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COPD: Pathophysiology and Anaesthetic Management

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ABSTRACT: The chronic obstructive pulmonary disease has become a disease of public health importance. Among the various risk factors, smoking remains the main culprit. In addition to airway obstruction, the presence of intrinsic positive end expiratory pressure, respiratory muscle dysfunction contributes to the symptoms of the patient. Perioperative management of these patients includes identification of modifiable risk factors and their optimisation. Use of regional anaesthesia alone or in combination with general anaesthesia improves pulmonary functions and reduces the incidence of post-operative pulmonary complications.

KEYWORDS: Chronic Obstructive Pulmonary Disease, Pathophysiology, Anaesthesia Management, General Anaesthesia, Regional Anaesthesia, Laparascopic Surgery, Bispectral Index, Postoperative pulmonary complications.

I. INTRODUCTION:

COPD is a disease of increasing public health importance around the world. GOLD estimates suggest that COPD will rise from the sixth to third most common cause of death world wide by 2020.[1] COPD includes: (i) Emphysema a condition characterised by destruction and enlargement of the lung alveoli; (ii) chronic bronchitis a condition with chronic cough and phlegm; and (iii) small airway disease in which small bronchioles are narrowed. COPD is present only if chronic airflow obstruction occurs. Chronic bronchitis without chronic airflow obstruction is not included with COPD.[2]

Areas Covered in this article review includes:-

a) COPD, Risk factors, Pathophysiology, Preoperative Evaluation and Management, Intraoperative Management, Postoperative Management.
b) Comparing General Anaesthesia vs Spinal Anaesthesia for patients with COPD undergoing Laparascopic Cholecystectomy.
c) Evaluation of usage of BIspectral Index in the assessment of hypercapnic encephalopathy in COPD patients.
d) Anaesthetic Considerations in patients with COPD undergoing laparascopic surgeries.
e) Risk factors of postoperative pulmonary complications in patients with asthma and COPD.

II. CRITICAL ANALYSIS OF ARTICLES[1,2,3,4]

Chronic obstructive pulmonary disease (COPD) is a chronic progressive inflammatory condition resulting in expiratory airflow limitation that is not reversible.

The global initiative for COPD guideline (GOLD) defines COPD as follows: 'COPD is a preventable and treatable disease with some significant extrapulmonary effects that may contribute to the severity in individual patients. The airway limitation (pulmonary component) is usually progressive and associated with an abnormal inflammatory response of the lung to noxious particles or gases and is not fully reversible'.[6]

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Risk factors:

1. Cigarette smoking: 80% of patients with COPD have significant exposure to tobacco smoking and manifest with accelerated decline in the volume of air exhaled in the forced expiratory volume at 1 s (FEV1), in a dose response relationship to the intensity of cigarette
smoking. Effects of passive smoking on COPD is unclear[7]
2. Increased airway responsiveness to various exogenous stimuli
3. Respiratory infections
4. Occupational exposures: Exposure to dust at work e.g. coal mining, gold mining and cotton textile dust
5. Ambient air pollution

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6. Genetic: Severe anti‑trypsin (α1 AT) deficiency is a proven genetic risk factor for COPD.[7] A recent study has found a genetic variant (FAM13A), associated with the development of COPD
in the COPD gene study.[8]

Pathophysiology:

Single physiological parameter that defines this syndrome is: Limitation of expiratory airflow.[9] It is because of the combination of small airway inflammation and parenchymal destruction. Several anatomical lesions contribute to airflow limitation, including the loss of lung elastic recoil and fibrosis and narrowing of small airways, both of which are likely to cause fixed airflow limitation.[10] It adversely affects both the ventilation/perfusion (V/Q) matching and mechanics of the respiratory muscles. In the patients with advanced COPD, the combination of V/Q mismatch decreased gas transfer and alveolar hypoventilation ultimately leads to respiratory failure. Multiple pathogenetic mechanisms contribute to the development of COPD among which the most important risk factor is cigarette smoking, which can affect the lungs by a variety of mechanisms.[11] However, recently, the role of genetic factors has also been implicated, with the finding that a genetic variant (FAM13A) is associated with the development of COPD in the COPD gene study.[12] Patients with COPD pose a challenge to the anesthetist because intraoperative and postoperative complications occur more commonly than in those without the disease and can lead to prolonged hospital stay and increased mortality.

PRE‑OPERATIVE EVALUATION AND MANAGEMENT

The risk of PPCs may be decreased if any reversiblecauses can be treated in advance. The basic physical examination findings can help predict the risk of PPCs.The predictive value of decreased breath sounds, prolonged expiration, rales, wheezes, or rhonchi has been shown in general surgical and thoracic patients [13,14]. For example, the likelihood of PPCs increases considerably with preoperative wheezing [odds ratio (OR) 6.2] , warranting aggressive treatment with bronchodilators and possibly inhaled and systemic steroids in the days before

surgery. Upper respiratory infections should be ruled out and treated as a cause of increased secretions and airway hyper-reactivity. Smoking increases the risk of PPCs (OR 1.04–1.26) [7,8]. Fifteen percent of all smokers will develop significant COPD during their lives, with increased upper airway sensitivity , sputum production , and decreased mucociliary function. Smokers have an increased risk of pneumonia , prolonged ICU stay, and prolonged mechanical ventilation. Smoking cessation has been shown to arrest the acceleration of lung function deterioration. However, the timing of smoking cessation in the preoperative period is critical. Smoking cessation was shown to decrease PPCs in patients undergoing pulmonary surgery if smoking is stopped more than 4 weeks before surgery. Poor nutritional status with a low serum albumin level (<3.5 mg/dl) is a powerful predictor of PPCs.

