest	16 cm	None	Trachea, right main bronchus	SVC	Hypoxemia during OLV (SpO_2 80-90%), intermittent hypotension; postoperative mechanical ventilation 24 hr for large amount of blood loss
3. Schwannoma	36	Pleuritic chest pain	8.5 cm	Restrictive	None	None	Intermittent intraoperative hypotension; responsive to fluids and vasopressors
4. Schwannoma	51	Dyspnea on exertion	18 cm	Obstructive	Trachea	SVC	Postoperative respiratory distress; reintubation due to RLN injury and atelectasis
5. Ganglioneuroma	39	None	7.4 cm	Normal	None	None	Hypoxemia during OLV (SpO_2 88-90%)
6. Thoracic chordoma	59	Dysphagia	9.8 cm	Normal	Trachea	None	Postoperative respiratory distress treated with BiPAP
7. Sarcoma	70	None	5 cm	None	None	None	Hypoxemia during OLV (85-90%)

BiPAP = bilevel positive airway pressure; CPAP = continuous positive airway pressure; OLV = one-lung ventilation; PFT = pulmonary function test; RLN = recurrent laryngeal nerve; SVC = superior vena cava

In four cases, there was failure to maintain oxygen saturation > 90% despite F_IO_2 of 1.0. Hypoxemia occurred mainly during one-lung ventilation (OLV). Two of these patients had masses that occupied a large proportion of their posterior mediastinum (Fig. 1). One patient had a bronchogenic cyst that resulted in desaturation to as low as 70% during OLV that was refractory to various rescue maneuvers, including position change and application of continuous positive airway pressure (CPAP). It was only with drainage of the cyst that oxygenation dramatically improved. While there was no direct airway compression seen on CT in this patient, preoperative PFTs showed a moderate obstructive defect with a predicted FEV_1 of 64%. The second patient had significant tracheal and SVC compression from a large neurofibroma that caused dyspnea at rest. With the head of the bed elevated at approximately 45° (semi-Fowler's position), intubation was performed using a small endotracheal tube and a flexible fibreoptic scope while the patient continued breathing spontaneously with intravenous ketamine. Subsequent maintenance on controlled ventilation with paralysis was uneventful. During OLV, however, there was persistent hypoxemia (SpO_2 80-90%) in addition to periods of hypotension. The patient had significant surgical bleeding from tumour involvement of the SVC requiring multiple blood product transfusions. Consequently, the patient remained tracheally intubated for 24 hr after the case due to the concern of transfusion-related acute lung injury.

In addition to the case described above, significant hypotension was also observed in another case in which a patient with a schwannoma presented with pleuritic chest pain. Intermittent brief hypotension (systolic blood pressure 65-70 mmHg) was effectively augmented using vasopressors and fluid boluses. This patient's tumour had no major vascular or airway involvement, and the periods of hypotension were attributed to surgical manipulation.

Two patients developed immediate postoperative respiratory distress. One had a large schwannoma causing tracheal displacement with lobar collapse as well as SVC syndrome. The presenting symptoms were hoarseness and dyspnea on exertion. The patient tolerated the surgery without issue, but reintubation for respiratory distress was deemed necessary due to a combination of recurrent laryngeal nerve palsy and significant hypoxemia. The second patient required noninvasive ventilation postoperatively for less than 24 hr for mixed metabolic and respiratory acidosis.

When compared with patients who had no perioperative complications, those who developed complications were significantly more likely to have larger mediastinal masses, with a median (interquartile range [IQR]) maximum diameter of 9.8 [7.4-16.0] cm *vs* 4.6 [4.0-6.5] cm (P = 0.001). It was also significantly more likely that evidence of airway compression would show on the preoperative CT scan (Table 3). Figure 2 shows the correlation between mass diameter and the presence of complications. By univariable analysis, a maximum diameter > 8 cm conferred an OR of 16 for complications (95% CI, 2 to 106), and presence of airway compression was associated with an OR of 6 for complications (95% CI, 1 to 38). In this

