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PERIOPERATIVE MANAGEMENT OF BRONCHODILATORS AND CORTICOSTEROIDS IN COPD (CHRONIC OBSTRUCTIVE PULMONARY DISEASE) SURGICAL PATIENTS

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ABSTRACT

Patients with chronic obstructive pulmonary disease (COPD) who have surgery are at high risk of having a postoperative pulmonary complication, and close optimization of pharmacological care during the perioperative period is necessary. Long-term inhaled bronchodilators, specifically long-term combined β 2-agonists and muscarinic antagonists (LABA + LAMA) should be maintained up until surgery day and restarted the next day after the operation to maintain lung function and minimalize symptom management load. ICS (inhaled corticosteroid) as Bronchodilator therapy is indicated in increasing airflow and de-escalating inflammation when inhaled corticosteroids and bronchodilators are given together in the patients with high frequent exacerbations or eosinophilic phenotype with consideration of pneumonia complications with increased dosage. Systemic corticosteroids (e.g. 3-5 days of methylprednisolone before surgery) can help to relieve airway reactivity during intubation, or in patients within recent exacerbations but have to be considered on an individual risk benefit basis because of the risk of causing wound healing complications. Steroid-treated patients who are chronically steroid-receptive might need stress-coverage during surgery to avoid adrenal sufficiency. Smoking cessation, chest physiotherapy, and pulmonary rehabilitation started days prior to elective operations should be considered in preoperative optimization as well. In summary, persistent bronchodilator usage, particularly dual long acting, is the mainstay of perioperative care in COPD with ICS added selectively, systemic steroids only as needed, and adjunctive nonpharmacologic treatment as a multidisciplinary approach to reduce complications and improve results.

Keywords: chronic obstructive pulmonary disease (COPD), ICS (inhaled corticosteroid, Pulmonary complications after surgery (PPCs) COPD Chronic Obstructive Pulmonary disease

LMIC Lower- and Middle-Income Countries, PPC. Postoperative Pulmonary Complications, FRC. Functional Residual Capacity, V/Q. Ventilation/Perfusion, ICU. Intensive Care Unit, IMV. Invasive mechanical Ventilation, BiPAP. Bilevel positive airway pressure, CPAP . Continuous positive airway pressure, SBT. Spontaneous Breathing Trials, HF. Heart failure, PSV. Pressure Support Ventilation, ATS. American Thoracic Society, VTE. Venous thromboembolism, EHR Electronic Health record, PDE-4. Phosphodiesterase-4

INTRODUCTION

1.1 Background

Chronic obstructive pulmonary disease also referred as COPD is a progressively worsening respiratory disease that is caused by inflammation and narrowing of the airways, destruction of the alveolar sacs and excessive production of mucus. It includes both chronic bronchitis and emphysema, of which the symptoms are shortness of breath, persistent cough, and sputum production (Vogelmeier et al., 2017). COPD results from long exposure to irritative particles and gases with smoking being the major precipitating factor. However, other factors also have their part play in disease pathogenesis, including environmental factors, for instance, pollution, jobs one is doing, and even genes, for example, alpha-1 antitrypsin deficiency (Soriano et al., 2020).

The prevalence of COPD in the global population increases and currently, COPD is the third leading cause of death in the world with 3 million deaths recorded per year (WHO, 2022). The disease is characterized by considerable morbidity, for that often requires admissions, reduces the quality of life and health care costs. As it is placed by the Global Burden of Disease Study, COPD affects an estimated 384 million people worldwide, with increased use identified in L&MICs regarding the early diagnosis and treatment (Collaborators of GBD, 2020). The burden of COPD is expected to rise due to the aging population, persistent exposure to risk factors, and a high prevalence of undiagnosed cases in primary healthcare centers.

Postoperative pulmonary complications play more frequently in patients with COPD due to compromised respiratory function and the attendant risks of surgery. It is known that other factors such as surgical procedures involving general anesthesia or mechanical ventilation deteriorate a patient's respiratory status and are associated with a higher incidence of PPCs (Canet et al., 2010). Some of the effects of anesthesia include decreased FRC, impaired mucociliary clearance, and impaired V/Q as well as ventilation; hence, patients with COPD are at a higher risk of developing atelectasis, pneumonia, as well as acute respiratory failure (Futier et al., 2016). Also, most of these patients have multiple comorbidities for instance, cardiovascular illness and diabetes resulting in increased risk during the operation (Merry & Edwards, 2019).

1.2 Rationale for the Review

Another valuable part of surgical planning is a risk assessment before the operation especially if the patient has Chronic Obstructive Pulmonary Disease. Knowledge of the side effects of operations helps clinicians encase preventive measures that can help manage ill-effects of operations. COPD thus places the patient at a higher risk of developing PPCs such as respiratory infection, acute exacerbation, mechanical ventilation, and increased need to be admitted to the ICU (Miskovic & Lumb, 2017). Research has further revealed that postoperative mortality is higher in patients diagnosed with COPD due to the fact that patients with obstructive lung disease are 1-2 times more likely to have postoperative complications as compared to non-pulmonary disease patients (Blanchet et al., 2021). Therefore, there is a need to systematically identify effective perioperative care management protocols driven by the three P's of preoperative preparation, intraoperative protection, and postoperative recovery.

COPD patients who undergo surgery are cared for in a widely varying capacity in health care facilities all over the world and there is not much information about how they are managed during the perioperative period. Environmental hazards also lack global standards in their assessment and this affects the approach used by patients in assessing risks thereby making their decisions less than optimal (Gujadhur et al., 2020). Previous guidelines provide recommendations that discourage smoking, advise pulmonary rehabilitation, and make pharmacologic adjustments; nevertheless, its application is infrequent owing to unknown factors and organization-related issues. Furthermore, the evolution of perioperative medicine like NIV and ERAS also posited an implication for traditional management strategies to yield the best surgical outcome for patients with COPD (Licker et al., 2017).

1.3 Objectives

The purpose of this review is therefore to discuss various aspects of perioperative complications to COPD and the factors that should be considered in relation to patients with this condition. Specifically, this article aims to:

Identify and comprehend the risks of developing surgical complications among patients who have COPD

This has to do with the pre-existing factors such as the disease process, the lung function, the type of

anesthesia used and type of surgery to be done. This particular review will therefore aim at discussing the effects of these variables in order to identify the most susceptible conditions and patients for increased adverse outcomes during the perioperative period.

Analyze risk-reducing evidence-based strategies in the perioperative management of patients with Chronic Obstructive Pulmonary Disease (COPD).

The review will evaluate current strategies with regards to preoperative, intraoperative, and postoperative management of patients with COPD. Preoperative options include pulmonary rehabilitation and bronchodilator therapy, intraoperative techniques involving lung-protective ventilation and anesthetic selection, and postoperative management including rewarding breathing and early mobilization. Through analyzing each of these interventions, this review hopes to establish a practical method of minimizing the occurrence of postoperative complications in the COPD patients.

Identify the areas of practice that require improvement with suggestions of what can be done to fill the gaps and some areas for future investigation as well.

However, much of this emerging field has several areas of uncertainty about strategies for the optimization of COPD patients in surgery. Specific limitations of this study include the lack of specific data-regarding the effectiveness of precise medicine in the context of the perioperative period, the efficiency of biomarkers as tools for risk stratification of patients with COPD and the outcome of interventions conducted in the context of the perioperative period on the overall progress of the disease.

2. PATHOPHYSIOLOGY OF COPD IN SURGICAL SETTINGS

2.1 COPD Pathogenesis and Its Impact on Surgery

Chronic obstructive pulmonary disease mainly refers to long-standing respiratory limitations caused by inflammation and destruction of the lung tissue and/or narrowing of airways. Such pathological alterations complicate the process of anesthesia, mechanical ventilation, and postoperative period in surgical practice due to the patient's reduced capacity to endure various interventions. The disease process is characterized by repeated episodes of exacerbation, presence of systemic inflammation, and gradual worsening of lung function, thus raising surgical risks regarding morbidities and mortality (Hurst et al., 2020).

