ANESTHESIA IN CHILDREN WITH ANTERIOR MEDIASTINAL MASSES – ANESTHETIC ALGORITHM AND PERIOPERATIVE CONSIDERATIONS

ANESTEZIJA KOD DECE SA PATOLOŠKIM MASAMA U PREDNJEM MEDIJASTINUMU – ANESTEZIOLOŠKI ALGORITAM I PERIOPERATIVNA RAZMATRANJA

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Abstract

Introduction. Mediastinal masses in children encompass a broad spectrum of histopathological and radiological entities. **Anatomy and Physiology.** The mediastinum is traditionally divided into three compartments, without discrete anatomical barriers between them, allowing lesions to extend across compartments. Physiological compromise results primarily from compression of the airway, heart, or major vessels. **Signs and Symptoms.** Clinical presentation varies widely depending on the size, location, and growth rate of the mass. **Preoperative Testing.** Preoperative evaluation typically includes radiography, contrast-enhanced computed tomography, pulmonary function testing, and transthoracic echocardiography. **Anesthetic Management and Procedure Location.** Operative procedures should be performed in an operating room. In extremely high-risk cases, extracorporeal bypass may be considered. **Monitoring and Vascular Access.** Large-bore intravenous access should be secured. Arterial monitoring may be required for continuous hemodynamic assessment. **Anesthetic Technique.** Anesthetic techniques include local, regional and general anesthesia. In many cases, general anesthesia is unavoidable. Inhalational induction with sevoflurane is commonly employed in pediatric patients. **Management of Intraoperative Complications.** In the event of impaired ventilation, management strategies include increasing inspired oxygen concentration, applying continuous positive airway pressure, and advancing the endotracheal tube distal to the site of obstruction. In cases of cardiovascular collapse, immediate interventions include rapid intravenous fluid administration and reduction of anesthetic depth. **Postoperative care.** Early communication with the intensive care unit is recommended when complications are anticipated. Extubation should be performed only when the child is fully awake. **Conclusion.** Comprehensive preoperative evaluation is essential to assess cardiopulmonary compromise and ensure safe anesthetic management in children undergoing diagnostic or surgical procedures.

Key words: Mediastinal Neoplasms; Lymphoma; Child; Anesthesia, General; Sevoflurane; Tomography, X-Ray Computed; Cardiopulmonary Bypass; Intraoperative Complications; Perioperative Care

Sažetak

Uvod. Medijastinalne mase obuhvataju širok spektar histopatoloških i radioloških entiteta. **Anatomija i fiziologija.** Medijastinum je podeljen na tri dela, pri čemu tumorske promene mogu da se nesmetano šire iz jednog dela ka ostalim. Kardiorespiratorne komplikacije se najčešće razvijaju usled kompresije disajnih puteva, srca ili glavnih krvnih sudova. **Znaci i simptomi.** Kod dece se javlja širok spektar znakova i simptoma, na koje utiču veličina, lokacija i brzina rasta tumora. **Preoperativna dijagnostika.** Preoperativna dijagnostika obuhvata rendgen grudnog koša, kompjuterizovanu tomografiju sa kontrastom, testove plućne funkcije i ehokardiografiju. **Operativne procedure.** Operativne procedure treba izvoditi u operacionoj sali. Kod visokorizičkih bolesnika, može se razmotriti primena ekstrakorporalne membranske oksigenacije. **Monitoring i vaskularni pristup.** Neophodno je plasirati intravenske braunile što većeg promera pre plasnirane hirurške procedure. Kod hemodinamički nestabilnih bolesnika, potrebno je plasirati arterijsku kanilu. **Tehnika anestezije.** Tehnike anestezije uključuju lokalnu, regionalnu i opštu anesteziju. U brojnim slučajevima, opšta anestezija je metoda izbora. Indukcija sevofluranom se često koristi kod dece. **Lečenje intraoperativnih komplikacija.** Kod nezadovoljavajuće ventilacije, pojedine tehnike modifikovanja parametara ventilacije jesu: povećanje inspiratorne koncentracije kiseonika, primena kontinuiranog pozitivnog pritiska u disajnim putevima i plasiranje endotrahealnog tubusa distalno od mesta opstrukcije disajnog puta tumorskom promenom. U slučaju kardiovaskularnog kolapsa, neophodno je ordinirati intravenski bolus tečnosti i smanjiti dubinu anestezije. **Postoperativna nega.** Ukoliko se očekuje ili dolazi do komplikacija, treba obezbediti mesto u jedinici intenzivnog lečenja. Ukoliko je moguće, dete treba probuditi i ekstubirati na kraju operativnog zahvata. **Zaključak.** Sveobuhvatna preoperativna evaluacija je neophodna za procenu kardiopulmonalne kompromitovanosti i bezbedno izvođenje dijagnostičkih i hirurških intervencija u anesteziji.

