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Perioperative Cardiorespiratory Complications in Adults with Mediastinal Mass

Incidence and Risk Factors

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Background: **Patients with a mediastinal mass are at risk for cardiorespiratory complications in the perioperative period. The authors' objectives were to evaluate the incidence of life-threatening intraoperative cardiorespiratory and postoperative respiratory complications in adult patients and to study the usefulness of clinical signs and symptoms, radiologic evaluation, and pulmonary function tests in the determination of the perioperative risk.**

Methods: **The authors reviewed the investigation and treatment of adult patients presenting with anterior or middle mediastinal masses for surgery under anesthesia between January 1994 and July 2000.**

Results: **Ninety-eight patients underwent 105 anesthetic cases. The incidences of intraoperative cardiorespiratory and postoperative respiratory complications were 4 in 105 and 11 in 105, respectively. No collapse of the airways occurred during anesthesia. However, a high incidence of early postoperative life-threatening respiratory complications was observed (7 in 105). In a multivariate logistic regression analysis model, perioperative complications were predicted by the occurrence of cardiorespiratory signs and symptoms at the initial presentation (odds ratio [OR], 6.2) and the presence of combined obstructive and restrictive patterns (mixed pulmonary syndrome) on pulmonary function tests (OR, 3.9). Intraoperative complications were associated with pericardial effusion on computed tomography scan (OR, 19.8). Postoperative respiratory complications were related to tracheal compression of more than 50% on preoperative computed tomography scan evaluation (OR, 7.4) and mixed pulmonary syndrome on pulmonary function tests (OR, 15.1).**

Conclusion: **Obstruction of the airway in an adult with a mediastinal mass is a rare event in the intraoperative period. Nevertheless, caution should be observed for the occurrence of early postoperative life-threatening respiratory complications. Patient at high risk of perioperative complications can be identified by the occurrence of cardiopulmonary signs and symptoms at presentation, combined obstructive and restrictive pattern on pulmonary function tests, and computed tomography scan findings (tracheal compression > 50%, pericardial effusion, or both).**

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PATIENTS with mediastinal masses can pose special problems for the anesthesiologist. Total occlusion of the airway and cardiovascular collapse are well-recognized complications in these patients during general anesthesia.[1,2] Numerous case reports have described fatal or near-fatal cardiopulmonary arrest in the course of anesthesia for diagnostic or therapeutic surgical procedures in patients with a mediastinal mass.[1–6] These complications can occur while placing the patient in supine position, at the induction of anesthesia, at extubation, and even a few days after extubation. The ability to identify which patients with mediastinal masses are at risk of cardiopulmonary complications is limited. A few retrospective studies and only one prospective study have tried to correlate the risk of general anesthesia with pulmonary function tests (PFTs) and tracheal cross-sectional area, but without clearly defining predictors of complication.[7–10]

Defining the actual incidence of complications associated with this condition is difficult. Some centers reported an incidence of 7–20% for the anesthetic period[7,8,11,12] and of 18% for the postoperative period.[13] However, studies that have tried to measure incidence and to identify patients at significant risk were performed essentially in pediatric populations.[7–10] These results can hardly be extrapolated to the adult population because of obvious anatomic and physiologic differences. We hypothesized that the true incidence of complication is less in the adult population.

For this purpose, we reviewed a cohort of consecutive adult patients with mediastinal masses who were presenting for any surgery in a tertiary university hospital to evaluate the incidence of perioperative complications. We also studied the usefulness of clinical signs and symptoms, radiologic evaluation, and PFT evaluation in the assessment of anesthetic and perioperative risk.

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Materials and Methods

Study Population

We reviewed the diagnostic, anesthetic, and surgical management of adults with a mediastinal mass admitted for diagnostic or therapeutic procedures performed under anesthesia between January 1994 and July 2000. All the patients had their surgical procedure performed at Laval Hospital (Québec City, Canada). Inclusion criteria included age greater than 18 yr and mediastinal mass of at least 15 cm^3 as evaluated by computed tomography (CT). Patients whose thoracic CT scan was performed more than 6 weeks before surgery and patients with a posterior mediastinal mass on thoracic CT scan were excluded from the study.[14] The hospital records data were analyzed for signs and symptoms, pathologic diagnosis, previous chemotherapy or radiotherapy (within 3 months before surgery), anesthesia management, surgical procedure, and for evidence of perioperative complications. This protocol was approved by the Institutional Review Board of Laval Hospital.

