Chapter 4
Anterior Mediastinal Mass (Pediatric)

Claire Sampankanpanich Soria

Case Outline

Learning Objectives

1. Describe preoperative workup for anterior mediastinal mass.
2. Describe induction considerations for anterior mediastinal mass.
3. Discuss anesthetic management intraoperatively for biopsy versus resection of anterior mediastinal mass.

Simulator Environment

1. Location: operating room in a children's hospital
2. Manikin setup:
   (a) Age: child
   (b) Lines: 1 x 22 Gauge (G) peripheral intravenous line (PIV) in hand
   (c) Monitors: non-invasive blood pressure (NIBP) cuff, 5-lead electrocardiogram (EKG), pulse oximeter
3. Medications available: normal saline, propofol, succinylcholine, rocuronium, epinephrine, dopamine, albuterol, fentanyl, ketamine, dexmedetomidine. Sugammadex is not available.

C. Sampankanpanich Soria (✉)
University of California, San Diego Medical Center, San Diego, CA, USA
e-mail: cssoria@health.ucsd.edu

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4. Equipment available
   (a) Airway equipment: ventilator, face mask, laryngoscope and cuffed and uncuffed endotracheal tubes (ETTs) of various sizes, stylet, oral airway, nasal trumpet, laryngeal mask airway (LMA), suction.
   (b) Lines: 18/20/22 G PIV catheters, tourniquet, IV pigtail and flush, arterial line setup.
   (c) Crash cart with defibrillator
   (d) Paperwork: pre-operative anesthesia history and physical

Actors

1. Scrub tech
   (a) The scrub tech is busy opening trays. They are helpful at providing manual labor assistance, such as repositioning the patient or bringing the crash cart into the room.
2. Circulator nurse
   (a) The nurse is helpful but nervous. This hospital does not take care of a lot of kids with anterior mediastinal masses, so she's not aware of all the precautions and complications that can occur.
3. Surgeon
   (a) The surgeon is on the phone at the computer dictating their operative note from a previous patient. It takes a few tries to get their attention.
4. Anesthesia tech
   (a) The anesthesia tech is helpful at handing equipment to the anesthesiologist in a timely fashion.

Case Narrative

1. Scenario background given to participants:
   (a) You are the anesthesiologist starting a case on a Friday at 6 pm of an 8-year-old, 27 kilogram (kg) girl with a newly diagnosed anterior mediastinal mass who is now undergoing resection.
   (b) Preoperative history: ex-full term; healthy; doing well in school, keeping up with peers, eating well, growing well; mild asthma exacerbated by pollen

and URIs. Parents brought her into the emergency department (ED) a week ago because she had been having a chronic feeling of difficulty breathing when lying flat. She normally plays in a soccer league but lately has been more tired than usual. At night, she sleeps most comfortably on her right side.

(c) Preoperative physical: well-nourished child, breathing comfortably when sitting upright in chair, but when lays flat, feels like she's suffocating.

(d) Preoperative vital signs: blood pressure (BP) 110/65, heart rate (HR) 87, oxygen saturation (SpO2) 100% on room air (RA), temperature (T) 37 degrees Celsius.

(e) Preoperative labs: potassium (K) 4.0, creatinine (Cr) 0.8, hemoglobin (Hb) 12.0, platelets (Plt) 220.

(f) Preoperative transthoracic echocardiogram (TTE) and computed tomography (CT) scan thorax with contrast (only available if the learner asks for these reports specifically): the mass is very large and causing severe compression of the distal trachea. The CT scan was done with the patient under minimal sedation with a thick pillow to elevate her head so she could breathe better. TTE was notable for moderate-severe compression of the left ventricle when lying supine, and mild-moderate compression with the patient upright. Otherwise, good right ventricular (RV) systolic function and impaired left ventricular (LV) diastolic filling and systolic function from compression.

2. Scenario development

(a) Phase 1: inability to ventilate after induction.

(i) The patient will complain that she does not feel good lying flat on her back. She will be anxious, tearful, and scared.

