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A Case Report and Review on the Anesthetic Considerations of Anterior Mediastinal Masses

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Cover Page Footnote

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INTRODUCTION

The mediastinum is anatomically divided into three anterior-to-posterior compartments, any of which can contain a pathologic mass. The nature of these masses tends to vary based on the compartment of the mediastinum. The anterior mediastinum is traditionally bound posteriorly by the pericardium, i.e., anterior mediastinal masses are found in front of the heart, great vessels, and airway. A common mnemonic taught to remember the most common anterior mediastinal masses is the "5 T's": thymoma, teratoma, thyroid, "terrible" lymphoma, and thoracic aortic aneurysm. Regardless of the cause of the mass, abnormalities in this area lend themselves to significant hemodynamic concerns due to proximity to vital structures. Because of this, anesthesia providers must make case-by-case considerations to prevent and prepare for vital compromise during diagnostic or therapeutic surgical procedures in these patients. A thorough physical examination and history can elicit valuable information detailing the severity of the mass's effect on surrounding structures. When planning the case, it is important to consider what hemodynamic and respiratory support must be available. Other considerations include any previous or current use of chemotherapy, particularly bleomycin, a commonly used chemotherapeutic for Hodgkin's Lymphoma. Additionally, the use of corticosteroids should be modified during anesthesia to decrease the risk of tumor lysis syndrome.

In this case we present a summary of a 15-year-old female presenting with an anterior mediastinal mass that required two operations under general anesthesia. This case provides an opportunity to discuss the important considerations in the anesthesia and perioperative care of a patient with a mass in this location.

CASE SUMMARY

A 15-year-old female with an unremarkable medical history presented to her primary care clinic in April 2023. She reported ongoing chest discomfort for an unspecified number of years. She was previously evaluated by pediatric cardiology in 2017 with a normal electrocardiogram (EKG) and echocardiogram. Her symptoms at that time were attributed to chest wall pain. Over the last two weeks, however, she was experiencing worsening chest pain and new dyspnea, which she first noticed during a recent track meet. She described the pain as prickly and stabbing, which was not reproducible by palpation. She had sought chiropractic care, thinking a rib might be out of place. Her chiropractic visit resulted in a brief relief of her pain, but it returned the following day. Despite those symptoms, she was able to complete the long jump and 100-meter dash at her track meet but could not finish the 200-meter run due to shortness of breath and chest pain. She also endorsed a 15-pound weight loss in the prior month. She denied orthopnea, fevers, and night sweats.

Her physical examination at the clinic was unremarkable, with stable vitals, no acute distress, no adenopathy, and a normal heart and lung exam. However, an anterior-posterior and lateral chest X-ray revealed abnormal fullness and lobular contour to the mediastinum, raising concern for a mass (Figure 1). A chest computed tomography (CT) scan with contrast was recommended for further assessment.

