Expert Consensus

Multidisciplinary international expert consensus on perioperative airway management

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Background: Perioperative airway management is critical for patient safety and optimal surgical outcomes. Effective airway management reduces postoperative pulmonary complications and accelerates recovery. This expert consensus aims to update the earlier consensus based on the latest research and emphasize aspects that were previously overlooked.

Methods: A comprehensive search up to June 2024 was performed. Earlier consensus documents were reviewed to ensure thorough coverage. A modified Delphi method involved 62 domestic experts from various surgical and anesthetic specialties who discussed and voted on preliminary recommendations in face-to-face meetings, requiring ≥70% agreement. Drafts were then reviewed by 18 international experts via email to incorporate diverse insights.

Results: Through the modified Delphi method, consensus was achieved with ≥70% agreement among the 62 domestic experts, ensuring that the preliminary recommendations were robust and widely supported.

Additionally, feedback from the 18 international experts provided diverse insights that further refined and validated the recommendations. Recommendations were established for preoperative airway preparation, anesthesia management, surgical approach, postoperative airway management, and managing coexisting respiratory diseases. These recommendations update the perspectives of earlier consensus documents based on the latest research and emphasize non-intubated surgery, inhalation therapy, and individualized treatment for patients with coexisting pulmonary diseases.

Conclusions: This expert consensus provides a valuable reference for clinical practice. Further technological optimization and clinical research are needed to improve perioperative airway management.

Keywords: Perioperative airway management; non-intubated surgery; anesthesia; inhalation therapy; coexisting pulmonary disease

Submitted Mar 08, 2025. Accepted for publication Apr 11, 2025. Published online Apr 16, 2025.
doi: 10.21037/tlcr-2025-273
View this article at: https://dx.doi.org/10.21037/tlcr-2025-273

Introduction

Perioperative airway management is critical for ensuring patient safety and optimizing surgical outcomes. Enhanced Recovery After Surgery (ERAS) protocols are now widely applied in clinical practice, with perioperative airway management being a crucial component of ERAS (1). Its clinical application can effectively reduce postoperative pulmonary complications, accelerate patient recovery, shorten the hospital length of stay (LOS), lower readmission and mortality rates, and reduce hospitalization costs. Previous consensus guidelines have strengthened surgeons' understanding of airway management, lung function protection, and the reduction of pulmonary complications (2-4). This has facilitated a more effective and integrated approach to perioperative airway management and ERAS.

In recent years, new evidence in airway management has highlighted the need to update the multidisciplinary international expert consensus on perioperative airway management. This update integrates clinical practice experience with the latest research findings from both domestic and international studies to ensure more rational and standardized application of airway management in clinical practice.

Highlight box

Key findings

- We recommend implementing non-intubated airway management for suitable patients to enhance airway status and expedite recovery, utilizing inhalation therapy tailored to perioperative airway conditions to improve patient outcomes, and providing personalized airway management for patients with coexisting pulmonary diseases to improve surgical safety and reduce complications.

What was recommended and what is new?

- Earlier expert consensus on perioperative airway management emphasized topics such as preoperative pulmonary function assessment, preoperative smoking cessation, and postoperative pulmonary rehabilitation.
- This consensus updates previously highly focused areas and places emphasis on non-intubated approaches, inhalation therapy, and the management of comorbid pulmonary diseases during the perioperative period.

What is the implication, and what should change now?

- This expert consensus implicates the continual advancements in surgical techniques, anesthesia methods, and pharmacological developments, recommending their integration into perioperative airway management to enhance patient outcomes. It emphasizes the necessity of individualized airway management tailored to unique disease profiles. Future clinical studies focusing on perioperative airway management in specific patient populations are essential to provide robust clinical evidence, thereby facilitating personalized perioperative care.

Methods

A comprehensive search was conducted on PubMed. Original articles published in English before June 2024 were included. Combinations of the following terms were searched online: "airway management", "multidiscipline", "perioperative", "preoperative", "postoperative", "lung function", "rehabilitation", "anesthesia", "tubeless", "surgery", "asthma", "obstructive sleep apnea syndrome", "pulmonary fibrosis", and "chronic obstructive pulmonary disease". Furthermore, previous consensuses about airway

management have also been scanned to avoid missing any qualified study.

To develop this consensus recommendation, we employed a modified Delphi method involving the following steps. A panel consisting of 62 domestic experts with relevant expertise in thoracic surgery, otolaryngology, general surgery, cardiac surgery, anesthesiology, and nursing fields were assembled to discuss and vote on preliminary recommendations. During an initial face-to-face meeting, all domestic experts engaged in discussions followed by a voting process to establish consensus on each recommendation. A minimum threshold of 70% agreement among participants was set to define consensus. Following the initial consensus-building phase, the draft recommendations were circulated to 18 international experts via email for their feedback and suggestions. This step ensured that the recommendations were informed by diverse perspectives and expertise. The titles of all discussed topics along with the rate of agreement for each are listed in *Table 1*. Personal points of view of different experts is included in the Appendix 1.

Consensus 1: preoperative airway preparation

(I) In which cases do you recommend that pulmonary ventilation and diffusion tests be routinely indicated? Preoperative pulmonary ventilation and diffusion function tests are recommended for elderly patients and those with pulmonary comorbidities. For patients undergoing pulmonary surgery, these tests are routinely required as they can not only predict the risk of perioperative complications and long-term quality of life, but also provide an objective basis for surgical decision-making (agreement rate 90%).

(II) For which patients are preoperative exercise tests necessary? Preoperative exercise tests are recommended for elderly patients and those with cardiopulmonary diseases. Exercise tests are recommended for pulmonary surgery when either the predicted postoperative forced expiratory volume in the first second (ppoFEV1) or the predicted postoperative diffusion capacity of carbon monoxide (ppoDLco) is below 60% (agreement rate 85%).

(III) Under what circumstances is arterial blood gas analysis advised? Arterial blood gas analysis is recommended for patients with symptoms of respiratory failure, severe respiratory comorbidities, or when pulmonary function tests are difficult to perform (agreement rate 97.5%).

(IV) How should a patient be managed if airway hyperresponsiveness (AHR), unstable asthma or chronic obstructive pulmonary disease (COPD) surgery be delayed in favor of using inhaled corticosteroids (ICS) with bronchodilators? If a patient is found to have AHR, unstable asthma or COPD during preoperative evaluation, the use of ICS in combination with bronchodilators, such as ICS + long-acting beta-agonists (LABA) or ICS + LABA + long-acting muscarinic antagonists (LAMA), is recommended and surgery should be temporarily delayed until a new evaluation is obtained, if possible (agreement rate 75%).

(V) Who should receive preoperative breathing and aerobic training? Preoperative breathing and aerobic training are recommended, especially for patients at high risk of postoperative complications, as they benefit more from prehabilitation (agreement rate 85%).

(VI) How should smoking cessation be managed prior to surgery? Smoking cessation at least 2 weeks before surgery is recommended. Patients should still be encouraged to quit smoking for as long as possible if they cannot follow a 2-week smoking cessation plan (agreement rate 75%).

(VII) For which patients is preoperative weight management and obstructive sleep apnea syndrome (OSAS) screening advised? Preoperative weight management is recommended for patients who are malnourished or obese before elective surgery. High-risk obese patients should also undergo screening for OSAS (agreement rate 75%).

(VIII) What should be done if airway obstruction is found on preoperative computed tomography (CT)? Bronchoscopy is advised for patients with airway stenosis seen on chest CT scan (agreement rate 100%).

Preoperative pulmonary function assessment plays a critical role in predicting surgical outcomes and postoperative complications, as well as guiding the selection of surgical type and scope. Pulmonary ventilation and diffusion function tests are routine preoperative examinations in pulmonary surgery. For non-thoracic surgery patients, these tests are recommended for elderly patients and those with heart or lung diseases. Due to significant individual differences, relying solely on the absolute value of forced expiratory

Table 1 List of consensus and agreement rate

Recommendation	Agreement rate (%)
Consensus 1: preoperative airway preparation	
Preoperative pulmonary ventilation and diffusion function tests are recommended for elderly patients and those with pulmonary comorbidities. For patients undergoing pulmonary surgery, these tests are routinely required as they can not only predict the risk of perioperative complications and long-term quality of life, but also provide an objective basis for surgical decision-making	90
Preoperative exercise tests are recommended for elderly patients and those with cardiopulmonary diseases. Exercise tests are recommended for pulmonary surgery when either the ppoFEV1 or the ppoDLco is below 60%	85
Arterial blood gas analysis is recommended for patients with symptoms of respiratory failure, severe respiratory comorbidities, or when pulmonary function tests are difficult to perform	97.5
If a patient is found to have AHR, unstable asthma or COPD during preoperative evaluation, the use of ICS in combination with bronchodilators, such as ICS + LABA or ICS + LABA + LAMA, is recommended and surgery should be temporarily delayed until a new evaluation is obtained, if possible	75
Preoperative breathing and aerobic training are recommended, especially for patients at high risk of postoperative complications, as they benefit more from prehabilitation	85
Smoking cessation at least 2 weeks before surgery is recommended. Patients should still be encouraged to quit smoking for as long as possible if they cannot follow a 2-week smoking cessation plan	75
Preoperative weight management is recommended for patients who are malnourished or obese before elective surgery. High-risk obese patients should also undergo screening for OSAS	75
Bronchoscopy is advised for patients with airway stenosis seen on chest CT scan	100
Consensus 2: anesthesia management	
Using a laryngeal mask airway for airway management can be applied in various types of surgical procedures to reduce airway epithelial damage caused by endotracheal intubation. For thoracic surgery, patients who are suitable for non-intubated spontaneous breathing anesthesia (tubeless VATS technique) should be taken to consideration	95
When performing endotracheal intubation, select the appropriate tube size and use a video laryngoscope for guidance. During ventilation, follow lung-protective ventilation principles	100
Intravenous propofol, combined with volatile anesthesia, is recommended as the primary maintenance drug. Short-acting anesthetics should be used to facilitate faster postoperative extubation	100
The use of a steroid muscular relaxant is recommended because the antagonist sugammadex can rapidly and completely reversed it, facilitating faster extubation	90
Intraoperative bronchospasm should be relieved with bronchodilators and intravenous corticosteroids or aminophylline	100
Fluid management during anesthesia is crucial to prevent postoperative pulmonary edema or sputum retention caused by airway dryness	100
Consensus 3: surgical approach	
Preoperative surgical path planning is essential to shorten the operation time and preserve normal structures that do not need to be damaged	100
For pulmonary surgery, it is recommended to preserve as much lung tissue as possible while ensuring radical tumor resection. Sleeve resection is recommended even in case of patient with good functional status and after neoadjuvant therapy	90
For laryngotracheal surgery, it is essential to prevent foreign objects from entering the airway and to protect the airway from damage by surgical instruments. Airway management should be crucial even during tracheal resection by cross-field intubation	100

