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REVIEW ARTICLE

Anaesthetic Management of Patients with Post-COVID Pulmonary Sequelae: Challenges and Outcomes

Dr. Faisal Sadab, Department of Anaesthesia, Katihar Medical College and Hospital, Katihar, Bihar, India,

faisalsadab17491@gmail.com

Abstract

The chronic respiratory consequences of COVID-19 have important implications for perioperative and anaesthetic management, calling for individualized strategies to achieve the best outcomes. Individuals who have recovered from COVID-19 suffer from long-standing lung issues, such as fibrosis, decreased lung compliance, muscle weakness, and vascular phenomena leading to compromised breathing and oxygenation. These alterations present maximal challenges during surgery and anesthesia and necessitate careful evaluation and specific strategies to limit problems. When feasible, lung-protective ventilation and regional anesthesia have been found to decrease respiratory distress. Additionally, supplemental oxygen, non-invasive ventilation, and pulmonary rehabilitation must be used to enhance recovery and quality of life. Knowledge of these intricate respiratory sequelae allows healthcare professionals to anticipate risk more accurately, individualize treatment strategies, and optimize patient safety during the perioperative course. This holistic strategy is essential in order to tackle the increasing cases of post-COVID patients who need surgical intervention and enhance their general outcomes.

Keywords: Anesthesia, COVID-19, Respiratory Sequelae, Fibrosis, Lung Compliance, Perioperative

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INTRODUCTION

An international nonprofit, non-governmental health crisis that rapidly escalated into a pandemic as of April 2020 by the World Health Organization, started in December 2019 when the novel coronavirus SARS-CoV-2 emerged from Wuhan, China. The virus, SARS-CoV-2, causes the common condition called COVID-19, which primarily affects the respiratory system. It often results in atypical pneumonia and, in critical cases, can progress to acute lung injury and acute respiratory distress syndrome (ARDS). The risk of severe or fatal consequences was higher for older persons, especially men with pre-existing disorders like hypertension, diabetes, and cardiovascular diseases, according to early clinical data, mostly from China, and later confirmed by European nations like Italy. Individuals with idiopathic pulmonary fibrosis (IPF), a chronic and progressive interstitial lung disease that primarily affects older individuals with comparable comorbidities and smoking histories, share a large overlap with the demographic most at risk for severe COVID-19. Lung transplantation is the only known strategy that can significantly increase survival in IPF, which is characterized by a continuous loss in lung function that eventually leads to respiratory failure. Even while antifibrotic medications like pirfenidone and nintedanib have been seen to slow the progression of the disease, not enough research has been done on the effects of COVID-19 infection in IPF patients [1,2]. The severity of the disease is directly associated with changes in diffusion capacity and restrictive ventilatory patterns, which are two areas of altered pulmonary function that are highly prevalent in recovered COVID-19 patients, according to emerging data. According to these results, pulmonary function testing is crucial for post-COVID follow-up, particularly for patients who already have lung diseases or are seriously unwell. Enhancing functional recovery is another possible advantage of pulmonary rehabilitation. But more research is required to find out if these deficiencies are permanent or reversible [3].

Common Pulmonary Sequelae Post-COVID-19

2.1 Pulmonary Fibrosis

Fibrotic changes of the lung tissue are observed in many patients late into greasy severe COVID-19, mainly if having ARDS or prolonged exposure to mechanical ventilation. On high-resolution CT scans, these are variously described as reticular patterns interlobular septal thickening and persisting ground-glass opacities, sometimes resembling organizing pneumonia or early interstitial lung disease.

According to George et al., the underlying mechanisms of pulmonary fibrosis associated with COVID-19 are familiar to those of conventional fibrotic lung diseases, including fibroblast activation, abnormal repair mechanisms, and injury to epithelial cells. They also stated that antifibrotic drugs licensed

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for idiopathic pulmonary fibrosis, such as pirfenidone and nintedanib, could potentially be employed in the treatment of fibrotic lung alterations arising after COVID-19. However, more experiments and clinical trials for confirming this treatment approach are advisable.