The development of COPD is mainly attributed to chronic inflammation of the lungs that is as a result of repeated exposure to injurious irritants including tobacco smoke, air pollution, and dust at the workplace. Thus, the airflow limitation is further compounded by excess mucus and dysfunctioning cilia, which hinder pathogens elimination and put the patient at a high risk for recurrent respiratory infections (Rabe et al., 2018). These structural alterations reduce the cardiac output thus put such patients at high risk of developing acute respiratory failure during and post-surgery.

Altered gas exchange is one of the major pathophysiologic derangements in COPD and it mainly stems from emphysema and ventilation-perfusion inequality. During the progression of emphysematous changes, the alveolar surface gets diminished which in turn decreases the efficiency of the lung for oxygen diffusion thus causing hypoxemia in chronic patients. Also, dead space ventilation is another factor that increases hypercapnia since alveolar ventilation is extremely ineffective in eradicating carbon dioxide (MacNee, 2019). These disturbances are especially significant in surgical contexts since the patient's oxygenation and CO2 levels fluctuations during the postoperative period can lead to life-threatening respiratory failure, arrhythmias, and encephalopathy (Lindenauer et al., 2020).

There is also another significant pathophysiological characteristic in the state of COPD known as airway hyperresponsiveness that receives deterioration due to chronic inflammation and mucus production. For this reason, COPD predisposes a patient to bronchospasm, especially when handled to surgical stimuli, endotracheal intubation or inhaled anesthetics (Peters et al., 2019). Our evidence also confirms the fact that due to high sensitivity of airways and ineffective mucociliary clearance, the patients suffering with COPD, are at the higher risk of developing infected pneumonia and viral-fashion which increase the risk rate of postoperative surgical complications (Wedzicha & Seemungal, 2018). For this reason, patients with COPD need careful planning throughout the operative period in an effort to reduce the risks of pulmonary deterioration and enhance surgical outcomes.

2.2 Pathophysiological Changes Induced by Surgery

Surgery is a major stress on the COPD patient for a number of reasons most of which affect the pulmonary system and mechanisms of gas exchange and homeostasis. One of the daunting consequences of surgery on the COPD patients is the ability of the anesthesia used to affect their pulmonary health.

Under general anesthesia the FRC reduces because of the relaxation of the diaphragm and changes in the compliance of the thorax. This leads to alveolar diminishing, or atelectasis, which is a prevalent and dangerous outcome in the postoperative period that aggregates hypoxemia and pneumonia risks (Moller et al., 2021). As the lung volumes and airway become smaller and close, delivers even more blood flow to regions with decreased ventilation and hypoxemia, this results in ventilation-perfusion inequality, although in COPD patients who congestive heart failure already experiences chronic imbalances in gas exchange (Bhatia et al., 2022).

CO-PD patients suffer from increased incidence of atelectasis and hypoxemia during the postoperative period. Atelectasis is due to reduced surfactant synthesis, patient's immobility and effects of mechanical ventilation, which result in alveolar consolidation and poor oxygenation (Sundar et al., 2019). This is compounded by opioid-based analgesia that depresses the respiratory center and worsens carbon dioxide accumulation which results in hypercapnic respiratory failure in vulnerable persons (Belcher et al., 2020). Furthermore, surgical stress initiates a cytokine release following surgery that potentially enhances inflammation of the airway, augments bronchoconstriction, and directly leads to acute COPD exacerbations, that inherently increases the risk of respiratory problems in turn, lengthens stay in the ICU (McDonald et al., 2020).

Some of the complications associated with the use of the ventilator include ventilator-associated pneumonia where COPD patients undergoing surgery are also vulnerable. Mechanical ventilation is mostly required in major surgeries and it brings about VILI: barotrauma, volutrauma and oxygen damage. Patients suffering from COPD have damaged lung parenchyma as well as thin alveolar septa and are candidate lungs for VILI, especially, it aggravates the existing emphysema and prolongs the need for ventilation (Apostolova et al., 2021). Moreover, VAP is more common in COPD due to the patient's ability to cough and clear secretions effectively which also relate their baseline colonization of the lower respiratory tract (Shorr et al., 2020).

Thus, since both COPD and the surgical environment pose multiple pathopharmacological questions for respiratory compromise, it is critical to employ measures that can effectively mitigate the possibility of this occurrence. Low tidal volume mechanical ventilation and PEEP are now recommended for the management of postoperative COPD patients as they prevent lung collapse, reduce alveolar dere recruitment and the formation of intraoperative atelectasis (Serpa Neto et al., 2018). Moreover, the selective administration of regional anesthetic procedures, where appropriate, would go a long way to counterbalance the effects of general anesthesia; this would lessen the occurrences of perioperative respiratory failure as indicated by Sessler et al., (2022).

3. Preoperative Risk Assessment for COPD Patients

3.1 General Considerations

Risk assessment before the operation is one of the most important activities that should be performed for copying patients with COPD. Due to the fact that these patients have higher risk of postoperative complications, the assessment is required to enhance perioperative care and surgical outcomes. COPD elevates PPCs, such as, respiratory failure, pneumonia, prolongation of mechanical ventilation, thereby determining greater morbidity and mortality conditions (Canet & Gallart, 2014). Therefore, a comprehensive preoperative evaluation assists in identifying high-risk patients, in the assessment of severity of COPD and, planning of optimal preoperative management of patients with COPD. A less common element of preoperative assessment is the definition of optimizable factors that may be amenable to intervention before the surgery. They are smoking related measures, pulmonary rehabilitation, optimization of bronchodilator therapy and management of comorbid conditions like cardiac and diabetic as they are known to be common among COPD patients (Miskovic & Lumb, 2017). Hence, the surgical procedure itself factors into the level of perioperative risk; it is established that thoracic and upper abdominal surgeries are at a higher risk of PPCs than peripheries and low-risk procedures (Kheterpal et al., 2016).

There is various risk stratification analyzes and guidelines that help clinicians in assessing the perioperative risk in patients with COPD. Several organizations such as the American College of Chest Physicians (ACCP) and the American Society of Anesthesiologists (ASA) have guidelines that determine the risk of patients before, during and after surgery. The ASA classification system, which classifies the patients according to their overall health, is used for the prognostic expectations of surgery, and the COPD is commonly described as ASA III or IV, which marks a high level of surgery risk (Keats et al., 2018). Furthermore, there is the ARISCAT, Assess Respiratory Risk in Surgical Patients in Catalonia

which is a tool used to predict probability of PPCs including age, respiratory infection, anemia, type of surgery and duration of surgery (Canet et al., 2010). However, these models are not sufficient to exclude clinical judgment in the management of the patient during the perioperative period since patient evaluation should be individualized for enhanced outcomes.

3.2 Pulmonary Function Testing (PFTs)

Pulmonary function testing [PFT] is a core aspect in the preoperative evaluation for patients with COPD who require surgery. Spirometry is now the most common PFT, offering several values which include FEV1, FVC, and the FEV1/FVC%. These parameters define the extent of the airflow limitation with regard to the FEV1 and predict the patient's pulmonary risk after surgery. Spirometry results indicating FEV1 of less than 50% further predicted value has been demonstrated to render the patient at higher risk of PPCs, longer hospital stay, and postoperative respiratory failure (Gupta et al., 2018).

Besides spirometry, diffusion capacity of carbon monoxide (DLCO) is another important marker in evaluating pulmonary reserve. DLCO is the diffusion capacity of the lung for carbon monoxide across the alveolar-capillary membrane. Decreased values in DLCO are suggestive of emphysematous changes and oxygen diffusion, which are in turn expected to have a negative impact on postoperative outcomes especially following surgeries that will require the use of mechanical ventilation (Cypel et al., 2019). The published literature shows that patients with DLCO of 50 percent of predicted or less are likely to develop postoperative complications when undergoing surgeries involving the thoracic cavity (Nici et al., 2020).