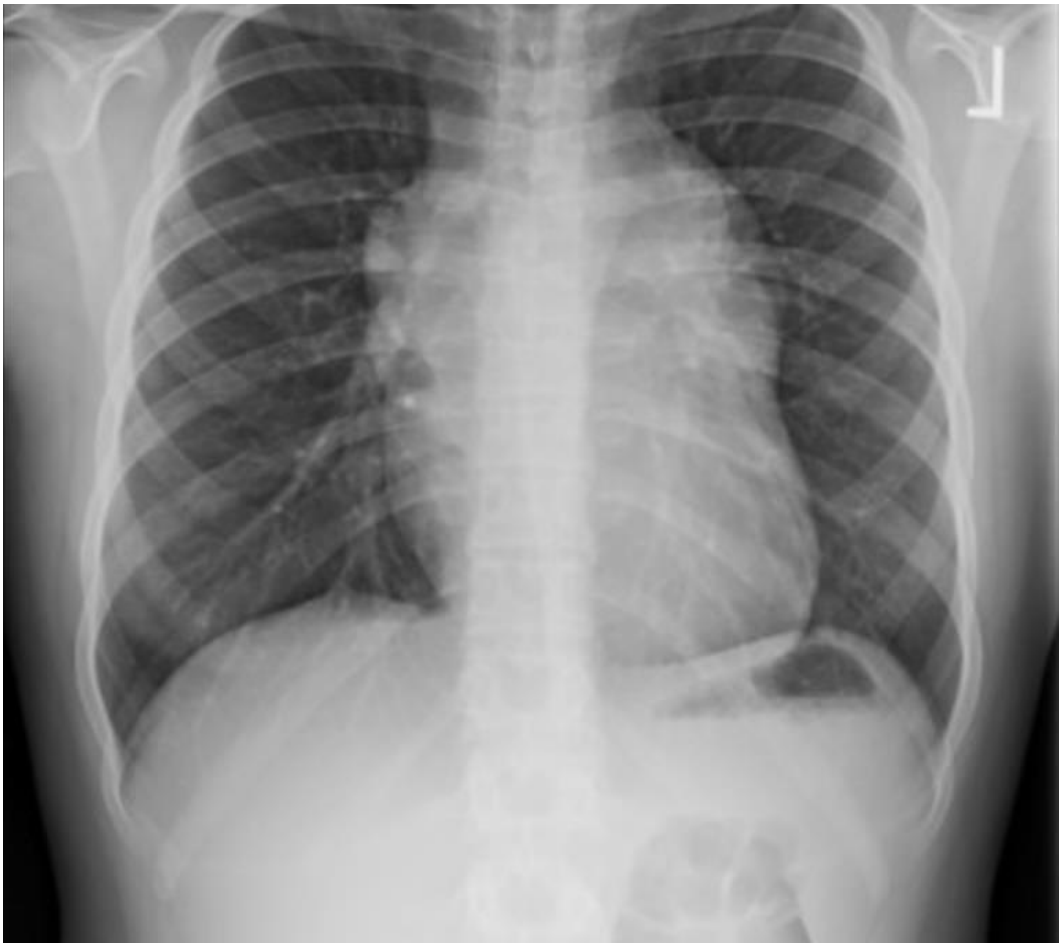

Figure 1: Anterior-posterior chest X-ray suspicious for an anterior mediastinal mass

The CT scan, performed the next day, confirmed the presence of a large anterior mediastinal mass measuring approximately 12.9 cm transverse by 6.9 cm anterior-posterior by 7.3 cm superior-to-inferior (Figure 2). The mass was fairly uniform in attenuation, but more heterogeneous along the left side, with an area of lower attenuation that might represent cystic change or necrosis. No calcifications were seen within the mass. The CT further revealed cervical lymphadenopathy and prominent pericardial effusion. No invasion of adjacent structure was noted.

Transthoracic echocardiogram showed mild compression of the right ventricular outflow tract and pulmonary artery without obstruction. The patient was admitted to the hospital for further management.

