Acta Anaesth. Bel., 2025, 76 (1): *53-63*

Review

Anesthesiologic considerations during interventional laryngoscopy and bronchoscopy: a narrative review

M. Wyseur[1], K. Vermeulen[1], S. Rex[1,2], A. Teunkens[1]

[1]*Department of Anesthesiology KU Leuven-University, Leuven, Belgium;* [2]*Department of Cardiovascular Sciences KU Leuven-University, Leuven, Belgium, University Hospitals Gasthuisberg, Herestraat 49, Leuven, 3000 Belgium.*

Corresponding author: dr. Wyseur Maxim, Department of Anesthesiology KU Leuven-University, Leuven, Belgium; University Hospitals Gasthuisberg, Herestraat 49, Leuven, 3000 Belgium. Phone + 32 479 35 38 76
Email: maxim.wyseur@uzleuven.be

Abstract

The recent and ongoing evolution towards minimally invasive procedures came with the exciting challenge for anesthesiologists to share the airway with the interventional pulmonologist or the otorhinolaryngologist. This narrative review aims to summarize the anesthesiologic considerations when preparing and performing these procedures. Medical Subject Headings (MESH) terms include 50 articles from PubMed® and Excerpta Medica Database (EMBASE) databases. Sharing the airway has led to several challenges, such as the possible loss or collapse of a safe airway. Several solutions have been found, each of which can be used in specific cases. Communication between the anesthesiologist and the interventionalist is crucial to settling on the best airway type. The literature is clear, and a thorough preprocedural assessment is needed. When surgery is performed during the apneic time, high-flow nasal oxygenation is suggested to prolong the apneic time. High-flow jet ventilation is advocated to ensure an approachable surgical field when a smaller-sized endotracheal tube is too big. Combining a flow-controlled ventilator and a small-lumen cuffed endotracheal tube can counter their possible drawbacks. A laryngeal mask is proposed in cases of high tracheal stenosis or bronchoscopic interventions. Total intravenous anesthesia is the golden standard when general anesthesia is needed, accompanied by the Bispectral Index to monitor the depth of anesthesia. The use of supplementary medication such as anticholinergics has been described and can be beneficial.

Keywords: **Anesthesia, bronchoscopy, laryngoscopy, airway management, ventilation, Evone®.**

Introduction

In recent years, there has been a significant evolution towards minimally invasive procedures, replacing the need for major surgical procedures with a higher interventional risk. For example, mediastinal staging can be done with the help of bronchoscopy instead of invasive thoracic surgery[1,2]. With these developments comes an exciting challenge for anesthesiologists to share the airway with the interventional pulmonologist or the airway surgeon[1,3]. Hence, a minimally invasive procedure means using a direct laryngoscopy or bronchoscopy to treat upper or lower airway pathology, encouraging research for novel airway management and ventilatory techniques. Many techniques are available, but no golden standard exists[4]. Interventional procedures range from bronchoscopic fine needle aspirations, endoscopic bleeding control, and bronchoalveolar lavage to suspension microlaryngoscopy to treat sometimes critical laryngotracheal stenosis. The decision between general anesthesia and moderate to full sedation depends upon the type of procedure and the patient's respiratory status, seeing that most patients suffer from conditions that impair gas exchange[1,2,4,5]. Pathologies of the upper airway, such as laryngotracheal stenosis, entail the possibility of difficult airway management. These comorbidities imply a decent preoperative anesthetic evaluation to ensure the best available perioperative anesthetic plan.

The objective of this narrative review is to create a summary of the ongoing research and provide a way to optimize the anesthesiologic and safety considerations during these procedures. We aim to summarize the possible anesthesiologic strategies, starting with general considerations when planning and performing these procedures. Further, we discuss the anesthesiologic approaches to laryngoscopic and bronchoscopic interventions and suggest the best possible approach if possible. Lastly, we end with several supplementary medications that can be used, but no clear evidence of clinical benefit was noted.

Search Methodology

A literature study was performed using PubMed® and EMBASE databases (Fig. 1). Several MeSH terms were applied to specify the search technique: anesthesia, bronchoscopic interventions, laryngoscopy, micro laryngoscopy, airway stenosis, and Evone®. Articles were divided into groups to distinguish between pulmonology and otorhinolaryngology procedures based on procedural techniques. A total of 50 articles were included to finalize the narrative review. In this process, we had to consider the possibility of selection bias; hence, we only selected papers that seemed interesting for this narrative review, and we had a particular interest in applying the Evone®.

Results

In this narrative review we have summarized the anesthesiologic considerations during interventional laryngoscopy and bronchoscopy. Therefore, we have evaluated a substantial number of articles based on title and abstract (Fig. 1). We will first discuss the general considerations to be taken preprocedural, followed up by more specialized approaches to specific interventions.

General considerations

Preprocedural assessment is essential. Evaluation of the nature and extent of the airway disease can contribute to the anesthetic planning regarding airway access, anesthetic management, and possible complications. Chest radiography, chest computed tomography, magnetic resonance and even nasofaryngolaryngoscopy studies can provide important information about airway abnormalities or mediastinal masses. Standard pulmonary spirometry includes valuable information about the general pulmonary function and the level of obstruction[1,3,6]. A preprocedural deliberation between the anesthesiologist and the proceduralist is advised to evaluate the