3.3 Blood Gas Analysis

Arterial blood gas (ABG) evaluates abnormalities of the arterial blood gas which pertain to a patient's COPD making it a critical part of the preoperative evaluation in patients suffering from the disease in order to predict the risk of developing respiratory failure during the postoperative period. COPD patients are known to be hypoxemic, hypercapnic and have respiratory acidosis which are signs of poor alveolar ventilation and high dead space. By identifying such abnormalities before surgery, it becomes easier for clinicians to treat patients with oxygen therapy, NIV, bronchodilator optimization in order to minimize the risk of respiratory complications after the operation.

Hypoxemia, which is a PaO2 of less than 60 mmHg, is present in most of the COPD patients as a result of V/Q inequality and impaired oxygen diffusing capacity. Literature reports have identified hypoxemia to be predictive of postoperative morbidity and mortality such as, the duration of mechanical ventilation and admission to the ICU (Ferrando et al., 2020). Additionally, an elevation of $PaCO_2$ greater than 45 mmHg is a characteristic of severe COPD and can significantly increase patients' risk for respiratory depression and the inability to pass through the mechanical ventilation (Arozullah et al., 2021). For this reason, patients with chronic hypercapnia have low chemosensitivity to CO2 and are more vulnerable to opioid-induced respiratory depression in the postoperative period.

Thus, ABG analysis is a very helpful method used in the evaluation of the preoperative risk of patients with chronic obstructive pulmonary disease. Analyzing the absolute value of PaO2, PaCO2, pH, and other parameters of ABG helps the clinician to recognize a patient at high risk of developing respiratory problems and needing preoperative preparation. When complemented with PFT and clinical risk prediction score, ABG analysis serves as a valuable tool in preoperative evaluation enabling the reduction in postoperative morbidity and mortality in patients with COPD undergoing surgery. Therefore, future research recommendations should continue to include ABG analysis of AMI patients and explore its combination with future biomarkers and ambulatory respiratory monitoring in this anemic patient's subgroup.

3.4 Imaging and Radiological Assessment

Imaging and radiological assessment should always be incorporated in any preoperative evaluation of patients with COPD who are to undergo surgery. Since, COPD has features like progressive airway obstruction, lung hyperinflation, parenchymal destruction, it becomes mandatory to do radiographic imaging to know the severity of lung involvement, presence of any structural abnormality and to identify any condition which may increase the risk during surgical intervention. Chest X-ray and CT are two forms of imaging that are quite frequently ordered for patients with COPD and have some specific benefits when it comes to evaluating COPD status in the preoperative period.

Chest x-ray is the most commonly used imaging modality in preoperative assessment because it is the

most readily available, economical and provides an overview of the lung. It is particularly helpful to use for hyperinflation, bullae, increased anteroposterior diameter, and diaphragm flattening that are hallmarks of COPD (Bhatt et al., 2020). However, chest X-ray can also detect other illnesses affecting the lungs including pneumonia, pleural effusion, pulmonary fibrosis, or a lung mass that may complicate patients' intra-and postoperative management (Fraser et al., 2019). The extent of bullous disease and other radiographic changes may require further investigations to assess the capacities for the intended surgeries on possible compromise after surgery on the patients. However, with regard to acute emphysematous changes and small airways diseases, chest X-ray is not very effective; and hence, CT with advanced imaging is required for a detailed assessment.

High-resolution computed tomography (HRCT) provides a better understanding of structural lung abnormalities in COPD patients especially in terms of preoperative risk assessment. HRCT imaging of the lung is effective in depicting lung tissue architecture, emphysema, airway disease, and bronchiectasis, important features in COPD (Castellano et al., 2021). Literature has also revealed that CT-based quantification of emphysema and airway remodeling is prognostic of clinical course in terms of lung function deterioration, as well as post-surgery complications (Labaki et al., 2019). Furthermore, CT imaging is also an important diagnostic tool in diseases like lung cancer, interstitial lung disease, and patients with significant bullous disease which may necessitate reversible intervention prior to surgery. Thus, in patients undergoing major thoracic surgery, such as LVRS or LT, CT scans are invaluable both for planning surgery and assessing risks, as they uncover the distribution and extent of emphysematous changes (Yoon et al., 2020). For these reasons, the use of CT imaging has been incorporated in preoperative risk assessment for COPD patients going for surgery and especially those who present some surgical risk factors. However, as with most imaging techniques, CT imaging does have its shortcomings and these are radiation and cost implications. For the CT imaging, it is important to focus on clinical indications, severity of the COPD, and the type of surgery to be carried out. For those situations where more specific anatomical evaluation is needed, CT-based segmentation and volumetric evaluations of the lung might add more information to identify and estimate the remaining pulmonary reserves as well as function after lobectomy (Gallardo-Estrella et al., 2018). The combination of imaging with pulmonary function tests and other investigations offer greater objectivity to preoperative risk assessment to give a better personalized approach to the management of patients with COPD during the operative period.

3.5 Cardiopulmonary Exercise Testing (CPET)

Cardiopulmonary exercise test or CPET is essential in measurement of functional performance as well as eligibility for surgery among patients with COPD. CPET is a direct measurement of gas exchange, ventilation, and cardiovascular during exercise and is one of the most accurate tests to predict the perioperative risk and postoperative status (Mets et al., 2018). Since a COPD patient commonly has exertional dyspnea and exercise intolerance, CPET helps to measure the functional limitation and risk of postoperative morbidity in the patients.

Among the elements considered in the CPET, the highest VO2 recorded, noted VO_2peak corresponds to the aerobic capacity and the cardiovascular reserve. VO_2max less than 15 ml/kg/min is considered a high risk for morbidity and mortality in the early postoperative period especially in major thoracic and abdominal surgeries West et al., (2019). On the other hand, patients with VO2max more than 20ml/kg/min are considered to be at a lesser risk of development of complications, and they are unlikely to have much respiratory impairment during and after surgery. Furthermore, CPET results in anaerobic threshold (AT), ventilatory efficiency (VE/VCO_2), and oxygen pulse to deliver a detailed physiologic evaluation of the dual relationship between pulmonary and cardiovascular systems in COPD patients undergoing surgery (Nakanishi et al., 2020).

3.6 Risk Prediction Models

Risk assessment indices are widely used to identify the overall risk of COPD patients within the perioperative period using patients' clinical profiles and scores from clinical models. Among all the guidelines available for preoperative assessment of pulmonary risks, one of the most well-known is the American College of Chest Physicians (ACCP) which contains recommendations on how to manage and evaluate COPD patients for surgery (Colice et al., 2021). From the statements, the ACCP has listed the absolute necessity of preoperative PFTs, smoking cessation, bronchodilator optimization, and perioperative respiratory support measures to minimize postoperative complications. Other guidelines include the utilization of scores for evaluation of perioperative morbidity as well as

planning for clinical care. ASA (American Society of Anesthesiologists) physical status classification system is another widely known risk assessment model applied in surgical care. Hence, COPD is considered as ASA III (severe systemic disease) or ASA IV (severe systemic disease with threat of life realization), indicating high perioperative risk of the illness (Minnaard et al., 2019). As it has been established before, the ASA classifying makes a broad perspective of fitness for a surgery, more particularly; it is ineffective in predicting such pulmonary complications hence the need to use other risk predictors.

The ARISCAT score is a risk prediction tool that was derived and validated for identifying the risk of PPCs in surgical patients undergoing surgical procedures in Catalonia. The postoperative complications risk estimate is based on age, preoperative oxygen saturation (SpO_2), respiratory infection within 1 month before surgery, type of surgery, duration of operation, emergency status, and anemia (Canet et al., 2015). Some researchers have established that higher ARISCAT implies poor outcomes such as pneumonia, development of respiratory failure and long periods of mechanical ventilation in patients with COPD who undergo surgery (Rosas et al., 2020).

Overall, risk prediction models can be helpful in stratifying perioperative risk in patients with COPD. Therefore, it is beneficial to incorporate ACCP guidelines, ASA classification, and the ARISCAT score together with objective results such as PFT, CPET, and ABG. Further research should continue to enhance these predictive models for postoperative COPD patients by incorporating more biomarkers, using advanced machine learning techniques in conjunction with progress in precision medicine in order to enhance the overall prognostication and surgical management of these patients.