Ključne reči: medijastinalni tumori; limfomi; deca; opšta anestezija; sevoflurane; CT; kardiopulmonalni bajpas; intraoperativne komplikacije; perioperativna nega

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Abbreviations

AMMs	– anterior mediastinal masses
SVC	– superior vena cava
CT	– computed tomography
ECHO	– echocardiography
GA	– general anesthesia
CPAP	– continuous positive airway pressure
PEEP	– positive end-expiratory pressure
IV	– intravenous
ECMO	– extracorporeal membrane oxygenation

Introduction

Mediastinal masses encompass a broad spectrum of histopathological and radiological entities. Common types in pediatric patients include lymphomas, thymomas, neurogenic tumors, and benign cysts, which together account for approximately 60% of cases [1]. Despite their clinical significance, there is a lack of high-quality evidence in the literature to guide risk stratification and operative planning for the safe administration of anesthesia and surgery in children with anterior mediastinal masses (AMMs) [2]. Managing children with AMMs is particularly challenging because of the risk of severe cardiopulmonary compromise, which may be exacerbated under general anesthesia [1].

Anatomy and Physiology

The mediastinum is divided into three compartments: anterior (with superior and inferior subdivisions), middle, and posterior. Although these compartments are identifiable on chest radiographs, no discrete anatomical planes separate them, and masses may extend across compartments. The heart and great vessels, tracheobronchial tree, esophagus, nerves, thymus, and lymphatic structures are all located within this confined space [2]. Anterior mediastinal masses pose the greatest perioperative risk, especially in children, where they are most commonly encountered. Lymphoma represents the most frequent cause of AMMs in pediatric patients [3].

Physiological compromise arises primarily from compression of the airway, heart, or major vessels. The mass may compress the right cardiac chambers, superior vena cava (SVC), pulmonary arteries, or pulmonary veins, leading to decreased cardiac output and right ventricular failure. Clinical manifestations of cardiac compression include syncope, tachycardia, jugular venous distension, SVC syndrome, and cyanosis [4]. Pulmonary artery compression may result in hypoxemia, hypoventilation, and right ventricular strain. Compression of the trachea or bronchi contributes to respiratory distress, manifesting as dyspnea, cough, and stridor [5].

Positioning and anesthetic depth significantly influence pathophysiology. The supine position increases intrathoracic pressure due to cephalad displacement of the diaphragm, exacerbating airway and vascular compression. These effects are amplified under general anesthesia due to airway smooth muscle relaxation and reduced airway tone – factors particularly relevant in children, whose airways are more collapsible. Maintaining spontaneous ventilation can mitigate compression, whereas positive pressure ventilation may worsen airway or vascular collapse. Neuromuscular blockade further reduces chest wall tone and increases the risk of complete airway obstruction.

Signs and Symptoms

Children with AMMs may present with a wide range of symptoms depending on the size, location, and growth rate of the mass. Compared with adults, pediatric patients more commonly exhibit rapidly growing and frequent malignant tumors that compress relatively softer airways and vascular structures. Preoperative anesthetic assessment should focus on identifying features associated with increased perioperative risk. Evidence suggests that tracheal or vascular compression and respiratory symptoms – such as cough, dyspnea, and stridor – are associated with higher perioperative complication rates [6,7]. However, similar symptoms may also occur in pneumothorax or pneumomediastinum and should be considered in the differential diagnosis [8]. The incidence of perioperative complications ranges from 9% to 20% based on single-institution case series. A retrospective 8-year review reported that 76% of children presenting with AMMs were symptomatic at diagnosis [2].

Preoperative Testing

Diagnosis is often initially made on chest radiography. The mediastinal mass ratio has been used for risk stratification [2]. An average mediastinal mass ratio of 0.56 was reported in children who experienced perioperative complications, suggesting that larger masses may confer greater risk [9]. Key preoperative investigations include:

– Contrast-enhanced computed tomography (CT): Provides essential information regarding mass location and the degree of airway or vascular compression. CT allows measurement of the tracheal cross-sectional area at its narrowest point; smaller areas correlate with increased perioperative risk [2].

– Pulmonary function testing: May aid in risk stratification but is often difficult to perform reliably in young children.

– Transthoracic echocardiography (ECHO): Assesses cardiac compromise, including pericardial effusion, or tamponade, which significantly increases perioperative risk [10,11].

It is important to note that echocardiographic assessment is performed in awake children; therefore, the hemodynamic effects of anesthetic agents may not be fully appreciated preoperatively [2].

Anesthetic Management and Procedure Location

Management requires a multidisciplinary approach involving oncology, anesthesiology, radiology, surgery, and critical care teams. Coordination is essential, particularly when balancing the urgency of obtaining a tissue diagnosis with patient safety. In selected high-risk patients, preoperative corticosteroid therapy may reduce airway compromise prior to biopsy [10].

