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REVIEW / DERLEME

Preoperative preparation and postoperative care in children in thoracic surgery

Toraks cerrahisinde çocuklarda ameliyat öncesi hazırlık ve ameliyat sonrası bakım

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ABSTRACT

Anesthesia for pediatric patients undergoing thoracic surgery continues to be distinctive due to differing anatomical and physiological characteristics compared to adults. Adequate preoperative preparation, appropriate tool selection for providing one-lung ventilation, perioperative pain management, and a multidisciplinary approach can ensure higher quality postoperative care. In this review, the perioperative anesthesia management for pediatric patients undergoing thoracic surgery will be discussed, starting from the preoperative preparation phase. Additionally, the issues related to the application and management of one-lung ventilation will also be assessed.

Keywords: One-lung ventilation, pain, pediatric anesthesia, postoperative care, thoracic surgery.

ÖZ

Toraks cerrahisi yapılan pediatrik hastaların anestezisi, erişkinden farklı anatomik ve fizyolojik yapıları nedeniyle ayrıcalıklı olmaya devam etmektedir. Sıkı bir ameliyat öncesi hazırlık, tek akciğer ventilasyonunu sağlamada uygun araçların seçimi, perioperatif ağrı yönetimi ve multidisipliner yaklaşım daha yüksek kalitede ameliyat sonrası bakım sağlayabilir. Bu derlemede, torasik cerrahi geçiren pediatrik hastaların ameliyat öncesi hazırlık döneminden başlayarak perioperative anestezi yönetimi gözden geçirilecektir. Ayrıca tek akciğer ventilasyonunun uygulanması ve yönetimine ilişkin hususlara da değerlendirilecektir.

Anahtar sözcükler: Tek akciğer ventilasyonu, ağrı, pediatrik anestezi, ameliyat sonrası bakım, torasik cerrahi.

Pediatric patients who have undergone thoracic surgery can pose various challenges for the anesthesia team. Due to their different anatomical and physiological structures compared to adults, they are at a higher risk of hypoxia during the perioperative period. Concurrent comorbidities, the location, and size of the surgery should be sufficiently assessed for safe and effective clinical care. The size of the patients often does not allow the use of standard equipment, requiring the anesthetist to be creative with the tools at hand. This article will review the perioperative anesthesia management of pediatric patients who have undergone thoracic surgery, starting from the preoperative preparation period. Additionally, issues related to single-lung ventilation and its management will also be discussed.

PEDIATRIC ANATOMY AND PHYSIOLOGY

Pediatric patients have significant anatomical and physiological differences compared to adults. In infants and small children, the occiput is more prominent, and their heads are relatively larger in proportion to their bodies. Due to this anatomical configuration, the neck can be slightly flexed when in a supine position, which can lead to difficulties in airway manipulation and intubation. Pediatric patients have relatively large tongues in relation to their oropharyngeal size, which can also lead to challenges during intubation. Additionally, the larynx is positioned more anteriorly and cephalad compared to adults (in comparison with C2-3, C4-5). The epiglottis is large, elongated, and may appear U-shaped. The narrowest part of the funnel-shaped larynx is located below the vocal cords

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at the level of the cricoid cartilage. In infants and small children, the trachea and neck are proportionally shorter than in adults. The airway is smaller and more susceptible to edema, which can lead to airway obstruction.[1,2]

Physiologically, horizontal ribs in pediatric patients prevent the "bucket-handle" motion observed in adults during breathing and limit the increase in tidal volume. Ventilation primarily relies on diaphragmatic action. The chest wall is significantly more compliant than that of an adult. Functional residual capacity (FRC) is relatively low and decreases with apnea and anesthesia, resulting in lung collapse. The way to increase tidal volume depends on the rate of minute ventilation. The closing volume is greater than FRC until the age of 6-8, increasing the tendency for airway closure at the end of expiration. Consequently, newborns and infants often require intermittent positive pressure ventilation during anesthesia, benefiting from a higher respiratory rate and the use of positive end-expiratory pressure.[3,4]

