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

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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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