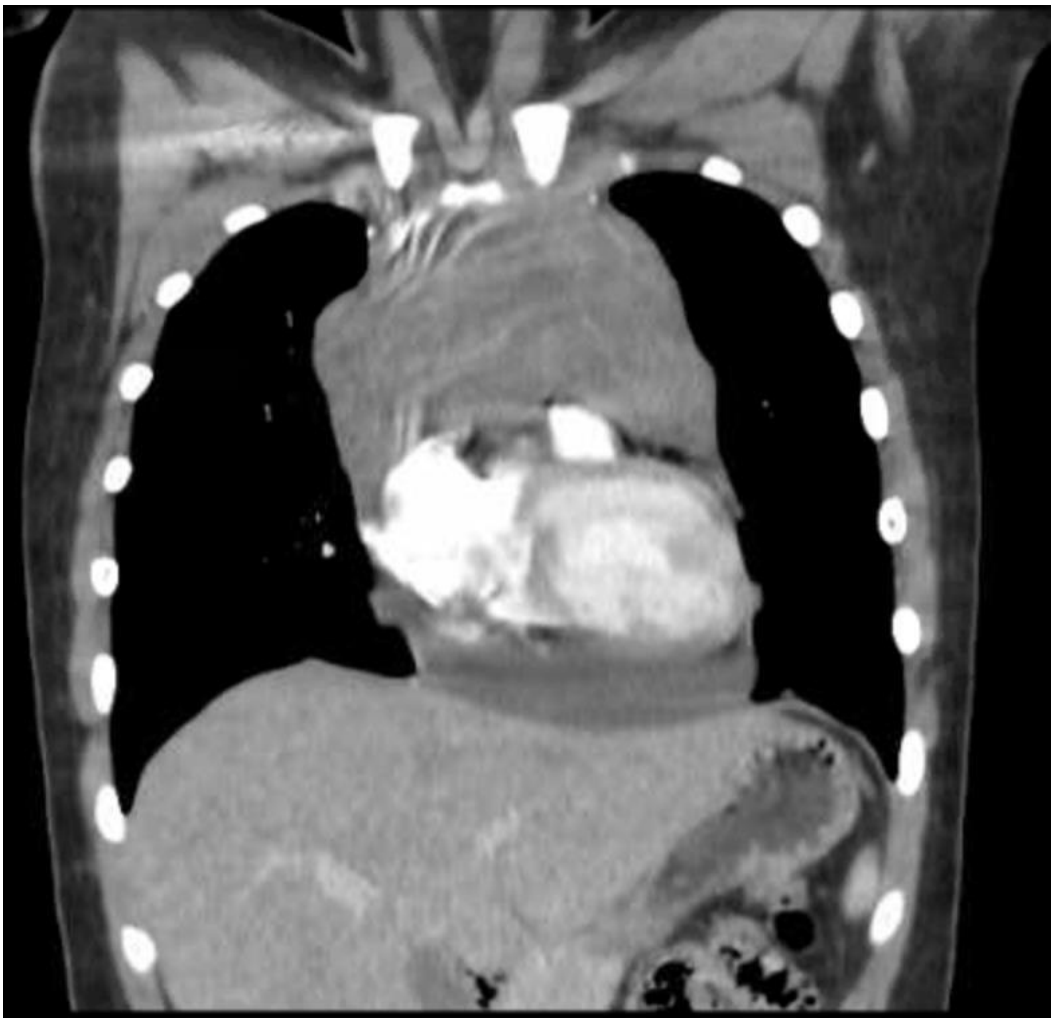

Figure 2: Coronal CT chest with contrast confirming the presence of the anterior mediastinal mass

Initial laboratory results included a complete blood count showing a white blood cell count of 10.9 K/uL, hemoglobin of 10.8 mg/dL, and a mean corpuscular volume of 73.0 fL. A peripheral smear confirmed microcytosis but was otherwise unremarkable. Her lactate dehydrogenase level was 107 U/L, and her comprehensive metabolic panel was within normal limits.

Later that day, the patient underwent a CT-guided biopsy of the mediastinal mass under general anesthesia. The anesthesia plan included general anesthesia with IV induction and a supraglottic airway. Medications used included ketamine, midazolam, propofol, and sevoflurane. The procedure was uncomplicated, and the specimen was sent to pathology. The initial biopsy was inconclusive, and a second biopsy was performed by pediatric surgery a few days later via thoracoscopy. The anesthesia plan was similar, that time with the addition of dexmedetomidine and remifentanil to the medication regimen. She had two large-bore upper extremity IVs placed, as well as an arterial line placed for continuous blood pressure monitoring. She experienced no perioperative complications.

Throughout her hospital stay, the patient remained stable, with reassuring laboratory results and no evidence of tumor lysis syndrome. She was discharged in good condition, with a plan to finalize a treatment plan once the biopsy results were complete. The pathology results ultimately revealed a diagnosis of classic Hodgkin lymphoma, nodular sclerosis subtype.