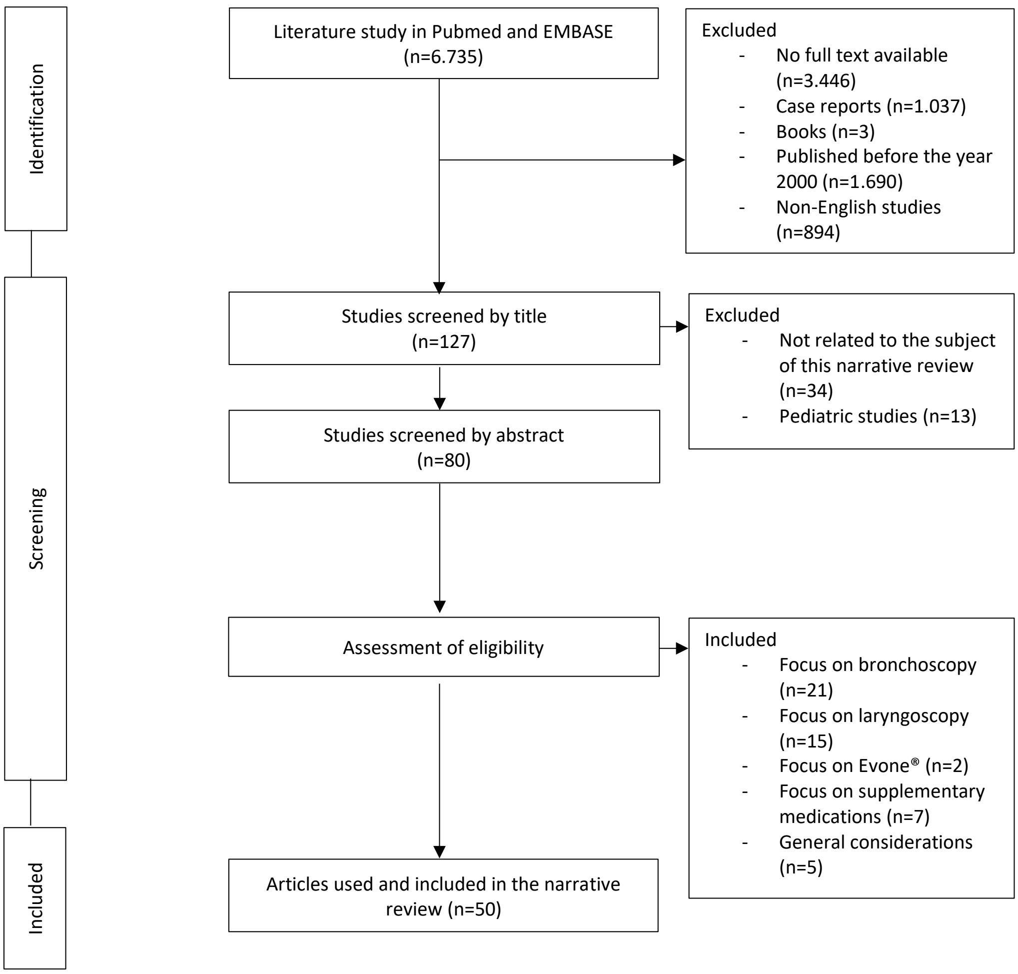

Fig. 1 — Search methodology.

anesthetic induction's success rate and the need for awake fiberoptic intubation or awake tracheostomy[7]. These awake procedures can be performed successfully when both teams (i.e. anesthesiologist, interventionalist and nurses) are fully prepared. The key to success is to inform the patient, ensure enough locoregional anesthesia, keep talking to the patient and the team, and have a backup plan ready.

Flexible laryngoscopy can be used to predict the difficulty of airway management when a rigid laryngoscopy is indicated, thus giving us valuable preoperative information. Transnasal or transoral flexible laryngoscopy is used to visualize the laryngeal and pharyngeal structures and is commonly performed with the help of topical agents. Patients are informed thoroughly about the procedure and, because of this, do not require any sedatives or analgesics. Aqueous gel has been used alone or with a nasal decongestant[19].

The introduction of the flexible fiberoptic bronchoscope in 1960 marked the beginning of the quest for innovative endobronchial procedures, discharging the need for major surgical procedures with a high interventional risk[1,2,5,8]. This establishment arranged new treatment options for patients not candidates for surgical treatment[9]. With the complexity of these procedures comes the need for new anesthesiologic expertise to ensure the safety of the patients. The presence of an anesthesiologist seemed unnecessary at the beginning of interventional pulmonology. However, it appears almost obliged to stabilize the airway and cardiorespiratory system during these complex procedures with simultaneous airway management[2,10]. This was of enormous importance when several deaths were noted related to sedation or local anesthetics in the 1970s during interventional bronchoscopy[10]. Sharing the airway, the wish for a motionless field, and aggressive airway suctioning lead to difficult ventilation and oxygenation of the patient[1].

The otorhinolaryngologist handles several types of airway narrowing, divided into airway emergencies (e.g., pediatric glottitis, compressing hematomas) and elective situations (tracheal stenosis, tumors, infections)[7]. Suspension microlaryngoscopy (SML) is performed to evaluate the endolaryngeal lesions, perform biopsies and treat the underlying pathology[11,12]. The aim is to obtain a sufficient depth of anesthesia, maximal exposure, unobstructed surgical field, adequate gas exchange, and satisfactory time for the proceduralist to carry out the procedure[12,13]. Total intravenous anesthesia (TIVA) of propofol and remifentanil has been the golden standard to ensure a satisfactory depth of anesthesia. The type of airway device and ventilation depends upon the location of the surgery (hypopharynx, supraglottic, larynx, subglottic)[14]. Several airway and ventilation types have been described, each with advantages and disadvantages.

The evolution to less invasive procedures came with the shift to outpatient instead of prolonged hospitalizations. This revolution was the foundation for non-operating room anesthesia (NORA) sites, also known as 'Hybrid ORs'[1,15]. An ideal NORA needs to be equipped with cardiorespiratory monitoring and resuscitation equipment. The recovery room will need an oxygen supply, vacuum suction, and cardiorespiratory monitoring. Post-anesthesia monitoring and the possibility of both bronchoscopic and surgical procedures in these hybrid ORs are critical to ensure the safety of the patients[6,15,16]. Performing these procedures outside the traditional operating room while maintaining the same patient safety and satisfaction level is the ultimate end objective. José et al. concluded that these cases were more cost-effective when performed in the NORA sites due to the combination of improved patient and proceduralist satisfaction and the rapid turnover of cases[17].

Central airway obstructions of the proximal airways incorporate the most feared complications for physicians. The loss of an airway can be disastrous and needs the presence of a surgical backup[9]. Preprocedural evaluation is of enormous importance to arrange the anesthesiologic plan. The anticipation of a difficult airway with the possibility of an awake fiberoptic intubation or a (awake) tracheotomy includes the need for this to be performed in the OR.

Standard monitoring is mandatory as defined by the American Society of Anesthesiologists. The use of transcutaneous capnometry in critically ill patients has been studied and suggested as a solution when end-tidal gas analysis is impossible or when a significant gas leak is present. Attention has to be paid to the delay in changes between arterial and transcutaneous CO2 levels[2,18].

The type of interventional procedure, pathology, and medical comorbidities dictate the type of airway management, but it is still a matter of debate[1,2,5]. Respiratory failure is a significant risk during these procedures, as the arterial partial pressure of oxygen can drop more than 20 mmHg[4]. During bronchoscopy, a bite block is needed to protect the bronchoscope and the patient's teeth[5]. In the following, we aim to summarize a list of interventional procedures and the possible types of anesthesia.

Rigid laryngoscopy

Rigid suspension microlaryngoscopy requires general anesthesia. TIVA is preferred over volatile agents. As a result of constant suctioning and gas leaks, the risk of inadequate depth of anesthesia is magnificent when volatile agents are used and are therefore averted[1,3,5,9,20]. Therefore, a propofol infusion (titrated between 75 mcg.kg-1.min-1 and 250 mcg.kg-1.min-1) combined with a short working opiate is advised[5]. When remifentanil is used, a higher dose (0.25-0.50 mcg.kg-1.min-1) is recommended to lower the risk of coughing, laryngospasm, hemodynamic response, and to increase procedural satisfaction[5,21]. The depth of anesthesia can be analyzed by the Bispectral Index (BIS Monitor), with a target between 40 and 60[22–24].