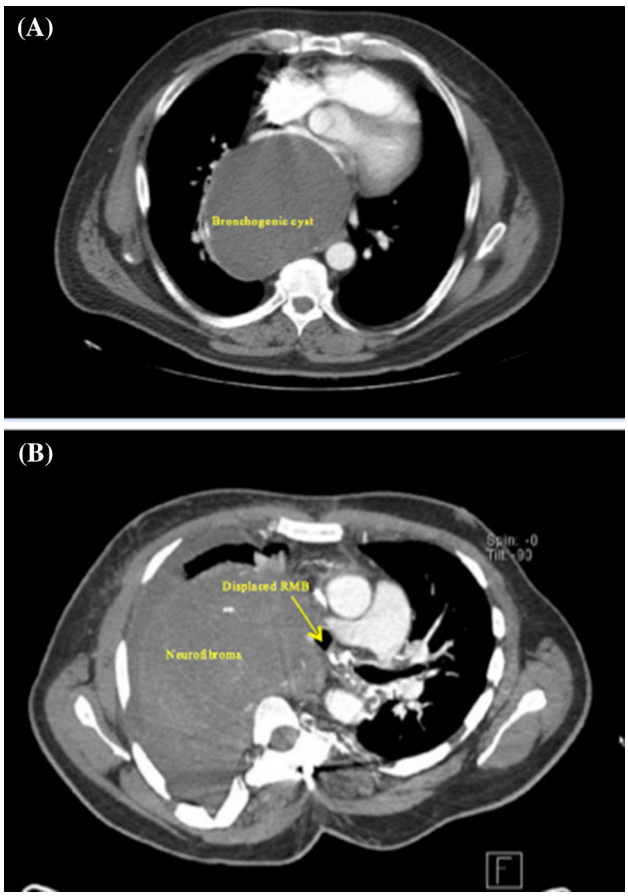

Fig. 1 (A) Transverse section of preoperative non-contrast CT of patient with large bronchogenic cyst (maximum diameter 13 cm) without significant airway compression. (B) Transverse section of contrast-enhanced CT of patient with atypical neurofibroma (maximum diameter 16 cm) causing compression of SVC, trachea, and right bronchial tree, with right-sided pleural effusion and compression atelectasis. CT = computed tomography; SVC = superior vena cava; RMB = right main bronchus

cohort, there was no statistically significant difference in age, ASA class, presence of symptoms, use of epidural, or evidence of vascular compression on imaging between patients who did and did not have perioperative complications.

Discussion

Anesthetic complications in patients with an anterior mediastinal mass are well described in the literature, which is replete with suggested management options should these complications occur. The management approach to the patient with a posterior mediastinal mass is less well defined. Posterior mediastinal masses are commonly thought to carry a lower anesthetic risk, although several case reports have illustrated major perioperative complications in patients with such tumours.[1-3] In this retrospective review, we intended to describe our clinical experience with this group of patients and to characterize some of the perioperative complications that can arise in this relatively rare condition.

We identified a 16% incidence of perioperative complications, which is comparable with the 14% incidence of cardiopulmonary complications identified in Bechard *et al.*'s[4] review of 105 cases involving anterior and middle mediastinal masses. In our study, patients with larger posterior mediastinal masses were more likely to develop perioperative complications. This finding is not surprising and speaks to the decrements in lung function from compression of pulmonary parenchyma as well as mediastinal structures. We also found a significant correlation between evidence of airway compression on CT and the occurrence of complications. Nevertheless, due

Table 3 Factors associated with perioperative complications

Factor	Complication	No Complication	*P* value
Age (yr), median [interquartile range]	51 [39-59]	43 [31-52]	0.15
ASA Class			0.06
- II	4	28	
- III	2	9	
- IV	1	0	
Presence of symptoms	5/7 (71%)	15/37 (41%)	0.13
Abnormal PFT	3/5 (60%)	4/14 (29%)	0.21
Maximal diameter (cm), median [interquartile range]	9.8 [7.4-16]	4.6 [4-6.5]	0.001
Airway compression	3/7 (43%)	4/37 (11%)	0.03
Vascular compression	2/7 (29%)	3/37 (9%)	0.12
Intraoperative epidural use	3/7 (43%)	27/37 (73%)	0.12

ASA = American Society of Anesthesiologists; PFT = pulmonary function test

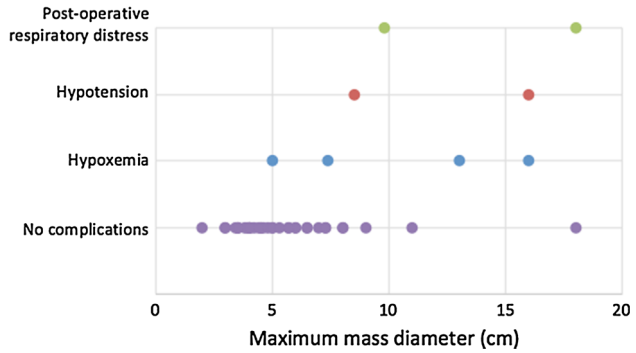

Fig. 2 Correlation between maximum mass diameter (cm) and the presence of hypoxemia, hypotension, and postoperative respiratory distress

to our limited sample size, we were unable to characterize the airway compression further in any meaningful way owing to the extent of compression or its location. In this cohort, we did not find statistically significant correlations between the presence of compression of major vessels, abnormal PFTs, or symptoms in predicting these events. Notably, no total cardiovascular collapse, airway occlusion, permanent injury, or death occurred in any of our patients.