Diagnostic Assessment

Signs and symptoms were grouped into three categories according to their occurrence and severity. This methodology was adapted from Azizkhan *et al.*[7] Minimal to moderate cardiopulmonary symptoms included cough, dyspnea on exertion, chest pain, fatigue, and vocal cord paralysis. Severe cardiorespiratory findings were defined by the presence of orthopnea, stridor, cyanosis, jugular vein distension, or superior vena cava syndrome.

Computed tomography scan confirmed the diagnosis of a mediastinal mass in all patients. The radiologic files were reviewed by a certified radiologist who was unaware of the histologic diagnosis and of the perioperative course. The CT scans were performed according to a standard protocol that included 7- or 10-mm sections from above the thoracic inlet to below both hemidiaphragms. Measurements were made from the CT tapes or hard copies. All CT scan evaluations were screened for the presence of atelectasis, pleural and pericardial effusion, and superior vena cava compression.

Tracheal compression was measured with a CT method adapted from King *et al.*[8] The cross-sectional area was measured from the CT slice showing the trachea at its narrowest (A_1) and at a portion of the trachea without extrinsic compression or endoluminal involvement (A_2). Calipers were used to measure major and minor diameters (d_1 and d_2) by reference to the centimeter scales (calibration) on the CT tapes or hard copies. Areas were calculated from the following equation: $A = \pi \times d_1/2 \times d_2/2$. The extent of tracheal compression was obtained from the following equation: tracheal compression (%) $= 100 - (A_1/A_2 \times 100)$. *Significant tracheal compression* was defined as greater than 50% diminution of tracheal cross-sectional area.[9,10]

Mass volume was estimated from the diameters in the three axes (d_x, d_y, d_z) as determined by CT scan. These masses were considered to be of ellipsoid shape because it is the form with the lowest volume that can be obtained from given diameters. Their volume was calculated by the following equation: volume $= 4/3 \times \pi \times d_x/2 \times d_y/2 \times d_z/2$, and was expressed in cubed centimeters.

Pulmonary function testing included evaluation of forced vital capacity (FVC), forced expiratory volume in 1 s (FEV_1), peak expiratory flow rate (PEFR), and lung volume measurements by body plethysmography. These measurements were obtained in the upright position and were expressed as percent of predicted values. Patients with severe symptoms had a flow volume loop in the upright and supine positions. Abnormal lung function test results were classified as obstructive, restrictive, or mixed.[15] *Obstructive abnormality* was defined as percent of an FEV_1 less than 80% predicted with an FEV_1:FVC ratio less than 70%. *Restrictive abnormality* was defined as total lung capacity less than 85% predicted. When the lung volumes had not been measured, FVC less than 80% predicted associated with an FEV_1:FVC ratio of 70% or greater was considered significant. A mixed pattern was consistent with combined obstructive and restrictive abnormalities. External compression or endoluminal involvement of the tracheobronchial tree was assessed by flexible bronchoscopy. When indicated (jugular distension, orthopnea, cyanosis, hypotension, pulsus paradoxus, or superior vena cava syndrome), transthoracic echocardiography was used to evaluate the presence of pericardial effusion and tumor involvement of the pericardium, the heart, and the great vessels.

Complications

Complications were divided according to the period in which they occurred. *Intraoperative complications* were defined as (1) inability to ventilate or peak pressure greater than 40 cm H_2O, (2) severe pulmonary shunt (pulse oximetry $< 95\%$ at a fraction of inspired oxygen [FIO_2] of 100%), and (3) hemodynamic instability (systolic pressure < 70 mmHg for 5 min or pulse rate < 40 or > 120 beats/min) necessitating aggressive treatment.