Muscle relaxation is needed when an endotracheal tube (ETT) is required. The choice of depolarizing and non-depolarizing agents depends on physician preference and patient profile[5]. When complex airway management is expected, we advise using rocuronium and, if needed, reversing with sugammadex. Cases of anterior mediastinal masses have been described in which they omitted muscle relaxation to prevent severe airway obstruction[15,25].

When general anesthesia is performed, preoxygenation with a non-rebreathe mask at 10-12 L.min-1 is advised[5]. The airway can be supported with the help of a supraglottic airway (SGA), especially in cases where subglottic stenosis makes using an ETT difficult and more traumatic[2,5]. A laryngeal mask (LMA) provides optimal examination and safe ventilation in patients with subglottic or high-tracheal lesions. Because of its fewer stimulation characteristics, lower doses of anesthesia are needed, and it allows topical anesthetics to be applied to the vocal cords[1,5,17,26].

SML traditionally implied the need for general anesthesia. Controlled mechanical ventilation has been performed successfully with a small endotracheal tube, offering the best airway protection and oxygenation. Due to the obstruction of the surgical site, the interventional proceduralist does not prefer this airway type. Collapse or obstruction of the airway is possible when the underlying pathology closes the airway. In this case, intubation with even a smaller endotracheal tube could be impossible and end dramatically[12,27].

Several methods have been found to bypass this dangerous complication. Intermittent ventilation or intubation is an acceptable option. In 1996, the superiority of this ventilation type was stated by offering an ideal surgeon view[28]. The most critical disadvantage is the risk of hypoxemia and hypercapnia, which can result in the occurrence or worsening of respiratory acidosis. Repeated airway manipulation can lead to unintentional airway injury and entail interruption of operative time[12,29,30].

High-flow nasal oxygenation (HFNO) with spontaneous ventilation is suggested to increase patient safety in compromised airways by tumors or stenosis. Trans-nasal humidified rapid insufflation ventilatory exchange (THRIVE) in combination with high flow nasal cannula (HFNC) can be used in spontaneously ventilating or apneic patients, prolonging the apneic time[11,12]. HFNO was used mainly in intensive care during hypoxemic respiratory distress to reduce reintubation. Still, an increasing interest is found in anesthesia to improve preoxygenation during rapid sequence intubation or in obese patients. Eventually, Courbon et al. described the successful maintenance of airway permeability and oxygenation with HFNO when laser resection was performed. In only 3 out of their 32 cases, there was a saturation <92%. This happened when FiO2 was decreased to 30% when lasering was performed. Courbon et al. stated that the lack of end-tidal carbon dioxide detection is a crucial limitation. Transcutaneous CO2 measurement could have been the solution[11]. However, the study of Zhen et al. clearly showed no significant differences in PaO2 and PaCO2 between THRIVE and facemask pre-oxygenation and apnea. They concluded a more prolonged and safer apneic time with the help of THRIVE[31].

The systematic review by Chan et al. stated that HFNC is a viable and safe alternative in low-risk patients. Although HFNC was associated with reduced operating time, conventional ventilation would be safer in higher-risk patients. Cardiovascular and respiratory diseases dictate poor candidates[27,29]. Conventional ventilation was dictated as mechanical ventilation with tracheal intubation or superimposed high-frequency jet ventilation (HFJV). They noted a higher desaturation rate, hypercapnia, and rescue intervention in the HFNC cases[29]. The same conclusion was found in the non-inferiority study of Min et al. They provided a cut-off of 28 minutes as a safe apneic period when HFNC was used to prevent the occurrence of significant respiratory acidosis[30]. Local or locoregional anesthesia can be used to optimize SML when spontaneous ventilation is obtained with TIVA. Lidocaine was applied topically to the tongue, glottis, and trachea and seemed critical to the success of the procedures. More evidence is needed to evaluate the possible added value of a superior laryngeal nerve block when performing an SML[12].

Several possible ventilation strategies have been illustrated when a carbon dioxide laser is used. HFJV can be applied supraglottically or subglottically[32]. HFJV combines a non-cuffed narrow-bore endotracheal tube and a specialized ventilator. Small volumes of air are insufflated at a supraphysiological rate of 100-150/min. The outer diameter of the endotracheal tube is around 4.3 mm, resulting in almost zero intubation fails[33]. The most important disadvantage of HFJV is the possibility of pneumothorax, pneumomediastinum, or subcutaneous emphysema due to the smaller diameter. This can occur when insufficient time is provided during exhalation[14,34]. Several authors indicated the anesthetist's vigilance as the best prevention of barotrauma[14,27]. Hence, the expiration exists out of passive airflow around the tube, and oscillation of the vocal cords is possible, resulting in an annoying operating field. This also implies the aerosolization of airborne particles with the possibility of infections for the whole operating team. Bulky tumors and severe airway stenosis form a relative contraindication to the HFJV, ensuring the likelihood of restricted air backflow. Another disadvantage of HFJV is the possibility of blood or tissue residues being forced distally[12,27,34,35].

The drawbacks of HFJV can be countered by Evone®, which uses flow-controlled ventilation with a small-lumen cuffed endotracheal tube (Tritube®) (Fig. 2). This flow-controlled ventilation uses negative pressure to remove the air from the lungs. Bernoulli's principle generates negative pressure and does not rely on the passive lung emptying phase. The Evone® ventilator (Fig. 3) is the automatized version of the Ventrain®[32].

The Evone® has been used by Meulemans et al. in an observational study during upper airway surgery. They concluded that Evone® was an ideal airway and ventilation type with no hypoxemia, hypercapnia, or other adverse events. The small diameter of the Tritube® (4.4mm outer diameter) ensured the perfect surroundings for the surgeon[32]. Intubation can be done with the help of a malleable stylet to preshape the Tritube®. The Tritube® contains three lumens to control the inflation of the cuff, monitor the pressure in the trachea, and ventilate the patient. Several parameters, such as minute inspiratory fraction of oxygen (FiO2), inspiratory flow rate, Inspiratory: Expiratory rate (I: E), PIP, and PEEP, can be adjusted. One of the most significant advantages of Evone® compared to the HFJV is the possibility of evaluating the end-tidal carbon dioxide with conventional capnography. These factors mentioned above make a safer environment possible with zero risk of air trapping and a safer practice for the patients and the surgeons thanks to the cuff[35].