(ii) The learner should ask the patient what position is most comfortable for her. Options include allowing the patient to sit upright until she is asleep, or raising the head of the bed and providing pillows while she lies down.

(iii) The learner may do a debrief with the operating room (OR) team.

1. Alert everyone to the fact that this patient may be difficult to ventilate, even if they have a normal airway exam and are easy to intubate, due to compression / mass effect on the tracheobronchial tree.
2. This patient may become hemodynamically unstable and decrease her cardiac output because of compression / mass effect on the heart or great vessels.
3. There should be extracorporeal membrane oxygenation (ECMO) capabilities nearby with a perfusionist and anesthesia tech readily available to assist.

4. The cardiothoracic surgeon should be paying attention to induction. There should be close communication between the anesthesiologist and surgeon, so the surgeon knows whether to intervene with a rigid bronchoscope or prepare for ECMO cannulation.

(iv) The following equipment and staff members are readily available but are not present in the room unless the learner specifically asks for them:

1. Rigid bronchoscope
2. Perfusionist
3. ECMO / cardiac bypass machine and cannulation equipment
4. Crash cart with an automated external defibrillator (AED).

(v) The learner should try to maintain spontaneous ventilation in the patient. Possible methods may include a variation of inhaled induction with sevoflurane, and a titrated IV induction with ketamine and dexmedetomidine.

(vi) IF the learner does not try to maintain spontaneous ventilation and makes the patient apneic (example: non-judicious administration of narcotic or propofol, or administers muscle relaxant), then the learner will find the patient is impossible to mask ventilate in the supine position. The patient will gradually begin to desaturate. If the learner does not take steps to improve ventilation, then the patient will become bradycardic and hypotensive.

(vii) IF the learner does maintain spontaneous ventilation, they will still have some difficulty ventilating the patient. The patient will have limited chest rise and shallow tidal volumes.

(viii) Either way, the learner should take the following steps:

1. Attempt to reposition the patient – sitting upright, raising the head of the bed, turning right lateral decubitus or left lateral decubitus.
2. May try using higher peak pressures to mask ventilate or providing continuous positive airway pressure (CPAP) via circuit mask if spontaneously ventilating.
3. Notify the surgeon immediately and ask them to prepare for a rigid bronchoscope.
4. Proceed to intubate by direct laryngoscopy and try to manually bag via the ETT.

5. The learner who has administered muscle relaxant may request sugammadex, but this will not be available because the OR Pyxis is out of stock.
6. The learner may give epinephrine or a fluid bolus if the patient is bradycardic and hypotensive.

(ix) With repositioning, the learner will be able to ventilate the patient better. Vital signs will normalize.

(b) Phase 2: additional lines and monitors.

(i) The OR and anesthesia tech will be helpful in assisting with line placement.
(ii) The learner should proceed with placement of a second PIV and an arterial line.

(c) Phase 3: hemodynamic instability.

(i) Ventilation has improved with lateral positioning, but the surgeon reports that they cannot operate like this. The surgeon will ask if the learner can get the patient spontaneously ventilating again. The patient still has 0 twitches.
(ii) At this point, an OR runner will come in and provide sugammadex so that the learner can reverse the muscle relaxant, if this had been given during induction.
(iii) The surgeon will ask if now is a good time to try going supine.
(iv) The learner will slowly reposition the patient from lateral decubitus to supine. Tidal volumes will noticeably decrease for a given peak pressure. The learner may ask if the table can be adjusted – head of bed elevated or reverse Trendelenburg positioning.
(v) The surgeon will move quickly to perform the median sternotomy. There is minimal bleeding. They will move efficiently but carefully.
(vi) The patient will demonstrate hypotension and tachycardia. The learner may administer fluid boluses or inotropes / pressors to treat. The hemodynamics will improve and surgery will progress uneventfully.
(vii) The scenario will end here.