Table 1 (*continued*)

Table 1 (*continued*)

Recommendation	Agreement rate (%)
Consensus 4: postoperative airway management	
Postoperative ICS + LABA + LAMA can help alleviate persistent cough after pulmonary resection	80
Patients who are able to walk should begin early mobilization. For those who cannot mobilize, healthcare personnel should assist with frequent repositioning to prevent hypostatic pneumonia	100
Preventing postoperative sputum retention is crucial. Effective early postoperative cough, combined with mechanical sputum clearance and the use of intravenous ambroxol or oral acetylcysteine to reduce sputum viscosity, are recommended	100
Postoperative individualized rehabilitation exercise is recommended for thoracic surgery, even though it is controversial if it reduces postoperative complications or shortens LOS. However, it can improve activity levels and quality of life after surgery	100
CPAP or NIV can be considered for acute respiratory failure but are not used routinely	85
Postoperative pain can limit adequate sputum clearance, especially after chest and abdominal surgeries. Effective postoperative pain relief facilitates sputum clearance and reduces pulmonary complications. We recommend a multimodal analgesia regimen based on NSAIDs, while minimizing the use of opioid analgesics	95
If there is no lung air leak, the postoperative chest drainage tube should be removed promptly. Be vigilant for pleural effusion following major upper abdominal surgery	95
Consensus 5: management of coexisting respiratory diseases	
It is recommended that patients with asthma control their symptoms as much as possible before surgery. Perioperative bronchospasm should be closely monitored	95
ICS + LABA + LAMA perioperatively is recommended for patients with COPD. Be vigilant for postoperative respiratory failure and provide respiratory support promptly if needed	90
Monitor for perioperative hypoxemia in patients with OSAS. Tracheal intubation is recommended for surgery, and postoperative care should avoid the supine position to prevent airway obstruction	85
For patients with pulmonary fibrosis, there are higher postoperative complications and long-term mortality rates. A sub-lobar resection may help reduce acute exacerbation of postoperative pulmonary fibrosis	95
A multidisciplinary consultation is recommended for patients with multiple respiratory diseases or complex respiratory conditions to evaluate surgical risk	100

AHR, airway hyperresponsiveness; COPD, chronic obstructive pulmonary disease; CPAP, continuous positive airway pressure; CT, computed tomography; ICS, inhaled corticosteroids; LABA, long-acting beta-agonists; LAMA, long-acting muscarinic antagonists; LOS, length of stay; NIV, non-invasive ventilation; NSAIDs, nonsteroidal anti-inflammatory drugs; OSAS, obstructive sleep apnea syndrome; ppoDLco, predicted postoperative diffusion capacity of carbon monoxide; ppoFEV1, predicted postoperative forced expiratory volume in the first second; VATS, video-assisted thoracoscopic surgery.

volume in the first second (FEV1) for screening may be biased. By considering factors such as gender, height, weight, and age, the use of ppoFEV1 as a percentage of the expected value better addresses individual variability (5). The diffusion function is primarily measured through the diffusion capacity of carbon monoxide (DLco) (6). Both FEV1 and DLco are independent factors in predicting postoperative complications and mortality following pulmonary resection. When both ppoFEV1 and ppoDLco are greater than 60%, surgery is considered low risk (7). Puente-Maestú *et al.* (8) show that postoperative complications significantly increase when ppoFEV1 or ppoDLco is as low as 30% to 40%. Ferguson *et al.* (9) show that when ppoFEV1 or ppoDLco is <30%, the all-cause mortality rate rises significantly. When both ppoDLco and ppoFEV1 are greater than or equal to 40% but either or both are less than 60%, a low-technology cardiopulmonary exercise test (CPET) like a stair-climbing test (SCT) or a shuttle walk test (SWT) is required. If either ppoFEV1 or ppoDLco is less than 40%, a comprehensive CPET is necessary, and a multidisciplinary consultation

with anesthesiology and pulmonology is recommended to assess surgical risk (10). Preoperative pulmonary function tests can also help detect undiagnosed chronic respiratory diseases, such as COPD (11). If preoperative pulmonary function show airflow limitation, such as FEV1/FVC <0.7, bronchodilator test is advised and a respiratory consultation should be requested to determine whether there is COPD or asthma (12,13).

Preoperative exercise tests, including CPET and low technology exercise tests, help assess cardiopulmonary capacity. For non-pulmonary surgery, exercise tests are recommended for elderly patients and those with underlying cardiopulmonary diseases. Preoperative exercise tests are recommended for patients whose ppoFEV1 or ppoDLco is less than 60% for pulmonary surgery. SCT or SWT can be considered when ppoFEV1 and ppoDLco are both greater than or equal to 40% but either is less than 60% (14,15). A meta-analysis from Boujibar *et al.* (16) demonstrated that an SCT distance of less than 10 meters was associated with a high risk for surgery, with a relative risk (RR) of 2.34 [95% confidence interval (CI): 1.59–3.43]. Win *et al.* (17) suggested SWT <400 meters indicates high surgical risk. CPET is recommended when either ppoFEV1% or ppoDLco% is less than 40% or SCT or SWT indicates high risk. A meta-analysis from Arbee-Kalidas *et al.* (18), including 37 studies with 6,450 patients, suggested that a higher maximum oxygen consumption (VO_2max) was significantly associated with a lower risk of mortality [mean difference (MD) =3.66; 95% CI: 0.88–6.43] and fewer complications (MD =2.06; 95% CI: 1.12–3.00). Patients with a VO_2max greater than 20 mL/(kg·min) are considered relatively safe for surgery (19). When VO_2max is between 10–20 mL/(kg·min), the extent of surgical resection should be calculated based on the patient's specific condition. VO_2max less than 10 mL/(kg·min) is associated with high postoperative mortality and complication rates (15,20). For patients with exercise tests, previous history of coronary disease, as well as active symptoms indicating high risk, further cardiology assessment with cardiac coronary CT or coronary angiography is necessary to evaluate coronary artery status. Additionally, a multidisciplinary consultation involving cardiology, pulmonology, and anesthesiology is recommended to assess the surgical risk thoroughly (21).

Arterial blood gas analysis can be performed on patients with symptoms of respiratory failure, severe respiratory diseases, or when pulmonary function tests cannot be obtained. This test can reveal conditions such as hypoxemia or hypercapnia (22). Routine blood gas analysis is unnecessary for younger patients in good physical condition, as arterial blood gas sampling is painful and offers limited clinical benefit.

Patients with AHR are at an increased risk of experiencing bronchospasm during and after surgery. If the preoperative evaluation reveals that a patient has AHR, unstable asthma or COPD, pre-treatment with ICS combined with bronchodilators, such as ICS + LABA or ICS + LABA + LAMA, is recommended. This pre-treatment strategy helps to stabilize the airway, reduce inflammation, and minimize the risk of perioperative respiratory complications.

Preoperative exercises like breathing exercises and aerobic training are beneficial. A meta-analysis from Xu *et al.* (23) found that preoperative interventions significantly reduced the risk of postoperative pulmonary complications [odds ratio (OR) =0.32; 95% CI: 0.22–0.47] and shortened the LOS [weighted mean difference (WMD) =–1.68 days; 95% CI: –2.23 to –1.13]. A meta-analysis from Gravier *et al.* (24), including 14 studies with involvement of 791 participants, reported that preoperative exercise could reduce postoperative complications (RR =0.58; 95% CI: 0.45–0.75) and recommended prehabilitation programs of no less than 2 weeks to improve preoperative criteria and reduce postoperative complications effectively. We also support the effectiveness of such short-term exercise programs, as they are unlikely to delay surgery and show good patient compliance. It is important to note that a previous study suggested that the benefits of preoperative exercise may be insignificant for low-risk patients (25). However, high-risk patients, particularly those with poor preoperative lung function or concomitant lung diseases, are more likely to benefit from preoperative exercise (26).

Several studies have shown that active smoking increases the risk of postoperative complications. A meta-analysis from Mills *et al.* (27), including 6 randomized controlled trials (RCTs) and 15 observational studies, indicated that smoking abstinence for at least 4 weeks or longer may be associated with reduced perioperative respiratory complications. However, the included RCTs did not specifically study the impact of smoking cessation on lung surgery. Fukui *et al.* (28) suggested that smoking cessation at any time before surgery benefits postoperative outcomes for lung resection. Kadomatsu *et al.* (29) did not find a definitive relationship between the duration of smoking cessation and the incidence of postoperative complications, suggesting that it is unnecessary to delay surgery for the sake of smoking cessation duration. Considering that the

previously recommended 4-week cessation period might delay surgery, we recommend at least 2 weeks of smoking cessation before surgery (27). If the patients are unable or do not have the time to follow a 2-week smoking cessation plan, such as those with large central tumor, they should still be encouraged to quit smoking for whatever duration possible. The smoking cessation of 2 weeks should not be treated as an "all or none" rule.

Studies have reported more significant morbidity and longer LOS in underweight patients compared to obese or overweight patients (30-32). Obesity itself is not a contraindication for lung resection, but it may be associated with increased difficulties with intubation and longer surgery times (32). The previous study also indicates that obese patients may have increased airway inflammation and a higher risk for OSAS (31). Therefore, it is recommended that underweight patients improve their nutritional status. Obese patients, especially those undergoing neoadjuvant therapy or elective surgeries, should aim for weight reduction. Additionally, they should undergo OSAS screening using tools like the Nutritional Risk Score (NRS), the Malnutrition Universal Screening Tool (MUST), and the Subjective Global Assessment.

Second-time thoracic surgery brings its own technical challenges. Second-time surgery on the same side is associated with significant intrapleural adhesions, longer operative duration and a greater likelihood of needing to perform surgery via thoracotomy. Second-time surgery performed on the opposite side to the first operation means that single lung ventilation is a particular challenge, as the ventilated lung may only consist of a single lobe. For patients undergoing a second-time lung surgery, blood flow and ventilation redistribution can result in disproportionate lobe function. Pulmonary imaging with ventilation-perfusion is recommended to assess the function of each lobe (33,34). This helps determine the ventilation and perfusion status of each lobe, guiding the surgical plan and avoiding severe pulmonary function impairment. Bronchoscopy is advised for patients with airway obstruction seen on a chest CT scan as this may add specific information about the airway involvement, the need for preoperative rigid endoscopy to recover the bronchial canalization and accurately evaluate the base implant of the tumor.

