11 Anesthesia Consideration for Flexible Bronchoscopy

Benjamin B. Bruins, Elizabeth K. Laverriere, and Todd J. Kilbaugh

Goals of an Airway Anesthesia Team

Patients presenting for flexible bronchoscopy frequently have the expectation that the procedure will be done under conditions of general anesthesia. Working with an anesthesia team provides several advantages for patient safety, most notably a team dedicated solely to patient monitoring, allowing the bronchoscopist to concentrate on the task at hand.

Shared Goals for Airway Anesthesia Team

1. Expectation setting for the optimal patient experience
2. Adequate oxygenation and perfusion to avoid end-organ ischemic injury
3. Establishment of optimal conditions for airway assessment
4. Rapid recovery to preprocedural status

Preoperative Assessment

The perioperative team should ensure that a comprehensive history and physical exam are completed before embarking on induction of anesthesia. External airway evaluation should include an assessment of the size of oral aperture, relative size of tongue, inter-incisor distance, mento-hyoid distance, active range of motion of the neck, and quality of dentition. Additionally, nil per os time and aspiration risk should be evaluated and optimal timing of induction should be established to limit the risk of aspiration. If available, previous anesthesia and sedation history may help elucidate prior untoward events and allow for alternative planning to mitigate these risks from recurring. Furthermore, presenting signs and symptomatology are important to discuss with the patient, family, and medical teams, including current respiratory support, severity of respiratory embarrassment, and extrapulmonary comorbid conditions.

Preoperative Preparation

Procedural success is contingent upon communication and preparation. Imperative team conversations include the specific goals of the procedure and selection of ideal location. It is helpful for the bronchoscopist and anesthesiologist to discuss the aspects of airway anatomy that need to be evalu-

B. B. Bruins (✉) · E. K. Laverriere · T. J. Kilbaugh
The Children's Hospital of Philadelphia, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA, USA
e-mail: bruinsb@email.chop.edu; laverrieree@email.chop.edu; Kilbaugh@email.chop.edu

S. Goldfarb, J. Piccione (eds.), *Diagnostic and Interventional Bronchoscopy in Children*, Respiratory Medicine, https://doi.org/10.1007/978-3-030-54924-4_11

ated, the need for bronchoalveolar lavage, and the need for dynamic airway evaluation. Critically ill patients with significant lung disease may benefit avoiding transportation and completing the procedure in the intensive care unit, while others will benefit from the additional space, equipment, and expertise that can be provided in an operative theater. Regardless of the locale, standard American Society of Anesthesiologists monitors should be available including continuous electrocardiogram, noninvasive blood pressure, pulse oximetry, temperature, and end tidal carbon dioxide monitoring [1]. Additional monitoring such as processed electroencephalography [2] or near infrared spectroscopy [3] has proven to have limited benefit, especially in pediatrics, but can be used in selected scenarios. It is crucial that emergency medications and tools be available during all phases of the process. An assortment of airway equipment should be available, including anesthesia masks, laryngeal mask airways (LMA), oral and nasal pharyngeal airways, and endotracheal tubes (ETT). Emergency medications should include Pediatric Advanced Life Support (PALS) [4] specific drugs such as epinephrine and atropine as well as agents to treat laryngospasm such as propofol and succinylcholine.

Induction and Maintenance of Anesthesia

After the preoperative discussion between bronchoscopist and anesthesiologist, anesthesia can be induced to achieve the predetermined goals. While there are many approaches to plan and execute an appropriate anesthetic, there are several overarching themes that are helpful to discuss. The first is whether there is a need to have the patient maintain spontaneous respiration. This is often necessary for dynamic airway assessment to evaluate for vocal cord mobility and airway malacia, but carries an increased risk of bronchospasm, laryngospasm, and hypotension. The second theme involves the need to have an unaltered airway to evaluate. Anesthesiologists frequently relieve glossoptosis with the jaw thrust maneuver, bypass upper airway obstruction with airway adjuncts, and provide airway pressure to distend collapsible airways. These routine practices for an anesthesiologist to minimize airway obstruction may adversely affect the diagnostic quality of the bronchoscopy. The goal should be to allow rapid assessment of the airway while providing optimal oxygenation, sometimes tolerating periods of hypercapnia if hemodynamics are not affected and these effects are not seen as detrimental to intracranial physiology. As such, special care should be taken to avoid this in patients with intracranial and pulmonary hypertension [5], as hypercarbia may lead to worsening of their underlying pathophysiologic process.