The postoperative period was screened for respiratory complications that could be attributed to the mediastinal mass. The definition of *postoperative respiratory complications* was adapted from Turoff *et al.*[13] Postoperative respiratory complications were defined as those occurring within 10 days after surgery and necessitating additional medical treatment such as reintubation, noninvasive mechanical ventilation, bronchoscopy, special inhalation therapy (racemic epinephrine, helium–oxygen mixture), or antibiotics for radiographically docu-

Table 1. Surgical Procedure Performed

Type of Procedure	No. of Procedures*	Perioperative Complications	Intraoperative Complications	Postoperative Respiratory Complications	Significance
Cervical mediastinoscopy	32	4	1	3	NS
Medial sternotomy and resection	29	3	0	3	NS
Anterior mediastinotomy	20	4	1	3	NS
Thoracotomy and resection	12	1	1	0	NS
Thoracoscopy	8	2	1	1	NS
Cervical mediastinal exploration	6	2	0	2	NS
Extrathoracic lymph node biopsy	5	0	0	0	NS
Others	3	1	0	1	NS
Total	115	17	4	13	NS

* Some patients had more than one surgical procedure.

NS = not significant.

mented pulmonary infection. *Perioperative complications* were defined as the summation of intraoperative and postoperative respiratory complications.

Statistics

Descriptive statistics (proportions, means, and SDs when appropriate) were used to characterize the study population and the occurrence of perioperative complications. We conducted univariate logistic regression analyses to predict perioperative, intraoperative cardiorespiratory, and postoperative respiratory complications using the results of the preoperative clinical signs and symptoms evaluations, radiologic assessment, and PFT results as independent variables. The cases performed under local anesthesia were excluded from the logistic regression analyses but included in the descriptive statistics. Because many patients had more than one anesthetic, the data were analyzed in terms of complications per anesthetic case rather than per patient. In this analysis, the mass volume was dichotomized according to the threshold that best predicted the occurrence of perioperative complications. This threshold was determined from a receiver operator characteristic analysis. Then, in a multivariate analysis, the predictors were incorporated into a stepwise logistic regression model. This analysis indicated whether complications might be independently predicted from any combination of predictors. The results of the regression analyses are presented as odds ratio (OR) and associated 95% confidence interval (CI). Throughout the analyses, statistical significance was set at 0.05.

Results

Study Population

Ninety-eight patients underwent 105 anesthetic cases. Their age ranged from 21 to 84 yr (mean, 51.7 ± 15.9 yr), and 58 were men. These 98 patients experienced 115 surgical procedures, because some patient had more than one procedure for the same anesthesia (table 1). No patient underwent radiation therapy before surgery, and only two patients had preoperative chemotherapy. The most frequent histologic diagnosis in this series was lymphoma (21.4%), followed by thymoma (15.3%). Table 2 summarizes the different diagnoses encountered in this cohort.

Table 2. Histologic Diagnosis

Diagnosis	No. of Patients	Perioperative Complications	Intraoperative Complications	Postoperative Respiratory Complications	Significance
Lymphoma	21	5	3	2	NS
Thymoma	15	2	0	2	NS
Metastases	14	3	0	3	NS
Hodgkin disease	10	0	0	0	NS
Carcinoma	8	1	0	1	NS
Intrathoracic goiter	6	1	0	1	NS
Thymic cysts	6	0	0	0	NS
Bronchogenic cysts	4	1	1	0	NS
Teratoma	2	0	0	0	NS
Intrathoracic thyroid carcinoma	2	1	0	1	NS
Other	10	1	0	1	NS
Total	98	15	4	11	NS

NS = not significant.