Consensus 2: anesthesia management

(I) For which procedures is a laryngeal mask airway recommended to reduce airway epithelial damage? Using a laryngeal mask airway for airway management can be applied in various types of surgical procedures to reduce airway epithelial damage caused by endotracheal intubation. For thoracic surgery, patients who are suitable for non-intubated spontaneous breathing anesthesia [tubeless video-assisted thoracoscopic surgery (VATS) technique] should be taken to consideration (agreement rate 95%).

(II) How should endotracheal intubation be performed to follow lung-protective principles? When performing endotracheal intubation, select the appropriate tube size and use a video laryngoscope for guidance. During ventilation, follow lung-protective ventilation principles (agreement rate 100%).

(III) Which anesthesia maintenance strategy is recommended for faster postoperative extubation? Intravenous propofol, combined with volatile anesthesia, is recommended as the primary maintenance drug. Short-acting anesthetics should be used to facilitate faster postoperative extubation (agreement rate 100%).

(IV) How should a muscle relaxant be selected? The use of a steroid muscular relaxant is recommended because the antagonist sugammadex can rapidly and completely reversed it, facilitating faster extubation (agreement rate 90%).

(V) How should intraoperative bronchospasm be managed? Intraoperative bronchospasm should be relieved with bronchodilators and intravenous corticosteroids or aminophylline (agreement rate 100%).

(VI) What should be considered in fluid management during anesthesia? Fluid management during anesthesia is crucial to prevent postoperative pulmonary edema or sputum retention caused by airway dryness (agreement rate 100%).

The primary goals of intraoperative anesthesia management include minimizing pulmonary and systemic inflammatory responses and facilitating early extubation. A laryngeal mask is a supraglottic airway device that does not require insertion into the trachea, theoretically reducing damage to the airway epithelium. It can be easily and safely used for laryngotracheal surgery, in particular for the airway management during laryngotracheal and cervical trachea resection and reconstruction (35). Many disciplines have conducted RCTs to verify the feasibility of laryngeal mask airway management (36-39). For selected patients, the tubeless VATS technique is the optimal choice for ERAS in experienced centers. Compared to the tracheal intubation method, the tubeless VATS technique uses a laryngeal

mask, which avoids damage to the airway mucosa and vocal cords caused by intubation, thereby reducing the incidence of postoperative coughing (40,41). The tubeless VATS technique minimizes the use of muscle relaxants, enhancing postoperative tracheal ciliary movement and sputum clearance. Additionally, it can shorten the LOS and benefit postoperative cognitive function (41,42). The tubeless VATS technique uses a laryngeal mask to assist in airway management, maintaining low tidal volume ventilation to ensure adequate oxygenation (43,44). Reasons for converting from tubeless VATS technique to intubation include persistent hypoxemia (PaO_2 <60 mmHg or SpO_2 <90%), severe hypoxemia (PaO_2 <55 mmHg or SpO_2 <85%), severe hypercapnia ($PaCO_2$ >70–80 mmHg), and acidosis (pH <7.1) (45,46). For safety reasons, a single-lumen endotracheal tube should always be prepared for emergencies, and a bronchoscope should be available to ensure safe access to the bronchial system (47). Anesthesiologists should be skilled in intubating patients in the lateral decubitus position. Tubeless VATS is not yet fully implemented worldwide, but it is being actively promoted globally. In China, its adoption is progressing very rapidly. Further research is needed to better highlight its clinical utility and support its broader application in clinical practice.

If tubeless VATS surgery is not possible or safety conditions are not met, double lumen tube placement continues to be the preferred option in most thoracic surgery centers.

The selection of an appropriately sized endotracheal tube is paramount to minimizing airway damage during endotracheal intubation. Applying lidocaine or beclomethasone spray during intubation can increase patient comfort with the tube and effectively reduce postoperative coughing (48,49). Using a video laryngoscope for intubation guidance helps the speed and success of positioning and reduces mal-positioning rates (50,51). In thoracic surgery, a double-lumen tube (DLT) is preferred for single-lung ventilation. A tidal volume of 6–8 mL/kg ideal body weight should be used during double-lung ventilation, along with appropriate positive end-expiratory pressure (PEEP) and lung recruitment maneuvers. Before one-lung ventilation, preoxygenation with pure oxygen can accelerate the collapse of the surgical side lung (1). During one-lung ventilation, a tidal volume of ≤6 mL/kg ideal body weight should be set, along with PEEP of 5–10 cmH_2O, and the lowest fraction of inspired oxygen (FiO_2) necessary to maintain satisfactory arterial oxygen saturation (52). Peak airway pressure should not exceed 35 cmH_2O, and plateau pressure should not exceed 25 cmH_2O, $PaCO_2$ is usually maintained at 35–45 mmHg (53). Both volume-controlled and pressure-controlled ventilation modes can be used, but pressure-controlled ventilation is recommended first if there are high-risk factors for lung injury (53).

Intravenous anesthesia with propofol and remifentanil, combined with inhalational anesthesia using sevoflurane or desflurane, can be used to maintain anesthesia in thoracic surgery (54). Using short-acting anesthetics as much as possible can shorten postoperative extubation time and reduce complications (1). Volatile anesthesia can reduce systemic and local inflammatory responses, but only subgroup analyses suggest that patients with severe surgical injuries benefit from the anti-inflammatory effects of volatile anesthetics (55). This anti-inflammatory effect does not show clinical significance in less severe cases. Tubeless VATS technique using vagal nerve blockade, intercostal nerve blockade, and pleural surface local anesthetic spraying to anesthetize specific nerves or regions, can lead to lower amounts of anesthetics used (56-58).

We recommend using steroid muscular relaxants, such as rocuronium (59,60). As non-steroid muscular relaxants cannot be completely reversed, whereas steroid muscular relaxants can be fully antagonized by sugammadex (61). Sugammadex is significantly faster than neostigmine in reversing neuromuscular blockade, with 2 mg/kg of sugammadex reversing moderate blockade 10.22 minutes (6.6 times) quicker than neostigmine 0.05 mg/kg, and 4 mg/kg reversing deep blockade 45.78 minutes (16.8 times) faster than neostigmine 0.07 mg/kg (62). In addition, sugammadex appears to have a better safety profile than neostigmine, with 40% fewer adverse events (62).

In the event of intraoperative bronchospasm, it should be promptly managed to ensure airway patency. Continuous oxygen inhalation should be maintained to provide adequate ventilation. The first choice for inhaled bronchodilators is terbutaline spray, administered repeatedly through the mouth or endotracheal tube, in combination with intravenous corticosteroids or aminophylline to relieve bronchospasm (63). These measures can quickly alleviate bronchospasm and ensure the smooth progression of the surgery.

Controlling the speed and volume of fluid administration during anesthesia is essential. Excessive or rapid infusion can lead to pulmonary edema and diffusion impairment (64). Insufficient fluid administration or excessive diuresis can cause dehydration, airway dryness, weakened mucociliary clearance, sputum retention, and even atelectasis.

Additionally, if the anesthesia duration is prolonged or if there are excessive airway secretions, intermittent bronchoscopic suctioning should be performed promptly to maintain airway patency.

Consensus 3: surgical approach

(I) How important is preoperative surgical path planning for improving surgical outcomes? Preoperative surgical path planning is essential to shorten the operation time and preserve normal structures that do not need to be damaged (agreement rate 100%).

(II) How should lung tissue be handled during pulmonary surgery to ensure both tumor resection and preservation? For pulmonary surgery, it is recommended to preserve as much lung tissue as possible while ensuring radical tumor resection. Sleeve resection is recommended even in case of patient with good functional status and after neoadjuvant therapy (agreement rate 90%).

(III) What precautions should be taken during laryngotracheal surgery to protect the airway? For laryngotracheal surgery, it is essential to prevent foreign objects from entering the airway and to protect the airway from damage by surgical instruments. Airway management should be crucial even during tracheal resection by cross-field intubation (agreement rate 100%).

Preoperative surgical planning is crucial. Shortening surgery time can reduce anesthesia duration and airway intubation time, thereby lowering the risk of postoperative airway complications. Ideally, surgical techniques should employ minimally invasive methods and instrumention to minimize injury of tissue. If conditions permit, it is advisable to perform preoperative three-dimensional reconstruction to clarify the surgical approach (65). Preserving typical structures in the surgical area as much as possible, such as branches of the vagal nerve and bronchial arteries during lung surgery, can reduce intraoperative and postoperative airway injury and inflammatory responses, helping to minimize postoperative cough (66,67).

For pulmonary surgery it is recommended that as much lung tissue is preserved as possible while meeting the oncological requirement (68). Minimizing lung tissue loss and avoiding excessive lymph node dissection are crucial to reducing postoperative respiratory complications. The JCOG0802 multi-center study (69) found that anatomical segmentectomy improved overall survival compared to lobectomy for peripheral stage IA non-small cell lung cancer (NSCLC), although it nearly doubled the local recurrence rate. Similarly, the CALGB 140503 study (70) showed no significant differences in overall survival or disease-free survival between sublobar resection and lobectomy for node-negative, peripheral stage IA NSCLC. These large, rigorous studies suggest that sublobar resection may be non-inferior in survival for patients with small, peripheral tumors. Moreover, less extensive resection implies less surgical trauma, which helps reduce airway complications caused by inflammation (41). Sleeve resection (bronchial and/or vascular) can avoid pneumonectomy in many cases of centrally-located lung cancer. It is recommended even in case of patient with good functional status and after neoadjuvant therapy (71). In case of laryngotracheal resection and reconstruction a laryngeal mask can be safely and easily used, moreover is recommended the use of cross-field ventilation of the distal tracheal stump after tracheal resection, and during the end-to-end reconstruction phase (35).

For otolaryngology surgeries, particularly those involving the use of a suspension laryngoscope within the airway, it is essential to ensure that the endotracheal tube cuff fully seals the airway to prevent blood, secretions, or foreign objects from entering the trachea during the procedure. Additionally, precautions must be taken in order to avoiding the ignition of flammable gases by laser or other thermal devices, which could damage the airway. Care should also be taken to prevent excessive airway pressure caused by surgical instruments' compression of the endotracheal tube by surgical instruments, as this can lead to CO_2 retention.