Design of an optimal anesthetic plan may involve more than one airway plan. The authors frequently utilize the following plan to minimize patient risks, while providing optimal conditions for a complete bronchoscopy. Initially, spontaneous respiration is maintained while oxygen is provided with a facemask via the anesthesia circuit without positive end-expiratory pressure (PEEP) or maneuvers to relieve upper airway obstruction, and bronchoscopy is performed through an adaptor attached to the mask. Upon completion of the evaluation of the supraglottic airway, an LMA is placed while the patient is still spontaneously ventilating without PEEP for dynamic lower airway evaluation. Controlled ventilation with PEEP is then used to clear carbon dioxide and re-recruit atelectatic lung units during the bronchoalveolar lavage portion of the examination. In the setting of hypoxemia – an ETT may be utilized to allow for additional mean airway pressure delivery to improve oxygenation. Frequent communication between all team members is essential to provide safe management of the patient while also allowing for optimal conditions for the diagnostic procedure. It is not uncommon for multiple airway plans to be utilized, and for the plan to change based on the patient's response to the anesthetic. Preparation and communication are key.

Regardless of the initial airway plan, all team members should work to optimize oxygenation. This allows for additional patient safety, and also eliminates the need for pauses in the procedure

due to oxyhemoglobin desaturation. Oxygen can easily be administered by the bronchoscopist through the working channel in the patient with a patent airway. Alternatively, passive oxygenation can be administered via anesthesia mask, nasal cannula, or an endotracheal tube insufflating in the pharynx. Patients at higher risk of oxyhemoglobin desaturation may benefit from controlled or assisted ventilation with oxygen delivery via LMA or ETT. LMAs are typically sized according to patient weight, and offer a conduit of adequate size for the bronchoscopy in almost all situations. Conversely, the external diameter of the bronchoscope can exceed the inner diameter of an age-appropriate ETT. A discussion regarding relative risks of ETT size versus scope downsizing is important in the optimal selection of ETT.

The selection of pharmacologic agents requires a working knowledge of the available agents and their relative benefits. Agents should provide analgesia, amnesia, areflexia, and akinesis. Below each agent will be discussed as a brief review.

Inhalational agents (volatile anesthetics such as sevoflurane) are a widely used class of medications which are delivered through specialized equipment. They have a reliable dose-response curve and can even be administered before intravenous access is obtained (inhaled delivery). To limit environmental contamination, these agents are best administered when the respiratory circuit has minimal leak. Additionally, a patent airway with continuous administration of volatile anesthetic is important to maintain a desired depth of anesthesia. Sevoflurane has smooth muscle relaxant effects that can be used in the setting of refractory bronchoconstriction. Lower doses of sevoflurane are needed to produce unconsciousness than those that are needed to prevent movement such as coughing. Vasodilation is commonly seen with use of volatile anesthetics and is directly related to the dose administered. Sevoflurane may be used as a sole agent for bronchoscopy but significant doses are needed to prevent airway reflexes and movement, necessitating close monitoring of hemodynamics. Volatile anesthetics are also known to be triggering agents for malignant hyperthermia, and should not be used in patients known or suspected to be at risk.

Propofol is a commonly used anesthetic agent that is delivered via intravenous route. Bolus doses of propofol are associated with rapid induction of unconsciousness, and if used for short procedures, they are associated with a rapid recovery of consciousness. The intravenous administration can be associated with pain at the injection site, which is mitigated with administration analgesics or intravenous lidocaine or delivery of the medication in a larger vein. Propofol does not have analgesic properties when used as a sole agent. Vasodilation and hypotension are also commonly seen with propofol administration and are directly related to dose administered. Much like sevoflurane, propofol can be used as a sole agent for bronchoscopy but significant doses are needed to prevent airway reflexes and movement, necessitating close monitoring of hemodynamics.