Procedures should ideally be performed in the main operating room, where experienced personnel, advanced airway equipment, and cardiopulmonary bypass support are readily available. In extremely high-risk cases, extracorporeal bypass may be considered, although cannulation is technically more challenging in pediatric patients [2,12].

Monitoring and Vascular Access

Large-bore intravenous access should be established in both upper and lower extremities, particularly in patients with suspected SVC syndrome. Arterial catheterization may be indicated for continuous hemodynamic monitoring depending on the patient's clinical condition.

Anesthetic Technique

Local Anesthesia

Obtaining tissue samples under local anesthesia is feasible in adults but often impractical in young children due to anxiety, poor cooperation, and potential airway compromise. Older, cooperative children may tolerate superficial lymph node biopsy under local anesthesia. More invasive procedures such as mediastinoscopy or awake fiberoptic intubation are generally not feasible.

Sedation and Regional Anesthesia

Sedation may facilitate biopsy in children who cannot tolerate local anesthesia alone. Preferred agents include dexmedetomidine and ketamine, as they preserve respiratory drive. Ketamine provides sympathomimetic support, helping maintain hemodynamic stability. Midazolam (0.1 mg/kg) may reduce ketamine-related psychotropic effects. Glycopyrrolate (10 mcg/kg) may be used as antisialagogue.

Suggested dosing:

– Dexmedetomidine: 1 mcg/kg loading dose over 10 minutes, followed by 0.25–2 mcg/kg/h infusion

– Ketamine: 1–2 mg/kg bolus over 2 minutes, with additional 0.5 mg/kg increments as needed

Regional techniques may assist in selected older children but are limited by cooperation and potential coagulopathy related to malignancy. Even under sedation, airway compromise may persist.

General Anesthesia

General anesthesia (GA) is often unavoidable. Intravenous access should be secured before induction whenever possible. Techniques preserving spontaneous ventilation are preferred to maintain airway tone and prevent dynamic collapse.

Inhalational induction with sevoflurane is commonly employed. Alternatively, intravenous induction with propofol - while maintaining spontaneous ventilation - may be performed by experienced pediatric anesthesiologists. Extreme caution is required, as apnea may result in inability to ventilate, intubate, or re-establish a patent airway.

If an unexpected AMM is discovered during induction for an unrelated procedure, immediate assistance should be summoned, neuromuscular blockade reversed if feasible, and anesthetic depth reduced to restore spontaneous ventilation [13–19].

Management of Intraoperative Complications

Respiratory Collapse

Immediate intervention is required if ventilation becomes impaired:

– Increase FiO_2

– Apply CPAP to splint airways and restore functional residual capacity

– Reposition (lateral or prone if necessary) to relieve compression

– Attempt positive pressure ventilation with PEEP

– Advance the endotracheal tube distal to the obstruction

– Consider one-lung ventilation for distal obstruction

A rigid bronchoscope should be immediately available to bypass obstruction and ventilate distal airways. CPAP may be delivered via a Mapleson F circuit attached to the bronchoscope, though air trapping must be considered. Heliox may temporarily reduce airway resistance but is limited in hypoxic emergencies due to reduced oxygen concentration.

Cardiovascular Collapse

Initial management includes:

– Rapid intravenous fluid bolus

– Reduction of anesthetic depth

– Repositioning (including prone positioning if beneficial)

If instability persists, emergent sternotomy with manual elevation of the mass from central mediastinal structures may be necessary. Respiratory and cardiovascular compromise are frequently interrelated; optimization of one system may improve the other [15,16,18].

Extracorporeal membrane oxygenation (ECMO) may be considered preemptively in extremely high-risk patients or as rescue therapy, although cannulation in is technically challenging and profound hypoxia may occur during setup [13,17].

Postoperative Care

Postoperative disposition depends on preoperative symptoms, intraoperative events, and residual mass effect. Early communication with the intensive care unit is recommended when complications are anticipated. Ideally, the child should be fully awake and extubated at the conclusion of surgery. If significant mass effect persists, enhanced postoperative monitoring is required. Even after mass removal, vigilance for bleeding or airway edema is essential [20].

Conclusion

Children with anterior mediastinal masses present significant anesthetic challenges. Comprehensive preoperative evaluation – including detailed history, imaging, and echocardiography – is essential for assessing cardiopulmonary compromise. Effective multidisciplinary communication, careful procedural planning, and individualized anesthetic strategies are critical for optimizing perioperative safety. Maintaining spontaneous ventilation when feasible, minimizing neuromuscular blockade, and preparing for emergent airway or cardiovascular intervention remain cornerstone principles in the management of these high-risk patients.

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