Consensus 4: postoperative airway management

(I) How can persistent cough after pulmonary resection be managed? Postoperative ICS + LABA + LAMA can help alleviate persistent cough after pulmonary resection (agreement rate 80%).

(II) When should early mobilization be initiated post-surgery, and what measures should be taken for patients who cannot mobilize? Patients who are able to walk should begin early mobilization. For those who cannot mobilize, healthcare personnel should assist with frequent repositioning to prevent hypostatic pneumonia (agreement rate 100%).

(III) What strategies are recommended to prevent postoperative sputum retention? Preventing postoperative sputum retention is crucial. Effective early postoperative cough, combined with mechanical

sputum clearance and the use of intravenous ambroxol or oral acetylcysteine to reduce sputum viscosity, are recommended (agreement rate 100%).

(IV) Should postoperative rehabilitation exercise be implemented after thoracic surgery? Postoperative individualized rehabilitation exercise is recommended for thoracic surgery, even though it is controversial if it reduces postoperative complications or shortens LOS. However, it can improve activity levels and quality of life after surgery (agreement rate 100%).

(V) When can continuous positive airway pressure (CPAP) or non-invasive ventilation (NIV) be considered post-surgery? CPAP or NIV can be considered for acute respiratory failure but are not used routinely (agreement rate 85%).

(VI) What is the impact of postoperative pain and how can it be controlled? Postoperative pain can limit adequate sputum clearance, especially after chest and abdominal surgeries. Effective postoperative pain relief facilitates sputum clearance and reduces pulmonary complications. We recommend a multimodal analgesia regimen based on nonsteroidal anti-inflammatory drugs (NSAIDs), while minimizing the use of opioid analgesics (agreement rate 95%).

(VII) When should a postoperative chest drainage tube be removed? If there is no lung air leak, the postoperative chest drainage tube should be removed promptly. Be vigilant for pleural effusion following major upper abdominal surgery (agreement rate 95%).

The incidence of postoperative persistent coughing is relatively high and significantly impacts quality of life. Sawada *et al.* (72) reported that ICS and bronchodilators can alleviate postoperative coughing. A recent RCT that was presented at the American Association of Thoracic Surgery demonstrated that postoperative use of the ICS + LABA + LAMA significantly reduced the incidence of persistent postoperative cough (13.73% *vs.* 40.38%, P<0.05) (73). This may be explained by the fact that surgical trauma can induce airway inflammatory responses, leading to AHR and bronchospasm (74). The combination of ICS and bronchodilators reduces inflammation and airway spasms, thereby decreasing the occurrence of postoperative cough.

Patients who are able to walk should begin early mobilization as soon as possible. Early mobilization is beneficial because it helps improve circulation, reduces the risk of blood clots, and promotes faster recovery (75). Additionally, it can enhance muscle strength and prevent muscle atrophy, thereby improving overall physical function. For patients who are intubated or unable to ambulate, healthcare personnel should assist with frequent repositioning. Repositioning is crucial in preventing hypostatic pneumonia, which can occur when patients remain in one position for too long (76). By regularly changing positions, the lungs are encouraged to fully expand, which helps in clearing secretions and maintaining respiratory function. Additionally, repositioning helps prevent pressure ulcers and other complications associated with prolonged immobility, contributing to a quicker recovery process.

Promoting clearance of airway secretions is critical to postoperative airway management, as poor secretion clearance can lead to inadequate lung re-expansion and an increased risk of pulmonary infection (77). Mechanical airway clearance can effectively promote secretion removal (78). Intravenous ambroxol or oral acetylcysteine can encourage the clearance of sputum (79,80). Effective active coughing postoperatively also aids in secretion removal (81).

Wang *et al.* (82) suggested that postoperative exercise training could significantly improve the quality of life of patients undergoing pulmonary surgery, as measured using short form 36 healthy survey (SF-36) physical and mental domain scores. Additionally, postoperative exercise may improve physical activity and cough symptoms after pulmonary resection (83,84). However, a meta-analysis from Xu *et al.* (23) suggested interventions delivered during the immediate postoperative period did not have any significant effects on either postoperative pulmonary complication (OR =0.85; 95% CI: 0.56 to 1.29) or LOS (WMD =–0.23 days; 95% CI: –1.08 to 0.63). Taken together, based on current evidence, postoperative exercise may or may not reduce the occurrence of postoperative complications or shorten LOS, but it probably improves the quality of life, postoperative activity level and cough symptoms.

A multicenter RCT conducted by Abrard *et al.* (85) where the most patients underwent cardiac and pulmonary surgeries demonstrated that prophylactic NIV does not reduce the incidence of acute respiratory failure. Lorut *et al.* (86) suggested prophylactic postoperative NIV did not reduce the rate of adverse events in COPD patients undergoing lung resection surgery and did not influence other postoperative complications rates, mortality rates, and duration of intensive care unit (ICU) and hospital stay. A meta-analysis by Lockstone *et al.* (87), which included 17 studies, confirmed that prophylactic postoperative CPAP or NIV did not reduce postoperative pulmonary complications.

Although these patients would seem to be the ones most likely to benefit with postoperative non-invasive ventilatory support, yet well-designed RCTs have confirmed its ineffectiveness. Thus, the routine use of CPAP or NIV to prevent postoperative complications has yet to be proven effective to date. However, for patients with postoperative acute respiratory failure, CPAP and NIV are still valuable as they help reduce the reintubation rate and improve perioperative outcomes (88,89). High-flow nasal cannula (HFNC) offers several advantages, including improved oxygenation, better patient comfort, and reduced airway resistance compared to traditional oxygen therapy methods. Post hoc analysis of an RCT (90) showed HFNC is not inferior to NIV in terms of treatment failure rates (13.3% *vs.* 15.4%, respectively, P=0.62), ICU mortality (2.2% *vs.* 5.9%, P=0.22), length of ICU stay (median 5.0 *vs.* 4.0 days, P=0.63), or length of hospital stay (median 10.0 *vs.* 11.1 days, P=0.71). However, skin breakdown at 24 hours was significantly more common with NIV than with HFNC (9.2% *vs.* 1.6%, respectively, P=0.01). Furthermore, when acute respiratory failure does occur, HFNC can be an effective treatment modality either on its own or in conjunction with CPAP or NIV (91).

Postoperative pain can limit effective coughing, leading to inadequate clearance of sputum and airway secretions. This increases the risk of atelectasis and pulmonary infections. Therefore, individualized pain management should be emphasized, and preventive and multimodal analgesia should be advocated. Using NSAIDs as the foundation of a multimodal pain management approach can reduce the need for opioids (92). This can be combined with various methods to enhance pain control, such as patient-controlled analgesia (PCA) pumps, local wound infiltration, intercostal nerve blocks, and paravertebral blocks (93-95).

For thoracic surgery, the drainage tube should be removed as soon as possible if there is no pulmonary air leak. A meta-analysis conducted by Zhang *et al.* (96) suggests that it is generally safe to remove the drainage tube when the 24-hour drainage volume is less than 300 mL, provided that bleeding and chylothorax are excluded. Additionally, other prospective studies have demonstrated that the removal of the drainage tube is safe when the volume is less than 450–500 mL (97,98).

Consensus 5: management of coexisting respiratory diseases

(I) What should be considered during the perioperative period for patients with asthma? It is recommended that patients with asthma control their symptoms as much as possible before surgery. Perioperative bronchospasm should be closely monitored (agreement rate 95%).

(II) What should be considered during the perioperative period for patients with COPD? ICS + LABA + LAMA perioperatively is recommended for patients with COPD. Be vigilant for postoperative respiratory failure and provide respiratory support promptly if needed (agreement rate 90%).

(III) What should be considered during the perioperative period for patients with OSAS? Monitor for perioperative hypoxemia in patients with OSAS. Tracheal intubation is recommended for surgery, and postoperative care should avoid the supine position to prevent airway obstruction (agreement rate 85%).

(IV) What should be considered during the perioperative period for patients with pulmonary fibrosis? For patients with pulmonary fibrosis, there are higher postoperative complications and long-term mortality rates. A sub-lobar resection may help reduce acute exacerbation of postoperative pulmonary fibrosis (agreement rate 95%).

(V) When should a multidisciplinary consultation be considered for patients with complex respiratory conditions? A multidisciplinary consultation is recommended for patients with multiple respiratory diseases or complex respiratory conditions to evaluate surgical risk (agreement rate 100%).

Patients with a recent history of acute exacerbation of asthma or who have experienced acute exacerbations have a higher likelihood of bronchospasm during and after surgery (99). Therefore, it is crucial to assess asthma control preoperatively. Patients with well-controlled asthma should maintain their current medication regimen before surgery. Patients with poorly controlled asthma should upgrade their regimens to ICS + LABA, ICS + LABA + LAMA, or even add systemic corticosteroids. Ideally, surgery should be performed after achieving complete asthma control. If asthma cannot be controlled in the short term or if the patient has a history of acute exacerbation within the past 6 months, a reevaluation of surgical and anesthetic risk is required. Preoperative use of short-term systemic corticosteroids for 3–5 days may reduce the likelihood of intraoperative bronchospasm (100). During intubation, gentle technique is essential as it can trigger bronchospasm. Postoperative NIV or CPAP may benefit patients with

persistent airway spasms after extubation.

The perioperative administration of ICS + LABA + LAMA can effectively improve airflow limitation in COPD, suppress inflammatory responses, reduce airway spasms, and alleviate lung hyperinflation and respiratory symptoms. Mucolytics should be used preoperatively for patients with excessive airway secretions (101). Protective ventilation strategies during surgery are recommended. It is essential to monitor closely for signs of respiratory distress after extubation. If such symptoms arise, prompt use of CPAP or NIV is necessary to ensure perioperative safety. Perioperative combined use of ICS and bronchodilators can effectively improve patients' respiratory function (102). Using ICS + LABA + LAMA is better than LABA + LAMA in improving lung function and postoperative outcomes in patients with lung cancer combined with COPD (103).

Patients with OSAS are prone to airway obstruction and hypoxemia during the perioperative period. If hypoxemia is present preoperatively, NIV or CPAP is recommended. During anesthesia, tracheal intubation is preferred for airway management. It is advisable to perform the extubation when the patient is awake and in a lateral or semi-upright position to prevent airway obstruction. Maintaining a semi-upright position is essential to post-extubation, and continuing to use of NIV or CPAP, if used preoperatively is crucial. Continuous monitoring of blood oxygen saturation is crucial.