The Evone® seems to be the holy grail for airway and ventilation. However, there are some hitches. Critical subglottic or tracheal stenosis with a diameter less than 4mm forms an absolute contraindication because the Tritube® cannot pass[32]. The Tritube® can be blocked by secretions or dislocated by coughing[36]. As stated before, the administration of glycopyrrolate can be considered. A complete neuromuscular blockade is needed before inflating the cuff to avoid any possible barotrauma caused by coughing. When extubating, total neutralization of neuromuscular blockade

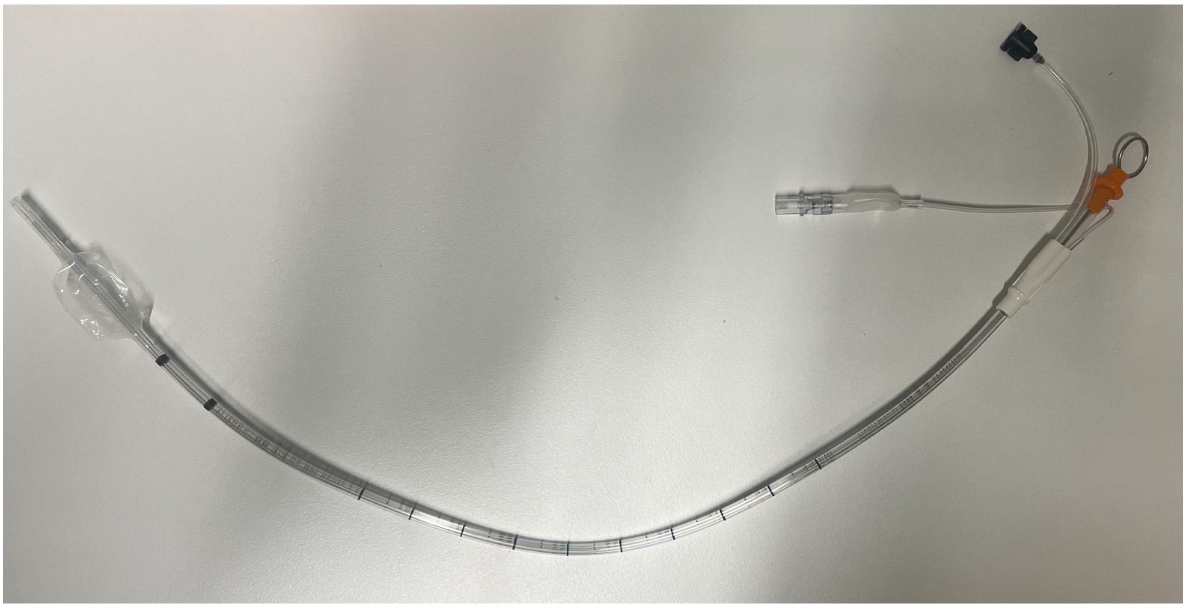

Fig. 2 — Tritube®.
The small-bore (outer diameter of maximum 4.4 mm) tube has three lumens: one for inflation of the cuff (white), one to monitor the pressure in the trachea (black), and one to ventilate the patient (orange). The malleable stylet is shown in the picture; this can help to preshape the Tritube®.

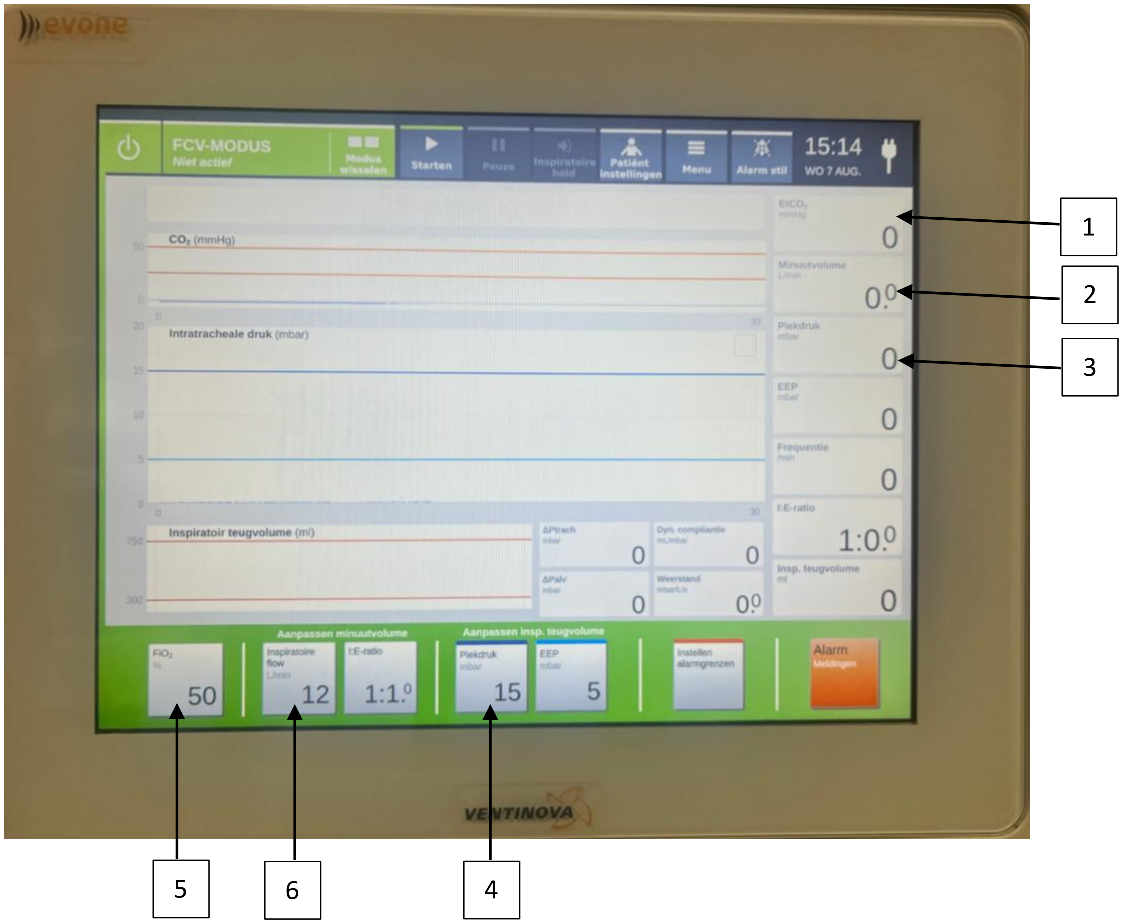

Fig. 3 — Display of the Evone® ventilator (Ventinova).
1. End-tidal CO2 - **2**. Tidal Volume (L/min) - **3**. Peak Pressure (mbar) (measurement) - **4**. Peak Pressure (mbar) (adjustable) - **5**. Inspiratory fraction O2 (adjustable) - **6**. Inspiratory flow (adjustable).

is required; the combination of rocuronium and sugammadex is advised. The Evone® needs calibration time and some time to prepare the setup. This can take up to 5 or 10 minutes, implicating its complex use during emergencies. The cost price of the Tritube® needs to be considered before starting an elective procedure[32].