Dexmedetomidine is intravenous alpha agonist which is typically inadequate as a sole agent for bronchoscopy but can be a valuable adjunctive medication. It is thought to preserve respiratory drive even at high doses. Administration of dexmedetomidine can significantly reduce the dose requirements of other agents needed for ideal procedural conditions. As an alpha-agonist it can induce significant bradycardia and at higher doses, hypertension. These responses are especially seen with loading doses of the medication [6]. Maintenance infusions can be associated with hypotension.

Ketamine is a dissociative anesthetic, antagonizing the N-methyl-D-aspartate (NMDA) receptor. It provides quality analgesia and amnesia as a sole agent or in combination with others. It has sympathomimetic effects which result in hemodynamic stability and are likely responsible for the bronchodilation which has been described with its use. Especially in older children, associated emergence hallucinations can be unpleasant, and warrant concomitant use of other agents. The use of ketamine is also associated with salivation, often prompting the use of anti-sialagogues.

Short-acting opioids such as fentanyl or remifentanil do not produce amnesia and so should

not be used as sole agents. Opioids reduce airway reactivity, allowing for optimal bronchoscopy conditions in the nonparalyzed patient, and provide antitussive effects during emergence. Opioids cause dose-related respiratory depression, so careful titration of dosage is required when spontaneous breathing is desired. Larger doses often necessitate controlled ventilation. Opioids also significantly reduce the dosage of other agents needed, limiting hemodynamic changes in the periprocedural period.

Neuromuscular blocking agents provide akinesis, but do not provide amnesia or analgesia, so should not be used as sole agents. The use of neuromuscular blockade nearly eliminates the risk of laryngospasm and allows dose reduction of other agents, allowing for improved hemodynamic profiles. Use of neuromuscular blockade is contraindicated if vocal cord motion, dynamic airway collapse, or other spontaneous breathing respiration assessments are needed.

Perioperative Events

Preparation for common intraoperative events can lead to rapid identification and treatment, ensuring optimal patient safety. The most common adverse events include hypoxemia and hypotension and can be multifactorial in their etiologies.

Hypoxemia is exceedingly common in patients undergoing bronchoscopy. Hypoventilation from respiratory depressant effects of anesthetic medications or from airway obstruction is commonly noted. Laryngospasm and bronchospasm are frequently noted airway reflexes that result in dynamic airway obstruction, and typically resolve with deepening of the anesthetic. Alternatively, ventilation and perfusion can become mismatched, especially after bronchoalveolar lavage or atelectasis from derecruitment of lung units in the supine position. This can be exacerbated by anesthetic blunting of the normal hypoxic pulmonary vasoconstriction and may be responsive to recruitment maneuvers.

Hypotension is an expected but undesirable side effect of many of the anesthetic drugs used for bronchoscopy. This can be exacerbated by medical comorbidities including preoperative diuresis, myocardial dysfunction, or sepsis. The preoperative assessment must include an estimation of intravascular volume and cardiac output – with contingency plans to augment preload, cardiac function, and systemic vascular resistance as needed for stable hemodynamics. This requires adequate intravenous access and may require pre-operative optimization of fluid status before induction of anesthesia. In most cases, it is helpful to have immediate access to vasoconstrictors and inotropes to optimize organ perfusion throughout the procedure.

Other life-threatening events are thankfully less common. Despite this, it is imperative for the anesthesiologist to have a working knowledge of all PALS algorithms and access to resuscitation equipment in the event of patient deterioration.

Recovery and Postoperative Care

Emergence is the cessation of anesthesia and the transition to postoperative care. This is often more challenging than the process of induction and requires significant vigilance on the part of the anesthesia team. Of utmost importance is selection of the patient who will require postoperative ventilator support for which emergence is inappropriate (Fig. 11.1).