Patients with pulmonary fibrosis who undergo pulmonary surgery have higher rates of complications and long-term mortality (104-106). Preoperative ventilatory function is usually normal, so the evaluation of diffusion capacity is crucial. Nintedanib, an antifibrotic agent, is used in the treatment of pulmonary fibrosis; however, its perioperative use to mitigate acute exacerbations remains controversial due to concerns regarding its potential to delay wound healing while it has been shown to slow the progression of fibrosis (107). A smaller resection extent may reduce postoperative complications, and the tubeless VATS technique might be suitable for these patients (108,109).

A multidisciplinary consultation with departments such as pulmonology, cardiology, radiology, and anesthesiology is recommended for patients with multiple respiratory diseases or complex respiratory conditions. A comprehensive assessment by the multidisciplinary team can provide a better understanding of surgical risks and potential complications, helping to develop a safer and more personalized anesthetic and surgical plan. This approach maximizes surgical success and improves postoperative recovery outcomes.

Discussion

This consensus updates some previously established practices and introduces several new vital aspects. We want to emphasize the importance of perioperative medication management and minimizing unnecessary intubations.

For patients with preoperative uncontrollable asthma, AHR, and COPD, ICS + LABA + LAMA can be used perioperatively. ICS + LABA + LAMA is a helpful treatment option for the maintenance treatment of COPD (110). Its components help reduce airway inflammation, thereby alleviating AHR and bronchospasm. Postoperative early decline in lung function, persistent cough, and shortness of breath may be associated with AHR and bronchospasm (74). ICS + LABA + LAMA has been shown to reduce persistent postoperative cough in single-center study (73). Further multicenter clinical trials are needed to validate its efficacy in postoperative airway management.

With the continuous improvement of laryngeal mask devices, clinical research across various disciplines has indicated that the ventilation provided by laryngeal masks can meet the requirements of many types of surgical procedures (36,37,39,111). For example, in thoracic surgery, the tubeless VATS technique reduces airway damage caused by intubation and requires fewer opioids and muscle relaxants. Additionally, it results in shorter operation times, earlier mobilization, and a reduced postoperative LOS (112). Currently, this technique can be safely applied to minor procedures like wedge resections and complex thoracic surgeries such as tracheal operations and extensive mediastinal tumor resections (43,113). Despite the potential advantages of tubeless VATS technology, its adoption has been limited to only a few high specialized centers. This may be attributed to the need for close cooperation between surgeons and anesthesiologists. To maximize patient benefits, anesthesiologists and surgeons must learn and master this technique actively.

Conclusions

In conclusion, this consensus highlights the critical importance of airway management, emphasizing the need for advanced techniques and early interventions. Moving forward, it is crucial to place even greater emphasis on optimizing airway management to improve patient outcomes.

Acknowledgments

None.

Footnote

Peer Review File: Available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-2025-273/prf

Funding: Supported by R&D Program of Guangzhou National Laboratory (Grant No. SRPG22-017).

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-2025-273/coif). Maria Rodriguez reports consulting fees and payment for lectures/activities from AstraZeneca, Abex/Intuitive and Johnson and Johnson. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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(English Language Editor: L. Huleatt)

Cite this article as: Liang H, Che G, Cui F, Dong J, Gu W, Gu C, Xu S, Ba Y, Cai K, Cao Q, Chen C, Chen C, Chen Q, Cheng L, Feng G, Gou Y, Guo W, He J, He J, Hu J, Huang Y, Wang W, Jiao W, Jiang S, Liu J, Lan L, Li W, Li X, Li Z, Li Y, Liang Z, Liu H, Liu Y, Mei X, Song X, Sun D, Tian H, Tian Z, Wang J, Wang G, Xu X, Xiang X, Xu G, Xue T, Yang C, Yan X, Yang N, Yao F, Yin D, Yin X, Yu B, Zhai W, Zhang Y, Zhang G, Zhang X, Zhang Q, Zhang Y, Zhao J, Zhong H, Brunelli A, Ploenes T, Bertolaccini L, Tam JKC, Kim MP, Refai M, Gonzalez M, Dyas AR, Ardò NP, Fernando HC, Maurizi G, Kocher GJ, Marulli G, Fuentes-Martín Á, Perroni G, Kim KS, Rodriguez M, Taylor M, Zou X, Wang W, He J. Multidisciplinary international expert consensus on perioperative airway management. Transl Lung Cancer Res 2025. doi: 10.21037/tlcr-2025-273

Appendix 1

Several issues on the perioperative airway management were further discussed as follows

Question 1: What complications should be monitored perioperatively in patients with preoperative airway hyperreactivity? How can medication interventions reduce the occurrence of these complications?

Expert opinion 1: Alessandro Brunelli

These patients may be at increased risk of postoperative pulmonary complications (PPC). Bronchodilators and steroids either by aerosol, inhalers or systemic are valuable help in this situation.

Expert opinion 2: Till Ploenes

Preoperative airway hyperreactivity can lead to spasm in the respiratory tract and should be treated with spamolytics (e.g., steroids) at an early stage.

Expert opinion 3: Luca Bertolaccini

In patients with preoperative airway hyperreactivity, perioperative complications such as bronchospasm, laryngospasm, respiratory infections, and exacerbation of chronic respiratory conditions must be closely monitored. Medication interventions play a crucial role in mitigating these risks. Preoperative and perioperative administration of bronchodilators (e.g., albuterol), corticosteroids (e.g., prednisone), and ICS (e.g., fluticasone) help reduce airway reactivity and inflammation. Leukotriene modifiers like montelukast may also be beneficial. Ensuring optimal preoperative respiratory function, choosing less irritant anaesthetic agents like propofol, and providing vigilant postoperative care can significantly reduce the occurrence of these complications.

Expert opinion 4: John Kit Chung Tam

Complications to monitor include wheezing, dyspnea, bronchospasms, asthma/COPD exacerbation, mucous plugging, and pneumonia.

Medications such as bronchodilator/steroid combination puffer (e.g., Symbicort) can control airway hyperreactivity. Mucolytics such as fluimicil can loosen the thickness of the mucous and prevent mucous plugging. Severe bronchospastic reactions may require a short course of oral or intravenous steroid to control the exacerbation. Early detection of pulmonary or pleural infections in the postoperative period is essential to initiate proper antimicrobial treatment if indicated.

Expert opinion 5: Majed Refai

In patients with preoperative airway hyperreactivity, you should mostly monitor the operated-lung expansion, considering that the onset of complications, as pneumothorax, pleural effusion and sputum retention could be responsible of a decrease in lung volume, of a bronchial hyperreactivity stimulation and further impairing lung function. In these conditions, hypercapnia causing transient tachypnoea, mediastinal displacement with compression of the non-operated lung and pneumonia may occur.

In order to avoid these complications, a physiotherapy care-plan with active patient involvement, allowing an improvement in pulmonary hygiene and re-expansion must be adopted. Moreover, longitudinal clinical and radiological checks (chest-X-ray) are crucial to evaluate post-surgical outcomes and potential infectious foci.

Expert opinion 6: Michel Gonzalez

Perioperative management of patients with preoperative airway hyperreactivity requires vigilant monitoring and targeted medication interventions to prevent typical complications like bronchospasm, laryngospasm, hypoxemia, and aspiration. Bronchospasm and laryngospasm, characterized by sudden airway constriction, are generally triggered by intubation or surgical manipulation. Prompt recognition and management are crucial to prevent hypoxemia. Continuous monitoring of oxygen saturation and end-tidal CO_2 is essential. Aspiration of gastric contents into the lungs can lead to pneumonia or even acute respiratory distress syndrome. I believe that medication interventions are vital. Preoperative inhaled or intravenous corticosteroids combined with bronchodilators, such as LABA can stabilize the airway and reduce inflammation minimizing thus the risk of bronchospasm and laryngospasm. Moreover, anesthetic management should prioritize agents less likely to provoke airway reactivity, such as using sevoflurane over desflurane, or even consider regional anesthesia techniques to avoid airway manipulation altogether.

Expert opinion 7: Nicoletta Pia Ardò

The complications to be monitored are acute respiratory failure caused by bronchospasm and atelectasis by bronchial hypersecretion the patients most susceptible to complications are those in whom pulmonary hypertension has already established.

Expert opinion 8: Gregor J. Kocher

Bronchospasm should be monitored and measures such inhalation of salbutamol is advisable, if there is a known hyperreactivity we routinely administer a single high dose of steroids with anesthesia begin.

Expert opinion 9: Giuseppe Marulli

Persistent cough, bronchospasm, sputum retention, pulmonary atelectasis and infection are the most frequent complications associated with airway hyperreactivity. A preoperative maximization of therapy (i.e., ICS + LABA + LAMA, if necessary), associated with an intraoperative accurate management in reducing airway inflammation and stimulation may prevent complications. If a bronchospasm happens a prompt pharmacological treatment and a O_2 supplementation are required.

Expert opinion 10: Álvaro Fuentes-Martín

Patients with preoperative airway hyperreactivity are at a higher risk of developing respiratory complications.

Complications to monitor in the perioperative period: bronchospasm, atelectasis and hypoxia.

Medicinal interventions to decrease complications:

- Bronchodilators: in selected patients, bronchodilators should be given as a preoperative to decrease the incidence of intraoperative bronchospasm.
- Costicosteroids: systemic pre-operative dosing may effectively decrease bronchospasm and postoperative respiratory complications in patients with AHR.
- Volatile anesthetic agents: certain volatile anesthetic agents, such as sevoflurane, have intrinsic bronchodilating properties. These anesthetic agents would be more preferable for induction and maintenance of anesthesia in a patient with AHR.

Expert opinion 11: Gianluca Perroni

Patients with AHR are at increased risk for sputum retention and require vigilant monitoring during the postoperative period. In cases where patients with AHR develop sputum retention, the use of aerosolized N-acetylcysteine (NAC) should be

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avoided due to the potential risk for bronchospasm resulting from direct airway irritation. Alternatively, intravenous or oral administration of NAC is equally effective compared to aerosolized forms, while presenting a lower risk of exacerbating AHR.

Expert opinion 12: Kyung Soo Kim

Laryngo-bronchospasm in asthmatic patients should be watched with consideration for risk of aspiration through endotracheal intubation procedures, avoiding trigger factors, such as bronchial secretion, infection, allergic agents and medications provoking bronchospasm; neuromuscular blocker, ß-blockers. Proper usage of corticosteroids, and maintenance of drugs for bronchodilation with anti-inflammatory regimen will help to reduce these complications, and anti-reflux agents also may relief cough reflex through the perioperative periods.