An LMA can be perfectly used as an airway device in cases of a high tracheal stenosis resection. It can be suggested for rigid infraglottic pathology. The LMA had several advantages, such as spontaneous or positive airway pressure ventilation, the possibility of a smooth emergence, and facilitation of the placement of the jet ventilator. Starting with an LMA as the airway device makes it possible to check the possibility and safety of the patient's ventilation without using muscle relaxation[36, 37].

Flexbile bronchoscopy

Flexible bronchoscopy has been performed with sedation with propofol and topical anesthetics. This resulted in amnesia, decreased coughing, and reduced feeling of suffocation[10,17,39]. Any difference between moderate sedation and general anesthesia for flexible bronchoscopy has been thoroughly examined. A superiority of general anesthesia was achieved via TIVA of propofol and remifentanil in combination with HFJV. A LMA provides safe airway management with little stimulation during placement and maintenance[17,26].

Different types of oxygenation strategies have been studied in non-intubated patients to avoid desaturation episodes during flexible fiberoptic bronchoscopy. They concluded a superiority of HFNC to conventional oxygen therapy in outpatients and a superiority of non-invasive ventilation to HFNC in patients with severe acute respiratory failure (ARF). Thoughts must be given on possible interference with the bronchoscopic procedure4. In the aftermath of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic, precautionary measures must be taken during aerosol-generating procedures. Air dispersion of the virus is possible and increases the risk of infection among healthcare personne[14,40]. Personal protective equipment and sufficient protective barriers are fundamental[41].

Rigid bronchoscopy

Standard diagnostic bronchoscopy can be done safely with topical local anesthetics and moderate sedation if required by the patient[2,5]. Skinner et al. demonstrated a non-inferiority of conscious sedation to general anesthesia regarding patient comfort, safety, or diagnostic accuracy. However, they stated the need for general anesthesia when longer and more complex procedures were performed[24]. General anesthesia results in superior conditions for physicians, reduced procedural time, and more patient satisfaction[1].

Bronchoalvealar lavage

Studies have been performed to evaluate the rate of adverse events when bronchoalveolar lavage (BAL) was performed on critically ill patients[45]. No significant difference was found between HFNC therapy and non-invasive ventilation when BAL was performed with non-intubated patients. HFNC is more accessible for care providers and explains the predominant use. Kamel et al. questioned the need for systematically intubating when performing BAL in patients most susceptible to adverse events. Further research is needed to answer this question. The lowest rate of adverse events was noted when procedures were executed by trained pulmonologists and ICU physicians[2,45].

Supplementary medication or anesthetics

The superiority of propofol and hydrocodone over propofol alone in suppressing cough has been demonstrated. Four to 5 mg hydrocodone increased patient and proceduralist satisfaction during BAL and transbronchial needle aspiration. Hemodynamic and respiratory parameters were similar[5,46].

Small doses of anticholinergics can be applied to reduce bronchial secretions. A reduction in airway secretions was concluded; unfortunately, no clinical benefit in reducing cough, patient discomfort, oxygen desaturation, or procedure time has been noted. Scrutiny is encouraged when administering atropine (0.01 mg/kg iv) or glycopyrrolate (0.005 mg/kg iv) and possible hemodynamic fluctuations. Routine use is discouraged by the American College of Chest Physicians[5,47,48].

Midazolam can be given preprocedural to induce anxiolysis, sedation, or anterograde amnesia. Conway et al. concluded no reduction in anxiety, discomfort, or participant satisfaction when comparing midazolam to placebo. However, patients preferred sedation with midazolam over no sedation at all[49]. Sedative premedication should be given with caution because of the possibility of hypoventilation and airway compromise[3]. When moderate sedation is demanded, Clark et al. stated that propofol boluses are superior to midazolam because of the shorter onset and recovery time, less pain, nausea, and breathlessness postoperatively[5].

Several anesthesiologists have used a combination of propofol, midazolam, and fentanyl. This triple sedation includes a reduced consumption of midazolam and propofol without a higher occurrence of complications compared to double sedation with propofol and midazolam[5].

Ketamine can be added to achieve identical sedation and analgesia in adults by conserving spontaneous ventilation. Because of its hemodynamically stable and potent bronchodilator effects, a more regular use of ketamine has been suggested. Caution is advised when used in patients with ischemic heart diseases and cardiomyopathies. The emergence delirium can be prevented with the co-administration of midazolam or propofo[15,12].

Lidocaine spray is advised as an excellent local anesthetic, given its short half-life and safety. Caution is advised in patients with advanced age, impaired liver function, or congestive heart failure. Transcricoid or transtracheal injection can be used instead of a lidocaine spray. The topical dose should never exceed 7mg/kg, and 1% lidocaine is suggested[5,48].

Conclusions

Several airway and ventilation types have been described as successful and safe, yet no golden standard exists. The airway management must be individualized and evaluated preprocedural by the interventionalist and the anesthesiologist. We aimed to summarize the findings of the literature about the airway and ventilation types during interventional laryngoscopy and bronchoscopy.

The preprocedural assessment is one of the most important factors dictating the rate of success of these minimally invasive procedures. The anticipation of possible complex airway management, airway collapse, or difficult ventilation can be assessed preprocedural with the help of standard pulmonary spirometry and flexible fiberoptic laryngoscopy or bronchoscopy. The latter can be done with the help of education and local anesthetics. Considering the possible complications, the procedure's feasibility in NORA sites must be evaluated preprocedural. Standard complete ASA monitoring is necessary wherever the procedure takes place.

Rigid laryngoscopy requires general anesthesia and implies the risk of an obstructed airway. In cases of high tracheal stenosis resection or rigid infraglottic pathology, we recommend using an LMA if resection is done through flexible bronchoscopy. When direct laryngoscopy is used, we recommend intermittent apneic ventilation, HFJV or Evone®. A smaller endotracheal tube can be used when there is sufficient room for the

Protocol UZ Leuven

The following protocol for anesthetic management is based on selected literature and conforms to the latest evidence-based medicine. It can be used to prepare and successfully complete complex airway cases.

UZ Leuven Protocol for anesthetic management during diagnostic and interventional bronchoscopy

1. Pre procedural evaluation[1–3,7]
    1) Complete preprocedural anesthetic reassessment.
    2) Pulmonary function and radiographic evaluation.
    3) Bronchodilatatory nebulizer.