Table 3. Perioperative Complications

No.	Diagnosis	Tracheal Compression, %	Mass, cm^3	Pericardial Effusion (+/−)	PEFR,* %	Pulmonary Syndrome	Anesthesia	Complication	Treatment
1	NHL	0	110	+	NA	NA	General	Intraoperative hypotension	Pericardial drainage
2	Bronchogenic cyst	0	231	+	NA	NA	General	Intraoperative atrial fibrillation with EMD	Electrical cardioversion, epinephrine, cyst drainage
3	NHL	31	25	−	NA	NA	General	Intraoperative atrial fibrillation	Spontaneous conversion
4	NHL	18	770	+	47	Mixed	General	Intraoperative hypoxemia Neoplastic lung infiltration	Oxygen PEEP, postoperative chemotherapy
5	Metastasis	0	143	−	NA	NA	General	Respiratory distress in PACU Airway edema	Corticosteroid, racemic epinephrine, inhalation
6	Intrathoracic thyroid carcinoma	50	141	−	26	Obstructive	General	Respiratory distress in PACU	Intubation, mechanical ventilation
7	NHL	82	259	−	NA	NA	Local	Postoperative respiratory distress Pneumonia, tracheal necrosis	Bronchoscopy, antibiotics, helium–oxygen, racemic epinephrine inhalation
8	Thymoma	0	130	−	68	Mixed	General	Postoperative respiratory distress Pneumonia	Intubation, antibiotics, bronchoscopy
9	Intrathoracic goiter	53	408	−	62	Normal	General	Postoperative pneumonia	Antibiotics
10	Thymoma	0	34	−	66	Mixed	General	Postoperative pneumonia Atelectasis	Antibiotics
11	Neurilemoma	53	2,154	−	26	Obstructive	General	Postoperative respiratory distress Atelectasis	Bronchoscopy
12	NHL	23	530	−	32	Obstructive	General	Postoperative respiratory distress Pneumonia, airway edema	Antibiotics, helium–oxygen and racemic epinephrine inhalation
13	Metastasis	0	38	−	64	Obstructive	General	Postoperative pneumonia	Antibiotics
14	Metastasis	0	110	−	78	Normal	General	Postoperative respiratory distress Airway edema	Intubation, corticosteroid, bronchoscopy
15	Carcinoma	0	264	−	NA	NA	General	Postoperative pneumonia	Antibiotics, bronchoscopy

* Peak expiratory flow rate, in percent of expected.

EMD = electromechanical dissociation; NA = not available; NHL = non-Hodgkin lymphoma; PACU = postanesthesia care unit; PEEP = positive end-expiratory pressure.

Anesthetic Management

All patients were evaluated preoperatively by a member of the department of anesthesiology. No surgery in this series was canceled by the assigned anesthesiologist after the preanesthetic evaluation. General anesthesia was selected for 97 of 105 anesthetic cases. For 15 of these cases, inhalation general anesthesia *via* endotracheal tube with spontaneous ventilation was favored, followed by neuromuscular blockade and controlled ventilation. In only three cases, general anesthesia with spontaneous ventilation was used for the entire anesthetic period. The other patients (79 of 97) received neuromuscular blockade at the time of induction of general anesthesia. There were 8 cases of local anesthesia that was supplemented with intravenous sedation. These patients were believed to be in the higher-risk group as assessed preoperatively, based on symptoms and radiologic evaluation. They had significantly larger masses (734.3 ± 643.2 *vs.* 174.6 ± 282.4 cm^3; $P < 0.001$), more cases of tracheal compression (6 of 8 *vs.* 20 of 97; $P = 0.003$), and pericardial effusion demonstrated by transthoracic echocardiography (3 of 8 *vs.* 8 of 97;

$P = 0.036$) compared with the group of patients who had general anesthesia. Only one patient in this group experienced perioperative complications (patient 7, table 3).

A rigid bronchoscope was available in the operating room in all cases to secure the airway in the event of total tracheal obstruction. Double-lumen tubes were used for all thoracotomies, all thoracoscopies, and some medial sternotomies. Patients with evidence of superior vena cava obstruction had a venous access secured *via* a lower extremity. Thoracic or lumbar epidural catheters were inserted in 21.9% (23 of 105) of all cases for postoperative pain relief. These patients had extensive surgery (thoracotomies and medial sternotomies). Parenteral opioid was available for postoperative pain relief for all other patients. We were unable to find any relation between complication rate and the modality of postoperative pain relief (epidural *vs.* parenteral opioid).