Expert opinion 13: Maria Rodriguez

I would be very careful with bronchospasm, postoperative respiratory insufficiency and other pulmonary complications. I think the best treatment is prevention. Therefore, I would routinely order pulmonary function tests and in those patients with airway hyperreactivity or those with COPD, would recommend pulmonology consultation and multidisciplinary discussion to optimize or start, if needed, bronchodilators therapy. I would carefully monitor compliance with this therapy in the perioperative setting.

Expert opinion 14: Marcus Taylor

All patients should have regular nebulisers to minimize the risk of airway hyperreactivity.

Question 2: What are your experiences with airway management in obese patients during the perioperative period? Does perioperative weight loss help in establishing long-term weight loss habits?

Expert opinion 1: Alessandro Brunelli

Most of the thoracic surgery patients are lung cancer patients, with very tight cancer deadline for treatment which make difficult to establish and implement weight loss programs.

Expert opinion 2: Till Ploenes

High obese patients can have problems during extubation. Perioperative weight loss is not helpful in establishing long-term weight loss habits.

Expert opinion 3: Luca Bertolaccini

Managing the airway in obese patients during the perioperative period presents unique challenges due to anatomical and physiological differences. Obese patients often have difficult airways characterised by increased soft tissue in the neck and pharynx, which can lead to difficult mask ventilation and intubation. These patients are also at higher risk for hypoxemia due to reduced functional residual capacity and increased oxygen consumption.

Experiences indicate the importance of preoperative planning and specialised techniques and equipment. Preoperative assessment should include evaluation for obstructive sleep apnea and a thorough airway examination. Techniques such as ramped positioning (aligning the external auditory meatus with the sternal notch), video laryngoscopy, and awake fiberoptic intubation can be invaluable. Postoperative care should include monitoring for respiratory complications, particularly in the context of opioid use and the potential for respiratory depression.

Perioperative weight loss, often achieved through structured preoperative weight loss programs, can provide immediate benefits regarding reduced perioperative risk. These benefits include improved respiratory mechanics, decreased risk of postoperative complications, and better overall surgical outcomes. Evidence suggests that patients who engage in perioperative weight loss programs may be more likely to adopt long-term healthy habits, leading to sustained weight loss. These programs often incorporate nutritional counselling, physical activity, and behavioural therapy, which collectively help patients develop and maintain healthier lifestyles postoperatively.

Expert opinion 4: John Kit Chung Tam

Obese patients are not very common in my patient population. Proper airway assessment preoperatively using Mallampati score is important to assess the level of difficulty expected during intubation. Consideration may also be needed to exclude the presence of obstructive sleep apnea in these patients, particularly those who have a history of snoring during sleep. Obese patients may need to be more awake and alert before the endotracheal tube is removed after surgery to prevent airway loss. Patient should be positioned to sit upright postoperatively to prevent airway obstruction from oral pharyngeal structures.

Perioperative weight loss does not necessarily help to establish long term weight loss habits unless the patients are given proper teaching regarding dietary habits and exercise routines.

Expert opinion 5: Min P. Kim

I would not recommend short-term perioperative weight loss, as significant weight loss takes time. In my experience, preoperative weight loss has not significantly contributed to establishing long-term weight loss habits. I also would not delay surgery until the patient loses weight, due to oncologic nature. For obese patients, securing the airway is a priority, and they may require higher PEEP along with effective secretion clearance, particularly during one-lung ventilation.

Expert opinion 6: Majed Refai

According to my experience, obese patients could be more predisposed to develop sputum retention in the post-operative period, requiring airway cleaning through bronchoscopy. Moreover, patients suffering from OSAS may require postoperative intensive care management due to the need of non-invasive/invasive ventilation. Obviously, weight loss can help to enhance perioperative course but, due to the oncological nature of the disease, I think that establishing long-term weight loss habits could not always be the best solution for dealing with post-operative therapies (adjuvant chemo-radiotherapy).

Expert opinion 7: Michel Gonzalez

Airway management in obese patients during the perioperative period is challenging due to anatomical changes, reduced chest wall compliance, and higher risk of obstructive sleep apnea. Difficult intubation is commonly experienced and we traditionally use video laryngoscopes to improve success rates. For patients with obstructive sleep apnea, continuing CPAP therapy preoperatively and postoperatively is crucial. These patients are generally monitored the first night in our intermediate care unit to avoid severe hypoxemia, particularly if they receive morphine.

Obviously, perioperative weight loss can improve airway management by reducing intra-abdominal pressure, enhancing respiratory mechanics, and decreasing obstructive sleep apnea severity. This is difficult to obtain in case of management of lung cancer surgery due to the necessity to operate in short period of time. However, long-term weight loss habits require comprehensive interventions, including nutritional counseling and behavioral therapy. While perioperative weight loss can

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offer immediate benefits, sustained weight loss typically depends on ongoing, structured weight management programs.

Expert opinion 8: Nicoletta Pia Ardò

NIV and HFNC are of great help for airway management in these patients. The NIV instruments already used by the patient are often utilized, other times the patient has never been classified and it is necessary to use NIV for the first time. Obesity causes a sort of restrictive syndrome and is often associated with dysventilation of the lower lobes. Pre-habilitation of the patient, associated, if possible, with weight loss, together with early mobilisation, can improve the outcome of these patients. Pain must also be treated because it is often higher than other patients; at the same time, fat tissue can act as a depot for opioids, with accumulation of side effects. Pre-habilitation and weight loss can improve quality of life after surgery, too.

Expert opinion 9: Hiran C. Fernando

Again, I'm not sure that from a practical stand-point we can wait for a patient to lose weight before operating for lung cancer. The only exception I can see is if we plan neoadjuvant treatment

Expert opinion 10: Gregor J. Kocher

Weight loss should be encouraged and especially during hospitalization a nutritionist should be involved to advise the patient about changes in the long term.

Expert opinion 11: Giuseppe Marulli

Perioperative weight loss is of paramount importance in order to reduce postoperative complications. Generally, if a perioperative program has been previously established, the patient if well motivated may be induced to continue the program, particularly if the surgery has been conducted with success. Obese patients frequently experience respiratory impairment during and after surgery; in particular in lung surgery the lateral decubitus and the one-lung ventilation may be difficult, thus requiring specific ventilation techniques varying pressures and volumes in order to preserve the airway integrity and reducing the inflammatory damage. In the postoperative period patient may benefit of NIV or CPAP during the night if OSAS is present.

Expert opinion 12: Álvaro Fuentes-Martín

Difficult intubation and mask ventilation: obesity is a well-acknowledged risk for difficult intubation.

Rapid desaturation: during apneic episodes, these patients show an already reduced functional residual capacity (FRC) with increased oxygen consumption so that rapid desaturation can occur during anesthetic induction. Such patients benefit from appropriate preoxygenation followed by mask ventilation using a PEEP method to avoid hypoxemia.

While short-term weight loss in the perioperative period proves beneficial with improved respiratory function and diminished surgical risks, it is less clear how preoperative weight reduction would contribute to establishing better behavior in terms of losing and maintaining weight in the long term. Perioperative weight loss will get the patient on a head start, provide a baseline moving forward with healthier behaviors, but successful long-term maintenance depends on the follow-up care and lifestyle changes.

Expert opinion 13: Kyung Soo Kim

Difficulties in airway management for obese patients is particularly issued in non-intubated VATS settings in Aaia. Despite of recommendations for requirement of preoperative weight loss to reduce perioperative complications, patient compliancesseems not effectively achievable due to limited times prior to planned surgery. Usage of video-laryngoscope for difficult endotraheal intubation, and postoperative CPAP maintenance is beneficial to manage obese patients. Motivations for change of dietary habits and exercise will help next time surgery during long-term surveillances.

Expert opinion 14: Maria Rodriguez

I manage these patients with the same protocols we use for non-obese patients. We routinely attend a weekly multidisciplinary team meeting with anesthesiologists and operation room (OR) nurses to discuss specific patients' characteristics and risks.

We normally don't have time to achieve significant preoperative weight loss, but during hospital admission and postoperative follow-up we encourage healthy habits as exercise, smoking cessation and healthy eating. If the patient wants to achieve a significant weight loss, we organize a nutritionist and an endocrinologist consultation.

Expert opinion 15: Marcus Taylor

As a surgeon this is not my area of expertise.

Question 3: The tubeless VATS technique demands higher numbers and skill levels of anesthesiologists. How can the dissemination of the tubeless VATS technique be increased?

Expert opinion 1: Alessandro Brunelli

Possibly through educational events, proctorship and mentorship programs offered to anaesthesiologists and surgeons.

Expert opinion 2: Till Ploenes

With increasing experience of the team (surgeons and anestesiologists), the technique can become more widespread, but a good setting must also be available and is absolute requirement.

Expert opinion 3: Luca Bertolaccini

Several strategic approaches can significantly increase the dissemination of the tubeless VATS technique. Firstly, enhancing education and training is crucial. Developing and implementing comprehensive training programs and workshops for anesthesiologists can provide them with the skills and knowledge necessary to effectively perform and support the tubeless VATS technique. These programs should be offered at various levels, from introductory sessions for those new to the technique to advanced workshops for experienced practitioners seeking to refine their skills.

Additionally, creating and distributing high-quality educational materials, such as detailed manuals, online courses, and instructional videos, can help spread knowledge and techniques related to tubeless VATS. These resources can be particularly effective if they include practical demonstrations and case studies that illustrate the technique's benefits and challenges.

Collaboration with professional societies and organisations can also be pivotal in disseminating. By integrating tubeless VATS into their curricula and continuing medical education programs, these bodies can help raise awareness and promote the adoption of the technique. Furthermore, presenting research findings and clinical outcomes related to tubeless VATS at conferences and seminars can stimulate interest and provide evidence of its benefits, encouraging more practitioners to adopt the technique.

Building a community of practice and facilitating peer-to-peer learning is a testament to the value we place on your expertise in the field. By creating platforms for experienced practitioners to share their experiences, tips, and best practices, we are fostering a culture of respect and acknowledgement within the community.

By fostering partnerships between academic institutions and clinical centres proficient in tubeless VATS, we are paving the

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way for a future where this technique is widely disseminated and integrated into routine practice. These combined efforts will not only advance the adoption and refinement of the technique but also significantly impact the future of thoracic surgery and medical education.

Expert opinion 4: John Kit Chung Tam

The dissemination of tubeless VATS technique can be increased by cross institutional sharing. Institutions which have good experience with this technique should welcome practitioners from other institutions to have an immersive learning experience. Doctors who are knowledgeable in this technique can also go to other institutions to give lectures and demonstrations. Workshops and meet the expert sessions to share the practicalities of this technique in regional and international conferences are important for dissemination.