Scoring Rubric

Table 4.1 Scoring rubric for case scenario on Anterior Mediastinal Mass

Topic: Anterior Mediastinal Mass (Pediatric)			
Participant Name:			
Evaluator Name:			
Score:			
		Completed	Not Completed
Pre-operative evaluation			
History and physical exam	Ask about symptoms: Exercise tolerance, dyspnea, orthopnea, favored positions, fatigue, syncope.		
	Obtain set of baseline vital signs.		
	Inquire about other co-morbidities: Cardiac, pulmonary, neuromuscular disorders.		
	Perform physical exam: Auscultate bilateral breath sounds, observe for signs of superior vena cava (SVC) syndrome.		
Labs/imaging	Inquire about preoperative labs: Complete blood count (CBC), coagulation panel.		
	Inquire about preoperative echocardiogram: Contractility, diastolic function, compression of major vessels, compression of any chambers.		
	Inquires about oncology plan: Consideration for radiation therapy or steroids to shrink tumor prior to surgical resection.		
Room preparation			
Communication	Provides comfort and reassurance to anxious patient.		
	May perform debrief with the OR team discussing potential dangers and backup plans.		
Equipment/ staffing	Confirms cardiothoracic surgery and perfusionist are available to cannulate and crash onto bypass if needed.		
	Confirms ear/nose/throat (ENT) surgeon is available to perform rigid bronchoscopy in case unable to ventilate.		
	Positions patient in comfortable position to optimize ventilation.		
	Confirms in situ peripheral intravenous line (PIV) is functional.		
	Has difficult airway equipment in room: Various sized blades/endotracheal tubes (ETTs), video laryngoscope, fiberoptic bronchoscope, rigid bronchoscope, jet ventilator, cricothyroidotomy kit, crash cart with automated external defibrillator (AED) and pads on patient.		

Table 4.1 continued

Inability to ventilate			
Induction	May perform combination inhalational and intravenous induction.		
	Attempts to maintain spontaneous ventilation.		
	Administers intravenous (IV) agents with the goal of achieving general anesthesia, avoiding bronchospasm, laryngospasm, coughing/bucking, but maintaining spontaneous ventilation.		
	Possible IV agents include: Ketamine, dexmedetomidine, propofol, narcotics cautiously.		
	Avoids administering muscle relaxants.		
Ventilation	Calls for help.		
	Recognizes apnea or shallow tidal volumes.		
	Attempts to reposition patient: Sitting upright, raising head of bed, turning right or left lateral decubitus, prone.		
	May try using higher peak pressures to mask ventilate or providing continuous positive airway pressure (CPAP) if still spontaneously ventilating.		
	Notifies ENT surgeon and asks them to prepare rigid bronchoscopy.		
	Notifies cardiothoracic surgeon and asks to prepare for emergent cardiopulmonary bypass.		
	Proceeds to intubate and try to manually bag via endotracheal tube (ETT).		
	If administered muscle relaxant, may attempt to restore spontaneous ventilation by reversing neuromuscular blockade.		
Hemodynamic collapse			
Lines/drains/ airway	Establishes large bore PIV access.		
	Places arterial line.		
Intervention	Identifies hypotension and tachycardia.		
	Administers fluid bolus: Crystalloid 20 milliliters per kilogram (ml/kg).		
	May initiate inotropes or pressors.		
	Considers repositioning patient to alleviate mass compression on heart/great vessels.		

Summary of Clinical Teaching Points

Where do mediastinal masses come from? [1, 2]

- Primary mediastinal tumors
  - 54% anterior mediastinum
  - 20% middle mediastinum
  - 26% posterior mediastinum

- Most common causes of mediastinal tumors
  - T-cell lymphoblastic lymphoma / leukemia
  - Hodgkin lymphoma
  - Others: primary mediastinal B cell lymphoma, thymic tumors, germ cell tumors, rhabdomyosarcoma, Langerhans cell histiocytosis

Who is involved in the pre-operative evaluation?