4. SURGICAL RISKS AND COMPLICATIONS IN COPD PATIENTS

4.1 Respiratory Complications

Specifically, COPD patients are at a higher risk of post-surgery respiratory complications because of underlying lung disease and limited reserve to handle various stress factors during theCourses of surgery. Some of the severe postoperative respiratory complications include the development of pulmonary infections and respiratory failure, prolonged requirement of mechanical ventilation among many others consequently resulting to high morbidity, longer hospital stay and increased mortality rates. In particular, postoperative pulmonary infections can be considered as one of the most common issues in patients with COPD after surgery. COPD patients with chronic bronchitis suffer from inflammation, increased secretion of mucus that affects mucociliary clearance, as well as lung infections caused by bacteria (Agusti et al., 2022). As pointed out above, the risk is even worsened by the use of endotracheal intubation during surgeries because this allows the bacteria into the lower respiratory system.

A common adverse health complication is ventilator-associated pneumonia (VAP), with COPD patient having higher VAP incidence compared with patients without COPD (Melsen et al., 2019). Finally, postoperative ileus, postoperative immobility, and the dangerous effects of anesthesia on the respiratory muscles and lung tissue predispose the patient to atelectasis, which is a good environment for the inception of an infection and unfavorable effects on the respiratory compromise (Moore et al., 2021). Several investigations established that patients with COPD who contracted postoperative pneumonia required increased ICCU admission rate and extended hospital stay implying the significance of avoiding infection risk factors in preoperative care, perioperative pulmonary care, and early mobility (Lipes et al., 2020).

Respiratory failure is another serious problem of patients with COPD who have received surgery, especially those with severe disease and pre-existing hypercapnia. It has been widely illustrated that postoperative respiratory failure results from opioid-induced respiratory depression, residual neuromuscular blockade, compromised VQ match due to surgery and anesthesia stress, and other factors (Alvarado et al., 2020). This ought to be a real reason to strive and develop even minimal surgical procedures; in patients with advanced COPD even minor surgical procedures could result into serious respiratory decompensation, leading to increased mechanical ventilation and ICU admission. The possibility of respiratory failure is even higher in cases of surgery on the thoracic and upper abdominal organs since diaphragmatic inhibition and, therefore, limited lung expansion are observed here (Xie et al., 2022). It causes barotrauma, volutrauma and other secondary complications for instance infections, and thus early liberation from mechanical ventilation and lung protective ventilation strategies are key interventions in patient's care (Netzer et al., 2021).

4.2 Cardiovascular Risks

COPD is a known pre-existing condition that has been shown to increase the risk of cardiovascular complications in the postoperative period; postoperative myocardial infarction, cardiac arrhythmias and cardiovascular instability are more frequent in patient's pts with COPD than in pts without respiratory disease (de Torres et al., 2022). COPD is associated with increased cardiovascular risk and one of the main reasons for this association is the effect of systemic inflammation, which leads to endothelial dysfunction and increased arterial stiffness, as well as an increase in thrombotic risks. In the perioperative environment, these factors in conjunction with hypoxemia and stimulation of the sympathetic nervous system put the COPD patients at risk of acute coronary event and arrhythmias.

COPD patients who undergo major surgical operations are 2 to 3 times more likely to suffer a myocardial infarction. Chronic hypoxemia in COPD increases myocardial oxygen demand and coronary blood flow capacity; however, it reduces the ability to meet the demand during periods of stress like hypoxia, hypercapnia and anesthetic-induced vasodilation increases the mortality risk in COPD patients (Bourjeily et al., 2020). Several reviews have established that patients with COPD are at a two-fold higher risk of having a perioperative myocardial infarction if they are to undergo non-cardiac surgery and this is more prevalent in cases of severe restriction of airflow and frequent COPD exacerbations (Lindenauer et al., 2021). To reduce the risk of this complication, effective preoperative oxygenation, restrictive fluid therapy, and close hemodynamic control are crucial in a patient with MS.

There are also increased risks of arrhythmias especially of atrial fibrillation and ventricular ectopy in patients with COPD who are undergoing surgeries. The continuous hypoxic and hypercapnic condition of COPD puts the patients at a high risk of autonomic dysfunction and increased sympathetic tone, factors that promote dysrhythmias (Barnes et al., 2019). Perioperative factors which include changes in electrolyte balance, variation in intraoperative fluid balance and release of catecholamine may also predispose the culled COPD patients to develop arrhythmias hence the need to monitor their cardiac status during surgery. Beta-blockers and calcium channel blockers are beneficial for lowering the risk of arrhythmia, though their usage should be justified due to the possible development of bronchospasm (Zhou et al., 2020).

Cardiovascular complications are also manifested in pulmonary hypertension and strain on the right heart in COPD patients arriving for surgery. Chronic hypoxemia leads to changes in the pulmonary vessels and an increase in PA pressures which puts a considerable load on the right ventricle (Douschan et al., 2021). This can present as postoperative right heart failure especially in patients undergoing major thoracic or abdominal procedures that increase intrathoracic pressure and affect the right ventricle. Perioperative fluid management in such patients is highly risky as large volume resuscitation leads to worsening of the right side of heart and contributes to hemodynamic compromise.

4.3 Anesthetic Considerations

A careful selection of anesthetic techniques influences perioperative moribundity in patients suffering from COPD. Due to the effects such as respiratory depression, inhibition of mucociliary clearance, and the potential for developing postoperative respiratory failure, the use of general anesthesia in patients with COPD is complicated (Yamakage et al., 2022). Due to the administration of volatile anesthetics and intravenous agents, the FRC and tidal volume are decreased, which promotes atelectasis and hypoxemia. Further, intubation causes irritation of the airway while moving the incisor tooth and potentiating the occurrence of bronchospasm in patients with reactive airways (Pedoto et al., 2020).

On the other hand, regional anesthesia has been recommended for use by subjects with COPD especially when; Neuraxial and peripheral nerve blocks used in patients present less respiratory depression risk compared to general anesthesia, and thus, make an option in avoiding postoperative pulmonary complications (Neuman et al., 2020). However, LA is not ideal for all types of operations, and many aspects of surgery should be considered when patient-general aspects are being determined. Other critical drugs in COPD patients include Neuromuscular blocking agents (NMBAs) and opioids. NMBAs may result in residual muscle weakness compromising respiratory efforts, hence predisposing patients to atelectasis and pneumonia after surgery (Della Rocca et al., 2022). Also, opioids that are often used for postoperative pain management are detrimental to the COPD patients especially those with chronic hypercapnia, they cause severe respiratory depression (Kurdi et al., 2021). The management strategies to prevent opioid-induced respiratory complications include multimodal

analgesia using ketamine, gabapentinoids and regional anesthesia.

4.4 Prolonged Hospital Stay and Mortality Risks

Surgical COPD patients have a higher risk for such factors as the length of the hospitalization period, ICU admission and postoperative mortality rates are higher and for good reasons because the patients have more comorbidities and a higher vulnerability to complications. Previous research has shown that patients with COPD stay much longer in ICU than the patients who are not affected with this disease; mechanical ventilation is one of the reasons for prolonged hospitalization (Quint et al., 2021). Duration of postoperative requirement of, non invasive ventilation and oxygen therapy another cause for the prolongation of recovery and utilization of the health care resources. Another concerning factor is the readmission rates after the surgery, where data from the studies revealed that up to 20 to 30 percent of the COPD patients who underwent surgery are likely to be readmitted to the hospital within the first 30 days of the surgery. These are mainly respiratory infections, exacerbation of COPD and cardiovascular events, hence implies the need to monitor patients closely in the outpatient settings.

Therefore, special attention should be paid to respiratory and cardiovascular risks in COPD patients who are candidates for surgery. This paper also reveals that management of preoperative lung function, choice of anesthetic interventions and effective treatment of postoperative complications are some of the essential actions towards improving outcomes. Further research studies should aim at the fine-tuning of perioperative care guidelines as well as coming up with new preventive measures in the effort to cut down the high rate of complication occurrences in this group of patients.