The patient was ultimately diagnosed with Hodgkin lymphoma stage IIa with bulky disease due to multiple lymph node sites above the diaphragm and disease being larger than 10 cm. She underwent 4 chemotherapy treatments with a regimen including doxorubicin, dacarbazine, vinblastine, and brentuximab. She completed therapy in August 2023. At the time of writing this case report her venous port catheter for chemotherapeutic administration was recently removed.

DISCUSSION

This case highlights the challenges of diagnosing and managing a patient with a large anterior mediastinal mass, with a focus on the anesthesia considerations for the procedures she underwent. The patient's course of care required a multidisciplinary approach, involving family practice, radiology, anesthesiology, general surgery, pathology, and hematology/oncology. This case provides valuable insights into the management of similar cases in the future.

The presence of a pathologic mass in the mediastinum is inherently concerning due to its proximity to so many vital structures. Compression of the heart, great vessels, and airway can lead to respiratory compromise or cardiovascular collapse. Though a patient may be entirely stable prior to surgery, the physiologic changes and stresses of general anesthesia and surgery may result in catastrophic issues. For this reason, providers must be diligent in their assessment and management before, during, and after surgery.

PHYSIOLOGY

Some models divide the mediastinum into four compartments (superior, anterior, middle, and posterior), while more traditionally, it is divided into three anterior-to-posterior compartments defined by the pericardial sac. In the three-compartment model, the anterior mediastinum is bounded anteriorly by the sternum, posteriorly by the pericardium, laterally by the pleural sacs, and superiorly by the thoracic outlet.[1] As such, pathologic masses in this compartment may compress the heart, the great vessels, and the airways. Furthermore, an aggressive mass may directly invade these vital structures, or it could lead to significant pleural effusions, pericardial effusions, or even cardiac tamponade. Any compressive effects may be exacerbated by general anesthesia.[2] Studies have shown perioperative cardiorespiratory complication rates to range from 9 to 20 percent in patients with anterior mediastinal masses.[3-5]

Various mechanisms may contribute to the risk of respiratory and hemodynamic complications in the perioperative period. First, the static and often supine positioning during surgery may lead to persistent compression due to gravity and the location and dynamics of the mass. In a conscious patient, they may begin to develop lightheadedness, shortness of breath, or pain that prompts them to reposition and intuitively relieve the compression. However, this protective mechanism is lost in the paralyzed and sedated patient. Furthermore, supine positioning in itself reduces functional residual capacity (FRC) due to cephalad displacement of the diaphragm.

Next, the medications used for anesthesia cause numerous changes to respiratory and cardiovascular dynamics. General anesthesia is known to reduce FRC by up to 20 percent.[6] Neuromuscular blockers are of particular concern in this population and should be avoided in favor of maintaining spontaneous ventilation whenever possible.[7] Loss of diaphragmatic and intercostal muscle tone resulting from paralytic use can alter the dynamic physiology of the chest wall and reduce the transpleural pressure gradient that maintains dilation of the airways, increasing the risk of intraoperative airway collapse. Similarly, anesthetics that relax bronchial smooth muscle will increase the compliance of these structures and exacerbate any compressive effects.[8] Finally, positive-pressure mechanical ventilation combined with supine positioning increases intrapleural pressure, reducing venous return and increasing compressive forces around the pulmonary artery and right ventricular outflow tract, potentially leading to sudden hypoxemia or hypotension.[9]

PREANESTHETIC ASSESSMENT AND PLANNING

Prior to surgery, it is important to ascertain the risk of acute issues in the operating room. A detailed history and exam can provide useful clues to the degree of functional change caused by the compression. Mediastinal masses may be discovered incidentally on chest imaging, or the patient may have symptoms that

prompt imaging. A patient's symptoms will vary greatly based on the location and characteristics of the mass.