- Emergency Department team
- Hematology-Oncology team
- Pulmonary Intensive Care Unit (PICU) team, even if PICU admission is not required, in case of a deterioration in clinical status
- Pediatric Surgery team
- Anesthesiology team
- Cardiology team, as patient may require a STAT echocardiogram
- All consultants must evaluate the patient in a timely fashion

When should you worry? [1, 2]

Table 4.2 Worrisome clinical signs and symptoms in anterior mediastinal mass in children

Critical Airway	Cardiac Compromise
Tracheal cross-sectional area <50% of predicted	Pericardial effusion causing tamponade
Peak expiratory flow rate in supine position <50% of predicted	Tumor impingement on any of the great vessels or cardiac chambers
Severe narrowing or complete occlusion of one or both mainstem bronchi	Signs of cardiac compromise: Hypoxemia, pulmonary edema, decreased cardiac output
Clinical findings of acute respiratory distress or impeding respiratory failure	Symptoms of cardiac compromise: Fatigue, shortness of breath, syncope, difficulty keeping up with peers, poor growth, loss of appetite
Signs of respiratory distress: Retractions, wheezing, stridor, hypoxemia, tachypnea, orthopnea, shortness of breath, anxiety	

What imaging and diagnostic studies should be done pre-operatively?

- Initial evaluation in the emergency department:
  - Chest radiograph (x-ray) to evaluate for the presence of a mediastinal mass

    Suspected leukemia
    Lymphadenopathy and suspected lymphoma
  - Labs: complete blood count (CBC) with differential, basic metabolic panel (BMP), uric acid, phosphate, lactate dehydrogenase (LDH), alpha fetoprotein (AFP), beta-human chorionic gonadotropin (HCG), disseminated intravascular coagulation (DIC) panel with coagulation studies

- All patients with evidence of mediastinal mass on chest x-ray should have a follow-up CT thorax in the ED to assess for tracheal size
- Consider ultrasound to evaluate for pericardial effusion, especially if there is evidence of cardiac compromise, for rapid preliminary evaluation
- All imaging must be read STAT
- Echocardiogram is mandatory

Why is the echocardiogram important?

- All patients with mediastinal masses require urgent / emergent echocardiogram
- What are you looking for?
  - Ventricular function
  - Pericardial effusion
  - Tamponade
  - Intravascular thrombi
  - Obstruction of great vessels

When is it safe to go to the operating room?

- CT thorax with contrast and ECHO are completed
- Ideally weekday morning when most staff available for back-up in case of intraoperative complications

What is the anesthetic management?

Table 4.3 Anesthetic management for biopsy versus resection of anterior mediastinal mass

Biopsy	Resection
Usually interventional radiology (IR)- or computed tomography (CT)-guided. Off-site at IR or CT suite versus in the main operating room (MOR) with portable IR/CT equipment	Done in the operating room
Maintain spontaneous ventilation	Maintain spontaneous ventilation
Perform under monitored anesthesia care (MAC)/sedation with local anesthetic	Requires general anesthetic
Supine position for bronchoscopy or mediastinoscopy	Lateral decubitus position for thoracotomy

What are your anesthetic goals?

Table 4.4 Anesthetic goals, challenges, and techniques for resection of anterior mediastinal mass

Anesthetic Challenges and Goals	Techniques
Maintain spontaneous ventilation	Titrated intravenous (IV) induction: Ketamine, dexmedetomidine, propofol infusion if anticipated difficulty airway or prolonged time to intubate Inhalational induction Minimize narcotics that would cause hypoventilation/apnea Consider regional anesthesia Whatever your medication of choice, use judiciously If muscle relaxation is needed, test small, short-acting dose and verify adequate ventilation and hemodynamics in that position with positive pressure ventilation (PPV)
Establish IV access quickly	Awake versus asleep peripheral intravenous line (PIV) Difficult IV equipment: Ultrasound machine, vein finder Experienced providers
Secure airway quickly	Difficult airway equipment Experienced laryngoscopist
Avoid collapse of mass onto critical structure that would lead to inability to ventilate and hemodynamic collapse	Reposition patient from supine position to alternatives that would alleviate compression from mediastinal mass: Lateral, prone, upright Rigid bronchoscope to elevate mass away from tracheo-bronchial tree and help restore ventilation and oxygenation Extracorporeal membrane oxygenation (ECMO) team on standby. Caution that even with team scrubbed in and pump primed, may take 15 minutes to establish cannulation and initiate ECMO. Hypoxic brain injury may occur during this time.