Patients on baseline noninvasive ventilatory support can often be successfully extubated at the completion of the procedure, but every effort should be made to return to noninvasive support immediately after extubation. However, plans

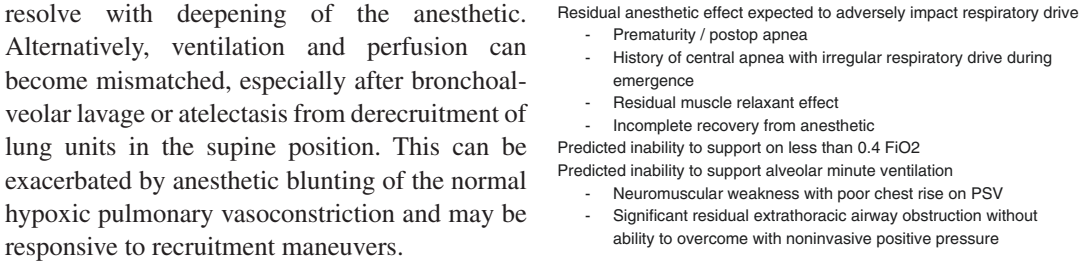

Fig. 11.1 Common indications for postoperative invasive mechanical support

should be made in case the patient requires a higher level of support following the procedure.

Removal of an LMA or ETT can occur while the patient is still under general anesthesia (deep extubation). This has the benefits of decreased coughing and increased efficiency from a room turnover standpoint. Alternatively, the LMA or ETT can be removed while the patient has recovery of protective airway reflexes (awake extubation). Awake extubation allows the practitioner to provide positive pressure throughout the emergence process, which is of particular benefit for patients with atelectasis or neuromuscular weakness.

Emergence agitation or delirium is commonly seen in pediatric patients. It consists of agitation not attributed to pain, and typically resolves after completion of emergence from anesthesia. There are many risk factors and treatment modalities that are beyond the scope of this text, but care should be taken to avoid patient self-injury during the period of emergence agitation.

Postprocedural pain is mild after most bronchoscopic procedures and is primarily attributed to sore throat. Treatment options include systemic analgesics such as nonsteroidal anti-inflammatory drugs, acetaminophen, or opioids. Alternatively, local anesthetic throat lozenges or sprays can provide pain relief. While opioids are infrequently needed for analgesia, they also offer antitussive effects which may be desirable for some patients after bronchioalveolar lavage.

Conclusion

Pediatric flexible bronchoscopy is frequently associated with administration of general anesthesia. Communication between the pediatric anesthesiologist and the proceduralist is paramount for the completion of a successful airway evaluation. Choice of anesthetic agents and airway plans is less important than the knowledge of specific advantages and disadvantages of each selection.

References

1. ASA Standards and Practice Parameters. Standards for Basic Anesthetic Monitoring: ASAHQ; [approved by the ASA House of Delegates on Oct 21, 1986, last amended Oct 20, 2010, and last affirmed on Oct 28, 2016]. Available from: https://www.asahq.org/~/media/sites/asahq/files/public/resources/standards-guidelines/standards-for-basic-anesthetic-monitoring.pdf.
2. Bannister CF, Brosius KK, Sigl JC, Meyer BJ, Sebel PS. The effect of bispectral index monitoring on anesthetic use and recovery in children anesthetized with sevoflurane in nitrous oxide. Anesth Analg. 2001;92(4):877–81.
3. Kasman N, Brady K. Cerebral oximetry for pediatric anesthesia: why do intelligent clinicians disagree? Paediatr Anaesth. 2011;21(5):473–8.
4. de Caen AR, Berg MD, Chameides L, Gooden CK, Hickey RW, Scott HF, et al. Part 12: Pediatric advanced life support: 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2015;132(18 Suppl 2):S526–42.
5. Abman SH, Hansmann G, Archer SL, Ivy DD, Adatia I, Chung WK, et al. Pediatric pulmonary hypertension: guidelines from the American Heart Association and American Thoracic Society. Circulation. 2015;132(21):2037–99.
6. Friesen RH, Nichols CS, Twite MD, Cardwell KA, Pan Z, Pietra B, et al. The hemodynamic response to dexmedetomidine loading dose in children with and without pulmonary hypertension. Anesth Analg. 2013;117(4):953–9.