5. Preoperative Risk Mitigation Strategies

Risk reduction measures in COPD must be done before surgery as this will enhance the general surgery process in these patients. Patients with one or more of these diseases are at risk of developing PPCs like respiratory infections, prolonged ventilation, or acute respiratory failure after surgery. In this paper, they discuss how these risks can be minimized and postoperative recovery enhanced, through preoperative interventions. Risk prevention in COPD patients includes smoking cessation, pulmonary rehabilitation, pharmacologic management, treatment of other diseases, and proper lung care, which are vital throughout the preoperative period.

5.1 Smoking Cessation and Pulmonary Rehabilitation

Smoking cessation is one of the well-established measures in the improvement of the patients with COPD during and after the surgery. Smoking is the chief cause of COPD and has been proved to magnify the rate of surgical complications because of poor mucus removal, hyper-responsive airway and systemic inflammation. In developing several studies, experts have proven that smoking cessation before an operation reduces the incidences of postoperative pulmonary infections and respiratory failure. The ACCP and ERS guidelines on postoperative risks suggest that smoking cessation should be done at least four weeks before elective surgery so as to allow for pulmonary function to improve (Warner et al., 2020). Reducing exposure to smoking for as short a time as two weeks has also been shown to significantly reduce PPCs, although more extended periods of smoking cessation are much more beneficial in terms of the changes in respiratory health that they bring, as Møller et al., has shown.

It is imperative for the patient to quit smoking not only for their specific surgery but for their overall health as well. Previous research has indicated that preoperative smoking cessation decreases the chances of further COPD episodes and cardiac issues (Lee et al., 2021). Smoking cessation also helps in increased oxygen delivery, improved immune function, less carbon monoxide content in the blood all facilitating improved surgical recovery. Moreover, the present findings of this study show that preoperative smoking cessation significantly decreases the demand for postoperative mechanical ventilation as well as the length of ICU stay (Haugen et al., 2020). Therefore, it is desired that COPD patients be instructed of the benefits of smoking cessation and should be prescribed appropriate pharmacologic and behavioral smoking cessation interventions such as NRT and CBT to enhance successes.

Another important preoperative prerequisite for COPD patients that we have is pulmonary rehabilitation. Preoperative pulmonary rehabilitation covers such components as exercise training, as well as knowledge and behavior modification in patients with respiratory disorders. The prehabilitation program means the exercise to enhance lung function and exercise capacity prior to operation have become effective in the reduction of PPCs and the length of

stay (Spruit et al., 2021). This kind of exercise involves aerobic exercise, strength training and breathing exercise like pursed lip breathing, diaphragmatic breathing which in turn exercises the lungs hence enabling more efficient use of the lungs and reduces the work of breathing.

Pulmonary rehabilitation for patients before surgery has been reported to be effective in the following studies. Boden et al. (2020) identified that COPD patients who completed preoperative pulmonary rehabilitation had better outcomes with low incidences of postoperative pneumonia and better functional status, and had lower thirty-day mortality than patients who did not undertake preoperative pulmonary rehabilitation. One of them showed that a four weeks' prehabilitation intervention could enhance six-minute walk distance (6MWD) and peak oxygen consumption, which are facets that help in achieving better surgical outcomes (Beauchamp et al., 2021). With these benefits in mind, it could be concluded that pulmonary rehabilitation should be implemented as a routine preoperative treatment for COPD patients who are planned for the major surgery.

5.2 Pharmacological Optimization

Pharmacotherapy forms an important part of preoperative risk management in the context of patients with COPD. Bronchodilators help in readiness to lung functions, inhaled corticosteroids minimize airway inflammation and use of mucolytics and systemic corticosteroids also decrease the chances of respiratory complications around the time of surgery. Bronchodilators including LABA and LAMA form the basis of COPD treatment and should be titrated prior to surgery. These ones help in opening of the airways through enabling the relaxation of the smooth muscles thereby increasing the airway resistance and improving the pulmonary mechanics. The use of bronchodilators prior to surgery helps to potentially enhance pulmonary functions and avoid postoperative bronchospasm (Vogelmeier et al., 2021). Salbutamol and ipratropium for exigent use are used before operation to avoid postoperative bronchospasm.

Inhaled corticosteroids (ICS) when administered as maintenance therapy are used in COPD for patients with frequent exacerbations or severe airway inflammation. However, the effectiveness of ICS in preoperative optimization is still to be questioned, although some interventions in prior research indicate that they help to decrease airway inflammation and enhance respiratory outcome (Kew et al., 2020). While ICS have provided a significant benefit for COPD patients, there are adverse effects of the drugs especially due to the long-term use and therefore, patients on ICS should be well selected.

Drugs like N-acetylcysteine (NAC) and carbocisteine could be used in COPD with cases of excessive production of mucus. These agents work to decrease the viscosity of the mucus, facilitate its clearance from the airways, and improve the caliber of the airways. Several studies have also used preoperative NAC for patients with COPD; according to Zheng et al. (2021) preoperative NAC significantly enhances postoperative lung function and reduces rates of PPCs. Considering the safety profile and the potential benefits of mucolytics, the drugs should be used in COPD patients with superimposed chronic bronchitis phenotype. Corticosteroids are a common treatment prescribed to manage the exacerbations of the COPD patient. Preoperative short courses of corticosteroids are justified in patients with severe airway inflammation or any exacerbation with a recent history within two weeks. However, long-term use of systemic steroids is not without its drawbacks; they bring immunosuppressive effects, hyperglycemia, and delayed wound healing at their back pocket' (Ritchie et al., 2020). A moderate course of action needs to be followed because there is a positive effect of reducing airway inflammation but there is also the possibility of systemic side effects.

5.3 Management of Comorbidities

COPD is often complicated by ischemic heart diseases, diabetes, and malnutrition which have significant implications on patient outcomes in surgery. A proper management of these comorbidities is therefore important in preventing these risks amongst the surgical patients. A high number of patients with COPD have cardiovascular disease because it was estimated that up to 50% of COPD patients also have coronary artery disease or heart failure (Mannino et al., 2021). In the preoperative assessment, control of blood pressure, optimization of heart failure, and elimination of excessive intraoperative and postoperative fluids are important for minimizing cardiac postoperative complications. Beta-blockers are useful for cardiovascular risk reduction however their use is restricted in COPD because they can provoke bronchospasm.

Another aspect that must not be overlooked is diabetes because postoperative patients that have either normal or high blood glucose levels experience a higher risk of infection and slow rates of wound healing. Insulin and

oral hypoglycemic medications should be adjusted in order to achieve optimal perioperative glycemic control (Forbes et al., 2021). The nutritional status of patients with COPD is poor as many of them suffer from malnutrition and muscle wasting which significantly affects surgical prognosis. In this view, prophylactic regimens such as protein-enriched diets and administration of vitamin D are effective in enhancing muscle function and thus promote recovery as indicated in the study by Collins et al. (2021).

5.4 Pulmonary Hygiene and Airway Clearance

Preoperative pulmonary hygiene and airway clearance measures are vital to enhance lung capacity and ensure that the lungs are as clear as can be made before surgery. Besides spirometry, another common practice involves actively promoting deep breathing and lung expansion in an attempt to prevent the formation of atelectasis and the development of postoperative pneumonia. According to various works of literature, pulmonary rehabilitation using incentive spirometry before the operation has been proven to decrease the occurrence of PPCs with patients of COPD who have undergone major surgery (Westerdahl et al., 2020). In conclusion, preoperative risk mitigation strategies in COPD patients encompass smoking cessation, pulmonary rehabilitation, pharmacological optimization, comorbidity management, and pulmonary hygiene techniques. These interventions are important in prevention of the complications that occur after surgeries and increase the success of surgeries. Thus, additional studies should be conducted to improve these approaches and combine new treatments to maximize the effect of perioperative management for patients with COPD.