Common presentations of mediastinal masses relate to compressive symptoms. Tracheobronchial obstruction may lead to dyspnea, tachypnea, orthopnea, cough, stridor, and hemoptysis.[10,11] Compression of the heart and great vessels can lead to syncope, arrhythmia, murmur, or hypotension.[7,9] More specifically, compression of the superior vena cava (SVC) or the brachiocephalic veins can lead to swelling of the face and upper extremities and compromised venous access, requiring specific procedural considerations.[12] Nerve compression in the neck may lead to hoarseness or Horner syndrome.

In addition to the mass effect of the tumor, specific masses may lead to systemic syndromes. Thymomas are often associated with myasthenia gravis, and this can further complicate the use of neuromuscular blocking agents.[10,13] Hematologic malignancies may display weight loss, as with our patient, or other nonspecific symptoms.

Regardless of symptoms, it is important to assess their severity and the factors that exacerbate or alleviate them. The mass effect of a neoplasm may vary greatly with position—a tumor may compress the airway and lead to significant dyspnea and stridor in the supine position but cause no symptoms when upright.[2] A patient may be able to naturally compensate for these positional symptoms to the point that they are not often bothered. However, when undergoing anesthesia, they lose any ability to change their position in response to their symptoms. Understanding the positional variations in compressive symptoms can guide surgical planning and intraoperative care.

Prior to the procedure, appropriate imaging of the mass is essential. A mass may often first be suspected based on a chest X-Ray, but this should be followed by a more detailed study to better understand the location, size, relationship to surrounding structures, and tissue characteristics. Typically, a chest CT with contrast will be sufficient to characterize the mass and plan for surgery.[14] Pericardial effusion discovered on preoperative imaging is especially associated with intraoperative complications, and tracheal compression of more than 50% on CT is predictive of postoperative respiratory complications.[5] In specific situations, MRI, PET, and other imaging modalities may provide additional utility. It is important to note that, while helpful, imaging studies cannot predict the changes that may occur during surgery.[2]

Though one might expect pulmonary function testing to be helpful in the dyspneic patient, flow volume loops do not correlate well with degree of airway obstruction beyond what can be gleaned from history, exam, and imaging.[15-17]

With a thorough preoperative assessment and appropriate imaging, a clinician can stratify a patient's level of risk prior to the procedure. Depending on the geography of the mass and risk of specific intraoperative complications, the

surgeon and anesthesiologist should be able to anticipate the most dangerous intraoperative possibilities.

PREOPERATIVE RADIATION, STEROIDS, AND CHEMOTHERAPY

As with the patient in this report, a malignant mass poses further considerations that may affect perioperative management. The use of radiotherapy, corticosteroids, and chemotherapy prior to surgery have a potential role in shrinking tumors for compressive or prognostic benefits.[4,18,19] However, there is hesitance with routinely taking this approach due to concerns that tumor shrinkage may interfere with histological diagnosis.[4,20,21] One study was able to make a definitive diagnosis in 95% of patients despite steroid use, so this historical concern may be exaggerated.[4] Additionally, therapeutics such as chemotherapy, corticosteroids, radiation, and anesthesia itself pose a risk of tumor lysis syndrome.[22] When initiating treatment that kills tumor cells, the lysis of these cells may lead to massive release of intracellular contents, leading to electrolyte derangements such as hyperkalemia that can impact hemodynamics.

Each of these interventions carries its own risk of side effects that may complicate the procedure. Radiotherapy to the mediastinum may cause changes to the airway that impact respiratory dynamics during mechanical ventilation. Certain chemotherapeutic drugs are associated with specific toxicity to the heart and lungs.

Bleomycin, a chemotherapeutic agent used to treat lymphoma, poses a unique concern. Bleomycin is well-known to be associated with acute pulmonary toxicity, but there is also concern for a lifelong risk of postoperative Acute Respiratory Distress Syndrome (ARDS) with bleomycin use. Earlier case reports and mouse studies have suggested that supplemental oxygen may be a risk factor for this phenomenon, and as such, decades of guidance have recommended strategies to restrict perioperative FiO2 in these patients.[23,24] The association with oxygen administration has been less substantial in some more recent studies, and a 2018 study even found no risk of postoperative pulmonary complications in their cohort.[24-26] It is possible that the lower risk in more recent studies may be related to changes in standard management over the years that mitigate this risk. As such, many providers will continue to minimize oxygen exposure in a patient with a history of bleomycin use.