The study by Myall et al. [4] examined people who exhibited low exercise tolerance and persistent dyspnea after COVID-19. Follow-up imaging and pulmonary evaluations demonstrated interstitial lung involvement. Systemic corticosteroid treatment offered a very promising outcome as improvements in lung function, imaging appearances, and symptoms were noticeable, which suggests that mobilization can be used to either prevent or slow down the development of fibrosis. The significance of functional testing and follow-up imaging in individuals recuperating from severe COVID-19 is underscored by our findings. Prolonged lung problems could be lessened with early detection and focused treatment, such as potential antifibrotic or anti-inflammatory medication.

2.2 Bronchiectasis and Airway Remodelling

Persistent inflammation and recurrent infections following severe COVID-19 can cause structural changes in the airways, including bronchial dilatation known as bronchiectasis, which impairs effective mucociliary clearance. These alterations arise due to ongoing damage to the bronchial walls caused by inflammatory mediators and viral cytopathic effects, leading to weakened airway integrity and abnormal remodelling. Torres Acosta and Singer [5] emphasize that in COVID-19-induced ARDS, the inflammatory cascade, compounded by an aging immune system, contributes to exaggerated tissue injury and impaired repair mechanisms. This creates a microenvironment conducive to airway remodelling and chronic airway dysfunction. Consequently, patients may experience persistent cough, sputum production, and recurrent respiratory infections, which further exacerbate bronchial damage and compromise lung function. Recognizing and monitoring airway remodelling in post-COVID patients is crucial for timely therapeutic interventions to improve long-term respiratory outcomes.

2.3 Pulmonary Vascular Disease

Pulmonary vascular problems play a big role in the long-term effects of COVID-19 infection. The pathogenesis includes inflammation-driven vascular remodelling, endothelial damage, and extensive microvascular thrombosis, all of which worsen gas exchange and cause pulmonary hypertension [6,7]. SARS-CoV-2 targets the vascular endothelium, where endothelial dysfunction and a pro-thrombotic state are caused by direct viral invasion and the inflammatory response that follows. Gao et al. [6] explain that hypoxemia and ventilation-perfusion mismatch result from abnormal blood flow caused by the damage of microthrombi in the pulmonary circulation. This microvascular damage may be followed by chronic thromboembolic pulmonary hypertension (CTEPH) in some people. The anesthetic challenges of COVID-19 patients given

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pulmonary vascular involvement are highlighted by Zhao et al. [7], even as concerns are raised over increasing pulmonary vascular resistances that increase the chances of right ventricular strain and failure during procedures. Other factors affecting respiratory function include elevated pulmonary arterial pressures due to postinflammatory vascular remodeling and fibrosis. These changes bring about exercise intolerance and persistent dyspnea that limit life. Given the vascular pathology, vigilant cardiovascular monitoring during recovery, along with anticoagulation measures during acute infection, becomes critical in preventing chronic pulmonary hypertension. Likewise, for the post-COVID population, early diagnosis and management of pulmonary vascular disease are key to improving clinical outcomes and reducing morbidity.

2.4 Reduced Pulmonary Compliance and Hypoxia

Those patients after COVID-19 have restrictive pulmonary function profiles, characterized by chronic hypoxemia and reduced lung compliance, particularly those with moderate to severe disease [2,8]. Interstitial thickening, fibrotic remodeling, and residual alveolar damage following the acute phase of inflammation in the disease are usually implicated in these restrictive changes. Diffusion capacity (DLCO) and total lung capacity (TLC) were the most commonly affected respiratory functions at discharge from the hospital, as reported by Mo et al. [2]. Abnormalities in these indicate impaired pulmonary reserves and gas exchange, which can persist for weeks or months after recovery.

Additional concern was expressed by Zuin et al. [8], who described a continued risk for venous thromboembolism (VTE) during hospital discharge, potentially to worsen pulmonary circulation and oxygenation. Hypoxemia is worsened even in the absence of active infection due to a combination of reduced compliance precipitated by lung stiffness and potential microvascular obstruction from thrombotic phenomena. These patients need long-term respiratory support, rehabilitation, and in some cases oxygen therapy because they may clinically develop exertional dyspnea, fatigue, and compromised exercise tolerance. For these people to have better respiratory outcomes and a higher quality of life, restrictive lung abnormalities must be promptly identified using pulmonary function testing and imaging, and systematic pulmonary rehabilitation programs must be put in place.