6. Intraoperative Considerations

Specifically, managing patients with chronic obstructive pulmonary disease (COPD) during operations is complex because they are at a high risk of perioperative complications and have compromised respiratory function as well as a high risk of developing postoperative pneumonia. Ventilatory mode, the type of anesthesia used and compliance to volume management can significantly influence COPD patients' surgery outcomes. Safe intraoperative practices, therefore, seek to avert respiratory depression as well as promote adequate gas exchange and stabilization of hemodynamics. Intraoperative management of COPD patients should be personalized to avoid hypoxemia, hypercapnia, bronchospasm, and PPCs, such as prolonged air leak, atelectasis, pneumonia, and respiratory failure.

6.1 Anesthesia Selection and Techniques

The choice of anesthesia in patients with COPD has several implications for respiratory outcomes in the postoperative period. Both the General anesthesia and regional anesthesia have certain advantages and disadvantages and are administered based on the type of surgery, preexisting lung condition of the patient and his/her co morbid conditions. Surgery requires general anesthesia more often and is dangerous for COPD patients because of various possible complications. The administration of general anesthetic agents flexes the FRC and tidal volume and thus results in atelectasis and V/Q mismatch (Hedenstierna & Edmark, 2020). These effects are worsen in COPD patients because of the underlying airway obstruction and impaired gas exchange. Also, GA entails endotracheal intubation that may lead to inflammation of the airway, bronchoconstriction, and development of ventilator-associated pneumonia (Neuman et al., 2021). Such combinations of drugs together with NBMA used in general anaesthesia can also cause postoperative respiratory depression and therefore requires close consideration when making a selection on the drugs to be used (Della Rocca et al., 2022).

Neuraxial techniques, including spinal and epidural anesthesia, which are types of regional anesthesia, are safer for COPD patients as they have reduced incidences of postoperative pulmonary complications. Compared to general anesthesia, regional anesthesia maintains spontaneous breathing thus negates the need to manipulate the airway and decreases postoperative failure of ventilation (Memtsoudis et al., 2019). There is evidence showing that patients undergoing regional anesthesia suffer from low rates of atelectasis and pneumonia in comparison with generalized anesthesia settings, especially in the courses of abdominal and lower limb operations (Gao et al., 2020). However, regional anesthesia is not for all surgical procedures and it has effects on respiratory mechanics. It especially has implications for patients with severe COPD who are likely to have compromised diaphragmatic integrity because of epidural block.

Another factor more specific to patient care in COPD clients is the choice of anesthetic agents used during surgery. Sevoflurane and desflurane are other inhalational anesthetics that exert bronchodilator effect; and thus, favored in patients with COPD who are likely to undergo generalized anaesthesia (Devine

et al., 2021). Nonetheless, the use of desflurane has been associated with airway irritation in some patients especially when they have severe airway sensitivity. Intravenous agents like propofol are preferred for induction because of their rapid acting nature for rapid induction and better cardiovascular effects. Ketamine has also been considered as a potential alternative anesthetic for patients with COPD because of its bronchodilator effect and its capacity to avoid triggering apnoea thus is useful in the high-risk patients (Chin et al., 2020). Non-pharmacological measures to decrease the dose of opioid involves the use of opioid sparing anesthetic regimens, which aims to prevent opioid induced respiratory depression; analgesia modalities include the use of agents such as dexmedetomidine and gabapentinoids (Weingarten et al., 2021).

6.2 Mechanical Ventilation Strategies

Influence of mechanical ventilation strategies on operative respiratory function is the question that has attracted a lot of interest as far as the management and treatment of COPD is concerned. Ventilator-associated lung injury prevention strategy includes low Vt ventilation and PEEP as a protective lung ventilation strategy after surgery (Serpa Neto et al., 2018). Since the patient's condition acts at high risk for dynamic hyperinflation and barotrauma, the treatment with a ventilator should help with the titration of ventilatory parameters.

With regards to the type of ventilation, low tidal volume ventilation, usually 6-8 ml/kg of predicted body weight is used to decrease alveolar overdistension and thereby minimising the occurrence of ventilator-induced barotrauma. Mechanisms of protective lung ventilation are seen to decrease PPCs cases and also the length of time for postoperative usage of mechanical ventilation in COPD patients, based on the DoR of Putensen et al. (2019). PEEP is useful in preserving alveolar recruitment and ensuring that no atelectasis takes place but the use of PEEP should be moderated in a manner that will not cause trapping of air and thereby, dynamic hyperinflation. PEEP should be adjusted according to lung physiology and breathing characteristics during the operation (Brower, Lanken, & MacIntyre, 2021).

6.3 Fluid Management and Hemodynamic Stability

Another element of COPD patient intraoperative care is fluid restriction because excessive increase in intravascular volume causing pulmonary edema is expected in such patients. COPD patients are particularly vulnerable to fluid overload because of right ventricular dysfunction, pulmonary hypertension, and change in intrathoracic pressure during mechanical ventilation (Frost et al., 2021). Close attention should be paid to fluids management with the intent of having good perfusion without causing overly pulmonary edema. COPD patients have been considered to benefit from restrictive fluid regimens with the intention of avoiding acute pulmonary edema and enhancing oxygenation. In this article, I reviewed conservative fluid therapy that involves minimizing intraoperative crystalloid administration and sparing use of diuretics in patients with COPD undergoing major surgery because it enhances respiratory outcomes, reduces the length of stay in the ICU (Bellamy et al., 2020). However, it is important to weigh in on the restrictions in the fluid intake against the need to ensure proper blood circulation in patients with associated cardiovascular diseases.

Ensuring sufficient oxygen supply and circulation in the microvasculature is crucial to achieve stability in the surgery. Such tools as invasive arterial pressure monitoring and echocardiography might be needed for patients with COPD, who have severe cardiac complications. Vasopressors and inotropic agents should be used based on the needs of the individual patient as well as those patients with pulmonary hypertension and right heart strain (Lange et al., 2021). It should be noted that perioperative management of COPD is highly complex and should include optimal anesthetic regimen, appropriate use of lung protective ventilation, and rational fluid therapy. COPD can be worsened by general anesthesia due to its inherent risks, and thus patients with this condition require the development of specific anesthetic management strategies aimed at reducing respiratory complications in the perioperative period. By setting the tidal volumes and individualized PEEP level, protective lung ventilation is very important since it helps in maintenance of intraoperative gas exchange without causing further lung injury. Managing fluids requires consideration of pulmonary edema risk and adequate tissue perfusion especially in patients with COPD with comorbid cardiovascular disease. More studies are needed to optimize intraoperative management of COPD patients with a view of enhancing the overall surgical outcomes and minimizing the levels of morbidity and mortality in these patients.

7. Postoperative Management and Risk Reduction

For COPD patients, postoperative care is equally important in order to avoid post-surgical complications and enhance the recovery process. Because of various pathological impairments associated with lungs and increased vulnerability to encounter postoperative pulmonary complications, COPD patients who are in need of surgery need not only constant monitoring but also proper management. This involves respiratory care, infection control measures, effective pain management as well as physical therapy. It aims at promoting lung healing, reducing the necessity of extending mechanical ventilation and keeping away from recurring long-term complications and rehospitalization.

7.1 Postoperative Respiratory Support

Respiratory support offered after an operation is among the most significant elements of patients with COPD in the postoperative period. Hence the following outcomes can arise in such patients; residual anaesthesia impacts, diaphragmatic paralysis, impaired gas exchange, and increased airway resistance lead to respiratory failure in these patients. Non-invasive ventilation (NIV) and invasive mechanical ventilation (IMV) are used to treat postoperative respiratory dysfunction; what kind of treatment is required again depends on the extent of the respiratory compromise and the patient's capability to maintain effective ventilation.

Increased knowledge about NIV in the management of postoperative patients with COPD has revealed that it can be useful in minimizing intubation rates and invasive mechanical ventilation (Vargas et al., 2021). NIV offers pressure support in breathing so as to facilitate breathing, increase oxygenation and reduce the amount of effort needed for the patient. Density of HF has been shown that the application of NIV in patients with the diagnosis of COPD after surgery leads to a decreased number of PPCs, the reduction of the length of ICU stays, and mortality rates (Osadnik et al., 2019). Among different modalities employed in NIV, patients are set on continuous positive airway pressure (CPAP) and bilevel positive airway pressure (BiPAP and are more helpful in decreasing carbon dioxide and increasing alveolar ventilation (Duan et al., 2022). NIV is most useful in cases of extubation for patients with COPD and subsequent risk factors for re-intubation.

