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ANESTHESIA FOR PATIENTS WITH ANTERIOR MEDIASTINAL MASS

Surgical Specialty:	General Surgery, Cardiac Surgery
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Background:

- General Considerations
  - The mediastinum is divided into four "compartments" defined by their relationship to the pericardium: superior, anterior, middle, and posterior. The middle compartment is essentially the contents of the pericardium. The anterior and superior compartments are contiguous and often classified as a single anterior mediastinum.[1-3]
  - There are no anatomical or fascial planes that separate the mediastinal compartments; thus, masses originating in one compartment can cross into another.
  - Masses arising in the anterior mediastinum are likely to involve the great vessels and the tracheobronchial tree. This can have significant respiratory and hemodynamic consequences as the masses enlarge.[1]
  - Masses arising in the posterior mediastinum can also compress the great vessels and tracheobronchial tree from behind.[6]
- Patient Considerations
  - Anterior mediastinal masses frequently present with respiratory symptoms and can mimic common respiratory conditions in children such as asthma and croup.
    - Often posture affects symptoms. Some patients cannot tolerate lying flat (orthopnea), especially supine. Turning to one side or another may improve or worsen symptoms.[2-3]
  - Clinical presentation, imaging, and blood tests (including looking for blast cells and tumor markers) can often confirm or significantly narrow a potential tumor diagnosis; however, tissue diagnosis is crucial for treatment planning.[2,5]
  - Associated Comorbidities/Syndromes
    - Tumors are the most common cause of mediastinal masses.[2-4]
    - Lymphomas (Hodgkin and non-Hodgkin) are the most common cause of anterior mediastinal masses in children. Other malignancies associated with anterior mediastinal masses include acute lymphoblastic leukemia and germ cell tumors.[4]
    - The frequency of the main causes of mediastinal pathologies varies according to the child's age:
      - Infant: Anterior – Morgagni's hernia; Middle – bronchogenic cyst; Posterior – enteric cyst

        - Child: Anterior – teratoma; Posterior – neurogenic tumor, neuroblastoma
        - Adolescent: Anterior – lymphoma; Posterior – dilated aorta (Marfan syndrome)

Anesthetic Planning:

- Pre-Anesthetic Evaluation
    - Cough, dyspnea, stridor, hoarseness, and orthopnea indicate airway compression.[1-3]
    - Syncope, tachycardia, jugular venous distension, and superior vena cava (SVC) syndrome indicate cardiac and/or great vessel compression.[1-3]
        - Signs of SVC syndrome (distended neck veins, prominent non-pulsatile jugular veins, face/neck swelling) are ominous and generally reflect extensive tumor infiltration.[2]
    - Determine the position that is most comfortable from a symptom standpoint for the patient – this "rescue" position should be noted and used perioperatively as able to relieve tumor compression of critical structures.[2,3]
    - Labs
        - Often patients have already had extensive lab work-up including complete blood count, chemistry panel, flow cytometry, LDH, and other blood work looking for blast cells and tumor markers.
        - Patients need an active type and screen.
    - Imaging
        - Diagnosis of an anterior mediastinal mass is usually made on a chest x-ray (CXR) demonstrating a widened mediastinum.[3]
        - Recent imaging is mandatory because some lymphomas double in size every 12 hours.
        - A CT scan of the chest is required to delineate the exact location of the mass and to evaluate the degree of compression of the airway, great vessels, and heart (especially the right ventricular outflow tract). Pleural and pericardial effusions are also common.[1-3]
        - A transthoracic echocardiogram (TTE) is indicated if the CT scan demonstrates any compression of the heart or major vascular structure, or if a pericardial effusion is seen.[2,3] If sedation or anesthesia is needed, there should be a very low threshold for obtaining a TTE.
    - Pre-op risk stratification
        - Airway compression on chest CT is the preoperative finding most consistently associated with anesthetic-related complications.[7]
        - Patients with large tumors and radiographic evidence of airway compression combined with respiratory symptoms are at high risk of perioperative complications.[2,7]
        - However, <u>even patients with no respiratory symptoms preoperatively can have cardiorespiratory compromise or collapse on induction of general anesthesia</u> and all patients with an anterior mediastinal mass should be treated with caution.[2,7,9]
    - Discussions to have with surgeon/family
        - A multidisciplinary huddle including oncology, radiology, surgery, critical care, and anesthesiology is required. Topics to discuss include:[2,5,7-9]
            - What procedures are needed? Is it reasonable to perform multiple procedures under one anesthetic? In what order should these procedures be done? (For example, drainage of a pericardial or

pleural effusion should be performed before bone marrow aspiration or lymph node biopsy, etc.)