CONDITIONS REQUIRING THORACIC SURGERY

During the first year of life, various tracheal, lung, vascular, and diaphragmatic lesions may necessitate thoracic surgery. These conditions include tracheal stenosis and malacia, pulmonary sequestration, pulmonary hypoplasia, congenital diaphragmatic hernia, tracheoesophageal fistula, esophageal atresia, aortic coarctation, and patent ductus arteriosus. After the first year of life, tumors, severe infections, arteriovenous malformations, pectus excavatum, and kyphoscoliosis become the more common reasons for thoracic surgery. Another cause may be foreign body aspiration, necessitating emergency thoracic procedures.[5]

PREOPERATIVE ASSESSMENT

Before surgery, it is necessary to conduct a thorough patient history and detailed physical examination. This assessment includes evaluating the current issue, reviewing the patient's family history, chronic medication use, a history of gastroesophageal reflux, as well as any medication, food, or environmental allergies, and an examination of the systems for accompanying medical problems.[6,7] For infants, in addition to the birth history, it is essential to review the perinatal medical history, including the presence of any syndromes, congenital heart diseases, or chromosomal abnormalities.[8]

In the physical examination of an infant or child, the airway, cardiovascular system, hydration status, and potential vascular access sites should be evaluated. Attention should be paid to any restrictions in mouth opening or neck movement. The use of preoperative laboratory tests depends on the patient's clinical condition, underlying conditions, and the planned procedure.[9] Laboratory studies, including the initial hemoglobin-oxygen saturation, complete blood count, and platelet count, should be reviewed. Additionally, a chest X-ray should be taken to evaluate any evidence of mediastinal shift, pulmonary herniation, or downward displacement of the hemidiaphragm.[5] In children, blood gas analysis is not mandatory. Evaluating peripheral oxygen saturation and venous bicarbonate concentrations is usually sufficient in children with chronic carbon dioxide (CO_2) retention.[4] Routine use of pulmonary function tests in small children is limited due to the challenges in obtaining cooperation and the lack of proven benefits in predicting outcomes in the general pediatric population.[7,10] Moreover, computed tomography, magnetic resonance imaging, or arteriography may also be performed. For certain conditions, echocardiography, ventilation-perfusion scans, and respiratory function tests may be indicated.[5] Understanding the anatomical location of the lesion to be surgically corrected and its relationship with nearby important anatomical structures is crucial. This examination can assist the anesthesiologist in being prepared for potential issues, such as difficult intubation or blood loss. In general, for most thoracic surgery procedures, given the proximity to major blood vessels, cross-matched blood should be available before the operation begins.

Recent or ongoing upper respiratory tract infections should be carefully reviewed since they are common in children and can increase the risk of perioperative oxygen desaturation, laryngospasm, bronchospasm, and postoperative croup.[11] Elective surgical procedures should be postponed for at least two weeks after a respiratory tract infection until airway hyperreactivity has completely resolved.[12] Certain thoracic surgery conditions may necessitate proceeding with surgical intervention in the presence of concurrent, common infections, such as congenital cystic adenomatoid malformations, reactive airway diseases (e.g., asthma), genetic conditions (e.g., cystic fibrosis), or restrictive diseases (e.g., kyphoscoliosis).[5] Regular use of bronchodilator medications is important for optimal lung function during the surgical procedure.[4] In such cases, extra caution for airway-related complications is crucial.

According to the American Society of Anesthesiologists guidelines, NPO recommendations state that no clear fluids should be consumed within

2 h before surgery, no breast milk should be given within 4 h before surgery, and no baby formula or light snacks should be given in the 6 h before surgery. Breast milk is high in fat content and can irritate lung tissues. Therefore, it should not be considered a clear fluid, and surgery should be delayed by 4 h after the consumption of breast milk.[13]

The Enhanced Recovery After Surgery program implemented postoperatively consists of strategies and interventions aimed at mitigating the surgical stress response and enabling the patient to return to their baseline condition, family, and social activities as soon as possible. Protocols have been developed for different diagnostic and treatment procedures in adults. Adapting adult Enhanced Recovery After Surgery protocols to the pediatric population is challenging due to physiological differences in children and their lower mortality rates. Nevertheless, the applicability and adaptation of these strategies in children are effective in reducing postoperative complications, shortening hospital stays, initiating enteral nutrition earlier, and reducing healthcare costs.[14,15]