2. Pre-induction
    1) Optimize patient positioning (table height, sniffing position, reverse Trendelenburg in obese patients).
    2) Full ASA monitoring[2].
        i. Apply the Bispectral Index (BIS Monitor) before induction to evaluate the depth of anesthesia during the procedure[22–24].
        ii. Apply the Neuromuscular Transmission (NMT) monitor, evaluating the train of four (TOF) periprocedural.
    3) Prepare the airway management. Consult the pulmonologist for the desired airway management. Anticipate the probability of a difficult airway.
    4) Pre-oxygenation with 100% FiO_2.
        i. In the case of bleomycin chemotherapy in medical history, be aware of the possibility of an exacerbation of bleomycin-induced lung injury when applying high concentrations of FiO_2. FiO_2 can be elevated when saturations drop to 88%[50].
    5) Induction with propofol and remifentanil, followed by muscle relaxation by choice.
    6) Mask ventilation to ensure a tidal volume of 10ml/kg.
    7) Intubation by an experienced anesthesiologist.
        i. The presence of multiple comorbidities implies situations not appropriate for airway teaching.

3. Maintenance
    1) Total intravenous anesthesia (TIVA) is the gold standard.
    2) High fresh gas flow is advocated.
    3) Lower FiO_2 as soon as possible.
        i. FiO_2 should be less than 40% to reduce the risk of airway fire when thermal therapies are performed[2].
    4) Use a swivel adapter to minimize the gas leak.
    5) Mechanical ventilation with PCV mode is advocated. Aim to achieve a tidal volume of at least 8 ml/kg with 8-12 mmHg PEEP levels.
    6) A recruitment manoeuvre is advised if lung re-inflation is desired after excessive suctioning.
    7) Complete reversal of neuromuscular blockade is required.
        i. Sugammadex is advised when rocuronium is used.

surgeon and in cases of intermittent intubation. HFNO is suggested to prolong the apneic time. HFJV is recommended for laryngeal tumors but implies several disadvantages and needs high vigilance from the anesthesiologist. The Evone® is advised to counter most of the HFJV drawbacks. General anesthesia showed superiority in preventing coughing and feeling of suffocation and giving the best accessible surgical field. We advocate the use of TIVA propofol and a short working opiate guided by the BIS monitor. Preoxygenation is crucial and can be done with a non-rebreathe mask or even with the help of THRIVE. Concerning the type of airway device, we did not find a 'one-size-fits-all'. Preprocedural evaluation and deliberation with the proceduralist are needed to decide the best-suited airway device. Effective communication is required to ensure patients' safest surgical and anesthetic conditions.

Financial support and sponsorships: none.
Conflicts of interests: none.

References

1. Abdelmalak BB, Doyle DJ. Updates and controversies in anesthesia for advanced interventional pulmonology procedures. Curr Opin Anaesthesiol [Internet]. 2021 Aug 1 [cited 2023 Mar 13];34(4):455–63. Available from: https://pubmed.ncbi.nlm.nih.gov/34148971/
2. Semmelmann A, Loop T. Anesthesia for interventional pulmonology. Curr Opin Anaesthesiol [Internet]. 2022 Feb 1 [cited 2023 Mar 13];35(1):82–8. Available from: https://pubmed.ncbi.nlm.nih.gov/34845140/
3. Brodsky JB. Bronchoscopic Procedures for Central Airway Obstruction. J Cardiothorac Vasc Anesth [Internet]. 2003 [cited 2023 Apr 9];17(5):638–46. Available from: https://pubmed.ncbi.nlm.nih.gov/14579222/
4. Pelaia C, Bruni A, Garofalo E, Rovida S, Arrighi E, Cammarota G, et al. Oxygenation strategies during flexible bronchoscopy: a review of the literature. Respir Res [Internet]. 2021 Dec 1 [cited 2023 Mar 13];22(1). Available from: https://pubmed.ncbi.nlm.nih.gov/34563179/
5. de Lima A, Kheir F, Majid A, Pawlowski J. Anesthesia for interventional pulmonology procedures: a review of advanced diagnostic and therapeutic bronchoscopy. Can J Anaesth [Internet]. 2018 Jul 1 [cited 2023 Mar 13];65(7):822–36. Available from: https://pubmed.ncbi.nlm.nih.gov/29623556/
6. Bolliger C, Mathur Members P, Beamis J, Becker H, Cavaliere S, Colt H, et al. ERS/ATS statement on interventional pulmonology. Eur Respir J [Internet]. 2002 Feb 1 [cited 2023 Apr 9];19(2):356–73. Available from: https://erj.ersjournals.com/content/19/2/356
7. Doyle DJ, Hantzakos AG. Anesthetic Management of the Narrowed Airway. Otolaryngol Clin North Am [Internet]. 2019 Dec 1 [cited 2023 Mar 13];52(6):1127–39. Available from: https://pubmed.ncbi.nlm.nih.gov/31540769/
8. Dooms C, Seijo L, Gasparini S, Trisolini R, Ninane V, Tournoy KG. Diagnostic bronchoscopy: state of the art. Eur Respir Rev [Internet]. 2010 Sep 1 [cited 2023 Mar 13];19(117):229–36. Available from: https://pubmed.ncbi.nlm.nih.gov/20956198/
9. Selzer AR, Murrell M, Shostak E. New trends in interventional pulmonology. Curr Opin Anaesthesiol [Internet]. 2017 [cited 2023 Apr 9];30(1):17–22. Available from: https://pubmed.ncbi.nlm.nih.gov/27783022/
10. Kern M, Kerner T, Tank S. Sedation for advanced procedures in the bronchoscopy suite: Proceduralist or anesthesiologist? Curr Opin Anaesthesiol [Internet]. 2017 Aug 1 [cited 2023 Apr 9];30(4):490–5. Available from: https://journals.lww.com/co-anesthesiology/Fulltext/2017/08000/Sedation_for_advanced_procedures_in_the.8.aspx
11. Courbon C. Spontaneous Ventilation With High-Flow Nasal Oxygen for Elective Suspension Microlaryngoscopy. OTO Open [Internet]. 2023 Apr [cited 2023 Sep 4];7(2):54. Available from: https://aao-hnsfjournals.onlinelibrary.wiley.com/doi/10.1002/oto2.54
12. Yoo MJ, Joffe AM, Meyer TK. Tubeless Total Intravenous Anesthesia Spontaneous Ventilation for Adult Suspension Microlaryngoscopy. Ann Otol Rhinol Laryngol [Internet]. 2018 Jan 1 [cited 2023 Mar 13];127(1):39–45. Available from: https://pubmed.ncbi.nlm.nih.gov/29171300/
13. Altun D, Çamcı E, Orhan-Sungur M, Sivrikoz N, Başaran B, Özkan-Seyhan T. High frequency jet ventilation during endolaryngeal surgery: Risk factors for complications. Auris Nasus Larynx [Internet]. 2018 Oct 1 [cited 2023 Mar 13];45(5):1047–52. Available from: https://pubmed.ncbi.nlm.nih.gov/29373164/
14. Werkhaven JA. Microlaryngoscopy-airway management with anaesthetic techniques for CO2 laser. Pediatr Anesth [Internet]. 2004 Jan 1 [cited 2023 Sep 4];14(1):90–4. Available from: https://onlinelibrary.wiley.com/doi/full/10.1046/j.1460-9592.2003.01195.x
15. Abdelmalak B, Burkle CM, Marco AP, Mathews DM. Non-Operating Room Anesthesia: Patient Safety, Scheduling, Efficiency and Effective Leadership. Effic Leadersh. 2019;1–4.
16. Mehta AC, Avasarala SK, Jain P, Deshwal H, Gildea TR. A Blueprint for Success: Design and Implementation of an Ideal Bronchoscopy Suite. Chest [Internet]. 2020 Mar 1 [cited 2023 Apr 10];157(3):712–23. Available from: https://pubmed.ncbi.nlm.nih.gov/31610160/
17. José RJ, Shaefi S, Navani N. Anesthesia for bronchoscopy. Curr Opin Anaesthesiol [Internet]. 2014 [cited 2023 Apr 9];27(4):453–7. Available from: https://pubmed.ncbi.nlm.nih.gov/24785119/
18. Schmidt GA. Monitoring Gas Exchange. Respir Care [Internet]. 2020 Jun 1 [cited 2023 Apr 10];65(6):729–38. Available from: https://pubmed.ncbi.nlm.nih.gov/32457167/
19. Joy AK, Philip A, Mathews SS, Ruby R, Albert A, Vellore I. Transnasal Flexible Laryngoscopy Using Different Topical Preparations and Methods of Application-A Randomized Study. 2020 [cited 2023 Dec 3]; Available from: https://doi.org/10.1016/j.jvoice.2020.10.009
20. Pawlowski J. Anesthetic considerations for interventional pulmonary procedures. Curr Opin Anaesthesiol [Internet]. 2013 Feb [cited 2023 Apr 9];26(1):6–12. Available from: https://pubmed.ncbi.nlm.nih.gov/23235522/
21. Hohlrieder M, Tiefenthaler W, Klaus H, Gabl M, Kavakebi P, Keller C, et al. Effect of total intravenous anaesthesia and balanced anaesthesia on the frequency of coughing during emergence from the anaesthesia. Br J Anaesth [Internet]. 2007 [cited 2023 Apr 9];99(4):587–91. Available from: https://pubmed.ncbi.nlm.nih.gov/17660457/
22. Bould MD, Mahtani DG, Davies R, Roughton M, Hunter DN, Kelleher A. Bispectral index values during elective rigid bronchoscopy: a prospective observational pilot study. Anaesthesia [Internet]. 2007 May [cited 2023 Apr 9];62(5):438–45. Available from: https://pubmed.ncbi.