Complications

Perioperative complications were encountered in 15 of 105 anesthetic cases (14.3%; table 3). The incidences of intraoperative cardiorespiratory and postoperative respiratory complications were 4 of 105 (3.8%) and 11 of 105 (10.5%), respectively. No patient experienced both intraoperative and postoperative complications. Basic information for all anesthetics is provided as a Web Enhancement on the ANESTHESIOLOGY Web site at http://www.anesthesiology.org.

Intraoperative Complications

There was no occlusion of the airway during anesthesia, despite some cases of severe compression of the tracheobronchial tree as determined by CT scans and bronchoscopic evaluation. One of the intraoperative complications resulted from severe pulmonary shunt, which was already present preoperatively. The other intraoperative complications were of hemodynamic origin. Two patients in this group had pericardial effusion and experienced cardiovascular collapse on initiation of positive-pressure ventilation (patients 1 and 2, table 3). There was no case of intraoperative mortality in this series.

Postoperative Respiratory Complications

The etiologies for the postoperative respiratory complications were pneumonia, airway edema, and atelectasis. All life-threatening respiratory events (7 of 11; 63.6%) occurred in the first 48 postoperative hours. The incidence of these life-threatening respiratory events was 7 in 105 (6.7%). There was no pulmonary complication diagnosed beyond the fifth postoperative day. No death occurred within 10 days after surgery.

Predictors of Complications

Tables 4–6 summarize the incidence of complications and their relations to selected predictors (univariate analysis).

Tracheobronchial Compression

All the patients (n = 8) with tracheal compression greater than 50% underwent general anesthesia without respiratory collapse (table 5). However, in the early postoperative period, three patients with tracheal compression greater than 50% experienced respiratory complications (table 6). There were four patients with left main stem bronchial compression and one with a right-side involvement without tracheal compression. Only one patient in this group experienced intraoperative complications (patient 1, table 3).

Volume of the Mass

The median volume of the masses in this series was 106 cm^3 (range, 16–2,154 cm^3; mean, 174.6 ± 282.4 cm^3). We determined from the receiver operator characteristic analysis that the volume threshold that best predicted the occurrence of perioperative complications was 130 cm^3 (table 4). However, a mass volume greater than 130 cm^3 was not identified as a significant predictor of complication in a multivariable logistic regression analysis.

Pulmonary Function Test

Seventy-seven patients underwent PFTs before general anesthesia. PEFR was available for 75 patients. Despite 10 cases of general anesthesia with PEFR of less than 50% of predicted and 6 cases of general anesthesia with PEFR of 40% or less of predicted, there was no airway collapse in this series (table 5). However, a PEFR of 40% or less of predicted was associated with a more than 10-fold increase in the risk of postoperative respiratory complication in univariate analysis (table 5).

Other Variables

The perioperative complication rate was not affected by the type of surgical procedure: therapeutic *versus* diagnostic (table 1). The histologic diagnosis had no influence the perioperative course, either (table 2).

In a multivariable logistic regression analysis model, the variables that remained significant in the prediction of *perioperative complications* were the occurrence of cardiorespiratory signs and symptoms at presentation (OR, 6.2; 95% CI, 1.2–31.5) and mixed pulmonary syndrome on PFT (OR, 3.9; 95% CI, 1.5–10.3). Pericardial effusion on preoperative CT scan was the only variable associated with *intraoperative complications* (OR, 19.8; 95% CI, 4.0–97.4). Finally, *postoperative respiratory complications* were related to tracheal compression greater than 50% on preoperative CT scan evaluation (OR, 7.4; 95% CI, 1.5–38.1) and mixed pulmonary syndrome on PFT (OR, 15.1; 95% CI, 1.9–120.8).