Monitoring

For any thoracic procedure involving general anesthesia, essential monitoring includes an electrocardiogram, noninvasive blood pressure measurement, pulse oximetry, end-tidal CO_2 monitoring ($EtCO_2$), and body temperature tracking. Unless a complex procedure, poor cardiopulmonary condition, or the likelihood of significant blood loss is anticipated, invasive arterial blood pressure monitoring is generally not necessary. In most cases, venous access can be achieved with two large-bore peripheral intravenous (IV) catheters, adjusted based on the patient's age. Central venous access is rarely needed; however, if peripheral venous access is poor or if the patient has any comorbidities that might require vasoactive infusions, central access should be established.[4,5,7]

Premedication and anesthetic induction

For premedication, oral midazolam (0.5-0.75 mg/kg) or intranasal midazolam (0.3 mg/kg) can be used. If an IV line is available, 0.05-0.2 mg/kg of midazolam can be administered in the preoperative waiting area just before taking the child to the operating room. It provides a rapid and reliable onset and minimal respiratory depression with forward amnesia.[16] Dexmedetomidine has also been used with the same effectiveness in some studies,[17] but it has limitations, including longer onset times (30 min) and a higher risk of bradycardia and hypotension at higher doses.[16]

Anesthetic induction can be achieved using the inhalation technique with sevoflurane or through an IV approach.[18,19] In children at risk of developing perioperative respiratory complications, IV induction is safer. For IV induction, propofol (2.5-4 mg/kg), dexmedetomidine (0.5-2 mcg/kg), fentanyl (1-2 mcg/kg), or remifentanil (1-4 mcg/kg) can be administered before endotracheal intubation. The induction technique may be followed by the administration of a nondepolarizing neuromuscular blocking agent.[7]

Children with mediastinal masses are at an increased risk of severe airway obstruction and hemodynamic instability with anesthetic induction. Symptoms of respiratory system distress, such as difficulty in breathing, cyanosis, stridor, wheezing unresponsive to bronchodilators, recurrent pneumonia, persistent atelectasis, pericardial invasion, arrhythmias, pulsus paradoxus, or signs of superior vena cava syndrome are warning signs for a complicated perioperative period. Echocardiographic examination is mandatory to assess the potential impact of the mass in children with mediastinal masses. Anesthetic induction is the riskiest period, particularly in previously symptomatic children. Reduced sympathetic tone, loss of spontaneous ventilation, and physiological changes due to patient positioning can weaken compensatory mechanisms and lead to obstruction. It is recommended to maintain spontaneous ventilation during anesthetic induction to ensure airway patency. In cases with symptoms of superior vena cava obstruction, induction should be done in a sitting position, and IV lines should be placed in the lower extremity veins.[7]

THORACIC SURGERY

One-lung ventilation

One-lung ventilation (OLV) allows for optimizing the visualization of the surgical field and isolation of the two lungs during intrathoracic surgeries. While isolation may not be necessary for most surgeries, its use can significantly enhance surgical access to deeper vascular and pulmonary structures.[19] The emergence of video-assisted thoracic surgery has also led to more widespread use of OLV. Various techniques for lung isolation in children have been described, but due to the small size of the trachea and bronchi in infants, only a subset of these techniques can be employed.[7,19] There are various equipment and methods for OLV (Table 1).

Selective bronchial intubation

Selective bronchial intubation can be easily achieved after intubation with a single-lumen

Table 1. Endotracheal tube selection for single lung ventilation in children[5]

Age (year)	ETT (ID mm)	Bronchial blocker (French)	Univent tube	DLT (French)
0.5-1	3.5-4	5		
1-2	4-4.5	5		
2-4	4.5-5	5		
4-6	5-5.5	5		
6-8	5.5-6	6	3.5	
8-10	6.0 cuffed	6	3.5	26
10-12	6.5 cuffed	6	4.5	26-28
12-14	6.5-7 cuffed	6	4.5	32
14-16	7. 0 cuffed	7	6.0	35
16-18	7.0-8.0 cuffed	7	7.0	35

ETT: Endotracheal tube; ID: Internal diamater; DLT: Double lümen tube.