nlm.nih.gov/17448053/
23. Myles PS, Leslie K, McNeil J, Forbes A, Chan MTV. Bispectral index monitoring to prevent awareness during anaesthesia: The B-Aware randomised controlled trial. Lancet [Internet]. 2004 May 29 [cited 2023 Apr 9];363(9423):1757–63. Available from: https://pubmed.ncbi.nlm.nih.gov/15172773/
24. Skinner TR, Churton J, Edwards TP, Bashirzadeh F, Zappala C, Hundloe JT, et al. A randomised study of comfort during bronchoscopy comparing conscious sedation and anaesthetist-controlled general anaesthesia, including the utility of bispectral index monitoring. ERJ open Res [Internet]. 2021 Apr 1 [cited 2023 Apr 10];7(2). Available from: https://pubmed.ncbi.nlm.nih.gov/34084784/
25. Abdelmalak B, Marcanthony N, Abdelmalak J, MacHuzak MS, Gildea TR, Doyle DJ. Dexmedetomidine for anesthetic management of anterior mediastinal mass. J Anesth [Internet]. 2010 Aug 8 [cited 2023 Apr 10];24(4):607–10. Available from: https://link.springer.com/article/10.1007/s00540-010-0946-x
26. Wang HB, Yang CX, Zhang B, Xia Y, Liu HZ, Liang H. Efficacy of target-controlled infusion of propofol and remifentanil with high frequency jet ventilation in fibre-optic bronchoscopy. Singapore Med J [Internet]. 2013 [cited 2023 Apr 10];54(12):689–94. Available from: https://pubmed.ncbi.nlm.nih.gov/24356755/
27. Jaquet Y, Monnier P, Van Melle G, Ravussin P, Spahn DR, Chollet-Rivier M. Complications of Different Ventilation Strategies in Endoscopic Laryngeal Surgery: A 10-year Review. Anesthesiology [Internet]. 2006 Jan 1 [cited 2023 Sep 11];104(1):52–9. Available from: https://dx.doi.org/10.1097/00000542-200601000-00010
28. Weisberger EC, Emhardt JD. Apneic anesthesia with intermittent ventilation for microsurgery of the upper airway. Laryngoscope [Internet]. 1996 [cited 2023 Sep 11];106(9 Pt 1):1099–102. Available from: https://pubmed.ncbi.nlm.nih.gov/8822713/
29. Chan KC, Yang TX, Khu KF, So CV. High-flow Nasal Cannula versus Conventional Ventilation in Laryngeal Surgery: A Systematic Review and Meta-analysis. Cureus [Internet]. 2023 May 6 [cited 2023 Sep 11];15(5). Available from: https://www.cureus.com/articles/140693-high-flow-nasal-cannula-versus-conventional-ventilation-in-laryngeal-surgery-a-systematic-review-and-meta-analysis#!/
30. Min SH, Yoon H, Huh G, Kwon SK, Seo J hwa, Cho YJ. Efficacy of high-flow nasal oxygenation compared with tracheal intubation for oxygenation during laryngeal microsurgery: a randomised non-inferiority study. Br J Anaesth [Internet]. 2022 Jan 1 [cited 2023 Sep 11];128(1):207–13. Available from: http://www.bjanaesthesia.org/article/S0007091221006085/fulltext
31. Hua Z, Liu Z, Li Y, Zhang H, Yang M, Zuo M. Transnasal humidified rapid insufflation ventilatory exchange vs. facemask oxygenation in elderly patients undergoing general anaesthesia: a randomized controlled trial. Sci Rep [Internet]. 2020 Dec 1 [cited 2024 Feb 29];10(1). Available from: https://www.nature.com/articles/s41598-020-62716-2
32. Meulemans J, Jans A, Vermeulen K, Vandommele J, Delaere P, Vander Poorten V. Evone® Flow-Controlled Ventilation During Upper Airway Surgery: A Clinical Feasibility Study and Safety Assessment. Front Surg [Internet]. 2020 Feb 28 [cited 2023 Mar 13];7. Available from: https://pubmed.ncbi.nlm.nih.gov/32185179/
33. Schmidt J, Günther F, Weber J, Wirth S, Brandes I, Barnes T, et al. Flow-controlled ventilation during ear, nose and throat surgery: A prospective observational study. Eur J Anaesthesiol [Internet]. 2019 May 1 [cited 2023 Mar 13];36(5):327–34. Available from: https://pubmed.ncbi.nlm.nih.gov/30730422/
34. Mora F, Missale F, Incandela F, Filauro M, Parrinello G, Paderno A, et al. High Frequency Jet Ventilation during Transoral laser Microsurgery for Tis-T2 laryngeal cancer. 2017 [cited 2023 Sep 12];7:29. Available from: www.frontiersin.org
35. Filauro M, Mora F, Vallin A, Della Casa P, Arceri C, Gratarola A, et al. Evone® Flow controlled ventilation: a new device for laryngotracheal surgery. Acta Otorhinolaryngol Ital [Internet]. 2022 Apr 1 [cited 2023 Mar 13];42(2):189–93. Available from: https://pubmed.ncbi.nlm.nih.gov/35612512/
36. Schmidt J, Günther F, Weber J, Wirth S, Brandes I, Barnes T, et al. Flow-controlled ventilation during ear, nose and throat surgery A prospective observational study. Eur J Anaesthesiol [Internet]. 2019 May 1 [cited 2023 Sep 12];36(5):327–34. Available from: https://journals.lww.com/ejanaesthesiology/fulltext/2019/05000/flow_controlled_ventilation_during_ear,_nose_and.3.aspx
37. Adelsmayr E, Keller C, Erd G, Brimacombe J. The Laryngeal Mask and High-Frequency Jet Ventilation for Resection of High Tracheal Stenosis. Anesth Analg [Internet]. 1998 Apr [cited 2023 Mar 13];86(4):907–8. Available from: https://journals.lww.com/anesthesia-analgesia/Fulltext/1998/04000/The_Laryngeal_Mask_and_High_Frequency_Jet.40.aspx
38. Schieren M, Böhmer A, Dusse F, Koryllos A, Wappler F, Defosse J. New Approaches to Airway Management in Tracheal Resections-A Systematic Review and Meta-analysis. J Cardiothorac Vasc Anesth [Internet]. 2017 Aug 1 [cited 2023 Mar 13];31(4):1351–8. Available from: https://pubmed.ncbi.nlm.nih.gov/28800992/
39. Gonzalez R, De-La-Rosa-Ramirez I, Maldonado-Hernandez A, Dominguez-Cherit G. Should patients undergoing a bronchoscopy be sedated? Acta Anaesthesiol Scand [Internet]. 2003 Apr [cited 2023 Apr 9];47(4):411–5. Available from: https://pubmed.ncbi.nlm.nih.gov/12694138/
40. Guan L, Zhou L, Zhang J, Peng W, Chen R. More awareness is needed for severe acute respiratory syndrome coronavirus 2019 transmission through exhaled air during non-invasive respiratory support: experience from China. Eur Respir J [Internet]. 2020 Mar 1 [cited 2023 Apr 10];55(3). Available from: https://pubmed.ncbi.nlm.nih.gov/32198275/
41. Sampsonas F, Kakoullis L, Karampitsakos T, Papaioannou O, Katsaras M, Papachristodoulou E, et al. Bronchoscopy during the COVID-19 pandemic: effect on current practices and strategies to reduce procedure-associated transmission. Expert Rev Respir Med [Internet]. 2021 [cited 2023 Apr 10];15(6):773–9. Available from: https://pubmed.ncbi.nlm.nih.gov/33798401/
42. Kamel T, Helms J, Janssen-Langenstein R, Kouatchet A, Guillon A, Bourenne J, et al. Benefit-to-risk balance of bronchoalveolar lavage in the critically ill. A prospective, multicenter cohort study. Intensive Care Med [Internet]. 2020 Mar 1 [cited 2023 Apr 2];46(3):463–74. Available from: https://link.springer.com/article/10.1007/s00134-019-05896-4
43. Schlatter L, Pflimlin E, Fehrke B, Meyer A, Tamm M, Stolz D. Propofol versus propofol plus hydrocodone for flexible bronchoscopy: a randomised study. Eur Respir J [Internet]. 2011 [cited 2023 Apr 2];529–37. Available from: https://publications.ersnet.org/content/erj/38/3/529
44. Malik JA, Gupta D, Agarwal AN, Jindal SK. Anticholinergic Premedication for Flexible Bronchoscopy A Randomized, Double-Blind, Placebo-Controlled Study of Atropine and Glycopyrrolate. 2009 [cited 2023 Apr 2]; Available from: https://journal.chestnet.org/article/S0012-3692(09)60468-2/abstract
45. Wahidi MM, Jain P, Jantz M, Lee P, Mackensen GB, Barbour SY, et al. American College of Chest Physicians consensus statement on the use of topical anesthesia, analgesia, and sedation during flexible bronchoscopy in adult patients. Chest [Internet]. 2011 [cited 2023 Apr 9];140(5):1342–50. Available from: https://pubmed.ncbi.nlm.nih.gov/22045879/