As for invasive mechanical ventilation (IMV), it should be used in COPD patients when they experience severe postoperative respiratory failure or when they are no longer able to be ventilated adequately using NIV (Scala et al., 2020). Although IMV allows full ventilatory support, some of its complications include the development of Ventilator associated pneumonia VAP, barotrauma and a longer stay in the ICU. It may be even more complicated in patients with COPD since patients may have diminished respiratory muscle strength and spontaneous PEEP during weaning from MV (Spina et al., 2021). Hence, a step-by-step approach with daily SBT and use of PSV should be used to achieve successful extubation.

7.2 Prevention of Postoperative Pulmonary Complications

Minimizing PPCs in COPD patients is a key goal of postoperative recovery because of the adverse impact these complications have on the patient's quality of life and survival. Among all the available approaches, one of the most effective types is early mobilization. Mobility decrease and bed rest are associated with atelectasis, VTE, and muscle deconditioning which also burdens the period of the recovery. Research has also revealed that postoperative mobilization starting from the first 24 hours also decreases the occurrence of PPCs such as pneumonia and respiratory failure (Liu et al., 2022). Incentive spirometry and deep breathing exercises and practice of pulmonary physiotherapy also increases lung compliance and minimizes the incidence of postoperative atelectasis (Hulzebos et al., 2020).

7.3 Pain Management Considerations

COPD patients should receive analgesia that will effectively relieve their pain without causing respiratory depression. If the pain is not well managed, the patient may develop shallow breathing, minimal coughing, and inadequate sputum production that result in atelectasis and pneumonia. However, as it is with nearly every medication, if taken in large doses, opioids can cause suppression of the respiratory center and increase the likelihood of postoperative respiratory failure. The PCA in COPD is best achieved through MMA, where different classes of analgesics are administered to reduce reliance on opioids (Gupta et al., 2021). Paracetamol and NSAIDs should therefore be preferred as much as possible since they do not interfere with breathing. Manipulations like epidural analgesia and peripheral nerve blocks are safe, effective methods of pain relief that are better than using opioids (Fletcher et al., 2020).

In case the patients receive opioids for pain relief, the rate of increase must be slow and frequently observe

the condition of the patient to avoid respiratory troubles. It must also be noted that the application of PCA with continuous monitoring of the end-tidal CO_2 level can minimize the threat of opioid-induced respiratory failure (Bateman et al., 2020). Other drugs like gabapentinoids and ketamine should also be used in an attempt to decrease the use of opioids and enhance postoperative pain management (van Boekel et al., 2020).

7.4 ICU Monitoring and Long-term Recovery

Supplemental O2 administration is crucial in the postoperative care of patients with COPD especially those who undergo major surgery or present with respiratory problems. Oxygen saturation, ventilation, hemodynamic status and infection indicators should be closely observed in a patient in the early postoperative period. Some of the non-invasive biomedical indicators include the transcutaneous CO_2 and the continuous pulse oximetry enables the identification of early respiratory deterioration (Neto et al., 2021).

COPD recovery is a chronic care that requires a systematic plan to rehabilitate the patient so that they can regain functional capacity and prevent hospitalization. Supervised exercise training along with nutrition interventions and general education should be recommended for pulmonary rehabilitation programs in order to enhance long-term COPD patients' outcomes after surgery (Spruit et al., 2021). Research has shown that pulmonary rehabilitation following surgery results in a decrease in the COPD exacerbations, better quality of life among the patients, and a decline in mortality rate (Evans et al., 2020). Besides, smoking cessation constitutes one more long-term practice that may influence the further disease state and postoperative complications. It is recommended that patients require smoking cessation intervention and pharmacological support like nicotine replacement therapy, and such counseling should be repeated (Tønnesen et al., 2021).

Therefore, sufficient post-operative care and risk mitigation measures should be implemented in order to enhance the prognosis of patients suffering from COPD. This explains how NIV for respiratory support, appropriate oxygen regulation, short-term mobilization of the patient, pulmonary care, and management of pains, as well as monitoring of patients in the ICU can help in the prevention or reduction of PPCs and promotion of the patient's recovery. Continued human rehabilitation and smoking cessation increases the general long-term outcomes Moreover, patients also have a decreased likelihood of future admission. Future studies should aim at the optimization of the process for patients pre-, during, and post-surgery to establish methods for enhancing the result of surgical operations for the identified high-risk group.

8. Evidence-Based Guidelines and Future Directions

The management of patients with COPD in the perioperative period has changed over the years as a result of new protocols by the international respiratory and anesthesiology societies. They have been designed and developed to provide healthcare professionals working in the preoperative period, operating theatre and immediate postoperative phase with a set of 'best practice' care guidelines that will minimize adverse outcomes and improve the quality of surgical care. However, current possibilities of prediction and intervention for postoperative risks and individualized treatment of patients with COPD still present certain difficulties. Further research is needed to improve the risk prediction models, discover new pharmacological and nonpharmacological treatments, and apply new technology to optimize the perioperative period care.

8.1 Current Guidelines and Best Practices

The guidelines from ATS, ERS and ACCP provide extensive guidance regarding the management of COPD patients requiring surgery. These guidelines are based on pulmonary function optimization, risk assessment, intraoperative lung protection and postoperative physical rehabilitation. The ATS guidelines contain a comprehensive overview of the assessment and management of the patient in the operative period and highlight PFT as a critical component of the preoperative evaluation (Mularski et al., 2021). Speaking of COPD patients, ATS recommends performing spirometry before major surgery as the degree of airflow limitation obtained would help to classify the risk during the perioperative period. They also warn against the use of cardiopulmonary exercise test (CPET) in the high-risk surgical candidates for the purpose of determining their functional capacity, as well as anticipating the postoperative adverse events. Some studies have stratified patients into high risk if their VO_2 max and VO_2 peak is less than 15 mL/kg/min depending on the study and it is recommended that high risk patients should go through prehabilitation.

The ERS guidelines are similar to the ATS but specifically above the preoperative interventions, smoking cessation and pulmonary rehabilitation get a

special focus (Gloeckl et al., 2022). Referring to the study done by ERS, the effects of smoking cessation about at least four weeks before the surgery will reduce the general postoperative pulmonary complications by enhancing the clearance of mucus and the immune requirements. Moreover, it is also recommended to incorporate individual elements of the exercise training, inspiratory muscle training into pulmonary rehabilitation programs to improve the lung function, especially in severe COPD patients. ERS guidelines also argue that the use of individual anesthetic protocols insisting that regional anesthesia should always be the first choice, if possible, as the development of postoperative respiratory failure is not desirable in patients with lung disease.

According to ACCP guidelines, risk assessment models are to be used to estimate the postoperative lung complications in the patients with COPD surgery (Colice et al., 2021). It also supports the use of the newly developed and externally validated index called the ARISCAT for estimating the perioperative risk. Consequently, factors such as age, the surgical site, respiratory infection, and preoperative SpO2 are the basis of ARISCAT and can show low-, intermediate-, and high-risk patients. The lung protective ventilation during surgery is also suggested by ACCP that includes low tidal volume ventilation, mean Vt of 6 -8 mL / kg predicted body weight, and the individualized, titrated PEEP for avoiding the VILI. These guidelines also enhance the understanding of postoperative NIV in preventing the rate of reintubation and shortening the hospital length of stay among COPD patients in their postoperative recovery period.

8.2 Future Research Needs

Altogether, there are several issues that should be discussed regarding the management of patients with COPD in the perianesthetic period. Among them, the enhancement of preoperative risk prediction models for optimizing perioperative patient management remains one of the main goals. For example, using ASA classification or ARISCAT score as predictors of the risk can be slightly helpful, but they are less accurate in identifying the risk of particular patients (Canet et al., 2021). New trends involve using measured learning in conjunction with AI to increase the chances of future risk prediction. The use of AI models based on real-time patient parameters such as pulmonary function tests, levels of inflammation, EHR data may help in the more personalized approach to perioperative risk assessment (Topalovic et al., 2022).