endotracheal tube (ETT). This method is best for achieving isolation in newborns and very small infants. The ETT is advanced to the desired side until sounds disappear while listening to respiratory sounds. Confirmation can be obtained by noticing a sharp decrease in $EtCO_2$ as the tube enters the main bronchus.[20] Due to the narrower separation angle of the left bronchus from the trachea compared to the right bronchus (25° *vs*. 45°), intubation into the right main bronchus is much more common. To intubate the left bronchus, the patient's head is turned to the right, and the tube is rotated 180 degrees. Turning the patient's head to the right helps reduce the angle of the left bronchus, increasing the chances of intubating the left main bronchus.[4,21] Selective bronchial intubation can also be performed using a fiberoptic bronchoscope or fluoroscopy to guide the ETT to the desired bronchus.[22] Cuffed ETTs can be used since they provide effective isolation. If an uncuffed tube is used, there is a possibility of a leak that would not allow the lung to collapse completely. It is important to remember that bronchi have a smaller diameter than the trachea, so using a very large tube could potentially cause trauma to the bronchi. An important drawback of selective bronchial intubation is that it may not allow for independent ventilation of each lung, aspiration, or the application of continuous positive airway pressure (CPAP).[4]

Bronchial blockers

A bronchial blocker with a balloon at its distal end is placed in the bronchus of the operated lung by advancing it through or alongside the ETT (Figure 1). This method is typically preferred for patients aged six months to eight years. It can only be used in an intraluminal position when its diameter is less than 50% of the ETT's inner diameter. Thus, the smallest 5-Fr (French) blocker with a diameter of 1.7 mm can only be placed coaxially within a 4.0 or larger-sized ETT.[23] Various methods are available for placing an extraluminal blocker in smaller patients.[24-26] Advantages of bronchial blockers include providing lung isolation, the ability to ventilate both lungs intermittently (by deflating the blocker), and the ability to aspirate blood and secretions from the operative side when using side-hole blockers.[7,22]

The Fogarty embolectomy catheter (Edwards Lifesciences, Irvine, CA, USA) is the most commonly used catheter for bronchial blockade in small infants (Figure 2).[27] The balloon used in this device has low volume and high pressure, which can potentially lead to bronchial mucosal ischemia with overinflation.[5]

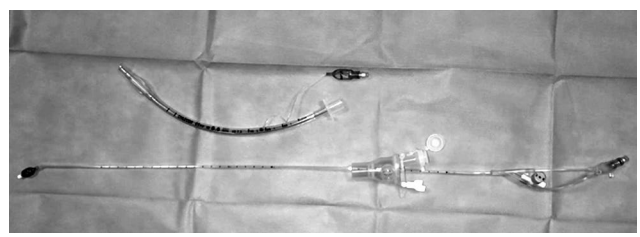

Figure 1. Uniblocker (Fuji Systems Corporation, Tokyo, Japan) and Coopdech (Daiken Medical Corporation, Osaka, Japan) are free-standing bronchial blockers with fixed bevels at their lower ends for easy insertion. The multi-way adapter has ports through which FB and BB can pass, and where ventilation continues by connecting to the breathing circuit while the BB is placed.
FB: Fiberoptic bronchoscopy; BB: Bronchial blocker.

The Arndt Endobronchial Blocker (Arndt Multi-port Adapter, Cook Medical Inc., Limerick, Ireland) is a balloon-tipped blocker with an internal lumen that has a loop-tipped wire passing through. It comes with an adapter (Arndt Multi-port Adapter, Cook Critical Care) that enables the insertion of a fiberoptic bronchoscope via one opening, the bronchial blocker through another opening, and the connection of the ETT to the ventilation system through a third opening.[28]

The EZ-Blocker (Rüsch and Hudson RCI Anaesthesia, Morrisville, NC, USA) is a Y-shaped bronchial blocker with two distal extensions, each containing a high-volume, low-pressure cuff designed to sit within the mainstem bronchi. It has a 7-Fr dual-cuffed design. The distal connection point between the two arms is 6.5 mm, limiting its use in smaller patients. Although designed for adults, the EZ-Blocker is also used in children as young as six years. The blocker can be guided for placement using a 5.5-mm ETT without cuffs, which has been longitudinally cut. Once passed through the glottis, the outer ETT is removed, and an appropriately sized ETT is inserted through the glottis.[29,30]