- What is the patient's rescue position? This can be determined by looking at the preoperative CT scan and asking the patient (or their parents) what position is most comfortable from a symptom standpoint – it can sometimes be lateral, prone, or sitting.
- Need for rigid bronchoscope/ENT involvement?
- ECMO candidacy and need for ECMO on standby?
    - If a patient has an extremely high-risk tumor, pre-operative steroid therapy to shrink the mass (if applicable) should be discussed. There is some evidence that a short steroid treatment does not hamper the histologic diagnosis but some tumors are steroid-resistant.[10]
    - High-risk masses for procedures that require general anesthesia – consider preparation of appropriate vessels (usually femoral) for ECMO/CPB cannulation with local prior to induction of anesthesia.
- Where is the procedure going to be performed? Are the appropriate equipment, personnel, etc. readily available if the procedure is being done at an off-site location? Does the procedure need to be performed in the operating room?

- Specific or Unique Room Set-up Requirements
    - Airway
        - Normal age-appropriate airway setup including reinforced ETTs of several sizes.
        - Have a rigid bronchoscope ready in the OR with appropriate ENT physician support (especially if there is evidence of compression of the airway).
    - Drugs/Infusions
        - Standard emergency medications including epinephrine, calcium, and succinylcholine.
        - Additional vasopressors available to bolus such as phenylephrine or vasopressin with the ability to start infusion(s) if needed.
        - Albumin and balanced crystalloid solution (lactated Ringers, Plasmalyte) available for rapid fluid bolus.
        - Heparin available if ECMO is on standby.
    - Monitors/Access
        - Standard ASA monitors (pulse oximetry, end-tidal carbon dioxide, continuous electrocardiogram, noninvasive blood pressure, temperature).
        - Arterial line (especially if general anesthesia is required).
        - Age-appropriate large-bore PIV access in both upper and lower extremities
            - Especially if SVC syndrome is present – venous return to the heart from the upper extremities can be compromised.[2]
    - Blood Availability
        - Must have an active type and screen.
        - Have appropriate blood products checked and in the OR if ECMO backup is required.
    - PICU Bed Availability
        - Have a PICU bed available, if needed.
    - Other Indicated Resources
        - Child life specialists (if available).

Intraoperative Considerations:

- General
  - **General anesthesia should be avoided, if possible. If general anesthesia is required, spontaneous ventilation should be maintained. Positive pressure ventilation (PPV) and loss of muscle tone can lead to cardiopulmonary collapse in pediatric patients.**[1-3,5,7]
    - During inspiration, the decrease in intrathoracic pressure may reduce the compressive effect of the mass and help maintain airway patency. PPV results in increased intrathoracic pressure and worsens compression of the trachea and bronchi. This is contrary to what has been observed in adult patients, whose airways are larger and less compressible.[6]
    - PPV can also impede venous return and decrease preload. This combined with tumor compression of major veins can result in a significant drop in cardiac output. Decreased preload is also poorly tolerated in patients with clinically significant pericardial effusions with tamponade physiology.
    - **Paralysis and loss of muscle tone can lead to further collapse and compression of these structures and acute decompensation or arrest.**
  - Most procedures will be diagnostic interventions amenable to being performed under local with anxiolysis or sedation:[8,11-13]
    - Bone marrow aspiration/biopsy
    - Lumbar puncture
    - Aspiration of pleural and/or pericardial effusions (+/- drain placement)
    - Needle or open biopsy of accessible superficial extra-thoracic lesions (e.g., lymph nodes)
    - Percutaneous mediastinal mass biopsy
    - Central venous access (PICC, CVC)
  - Open surgery for biopsy or resection of an anterior mediastinal mass in children is *rarely* required.[2,8]
- Induction
  - The minimum sedation/anesthesia necessary should be used and spontaneous ventilation maintained.
    - Depending on the patient's age and developmental status, consider local only +/- anxiolysis. Child life specialists can be an indispensable part of the perioperative team, helping to calm and redirect a child's focus and minimize sedation needs.[13]
  - Various combinations of midazolam, ketamine, and dexmedetomidine can provide greater sedation and systemic analgesia if needed while maintaining spontaneous ventilation. <u>Careful, slow titration is vital.</u> *(Sample for guidance – tailor to patient's individual need):*[7]
    - Pre-med:
      - Midazolam 0.05 – 0.1 mg/kg IV +/- glycopyrrolate 0.1 mg/kg IV *(for antisialagogue effect)*
    - Induction:
      - Dexmedetomidine 0.5 – 1 mcg/kg IV over ten minutes
      - Ketamine 1.5 mg/kg IV
    - Maintenance:
      - Dexmedetomidine 1 mcg/kg/hr IV (additional small boluses as needed)
      - Ketamine 1 mg/kg/hr IV (additional small boluses as needed)
      - Midazolam can also be readministered in small boluses.