Table 4. Predictors of Perioperative Complications (Univariate Analyses)

Independent Variables	Incidence of Complications	OR	95% CI	*P* Value
Signs and symptoms				
None	0/19	Referent		
Minimal/moderate	6/59	4.7	0.3–14.0	0.490
Severe	8/19	28.8	1.7–85.8	0.008
Tracheal compression on CT				
< 50%	11/89	Referent		
≥ 50%	3/8	4.3	0.9–20.3	0.070
Mass volume on CT*				
< 130 cm^3	5/59	Referent		
≥ 130 cm^3	9/38	3.4	1.0–10.9	0.045
Pleural effusion on CT				
Absent	7/74	Referent		
Present	7/23	4.2	1.3–13.6	0.018
Pericardial effusion on CT				
Absent	11/93	Referent		
Present	3/4	7.8	1.7–76.8	0.005
Atelectasis on CT				
Absent	10/82	Referent		
Present	4/15	2.6	0.7–9.8	0.151
Superior vena cava compression on CT				
Absent	10/72	Referent		
Present	4/25	1.2	0.3–4.2	0.800
Peak expiratory flow rate				
> 40% predicted	6/69	Referent		
≤ 40% predicted	3/6	10.5	1.7–63.9	0.011
Pulmonary function test results				
Normal	2/48	Referent		
Obstructive	4/16	7.7	1.0–25.4	0.048
Restrictive	0/9	1.0	0.3–26.2	0.440
Mixed	3/4	69.0	3.5–272.4	< 0.001

* Threshold determined from the receiver operator characteristic analysis (see text).

CI = confidence interval; CT = computed tomography; OR = odds ratio.

Discussion

Previous series have found an incidence of anesthesia-related life-threatening respiratory complications of up to 20%.[7–12] However, these series were essentially performed in pediatric populations. Azarow *et al.*[16] compared perioperative morbidity and mortality in adult and pediatric patients with a mediastinal mass. There was no statistically significant difference in mortality between children and adults; however, a difference in anesthetic risk was clearly suggested by the different etiologies of mortality in the two groups. Death in children was associated with perioperative respiratory complications, whereas adult death was attributable to uncontrolled malignancy. The incidence of intraoperative airway obstruction in our series was 0%. Therefore, the adult population seems less at risk of intraoperative respiratory problems. This could be explained by the fact that infants and small children may be more susceptible than adults to extrinsic airway obstruction because the airways are more compressible. Also, small decreases in airway diameter produce relatively larger decreases in tracheal luminal area and increases in airway resistance.[7] Nevertheless, we found a relatively high incidence of early life-threatening respiratory complications in the postoperative period (6.7%). The first 48 postoperative hours seem crucial in this regard. Caution should be taken in prevention of the occurrence of these morbid events.

We are unaware of any previous studies, except for the study of Azarow *et al.*,[16] that have evaluated retrospectively the incidence of intraoperative life-threatening cardiovascular complications in patients with a mediastinal mass. In this series, 3 of 105 anesthetic cases (2.9%) were encountered. In two of these cases (numbers 1 and 2, table 3), intraoperative cardiovascular problems were easily predictable in view of preoperative evaluation (CT scan and echocardiography). Pericardial effusion is well known to have a deleterious hemodynamic effect when added to positive-pressure ventilation.[17] Preoperative pericardial drainage, cardiopulmonary bypass, or both could have avoided these life-threatening complications.

Turoff *et al.*[13] reported an incidence of postoperative respiratory complications of 18% in a group of 97 patients with Hodgkin disease who had a staging laparotomy. This study included children and adults, with a mean age of 23 yr. We found a lower incidence of postoperative respiratory complications (12%), which could be attributed to the type of surgical procedure,

Table 5. Predictors of Intraoperative Complications (Univariate Analyses)