It is important to note that bronchial blockers can potentially dislodge from the bronchus during repositioning or surgical manipulations, causing blockage of the tracheal lumen immediately distal to the ETT. This can lead to a sudden increase in airway pressure, a decrease in ventilation or an inability to ventilate, and a loss of capnography monitoring. Additionally, using saline instead of air to inflate the balloon at the end of the bronchial blocker can limit movement within the bronchus.[31]

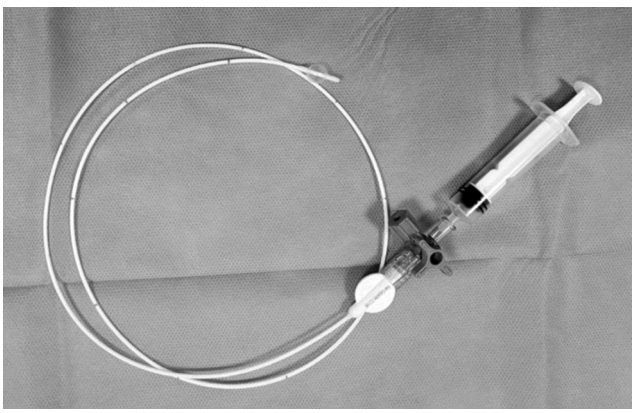

Figure 2. Fogarty embolectomy catheter for use as a bronchial blocker during one-lung ventilation. These catheters have an inflatable, high-pressure balloon at the tip that can be placed into and occlude the bronchus of the operative lung. They are available in a variety of sizes for use in a wide range of patient ages.

The univent tube

The Univent Tube (Fuji System Corporation, Tokyo, Japan) is a single-lumen tube with an integrated bronchial blocker balloon on the tube's wall.[23] The tip of the occlusive balloon is hockey stick-shaped and can be advanced and rotated into position. Although it is narrow, the lumen of the second tube can be used for delivering oxygen, inhalation agents, or evacuating the operated lung, but this feature is only available in Univent tubes with an inner diameter of 6 mm or larger. The blocker balloon of the Univent tube also has low-volume, high-pressure characteristics.[32]

Double-lumen tube (DLT) ETTs

In older children and adolescents, lung isolation is most commonly achieved using a DLT ETTs, typically positioned on the left side (Figure 3). The smallest commercially available DLT, which can be used in children up to eight years old, is 26-Fr. The 28- and 32-Fr DLTs are generally suitable for children aged 10 and older.[33] Double-lumen ETT provides true lung isolation and allows for aspiration and CPAP application. Assessing the position of each lumen requires a small fiberoptic bronchoscope. It is important to be aware of the potential for increased airway resistance to cause barotrauma during OLV. This generally occurs in the ventilated, dependent lung but can sometimes happen in the nondependent lung upon reinflation.

Anesthesia maintenance

During the maintenance phase of surgery, the planning of anesthesia and ventilation management, and the effect of anesthetic agents on hypoxic pulmonary

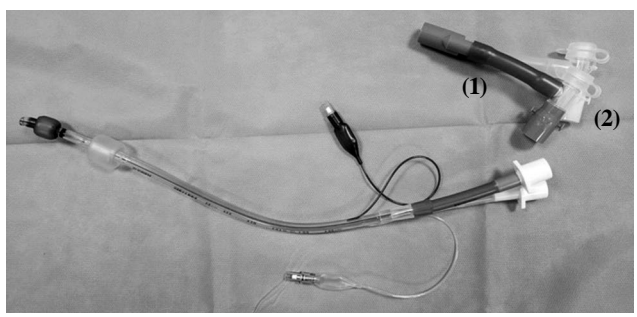

Figure 3. Standard DLT for one-lung ventilation. Adaptor for a DLT. The adaptor has a standard 15-mm connector(1), and two ports(2) for passage of a fiberoptic bronchoscope or a suction catheter. The short segment(2) of the tubing can be clamped during one-lung ventilation, and the port is opened to allow the lung to deflate.
DLT: Double-lumen tube.