46. Conway A, Chang K, Mafeld S, Sutherland J. Midazolam for sedation before procedures in adults and children: a systematic review update. Syst Rev [Internet]. 2021 Dec 1 [cited 2023 Apr 9];10(1). Available from: https://pubmed.ncbi.nlm.nih.gov/33673878/
47. Conway A, Rolley J, Sutherland JR. Midazolam for sedation before procedures. Cochrane database Syst Rev [Internet]. 2016 May 20 [cited 2023 Apr 9];2016(5). Available from: https://pubmed.ncbi.nlm.nih.gov/27198122/
48. Clark G, Licker M, Younossian AB, Soccal PM, Frey JG, Rochat T, et al. Titrated sedation with propofol or midazolam for flexible bronchoscopy: a randomised trial. Eur Respir J [Internet]. 2009 Dec 1 [cited 2023 Apr 9];34(6):1277–83. Available from: https://publications.ersnet.org/content/erj/34/6/1277
49. Müller T, Thümmel K, Cornelissen CG, Krüger S, Dreher M. Analogosedation during flexible bronchoscopy using a combination of midazolam, propofol and fentanyl – A retrospective analysis. PLoS One [Internet]. 2017 Apr 1 [cited 2023 Apr 9];12(4). Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0175394
50. Fruchter O, Manevich Y, Carmi U, Rozengarten D, Kramer MR. Prospective Randomized Trial Evaluating Ketamine for Adult Bronchoscopy. J Bronchol Interv Pulmonol [Internet]. 2017 [cited 2023 Apr 9];24(4):279–84. Available from: https://journals.lww.com/bronchology/Fulltext/2017/10000/Prospective_Randomized_Trial_Evaluating_Ketamine.6.aspx

doi.org/10.56126/76.1.08