Another worthy focus area of research being the pharmacological and non-pharmacological management strategies to enhance COPD related patient's perioperative prognosis. Newer drugs like LABA-LAMA are under trials with the hope of enhancing lung function particularly during the period of surgery. Other drug classes that have emerged include anti-inflammatory drugs aiming at neutralizing neutrophilic airway inflammation, biologic agents and phosphodiesterase-4 (PDE4) inhibitors as a means of overcoming airway reactivity and reducing exacerbations during the period of surgery. Other nonpharmacological treatments such as high flow nasal oxygen through cannula (HFNC) and targeted lung recruitment are being used in view of preventing respiratory failure after surgery. HFNC has been found helpful in increasing oxygenation, decreasing the work of breathing and also increasing removal of CO2 in patients with COPD with postoperative hypoxemia (Spoletini et al., 2021). Future research should therefore aim at determining the appropriate settings of HFNC and for which specific patient populations it is most beneficial.

End-of-surgery procedures also now attract a lot of scholarly focus in the field of perioperative rehabilitation. Although pulmonary rehabilitation has been evident by its ability to produce positive surgical morbidity, there are certain barriers of access to this service. As of the potential solutions to provide preoperative and postoperative rehabilitation services, telemedicine-based rehabilitation programs such as virtual exercise training and remote patient monitoring are under consideration (Ramos et al., 2021). By incorporating wearable sensors and digital health platforms, an end-to-end monitoring of the exacerbation of patients' symptoms and early detection of complications in the early postoperative period in patients with COPD is hypothetically possible.

Other areas of significant interest are the durable effects of the perioperative interventions on COPD status and on the disease progression and quality of life indices. Although modern approaches to optimizing the patients' short-term prognosis do not consider long-term consequences of the management, including the rate of disease exacerbation, changes in lung function, and further healthcare contact. It, therefore, calls for prospective cohort studies and randomized controlled trials to determine the effectiveness of the aggressive modulation of these COPD treatment goals in changing its natural history and long-term outcomes. Thus, further research should investigate economic aspects of perioperative management of

patients with COPD. Due to the high cost of managing patients with COPD especially in the postoperative period, it is important that HAL research explore the costs of such interventions as prehabilitation programs, non-invasive ventilation, and lung protective ventilation (Shafazand et al., 2022).

9. Conclusion

Chronic obstructive pulmonary disease which is abbreviated as COPD is well known to increase the risk of postoperative complications in surgical patients. Thus, due to the progression of the pathology accompanied by the deterioration of the respiratory function, the perioperative management of the patients with COPD remains a challenging task for anesthesiologists, surgeons and intensive care specialists. In this paper, issues of risk assessment, strategies during surgeries, management after surgeries, and recommendations based on guidelines have all been addressed in detail. Optimization on COPD patients, including preoperative, intraoperative, and postoperative is crucial to have better clinical results, prevent postoperative respiratory failure and decrease PPCs in general.

9.1 Summary of Key Findings

Time before the surgery is significantly significant for the patients with COPD in order to reduce various risks. Current research indicates that preoperative investigation including pulmonary function testing, cardiopulmonary exercise testing (CPET) and arterial blood gas (ABG) analysis are required for risk assessment and management of patient risk. Disease of the lung can be diagnosed by imaging techniques like chest X-ray, HRCT hence information on structural changes may affect the perioperative period. Smoking cessation, pulmonary rehabilitation, use of bronchodilators and inhaled corticosteroids have been known to enhance postoperative pulmonary function. With regards to intraoperative considerations, premedication's and the choice of triplet anesthetic technique need to be determined correctly to prevent respiratory complication through appropriate ventilation. Similarly, although general anesthesia is normally used for any major surgery, regional anesthesia is occasionally preferable due to fewer risks of respiratory depression. Low VT, contributes to sufficient Oxygenation, PEEP is set according to patient characteristics, protective lung ventilation policies are widely practiced intraoperatively. Reducing oxygen administration and maintaining haemodynamics are largely important measures to reduce the risk of pulmonary complication.

Coping for the patient after the operation is especially important in the prevention of respiratory failure and quick improvement. It also reduces the risk of reintubation in COPD patients, and non-invasive ventilation supports oxygenation: however, oxygen administration should be moderate due to risks of hypercapnia. More importantly, early mobilization, pulmonary hygiene and prophylactic antibiotics reduce the incidence of pneumonia, as well some of the other postoperative complications. Multimodal analgesia to reduce opioid-induced respiratory depression following surgery is another reason that can be listed in favor of improved postoperative outcomes. They include structured pulmonary rehabilitation, smoking cessation support and other long-term rehabilitation programs which are important in trying to prevent early hospital readmissions and worsening of the disease.

Perioperative management of patients with COPD can be simplified by evidence-based guidelines that are developed by the American Thoracic Society (ATS), European Respiratory Society (ERS), and American College of Chest Physicians (ACCP). However, the degree of compliance to these guidelines is still a cause of concern and there is a need to enhance compliance with guidelines involving the implementation of standard risk assessment instruments such as the machine learning algorithms and AI-Predictive models.

9.2 Clinical Implications for Anesthesiologists and Surgeons

Due to the many potential risks associated with surgery in COPD patients, anesthesiologists are crucial in coordinating adequate CPAP application by the surgeons. In individuals, the kind of anesthesia shall depend on the patient's lung condition, other illnesses, and surgery demands. Depression of the respiratory activity should be avoided by using agents that have less effect in this regard such as the inhaled anesthetic agents like sevoflurane. There are some guidelines that need to be followed to prevent the dynamic hyperinflation and barotrauma risk regarding the ventilation strategies. Intraoperative ABG checks let the doctor oversee the state of oxygenation and ventilation, and effectively control hypercapnia and hypoxia in real-time.

This means that working for the ICU requires that the intensivist deal with postoperative emergencies such as the acute on chronic obstructive pulmonary disease,

the postoperative ventilator – associated pneumonia, and persistent hypoxic episodes. Previous studies have demonstrated that both HFNC and NIV can prevent the intubation of COPD patients with mild to moderate respiratory compromise. In patients who need prolonged ventilation, measures to attempt for early liberation of breathing tubes and avoiding VAP should be the focus. Hence, the primary support measures aimed at effective weaning include spontaneous breathing trials and progressive ventilatory ventilation reduction in patients with COPD.

9.3 Final Recommendations for Optimizing Surgical Outcomes in COPD Patients

Preoperative and postoperative management of these patients must involve the cooperation of anesthesiologists, pulmonologists, surgeons, critical care teams and the primary carers. Pulmonary function tests, chest imaging and cardiopulmonary exercise testing prior to major surgery in patients with COPD should be routine. The patient education and smoking cessation and pulmonary rehabilitation should be available for all patients, as these quality-improving interventions have been closely related to the enhancement of surgical outcomes.

Since the choice of anesthesia induction and maintenance agents is best personalized it is important to have an effective means of minimizing postoperative risk. It is, therefore, advisable to avoid general anesthesia when using machinery to offer regional anesthesia where possible to keep the respiration function intact. For patients in the surgical operations under general anesthesia, a proper ventilation process must be adopted to avoid causing further harm to the lungs in case they already have or are in danger of developing VILI. Pulmonary edema should be avoided at the same time as tissue perfusion is maintained. Mobile telemetry, transcutaneous PCO2 monitoring and pulse oximetry should be utilised in order to monitor the patients' gas exchanges and ventilation in real time. Measures for PRR include early liberation from mechanical ventilation,Another nursing intervention that should be implemented is the structured pulmonary hygiene program consisting of incentive spirometry, deep breathing exercise, and airway clearance to prevent Postoperative atelectasis and Pneumonia. Patients should be encouraged to use regional anaesthesia, non- opioid medication, and other techniques in order to reduce the effects of opioids that cause respiratory depression.

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