vasoconstriction (HPV) should be taken into account. Hypoxic pulmonary vasoconstriction is the response of pulmonary capillaries in poorly ventilated areas to redirect blood flow towards better-ventilated regions to improve oxygenation. Many factors, including pH, partial pressure of CO_2, cardiac output, and antihypertensives, affect HPV. All volatile anesthetic agents suppress HPV in a dose-dependent manner. Isoflurane and halothane can suppress HPV by 50% at 2 MAC (minimum alveolar concentration). Intravenous induction agents do not appear to have such an effect. During intrathoracic procedures, the vessels in the ventilated lung are often prone to maximum vasodilatation due to the high inhaled oxygen concentration, which worsens the ventilation/perfusion (V/Q) matching.[34] For these patients, positioning in lateral decubitus can significantly worsen V/Q matching compared to an adult. In adults with unilateral lung disease, oxygenation is better when the healthy lung is dependent and the diseased lung is independent due to the relative increase in perfusion of the dependent lung. However, the situation is reversed in infants: oxygenation improves when the healthy lung is nondependent and the diseased lung is dependent.[4,5] This is due to FRC being close to residual volume, which causes airway closure, proportionally lower abdominal hydrostatic pressure, and a decreased hydrostatic pressure gradient between the independent and dependent lungs. Additionally, pediatric patients have relatively higher oxygen requirements (6-8 mL/kg/min of oxygen in an infant versus 2-3 mL/kg/min in an adult), which puts them at a higher risk of severe hypoxemia during lateral positioning.[4,35]

Intraoperative lung-protective ventilation strategies are increasingly recommended.[36] If adequate oxygenation cannot be achieved during OLV, various interventions may be required, including, respectively, increasing the inhaled oxygen concentration, using repositioning maneuvers for the ventilated lung, and applying CPAP at 4-5 cmH_2O to the operated lung.[37] If these measures fail, intermittent two-lung ventilation may be necessary.

Specific procedures

Specific congenital intrathoracic conditions requiring surgical intervention in infants and children will not be discussed here. Only flexible bronchoscopy and rigid bronchoscopy, which are also used in emergency diagnosis and treatment, will be discussed. Valuable points in anesthesia management have been mentioned in the preoperative assessment.

Flexible bronchoscopy

Flexible bronchoscopy is an endoscopic technique primarily used for the visualization of the trachea and bronchi for diagnostic purposes. It is often performed in pediatric anesthesia to assess airway patency. Spontaneous ventilation is required to assess dynamic obstructions. Topical anesthetics are often sufficient. In cases where patient movement can lead to severe complications, such as the dilation of stenotic lesions with balloon, laser-assisted procedures, and foreign body removal, neuromuscular blockade and controlled ventilation are preferred.[4]

Rigid bronchoscopy

Rigid bronchoscopy is mainly used for the diagnosis and treatment of intraluminal or extraluminal mass effects. Due to its stimulating effects, it is performed under general anesthesia. In pediatric patients, the most common indication for rigid bronchoscopy rigid bronchoscopy is tracheobronchial foreign body aspiration.[4,7] Additionally, under rigid bronchoscopy, procedures such as bronchoalveolar lavage, endobronchial biopsy, dilation of subglottic stenosis, tracheal stent placement, laser surgery, cryotherapy, and diagnostic procedures can be performed. Hemodynamic stability is attempted to be maintained during the procedure through apneic oxygenation, spontaneous-assisted ventilation, or positive pressure ventilation methods. Since $EtCO_2$ monitoring is not feasible, transcutaneous CO_2 analysis can provide continuous estimation of arterial CO_2 values. Bispectral index monitoring is recommended to assess the depth of anesthesia.

POSTOPERATIVE CARE

Unlike in adult patients, the role of tests used in the preoperative assessment of pediatric patients in determining the need for postoperative mechanical ventilation or the risk of postoperative complications is limited.[7] This is due to issues with test compliance in this age group and the lack of proven benefits of these tests in predicting outcomes. In the presence of congenital cardiopulmonary disease, the need for postoperative mechanical ventilation is high.[38] Arrhythmias, respiratory tract infections, atelectasis, and thromboembolic events are commonly seen during the postoperative period. Therefore, it is recommended to monitor patients undergoing major thoracic surgery in the intensive care unit for 24-72 h postoperatively.[7] Close cardiopulmonary monitoring, prevention of nausea and vomiting, monitoring of thoracic drainage, multimodal analgesia, and the use

of regional anesthesia techniques to eliminate pain can reduce the development of postoperative adverse events.