Independent Variables	Incidence of Complications	OR	95% CI	*P* Value
Signs and symptoms				
None	0/19	Referent		
Minimal/moderate	1/59	1.0	0.03–3.2	0.408
Severe	3/19	8.3	0.4–25.3	0.292
Tracheal compression on CT				
$<$ 50%	4/89	Referent		
$\geq$ 50%	0/8	1.1	0.1–8.0	0.468
Mass volume on CT*				
$<$ 130 cm^3	2/59	Referent		
$\geq$ 130 cm^3	2/38	1.6	0.2–5.8	0.944
Pleural effusion on CT				
Absent	0/74	Referent		
Present	4/23	34.4	2.1–102.9	0.003
Pericardial effusion on CT				
Absent	1/93	Referent		
Present	3/4	276.0	9.8–1,144.9	$<$ 0.001
Atelectasis on CT				
Absent	2/82	Referent		
Present	2/15	6.2	0.6–23.1	0.213
Superior vena cava compression on CT				
Absent	3/72	Referent		
Present	1/25	1.0	0.3–11.2	0.584
Peak expiratory flow rate				
$>$ 40% predicted	1/69	Referent		
$\leq$ 40% predicted	0/6	3.5	0.0–1.1	0.651
Pulmonary function test results				
Normal	0/48	Referent		
Obstructive	0/16	2.9	0.1–11.4	0.553
Restrictive	0/9	5.1	0.1–19.9	0.649
Mixed	1/4	41.6	1.1–139.5	0.043

* Threshold determined from the receiver operator characteristic analysis (see text).

CI = confidence interval; CT = computed tomography; OR = odds ratio.

differences in histologic diagnosis, or the absence of pediatric patients.

In view of our results and of previous studies, defining the actual incidence of cardiorespiratory problems with anesthesia in patients with a mediastinal mass remains difficult.[18] First, some high-risk patients are pretreated before biopsy (chemotherapy or radiotherapy) or have tissue diagnosis made by alternative means (percutaneous radiographically guided needle biopsy). Second, the extent of procedures performed under local anesthesia influences the true incidence because these patients are usually in the high-risk group and therefore more prone to complications. Finally, some series may include very small masses or posterior mediastinal masses, which are associated with a low risk of cardiorespiratory problems.

A few previous series have correlated respiratory symptoms with the extent of the tracheal compression as measured on CT scan.[7,8] King *et al.*[8] were the first to propose that respiratory symptoms were a reasonably accurate indicator of both the significance of the airway compression and the risk of general anesthesia. In the study of Hnatiuk *et al.*,[19] symptomatic patients were more likely to experience complications than asymptomatic patients (14.3% *vs.* 0%), but the difference was not statistically significant. Our study is the first to positively correlate the presence of signs and symptoms with perioperative complication rate. We also observed a high perioperative complication rate for patients with severe cardiorespiratory symptoms (stridor, orthopnea, cyanosis, jugular distension, and superior vena cava syndrome) in the univariate analysis. However, the severity of cardiorespiratory symptoms did not remain a significant predictor of complication in a multivariate logistic regression analysis, which probably reflected a lack of statistical power. Nevertheless, it seems prudent to avoid general anesthesia if possible, whenever severe cardiorespiratory symptoms are encountered.

A number of asymptomatic or minimally symptomatic children have experienced severe airway obstruction during anesthesia.[4,20,21] This seems to be an unusual finding in the adult population because we were unable to find a single adult case report in the literature. In this series and others,[7,8] there were no perioperative complications in asymptomatic patients. This finding suggests that general anesthesia can be induced safely in the adult asymptomatic population if the results of the radiographic and bronchoscopic evaluations are reassuring.

Azizkhan *et al.*[7] found a high rate of total airway obstruction during general anesthesia in children with tracheal compression greater than 50%. They suggested

Table 6. Predictors of Postoperative Respiratory Complications (Univariate Analyses)

Independent Variables	Incidence of Complications	OR	95% CI	*P* Value
Signs and symptoms				
None	0/19	Referent		
Minimal/moderate	5/59	3.9	0.2–11.7	0.624
Severe	5/19	14.7	0.8–44.4	0.077
Tracheal compression on CT				
$< 50\%$	7/89	Referent		
$\geq 50\%$	3/8	7.0	1.1–24.2	0.042
Mass volume on CT*				
< 130 cm^3	3/59	Referent		
≥ 130 cm^3	7/38	4.2	0.9–11.9	0.077
Pleural effusion on CT				
Absent	7/74	Referent		
Present	3/23	1.4	0.3–4.5	0.919
Pericardial effusion on CT				
Absent	10/93	Referent		
Present	0/4	0.9	0.1–3.4	0.516
Atelectasis on CT				
Absent	8/82	Referent		
Present	2/15	1.4	0.2–5.2	1.000
Superior vena cava compression on CT				
Absent	7/72	Referent		
Present	3/25	1.3	0.2–4.0	0.953
Peak expiratory flow rate				
$> 40\%$ predicted	5/69	Referent		
$\leq 40\%$ predicted	3/6	12.8	1.5–47.1	0.010
Pulmonary function test results				
Normal	2/48	Referent		
Obstructive	4/16	7.7	1.0–25.4	0.048
Restrictive	0/9	1.0	0.3–26.2	0.440
Mixed	2/4	23.0	1.3–100.8	0.020