2.5 Respiratory Muscle Weakness (Post-ICU Syndrome)

One of the most common symptoms of post-intensive care syndrome (PICS) among COVID-19 survivors who needed prolonged mechanical ventilation or lengthy intensive care unit stays is respiratory muscle weakness. The diaphragm is among the most impacted muscles, and it may deteriorate as a result of disuse atrophy, neuromuscular blockade, extended immobility, and sedative usage [9]. According to Laveneziana et al. [9], diaphragm dysfunction can be

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made worse by systemic inflammation and critical illness neuropathy or myopathy, which are frequently observed in patients recuperating from severe COVID-19. It is also a result of mechanical ventilation.

This weakening of the respiratory muscles causes decreased tidal volumes, ineffective coughing, and a diminished ventilatory response to exercise, which frequently results in tiredness and chronic dyspnea. In extreme situations, patients could still need non-invasive help or ventilatory support even after the initial infection has been treated. Early mobilization during ICU care and pulmonary rehabilitation programs that emphasize strengthening the respiratory musculature have been demonstrated to lessen these effects and speed up the recovery of functional breathing capacity.
To treat respiratory muscle weakness and enhance the overall recovery trajectory in post-COVID-19 patients with a history of severe illness, close monitoring and focused therapies are necessary.

Preoperative Evaluation

3.1 History and Clinical Examination

The severity of pre-existing COVID-19 infection, including the history of hospitalization or the application of respiratory aids, needs to be documented. Dyspnea and fatigue are quite commonly stated to occur in the post-acute phase and can diminish the patient's physical function, thus increasing the general anesthesia risk [10]. These sequelae can also affect airway management, oxygenation, and surgical recovery, especially in patients who have established the presence of COVID-19 by hospitalization. Easy prediction of potential hazards and the planning of anesthesia will be much facilitated by good history-taking.

3.2 Investigations

- **Pulmonary Function Tests (PFTs)**: To assess restrictive patterns and diffusion capacity [2].
- **High-Resolution CT (HRCT)**: Identifies fibrotic and bronchiectatic changes [1,5].
- **Arterial Blood Gas (ABG)**: Evaluates baseline oxygenation and CO_2 retention [8].

Echocardiography: Essential if pulmonary hypertension is suspected [6].

Risk Stratification

Effective risk stratification remains key for anaesthesiologists caring for post-COVID-19 patients. In view of the severity of COVID, comorbidities, residual symptoms, and time since recovery, as the author suggests, a tailored approach should be taken [11]. Patients who continue to experience adverse respiratory or cardiovascular manifestations may be at an increased perioperative risk for hypoxia or hemodynamic instability. The use of a measurement tool within a structured

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assessment format and on a multidisciplinary basis helps ensure a balanced decision of the surgical readiness that guides anaesthetic planning with the least complications possible.

4.1 Anaesthetic Considerations

Intubation after COVID-19 is difficult due to secondary airway edema or fibrosis and tracheal stenosis that have arisen from prolonged intubation or endothelitis. Any of these anatomical changes may lead to difficulty with intubation, making conventional approaches less useful. Brower and Rubenfeld [12] argue for approaches that include minimal trauma to the airway and support lung protection. In such cases, advanced tools like video laryngoscopy or awake fibreoptic intubation should be considered to ensure a secure and atraumatic airway, especially in patients with suspected difficult airways or residual pulmonary compromise.

4.2 Ventilation Strategy:

Because of the possibility of lingering lung damage, lung protection should be the top priority in ventilatory treatment for patients recovering from COVID-19. Reduce ventilator-induced lung damage by using low tidal volumes (about 6 mL/kg of ideal body weight), properly titrating PEEP, and keeping plateau pressures below 30 cmH_2O [13]. Furthermore, extended exposure to high concentrations of inspired oxygen (FiO_2) can exacerbate lung damage and lead to oxygen toxicity, hence, it is best to avoid them unless clinically required [14]. For these patients, proper anesthetic care requires adjusting breathing techniques based on the patient's lung mechanics.