Pain management

Thoracic surgery is considered one of the most painful surgical procedures. Pain mechanisms vary and are influenced by the size of the surgical procedure and patient factors. Postoperative respiratory complications can lead to poor outcomes, such as longer hospital stays and chronic pain syndrome. A multimodal approach to postoperative pain that combines systemic and regional anesthesia is shown to be the most effective method in optimizing analgesia in these patients.[39] In pediatric thoracic surgery, the goal of pain management is to provide adequate analgesia without excessive sedation and to maintain sufficient respiratory function in the face of problems arising from postoperative ventilation-perfusion abnormalities.[40] If left untreated, chronic pain can develop. Chronic pain is defined as pain that continues along the thoracotomy incision two months after surgery. It is reported to have an incidence of 20% in pediatric patients.[4]

Despite their side effects such as nausea, vomiting, drowsiness, respiratory depression, and urinary retention, opioids continue to be an important part of multimodal protocols for the management of moderate to severe pain in thoracic surgery. Intravenous patient-controlled analgesia (PCA) is one of the most commonly used strategies for the administration of postoperative opioids in these patients. Morphine is the most commonly used drug for PCA, but pethidine, fentanyl, and hydromorphone are also used. In infants and children, the loading dose of morphine is between 0.05-0.1 mg/kg, followed by a PCA bolus dose of 0.01-0.03 mcg/kg at intervals of 6-10 min.[41] Tramadol represents another alternative to manage moderate pain and facilitate the transition from other opioids on the second postoperative day. The dose is 1-2 mg/kg every 4-6 h (IV or oral administration).[41]

Nonsteroidal anti-inflammatory drugs and paracetamol should be applied systematically as part of a multimodal analgesic strategy. They are shown to reduce postoperative opioid requirements in pediatric surgical patients.[42] Ideally, paracetamol should be given intravenously by 15-min infusion at a dose of 7.5 mg/kg in children under 10 kg and 15 mg/kg every 6 h for children over 10 kg up to the third postoperative day.[43]

N-methyl-D-aspartate receptor antagonists, such as ketamine and magnesium sulfate, can be used during surgery to reduce postoperative opioid consumption early on. Ketamine is typically dosed intravenously between 0.25-0.5 mg/kg up to 20 mg. Dexamethasone can also be applied at a dose of 0.15 mg/kg, both as an antiemetic and an analgesic. Gabapentinoids like gabapentin and pregabalin can also be used in children as part of a multimodal analgesic strategy.[41]

Thoracic epidural analgesia is commonly used for major thoracic procedures. It often involves placing an epidural needle at T3-T7 levels and then inserting an epidural catheter directly or at the sacrococcygeal hiatus level, followed by its placement into the thoracic epidural space under fluoroscopic guidance.[5] Dosage approaches may include a single bolus or continuous infusion of local anesthetics. Commonly used local anesthetics for epidural infusion in pediatric patients include bupivacaine, ropivacaine, or levobupivacaine. For small infants, maximum infusion rates of 1 mg/kg per hour for lidocaine and 0.2-0.3 mg/kg per hour for bupivacaine are recommended. Clonidine (0.5-1 mcg/mL), morphine (5-10 mcg/mL), or fentanyl (2-5 mcg/mL) can also be used as adjuvants in the epidural infusion solution.[41,44]

The concurrent use of opioids allows for the use of lower concentrations of local anesthetics and reduces the risk of local anesthetic toxicity. The placement of an epidural catheter can lead to various complications, including misplacement, knotting, migration, particularly if too advanced, rupture, infection, leakage, epidural hematoma, and neurological damage.[4]

Thoracic paravertebral block has been reported as an alternative to thoracic epidural analgesia with fewer side effects for patients undergoing thoracic surgery.[45] Studies reporting successful application of erector spinae plane block and serratus anterior plane block in pediatric patients also exist.[41,46] However, there is not enough data on the individual dosage of local anesthetics and the number of injection sites needed to achieve maximum analgesic effect.

In conclusion, anesthesia management in pediatric thoracic surgery can be quite challenging for anesthesiologists. Having experience in pediatric anesthesia, conducting detailed preoperative assessments, preparing appropriate airway management for different age groups, and implementing a comprehensive anesthesia plan that includes perioperative pain management strategies are essential. Additionally, collaboration between the surgical and anesthesia teams is crucial to minimize postoperative complications.

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