Expert opinion 5: Min P. Kim

The tubeless VATS technique may be safer in thin patients, but it is not commonly practiced in the U.S., where a significant portion of the population is overweight or obese. Given the additional challenges and risks in these patients, this technique is not recommended in such cases.

Expert opinion 6: Majed Refai

I think the tubeless VATS technique can be increased starting with easy procedures requiring small lung resection in fit patients. After a large experience in these cases and in collaboration with skilled anesthesiologists, able to intubate in lateral decubitus too, this technique can be applied to the more complex resections.

Expert opinion 7: Michel Gonzalez

The tubeless VATS technique requires a high level of skill and collaboration between anesthesiologists and surgeons. To increase its dissemination, I believe that comprehensive training programs should be developed, including workshops, simulation-based training, and hands-on courses. These programs should focus on mastering non-intubated anesthesia, regional nerve blocks, and patient selection criteria. Publishing detailed guidelines, best practices, and case studies in medical journals can also spread knowledge and encourage adoption. Unfortunately, I have no experience on this technique.

Expert opinion 8: Adam R. Dyas

The problem with tubeless VATS is lack of single lung isolation generally required for lung resection.

Expert opinion 9: Nicoletta Pia Ardò

The increase of tubeless VATS depends on surgeons' habits, before anaesthesiolgists' preferences, the change must be desired by both, surgeon and anesthesiologist.

Expert opinion 10: Hiran C. Fernando

I agree with the need for increased skill set. However, we also need randomized trials or at a minimum good comparative cohort study to convince surgeons and anesthesiologists that there is a reason to make the commitment to offer tubeless surgery.

Expert opinion 11: Gregor J. Kocher

Tubeless VATS can best be 'trained'when patients are in a normal supine position for surgery or in a beach chair position (easier intubation if necessary)—therefore bilateral sympathectomy in a beach chair position is a good first step into tubeless VATS. Once getting comfortable with this approach also surgeries in a lateral decubitus position can be started tubeless—with simple procedures such as wedge resections etc. to begin with.

Expert opinion 12: Giuseppe Marulli

The main way to disseminate and increase the tubeless VATS technique is to stimulate the participation of both, surgeons and anesthesiologists, to dedicated masterclasses in order to allow familiarity with this technique. The creation of a strict collaboration and feeling between these two figures is essential to start a tubeless program.

Expert opinion 13: Álvaro Fuentes-Martín

The diffusion of the tubeless VATS technique requires improved training for anesthesiologists in this approach, as the success of the procedure depends on their ability to manage spontaneous ventilation while maintaining adequate sedation, analgesia, and respiratory function. To achieve this, it is essential to develop standardized protocols to reduce the learning curve and facilitate its implementation. Finally, it is crucial to continue gathering solid data to generate strong scientific evidence that demonstrates the safety and efficacy of the technique, supporting its broader adoption.

Expert opinion 14: Gianluca Perroni

Increasing the level of evidence. To date, RCTs are missing and therefore a non-inferiority study could solve doubt about the benefits of tubeless VATS.

Expert opinion 15: Kyung Soo Kim

To increase the tubeless VATS technique, cooperations with dedicated educations for simulations of unexpected events should be continued by team works, and proper indications for surgical planning must be discussed for appropriate anesthetic planning.

Expert opinion 16: Maria Rodriguez

I don't have experience in tubeless VATS, but as most of the techniques I would argue it would require training and mentorship to assure safe implementation.

Expert opinion 17: Giulio Maurizi

Large randomized trials are needed and expected in order to support the usefulness of this technique. In my opinion there is not a real advantage for the patients with tubeless technique.

Question 4: What effective treatments are available for shortness of breath and dyspnea after lung resection surgery?

Expert opinion 1: Alessandro Brunelli

Prevention of shortness of breath is critical and include appropriate choice of the extent of lung resection and patient selection. In the postoperative period, rehabilitation and chest physiotherapy delivered by qualified physiotherapists may help in reducing this complication.

Expert opinion 2: Till Ploenes

The question is if we are faced dyspnea or hypoxemia/hypercapnia. If hypoxemia occurs treatment of the cause should have the priority (e.g., treatment of postoperative pneumonia). If this is not possible, home oxygen should be offered and the surgeon must ask oneself whether the indication for the operation was justified. More difficult (and rarer) is the occurrence of dyspnea without functional correlation. In these cases, physiotherapy and, as a last resort, drug treatment (e.g., low-dose

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morphine) can help.

Expert opinion 3: Luca Bertolaccini

After lung resection surgery, managing shortness of breath and dyspnea effectively involves a multifaceted approach tailored to the patient's specific condition and recovery needs. Postoperative dyspnea can arise from several factors, including residual lung inflammation, atelectasis, pleural effusions, or infection. Therefore, addressing these underlying causes is crucial for effective management.

One of the primary treatments is the use of supplemental oxygen to ensure adequate oxygenation and reduce the work of breathing. This can help alleviate symptoms of dyspnea and improve overall comfort.

In cases where atelectasis, or lung collapse, contributes to shortness of breath, techniques such as incentive spirometry, deep breathing exercises, and physical therapy are employed to promote lung expansion and improve pulmonary function. These interventions help to prevent or resolve atelectasis and enhance airway clearance.

Pharmacologic treatments also play a role in managing postoperative dyspnea. Analgesics are essential for controlling pain, which can otherwise restrict breathing and contribute to feelings of breathlessness. Opioids are commonly used, but their dosages need careful management to avoid respiratory depression. Additionally, bronchodilators and corticosteroids may be prescribed if there is evidence of bronchospasm or inflammation.

Addressing pleural effusions and accumulations of fluid in the pleural space might require interventions such as thoracentesis or chest tube placement to relieve pressure on the lungs and facilitate better lung expansion.

Monitoring and managing possible postoperative complications such as pneumonia or infection is also vital. Antibiotics and other treatments targeted at infection can help reduce inflammation and fluid accumulation in the lungs, which may otherwise exacerbate dyspnea.

Lastly, patient education on proper breathing techniques and activity pacing can empower individuals to manage their symptoms more effectively and improve their quality of life during recovery.

Overall, treating shortness of breath and dyspnea after lung resection surgery involves a combination of pharmacologic and non-pharmacologic strategies to address the underlying causes and improve pulmonary function.

Expert opinion 4: John Kit Chung Tam

Proper workup of pulmonary function before surgery, and lung parenchymal sparing surgery such as sublobar resections are important to prevent postoperative dyspnea. Oxygen supplementation if needed is helpful to relieve the subjective symptom of dyspnea after surgery. Incentive spirometry and chest physiotherapy are important for pulmonary recruitment and encourages functional respiratory recovery. If there are other underlying causes of dysnea such as lung infection, mucous plugging, fluid overload, or congestive heart failure, it is vital to treat them as soon as possible to ensure optimization of postoperative lung function and encourage full pulmonary recovery.

Expert opinion 5: Min P. Kim

Effective treatments for shortness of breath and dyspnea after lung resection surgery include optimizing oxygen therapy, pulmonary rehabilitation, and bronchodilators, depending on the underlying cause. In cases where fluid overload is contributing to the symptoms, diuretics can be particularly effective. Typically, fluids are minimized during surgery to reduce the risk of fluid overload—aiming for less than 700 cc during a 4-hour procedure. If the patient receives excess fluids or undergoes a larger lung resection, such as a pneumonectomy, diuretics are often used right after surgery to alleviate shortness of breath by helping to remove excess fluid from the body.

Expert opinion 6: Majed Refai

The treatment for postoperative shortness of breath and dyspnea depends on the underlying cause. Obviously, a physiotherapy care-plan with active patient involvement, allowing an improvement in pulmonary hygiene and re-expansion are crucial to enhance the recovery. However, immediately following pulmonary resection, several conditions may increase extravascular lung water that could lead to acute lung injury (ALI) or, more rarely, acute respiratory disease syndrome (ARDS). In these cases, steroids and diuretics may improve the symptoms. Moreover, shortness of breath and dyspnea could be related to an infective complication. Here, bronchoalveolar lavage (BAL) and specific antibiotic therapy are the best treatments. Finally, a cardiac complication can be responsible of these symptoms. Therefore, a cardiac evaluation is recommended if other causes are excluded.

Expert opinion 7: Michel Gonzalez

In my opinion, effective treatments for shortness of breath and dyspnea after lung resection surgery include pulmonary rehabilitation, bronchodilators, and supplemental oxygen. Pulmonary rehabilitation including supervised exercise programs, breathing exercises, and education, may be proposed in compromised patients to improve lung function and overall fitness. Bronchodilators, such as beta-agonists, anticholinergics or ICS may be introduced after multidisciplinary discussion with pneumologist to open airways and facilitate breathing. Pain management is crucial as it facilitates effective coughing and sputum clearance. We routinely use a multimodal analgesia, combining non-opioid and opioid medications, along with nerve blocks to effectively control pain.

Expert opinion 8: Nicoletta Pia Ardò

Prehabilitation and early mobilization are the best way to prevent postoperative dyspnea. Thanks to ERAS application, patients previously ineligible for surgery can benefit from surgical therapy. Patients with borderline respiratory function should be informed of the possibility of a temporary tracheostomy to manage secretions and eliminate respiratory dead space.

Expert opinion 9: Gregor J. Kocher

- High flow nasal O_2.
- NIV.

Expert opinion 10: Giuseppe Marulli

The treatment depends of the cause, generally the O_2 supplementation by high flow oxygen therapy or the use of NIV or CPAP may alleviate the symptoms, the pain control and the fluid restriction to avoid pulmonary edema may be sometimes indicated.

Expert opinion 11: Álvaro Fuentes-Martín

Postoperative dyspnea is the most common symptom in patients following lung resection procedures. The primary approach to this symptom should be the treatment of its underlying cause. Nevertheless, pulmonary rehabilitation and respiratory physical therapy play a key role in the restoration and relief of dyspnea symptoms after lung resection. Similarly, the use of inhaled bronchodilators, including β2-agonists and anticholinergics, can be helpful, as they reduce dyspnea caused by

https://dx.doi.org/10.21037/tlcr-2025-273

reversible bronchospasm or underlying obstructive lung disease by improving airflow. The use of low-dose opioids for symptom relief has also been shown to decrease the perception of dyspnea. Although opioids do not improve the physiological cause of dyspnea, they modify its perception centrally. However, opioid therapy should be administered with caution to avoid respiratory depression, especially in postoperative patients.