* Threshold determined from the receiver operator characteristic analysis (see text).

CI = confidence interval; CT = computed tomography; OR = odds ratio.

that general anesthesia should be avoided in children with less than 66% of the normal tracheal area. In a subsequent evaluation, Shamberger *et al.*[9] did not find any anesthetic complication in 10 children with tracheal area of less than 66% who underwent general anesthesia. They suggest that patients with a tracheal area less than 50% should not receive general anesthesia. In the current study, there was no airway obstruction in the course of general anesthesia despite the fact that eight patients had severe tracheal compression (> 50%). The absence of airway collapse in this series of adult patients makes the definition of the critical tracheal area difficult. However, tracheal area was related to the extent of postoperative respiratory complications. When tracheal compression was greater than 50%, a sevenfold increase in the risk of postoperative respiratory complications was observed. Therefore, it seems reasonable to use the guidelines suggested by Shamberger *et al.*[10]

Shamberger *et al.*[10] examined the usefulness of preoperative PEFR in the assessment of intraoperative risk of respiratory collapse. They demonstrated that general anesthesia could be used safely in a pediatric population with a PEFR of at least 50% of predicted and with tracheal compression less than 50% of predicted. However, the postoperative course was not assessed, and besides PEFR, the other results of PFTs were not used to predict respiratory compromise. In our series, 10 patients underwent general anesthesia with less than 50% of the predicted PEFR (26–49% of predicted) without airway collapse. Nevertheless, the risk of perioperative complications was increased more than 10-fold when the PEFR was 40% or less of predicted (univariate analysis). Also, when the results of PFTs were analyzed in terms of pulmonary syndrome, a combination of obstructive and restrictive patterns (mixed pulmonary syndrome) was associated with a high rate of postoperative respiratory complications (OR, 15.1; multivariate analysis). These findings imply that alternative to general anesthesia should be prioritized when PEFR is severely reduced or a mixed pulmonary syndrome is present on PFT.

Flow volume loop in the upright and supine position is recommended as part of the preoperative evaluation in asymptomatic patients undergoing surgery for mediastinal masses.[22] Despite this, postural spirometry was not use routinely in the preoperative evaluation of asymptomatic or minimally symptomatic patients in our center. This omission was based on the clinical impression that postural spirometry could not offer any additive benefit in predicting perioperative complications in a minimally symptomatic population. The utility of upright and supine spirometry as part of the preoperative evaluation in the adult patient undergoing surgery for anterior mediastinal masses has been challenged recently by Hnatiuk *et al.*[19] They concluded that the recommendations to perform upright and supine spirometry before surgery for anterior mediastinal masses are based on anecdotal data and that upright and supine spirometry may not be any better at predicting perioperative complications than symptoms and CT scanning. Larger studies are needed to correlate upright and supine spirometry findings with perioperative risk.

In summary, adults with a mediastinal mass seem less at risk of perioperative complications than children are. Nevertheless, a high suspicion index for the occurrence of early postoperative life-threatening respiratory complications should be observed. Patients at high risk of perioperative complications can be identified by the presence of cardiorespiratory signs and symptoms at presentation, CT scan evaluation (tracheal compression $> 50\%$ or pericardial effusion), and mixed abnormality (*i.e.*, combined obstructive and restrictive patterns) on PFTs. The perioperative course should be managed in view of these findings.

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