  - CPAP administered via face mask may assist in maintaining airway patency.[2]
  - If general anesthesia is required, maintain spontaneous ventilation and avoid PPV and paralysis.
    - Small, incremental doses to avoid overshooting the depth of anesthesia.
    - Topical analgesia with lidocaine to the airway may facilitate the maintenance of spontaneous ventilation with intubation when needed. Opioids can also facilitate intubation without paralysis but must be used cautiously to avoid apnea.[2]
    - Have rigid bronchoscope with ENT physician, ECMO back-up with appropriate team ready as needed.
- Positioning
  - Dependent on the specific procedure. Avoid supine positioning if possible due to the gravitational effects on the chest wall and mediastinal mass.
  - If possible, let the child position themself.
  - Have a plan in place for quickly turning the patient lateral and/or prone to relieve acute compression if cardiopulmonary compromise occurs.[2-3,8]
- Maintenance
  - As discussed above. Avoid oversedation and loss of muscle tone, paralysis, and PPV.
  - Discuss with the oncology team before administering any steroids (i.e., dexamethasone) due to the potential for tumor lysis syndrome.[3]
- Hemodynamic/Physiologic goals
  - Avoidance of loss of muscle tone, paralysis, and PPV as discussed above.
  - Maintain preload and avoid significant decreases in SVR.
- Surgical Considerations (such as neuromonitoring, muscle relaxation, anticipated blood loss)
  - As discussed above.
- Emergence/Disposition
  - Disposition and post-op care are highly dependent on the procedure performed, level of anesthetic required including if intubation was performed, and cardiopulmonary status. A PICU bed should be available if needed.
- Post-op Care
  - Per above.

Case-Specific Complications/Pitfalls

- Cardiopulmonary compromise/collapse
  - Secondary to worsened mass effect on the tracheobronchial tree and/or great vessels.
  - Management:[3-5,7]
    - Place patient prone or in a predetermined "rescue" position to decrease gravitational effects on the mass. Lifting the mass by grasping the sternum via the manubrium and xiphoid process can also be useful.[9]
    - Decrease the depth of anesthesia.
    - Rapid fluid bolus; consider early use of vasopressor support to augment filling pressures (phenylephrine, vasopressin).
    - Consider the application of CPAP or attempt to ventilate with PPV to relieve airway compression.
    - With complete airway collapse, placement of a rigid bronchoscope may lift the mass away from the trachea and restore effective ventilation (have reinforced ETT ready).

            - Large masses may cause bilateral bronchial compression, which is not relieved by rigid bronchoscopy.
        - Early cannulation for ECMO if impending or acute cardiopulmonary collapse (consider having appropriate vessels prepped for cannulation with local only prior to induction of anesthesia in extremely high-risk patients – this is rare).
        - As a last resort, an emergency sternotomy to lift the mass and relieve compression may be required.
- Location of procedure
    - Procedures performed in off-site locations can pose significant challenges, especially with resource availability (including equipment and specialized personnel). This can become prohibitively dangerous if emergency plans (e.g., rigid bronchoscopy or initiation of ECMO) cannot be activated quickly.
- Lack of multidisciplinary huddle
    - Collaboration across several disciplines including oncology, radiology, surgery, critical care, and anesthesiology is essential in the care of these high-risk patients.
    - Appropriate preparation **requires** multidisciplinary discussion regarding the need and type of procedure(s) required (and in what order), the risks involved, and specific emergency plans for potential respiratory and/or cardiovascular collapse.
    - Procedural location and availability of resources must also be considered.

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