Expert opinion 12: Kyung Soo Kim

Clinical correlations between radiologic findings and symptoms of dyspnea have to be assessed to find the causal factor prior to proper intervention or medications. Preventive alternative application of nebulizers may be effective with combination of mucolytic agents, proper steroid usage, and anti-cholinergic or leukotriene modifiers can also be optional. High flow oxygen therapy and non-invasive positive pressure ventilation (NIPPV) is thought to be useful means for management of acute dyspnea, avoiding intubation with ICU care after lung resection surgery.

Expert opinion 13: Maria Rodriguez

It depends if they are associated with respiratory insufficiency and hypoxia or not. In case there is an association, home oxygen therapy, closely monitored by pulmonology and if possible, temporary, would be required.

If there is no association, repeat pulmonary function test can guide the need for bronchodilator therapy. Furthermore, depending on the extent of the resection some temporary shortness of breath (SOB) could be expected. In these cases, clear discussion of the expected recovery with the patient can help manage his expectations. In addition, aerobic exercises and directed chest physiotherapy (PT) could help improve these symptoms.

Expert opinion 14: Marcus Taylor

Pre-operative pulmonary habilitation is important to reduce the incidence of post-operative dyspnoea.

Question 5: For patients with pulmonary fibrosis undergoing lung resection surgery, what perioperative measures can be taken to reduce the occurrence of acute exacerbations postoperatively?

Expert opinion 1: Alessandro Brunelli

Appropriate patient selection, minimise operative time duration, steroid administration or pirfenidone have been tried with variable results.

Expert opinion 2: Till Ploenes

The key point is not so much the surgery (although the trauma should be kept to a minimum and the procedure should be as minimally invasive as possible) but the ventilation. This means the lowest possible ventilation pressures and the lowest possible FiO_2. Preoperative cortisone therapy can be very helpful in preparing the patient.

Expert opinion 3: Luca Bertolaccini

In patients with pulmonary fibrosis undergoing lung resection surgery, reducing the risk of acute exacerbations postoperatively involves a comprehensive approach that addresses both surgical and respiratory management aspects.

Optimising the patient's pulmonary status preoperatively is crucial. This includes thorough preoperative assessment and optimisation of lung function through interventions such as smoking cessation and managing any pre-existing respiratory infections. Pulmonary rehabilitation programs may also be beneficial to improve overall respiratory strength and endurance.

Careful anaesthetic management intraoperatively is essential to minimise the risk of exacerbations. Using lung-protective ventilation strategies, such as low tidal volume ventilation and appropriate PEEP, helps reduce ventilator-associated lung injury and maintain optimal oxygenation. Additionally, avoiding excessive fluid overload during surgery can prevent pulmonary edema and complications related to fluid balance.

Monitoring and early intervention are key postoperatively. Implementing aggressive postoperative pulmonary care, including early mobilisation and respiratory physiotherapy, helps prevent complications like atelectasis and pneumonia, which can precipitate acute exacerbations. Regular use of incentive spirometry and chest physiotherapy can also aid in maintaining lung function and preventing complications.

Pharmacologic measures should include the judicious use of anti-inflammatory agents, such as corticosteroids, if indicated, to manage inflammation and prevent exacerbations. However, their use must be balanced with the risk of potential side effects.

Preventive strategies also involve close monitoring for early signs of exacerbation and prompt management of any respiratory issues. This might include the use of supplemental oxygen and, if necessary, early initiation of treatments tailored to the patient's specific needs, such as antibiotics for infections or diuretics for managing fluid overload.

In summary, reducing the occurrence of acute exacerbations in patients with pulmonary fibrosis undergoing lung resection requires a proactive and multidisciplinary approach, combining preoperative optimisation, careful intraoperative management, and vigilant postoperative care.

Expert opinion 4: John Kit Chung Tam

The keys to reduce exacerbation of pulmonary fibrosis after lung surgery are (I) judicious patient selection to ensure they are good candidates for surgery, (II) perioperative chest physiotherapy and pulmonary rehabilitation to ensure optimal lung function before and after surgery, (III) judicious use of intravenous fluid intraoperatively to avoid fluid overload into the alveoli space, (IV) use of minimally invasive surgery to minimize pain and encourage good respiratory effort after surgery, (V) avoid or minimize the use of opioid narcotics intraoperatively and postoperatively, and (VI) early detection and treatment of lung infection postoperatively.

Expert opinion 5: Min P. Kim

For patients with pulmonary fibrosis undergoing lung resection surgery, perioperative measures to reduce the risk of acute exacerbations include careful patient selection and opting for limited resections when possible. Minimizing surgical stress, optimizing preoperative lung function, and closely monitoring postoperative care are also crucial in reducing the likelihood of exacerbations.

Expert opinion 6: Majed Refai

All patients with pulmonary fibrosis are preliminarily discussed with pneumologist in order to define the best timing for surgery and the best perioperative medical treatments. Therefore, in these cases, in accordance with the colleagues, we are used to optimize the home therapy and to add, in the immediate postoperative period, low-dose of steroids and antibiotic therapy as prophylaxis. Obviously, a physiotherapy care-plan with active patient involvement for all the perioperative period are crucial to enhance the recovery, allowing an improvement in pulmonary hygiene and re-expansion.

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Expert opinion 7: Michel Gonzalez

Preoperative use of medications like corticosteroids or antifibrotic agents (e.g., nintedanib) may help stabilize the disease but the introduction and continuation of these treatment are generally discussed with pneumologist before the operation.

Lung-protective ventilation strategies with appropriate PEEP is essential to prevent alveolar collapse. In addition, we use low tidal volumes and high-frequency ventilation to minimize lung injury.

Postoperatively, we maintain adequate oxygenation with supplemental oxygen and monitoring for early signs of respiratory distress with surveillance in intermediate care. Prompt initiation of NIV can help manage acute exacerbations if they occur. Of course, early mobilization and pulmonary rehabilitation can also aid in reducing complications and improving recovery. I really think that in these patients, a multidisciplinary approach, involving pulmonologists, anesthesiologists, and thoracic surgeons, is crucial for tailored perioperative management.

Expert opinion 8: Nicoletta Pia Ardò

Regarding the management of patients with pulmonary fibrosis, it is important to avoid barotrauma related to invasive ventilation, and to use staple line reinforcement (e.g., bovine pericardium or other materials) to prevent the onset of prolonged air leaks.

Expert opinion 9: Gregor J. Kocher

- Single high dose of steroids with begin of anesthesia.
- Routine inhalations with salbutamol at least 4× daily in the postoperative course.
- Monitor blood parameters and start antibiotics if needed.

Expert opinion 10: Giuseppe Marulli

Every measure that reduces airway inflammation and surgical stress is recommended in pulmonary fibrosis patients submitted to lung resection. In particular, the minimal amount of parenchyma should be resected, if possible, a tubeless VATS resection should be carried out, low dose corticosteroids therapy could be adopted in the postoperative period.

Expert opinion 11: Álvaro Fuentes-Martín

- Preoperative Evaluation:
  - Pulmonary Function Testing: Significant baseline pulmonary function should be evaluated using spirometry, as well as diffusion capacity (DLCO).
  - Multidisciplinary Assessment: It requires a team approach comprising thoracic surgeons, pulmonologists, and anesthesiologists. Preoperative pulmonology consultations should emphasize optimizing pulmonary function and the medical management of the underlying lung, cardiac, and vascular diseases, e.g., pulmonary hypertension, or coronary artery disease.
  - Preoperative Pulmonary Rehabilitation: Pulmonary prehabilitation would improve lung function, exercise tolerance in patients, and overall conditioning, which may reduce postoperative morbidity.
  - Pharmacologic interventions are necessary to stabilize pulmonary function and reduce the frequency of exacerbation incidents.
- Intraoperative Measures
  - Management here implies the need for special anesthetic and surgical procedures that, in patients with these procedures prevent sensitizing triggers of acute exacerbations—lung injury and inflammation.
  - Lung-protective Ventilation: Mechanical ventilation during surgery can precipitate lung injury in the setting of fibrotic lungs. The ventilatory strategy should be protective, including low tidal volumes, low driving pressures, and adequate PEEP to avoid barotrauma and volutrauma. Also, use strategies to minimize hyperoxia and avoid large swings of oxygen.
  - Judicious fluid management: Patients with pulmonary fibrosis are at increased risk of developing pulmonary edema, which may significantly worsen the respiratory status, in addition to precipitating acute exacerbations. Fluid therapy should aim at attaining perioperative euvolemia without hypovolemia or overhydration.
- Postoperative Care:
  - Proper care postoperatively is required for the patient to have a safe recovery without any exacerbation of the condition.
  - Prevention of atelectasias: Atelectasis can exacerbate hypoxia and contribute to lung injury. Early mobilization and use of incentive spirometry together with the use of noninvasive positive pressure ventilation if indicated, to prevent atelectasis and enhance lung expansion.
  - Postoperative Pain Control: Adequate pain control should allow for proper deep breathing and mobilization, which helps with the reduction of the possibility of postoperative respiratory complications. This should normally be by epidural analgesia or regional nerve blocks, which provide effective analgesia while minimizing the need for systemic opioids, which depress respiratory function.

Expert opinion 12: Kyung Soo Kim

Pulmonary rehabilitation for breathing exercise, and early ambulation with chest physiotherapy is significant with expectoration of bronchial secretion and cessation of smoking preoperatively. Protective low-tidal ventilation, avoiding high airway pressure is also important.

Short operation time with minimally invasive procedures is critical to reduce trauma to lung tissues. Prophylactic pirfenidone treatment have been studied with effectiveness to reduce acute exacerbations in patients with idopathic pulmonary fibrosis (IPF) that can be considered with multi-disciplinary approach.

Expert opinion 13: Maria Rodriguez

Even if the fibrosis is stable and the patient is well compensated, I would argue for lung sparing resections, preserving as much lung parenchyma as possible, multidisciplinary evaluation to optimize fibrosis treatment if needed, careful perioperative fluids management and cautious monitoring of signs and symptoms of fibrosis exacerbation during the postoperative period.

Expert opinion 14: Marcus Taylor

Very little can be done. Steroids tend not to help. Important to avoid judicious fluid administration and needs gentle ventilation to avoid barotrauma. Ideally should be discussed at an interstitial lung disease (ILD) multidisciplinary team (MDT) prior to surgery to have an accurate ILD prognosis and to ensure medical therapy is optimized.

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