In this study, induction of general anesthesia was not associated with any significant cardiopulmonary embarrassment. Intravenous induction and direct laryngoscopy facilitated by muscle relaxation were performed in all but one patient. This is in contrast to the well-described risks of airway occlusion upon change from negative to positive pressure ventilation in patients with an anterior mediastinal mass,[5] particularly in the pediatric population in whom the airway is smaller and more compressible.[6-9] All intraoperative complications in this series occurred mid-surgery, and for six of seven patients, this occurred in the lateral position. It is conceivable that the loss of muscle tone under GA has less of a detrimental effect on the airway in patients with a posterior mediastinal mass *vs* those with an anterior mediastinal mass, as the mass is not directly overlaying the airway when the patient is supine. Nevertheless, with the patient turned to the lateral decubitus position, the mechanical effect can become more apparent, which may explain the relatively smooth induction process seen in our study followed by the occurrence of cardiopulmonary complications after positioning the patient for surgery.

While no significant difficulty in ventilation was encountered in the study patients, severe hypoxemia during OLV was noted in four patients. Hypoxemia in this study was defined as $SpO_2 < 90\%$ despite F_IO_2 100%. Unfortunately, we do not have data on the P_aO_2:F_IO_2 ratio for these patients (as arterial blood gases were not always sent), which would have allowed calculation of the alveolar-arterial gradient. Not unexpectedly, hypoxemia occurred mainly in patients with large masses (mean maximum diameter 10 cm). In addition to the usual ventilation and perfusion mismatches encountered during OLV, the direct and gravitational compression of the mediastinal mass against adjacent structures during open thoracotomy can further aggravate the closure of restricted airways and worsen pulmonary shunting.[10] Treatment options for refractory hypoxemia may include repositioning the patient in the direction of least compression by the mass, surgical elevation of the mass away from the airway or great vessel, and if appropriate, drainage of the contents, which was effective in one study patient with a large bronchogenic cyst. As always, standard methods to improve oxygenation in OLV should be considered, including application of CPAP to the operative lung, increasing mean arterial pressure, reinstitution of two-lung ventilation, clamping the pulmonary artery, and extracorporeal life support.

Two patients in this series had SVC compression and another two had encroachment on a pulmonary vein. One of the patients with SVC compression developed significant intraoperative hypotension associated with a large amount of blood loss. The presence of major vascular involvement was not a predictive factor in the development of perioperative complications either in this study or in Bechard's[4] study of anterior and middle mediastinal masses, which could be due to inadequate power in detecting an infrequent complication. Mediastinal masses are known to cause acute cardiovascular collapse, due to obstruction of venous return or direct compression on the heart, as well as lead to significant surgical bleeding during dissections around major vessels. The left atrium, left ventricle, and pulmonary veins are particularly susceptible to compression by posterior mediastinal masses due to their inferoposterior location.[11] Anderson *et al.*'s[1] case report of a posterior mediastinal mass necessitating urgent cardiopulmonary bypass (CPB) upon induction of anesthesia is an example of extreme cardiovascular perturbations seen with mediastinal masses. In our study, the majority of patients remained hemodynamically stable throughout their surgery, and any occurrence of cardiovascular instability could be effectively stabilized with vasopressors or treated with volume support. We did not have "standby" CPB for the patients identified to have masses with major vascular involvement. While theoretically appealing, CPB has been shown to be difficult to implement rapidly in the event of true cardiopulmonary collapse.[12] Of importance, intraoperative transesophageal echocardiography may prove valuable in the management of patients at risk for cardiovascular compression. Transesophageal echocardiography can be used to provide both anatomic

and physiologic correlations for the perceived hemodynamic changes during surgery, and it should be immediately considered as a diagnostic tool in patients with unexplained hypotension.

Our study is inherently limited by its retrospective nature. While most patients in this series were otherwise healthy (majority ASA II), the contribution of their comorbidities to the development of complications was not elucidated. The authors' reliance on interpretation of electronic records may mean subtle features of the case were missed or misinterpreted. In addition, as almost all of the cases involved thoracotomy and OLV, which have a physiologic impact of their own, the study may not be generalizable to patients with posterior mediastinal mass who may undergo other surgical procedures. We did not extend our review beyond the first 24 hr of surgery, and as a result, we were unable to examine the incidence of postoperative complications that are associated with this condition.

Posterior mediastinal masses are unusual, and while the sample size of our study is limited, it reflects that most patients with a posterior mediastinal mass can tolerate GA fairly well. Nevertheless, it is important to emphasize that none of the patients in this series presented with significant orthopnea or other positional symptoms, unlike those described in the recent case reports. Our study of posterior mediastinal masses shows an incidence of perioperative complications similar to that of anterior mediastinal masses in adults. Reassuringly, however, the risk of total cardiovascular collapse or airway obstruction with a posterior mediastinal mass appears to be quite low, unlike the risk with an anterior mediastinal mass. Patients at increased risk of developing complications can potentially be identified by the presence of a mass with a large diameter and/or the presence of airway compression on CT. As with all mediastinal masses, the anesthesiologist should be alerted to the vastly variable physiologic effects depending on the size, location, and nearby thoracic structures of a given mass.

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Conflicts of interest None declared.

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