INTRAOPERATIVE MANAGEMENT

The management of these patients intraoperatively is complicated, and fully exploring the variety of considerations is beyond the scope of this paper. Nevertheless, there are some key points to appreciate and some specific situations worth discussing.

Whenever possible, using only local or regional anesthesia for simpler procedures such as thoracoscopic biopsy avoids the numerous risks involved with general anesthesia. However, this is less practical in the pediatric population.

Each patient will require a highly personalized operative plan, depending on the location of the mass, suspected nature of the mass, degree of compressive symptoms at baseline, clinical suspicion for decompensation with anesthesia induction, surgical procedure and approach, and patient comorbidities. It is crucial for the anesthesiologist to understand the procedure and communicate with the surgeon regarding the risks related to anesthesia. It is important to be prepared for emergent changes, especially if the preoperative evaluation raises any specific concerns.

As discussed above, it is generally preferable to avoid neuromuscular blocking agents and maintain spontaneous respiration. Even with spontaneous breathing, however, there is still a risk of intraoperative respiratory compromise. If this occurs, a conservative intervention that may help is simply repositioning the patient. Placing a supine patient on their side or even laterally tilting the operating table may mitigate the compressive effects of the tumor.[7]

If repositioning the patient is impractical or unsuccessful, there are a variety of supplies for advanced airway management that should be available in higher risk cases: specialized endotracheal tubes (varying lengths and collapsibilities, double-lumen ETT), video double-lumen endobronchial tube, and both rigid and flexible bronchoscopes.[11,27] Especially important is the availability of a rigid bronchoscope, as this will allow emergent stenting of the airway in case of collapse due to tumor compression.

In the highest risk cases, it may be appropriate to cannulate and prepare a patient for cardiopulmonary bypass or extracorporeal membrane oxygenation (or even initiate these interventions) prior to the surgery, as the time necessary to prepare these as rescue methods could render them futile amid a true catastrophe.[7,28]

Preparations for hemodynamic monitoring include intraarterial catheterization, central venous catheterization, pulmonary artery catheterization, and transesophageal echocardiography. Providers should be ready to administer fluids, blood products, vasopressors, and inotropes as necessary.[2,11,29] The preoperative evaluation proves especially important for the intraoperative management of hemodynamics. If SVC syndrome is present or if the mass is otherwise interfering with the large veins of the neck and chest, routine central venous access may be compromised, and additional access to the inferior vena cava (IVC) may be achieved by peripheral right femoral artery catheterization. As discussed, the SVC is at particular risk compared to the IVC in anterior mediastinal masses due to its anatomic location.

Just as repositioning can be helpful for airway compromise, moving the patient can alleviate hemodynamic insufficiency that may be related to compression of the right ventricular outflow tract or pulmonary artery.

POSTOPERATIVE MANAGEMENT

Postoperative management in these patients is largely similar to any patient. However, a higher suspicion for complications related to the airway and blood vessels is necessary. One study showed a higher rate of complications postoperatively than perioperatively, with 6.7% of patients having life-threatening respiratory complications less than 48 hours after their procedure.[5] It may be prudent to perform a bronchoscopy prior to extubation in order to evaluate the integrity of the airway, especially if the resected mass was adherent to the trachea or if there is any concern for possible injury. In the post-anesthesia care unit, any signs suggesting bleeding or airway compromise require emergent evaluation and a low threshold for returning to the operating room.

CONCLUSION

Anterior mediastinal masses present unique challenges in the perioperative setting. The unique compartmental anatomy combined with the physiological changes encountered under general anesthesia increases the risk for respiratory or cardiovascular decompensation. As such, these cases demand a thorough preoperative evaluation, a well-communicated operative plan, and close post-operative monitoring.

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