Why is spontaneous ventilation better than controlled ventilation for anesthetic management of anterior mediastinal mass?

Table 4.5 Comparison of spontaneous versus controlled ventilation for anesthetic management of anterior mediastinal mass

Spontaneous Ventilation = Negative Pressure Ventilation	Controlled Ventilation = Positive Pressure Ventilation
Decrease in intrathoracic pressure with inspiration	Positive pressure ventilation increases intrathoracic pressure
Less compressive effect of anterior mediastinal mass	Possible complete collapse of trachea, bronchi, or major vessels
Better at maintaining airway patency	Neuromuscular blockade increases collapse because lose tone of supporting muscles of chest wall, neck, and supraglottic airway

What happens under general anesthesia?

Table 4.6 Comparison benefits and dangers of general anesthesia for anesthetic management of anterior mediastinal mass

Benefits	Dangers
Establish secure airway – Potentially helps ventilate stenotic or compressed portions of trachea	Muscle relaxation from volatile anesthetic even without administration of paralytics
Comfort for patient – Lateral decubitus position for thoracotomy	Compression of tracheo-bronchial tree or cardiac structures
Ability to control ventilation in event of intraoperative hemodynamic collapse	Ventilation/perfusion (V/Q) mismatch, shunting, decreased lung volumes, inability to ventilate
Reduced risk of aspiration if esophageal compression is present	Hemodynamic collapse
	Pediatrics: More collapsible airway tissue More compliant chest wall

Preparation and Anticipation

- It is a good idea to do a team timeout before induction.
- Alert everyone to the fact that this patient may be difficult to ventilate, even if they have a normal airway exam and are easy to intubate, due to compression / mass effect of the anterior mediastinal mass on the tracheo-bronchial tree.
- Patient may become hemodynamically unstable and decrease their cardiac output because of compression and mass effect on the heart or great vessels.
- There should be ECMO capabilities nearby with a perfusionist and anesthesia tech readily available to assist.
- The cardiothoracic surgeon should be paying attention to induction. There should be close communication between the anesthesiologist and surgeon, so the surgeon knows whether to intervene with a rigid bronchoscope or prepare for ECMO cannulation.

What should you do if you cannot ventilate?

- Attempt to reposition the patient – sitting upright, raising the head of the bed, turning right lateral decubitus or left lateral decubitus.
- May try using higher peak pressures to mask ventilate or providing CPAP if spontaneously ventilating.
- Notify the surgeon immediately and ask them to prepare to perform rigid bronchoscopy.
- Proceed to intubate by direct laryngoscopy and try to manually bag via the ETT.

- Consider giving epinephrine or a fluid bolus 20 cc/kg to prevent the patient from becoming bradycardic and hypotensive due to mass compression and hypoxemia/hypercarbia.

What should you do if your patient becomes hypotensive?

- Know your pre-operative imaging: CT thorax and especially the ECHO
- Notify surgeons immediately so they can prepare to quickly open the chest and take the pressure of the anterior mediastinal mass off of the heart and great vessels
- Administer a fluid bolus to augment preload
- Consider inotropes (dopamine, epinephrine, etc.) to augment myocardial contractility
- Consider pressors to improve mean arterial pressure (MAP) and end-organ perfusion

In Summary

- When you hear "anterior mediastinal mass," PAUSE TO THINK.
- Remember your anatomy.
- Remember your physiology.
- Mobilize resources.
- Think of plans A, B, and C.

References

1. McLeod M. Anterior mediastinal masses in children. British Journal of Anesthesia. 2019;19(1):21–6.
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