4.3 Choice of Anaesthesia

In post-COVID-19 patients, anaesthesia choice should minimize respiratory compromise and infection risk. Regional anaesthesia is often preferred when appropriate, as it avoids airway manipulation and reduces the potential for aerosol generation [15]. When general anaesthesia is required, Total Intravenous Anaesthesia (TIVA) is a favorable option. Unlike volatile agents, it prevents aerosolization and provides more steady hemodynamic control, which is important in a patient with residual cardiorespiratory effects post COVID-19 [16].

4.4 Surveillance and Pulmonary Evaluation

Close intraoperative monitoring may be required for a patient having COVID-19 postoperatively. Combining the traditional ASA monitors with arterial blood pressure monitoring and capnography, especially where there is impairment in pulmonary function, will be of greater use in assessing respiratory and cardiovascular stability [17]. Example bedside tools include lung ultrasonography, which allows dynamic assessment of lung aeration, helps in detecting pleural abnormalities, and also keeps track of any developing problems such as effusions or interstitial alterations, contributing to real-time decision-making in anesthesia [18].

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5. Postoperative Management

5.1 Oxygen Therapy and Monitoring

Patients may need oxygen therapy or noninvasive ventilation (NIV) due to persisting hypoxia and

compromised lung function in the recovery period following COVID-19 [8,19].

5.2 ICU Admission

Intra or postoperative respiratory decompensation, especially in fibrotic lung disease or pulmonary

hypertension may warrant ICU admission for close monitoring and advanced support [10].

5.3 Pulmonary Rehab

Pulmonary rehabilitation may include breathing exercises.

6. Challenges

Patients recovering from COVID-19 present unique challenges to anaesthesiologists. Their symptoms and recovery can vary widely, and clinical deterioration may occur unexpectedly. Some patients may seem stable preoperatively but develop complications under anaesthesia due to lingering respiratory or cardiovascular changes that are not always immediately apparent [3,7].

Another major concern is that there are very few guidelines to assist. Despite all the research about COVID-19, no standard anaesthetic protocol is available for this subset of patients. Clinicians are compelled to rely on their judgment and adapt anaesthetic management on a case-by-case basis, particularly when dealing with those having long-term pulmonary or cardiac sequelae [10].

Furthermore, mental health considerations are paramount. Many post-COVID patients attest to chronic anxiety, depression, or fatigue symptoms. These psychological manifestations can influence anaesthetic tolerance and contextually interpret the recovery course following surgery. Therefore, perioperatively, going along with the acknowledgment of physical health evaluation and risk mitigation is an assessment and management of these concerns [11].

Thus, anaesthetic management would require a more collaborative and flexible approach encompassing the complex and changing nature of post-COVID recovery.

7. Result:

Gentle ventilatory techniques that protect the lungs, such as low air volume and controlled pressure, allow patients to recover better from COVID-associated lung pathology. Regional anesthesia should thus be preferred when possible, as it avoids placing tubes into the airways, which could be dangerous for patients with fragile lungs. Many patients continue to feel exhausted and short of breath, even long after the COVID infection [19]. Anesthesia must be planned carefully, and their breathing monitored closely during and after surgery, keeping patient comfort and safety as a priority.

CONCLUSION

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In summary, fibrosis, muscle weakness, vascular problems, and decreased lung function are some of the lung issues that a person who is recuperating from COVID-19 may face. These issues often require vigilant care throughout anaesthesia and surgical procedures, alongside cautious postoperative care. Preference for regional aesthetic, wherever possible, and application of lung-friendly ventilation techniques are ways to reduce complications. Early rehabilitation and careful monitoring will contribute to an improved recovery process and quality of life. Recognizing the special needs of COVID-19-recovering patients will allow the medical community to offer safer and more efficient care directly catered to their course of recovery.

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