Prior to induction of anesthesia, the patient must be assessed for the likelihood of hemodynamic instability upon induction of anesthesia and initiation of positive pressure ventilation (PPV). Placement of an arterial catheter for beat-to-beat blood pressure (BP) monitoring may be considered because noninvasive BP monitoring may not be rapid or reliable enough to allow a rapid response to hypotension. In addition, arterial access may be useful for frequent blood gas analyses to treat hypercapnia. Epidural anesthesia provides excellent pain control and improved pulmonary function in the postoperative period.

INTRAOPERATIVE MANAGEMENT

Induction of anesthesia in patients with severe COPD presents a challenge because of the risk of hemodynamic instability resulting from air trapping and elevated intrinsic positive end-expiratory pressure (PEEPi).
Both reduced preload and increased right ventricular afterload may be significant
Treatment of expiratory airway obstruction intraoperatively:
A) Allowing for more time to exhale:
Decrease respiratory rate
Decrease I : E ratio
Allow permissive hypercapnia
Increase inspiratory flow rate and tolerate higher peak pressures
Switch to PCV
Apply extrinsic PEEP

B) Medical treatment of bronchospasm:
Fast-acting inhaled bronchodilators
Inhaled anticholinergics
Increase volatile anesthetic concentration and favor sevoflurane over more irritant agents such as desflurane
Propofol to blunt airway reflexes

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C) Prophylaxis against postextubation respiratory failure:
Periextubation bronchodilator and anticholinergic treatment
Intraoperative stress dose for patients currently on steroids
Extubation to CPAP or BIPAP

POSTOPERATIVE MANAGEMENT

Close surveillance of the patient with COPD in a recovery room or ICU setting is warranted so that timely interventions can prevent complications such as respiratory failure due to air trapping, inability to clear respiratory secretions, or lowered respiratory drive due to analgesia with narcotics. Air trapping and respiratory failure requiring reintubation in the postoperative period is associated with considerable morbidity and mortality in patients with COPD.

Although the literature supports using noninvasive ventilation or CPAP in an effort to delay or avoid endotracheal intubation in exacerbations of COPD in the nonoperative patient, there is only weak evidence for the COPD patient who has undergone surgery.

Correction of hypoxia with supplemental oxygen has been the subject of controversy. Abolition of hypoxic drive in patients who have chronically elevated pCO2 using aggressive oxygen therapy has been thought to raise the likelihood of 'CO2 narcosis' based on anecdotal evidence.

Pain control should be achieved preferably with thoracic epidural analgesia, especially after thoracotomy because improvements in pulmonary function test have been demonstrated. Irritation of the diaphragm or thoracic apex due to chest tubes will often require additional systemic analgesics. If renal function and hemostasis are sufficient, nonsteroidal (nonnarcotic) analgesics such as intravenous ketorolac are preferable.

Comparing General Anaesthesia vs Spinal Anaesthesia for patients with COPD undergoing Laparascopic Cholecystectomy:

In the study conducted by Mehmet Bayrak and Yasemin Altintas, who prospectly evaluated COPD patients who underwent laparoscopic cholecystectomy under general Anesthesia and spinal anesthesia. Patients with COPD were further divided into groups according to their preoperative stages (Stage 1–4). Intraoperative vital findings, postoperative pain, complications, and length of hospitalization were compared between the general (GA) and spinal anesthesia (SA) groups. The mean age of the patients in the GA group was 61.0 ± 6.7 years and was 61.0 ± 7.7 years in the SA group. In the GA and SA groups, the mean ASA score was 2.8 ± 0.6 and 2.9 ± 0.6, respectively, the mean operation duration was 31.7 ± 5.1 and 30.6 ± 5.1 min, respectively, and the length of hospitalization was 3.2 ± 1.7 and 1.5 ± 0.5 days, respectively. The partial carbon dioxide rates (PaCO2) at the postoperative 5th and 20th minutes were lower in the SA group than in the GA group. Further, the requirement for postoperative analgesia was lower in the SA group, and the length of hospitalization was significantly shorter in the SA group. There was no significant difference between the two groups in terms of operation duration. It was concluded that laparoscopic cholecystectomy can be performed safely under GA and SA in patients with
COPD. It was recommended that SA should be used in COPD patients, as it reduces the risk of extubation, bronchoconstriction and respiratory depression, and decreases the requirement for postoperative mechanical ventilation, leading to a faster postoperative recovery.

Evaluation of usage of BIspectral Index in the assessment of hypercapnic encephalopathy in COPD patients:

In the study conducted by Chalela et al, who evaluated the utility of Bispectral Index in the assessment of intensity of hypercapnic encephalopathy in COPD patients. A total of ten COPD exacerbation patients were included, and the level of brain activity was assessed using BIS and different scales: Glasgow Coma Scale, Ramsay Sedation Scale (RSS), and Richmond Agitation–Sedation Scale. The evaluation was performed both in the acute phase and 3 months after discharge. BIS was recorded for a total of about 600 minutes. During COPD exacerbation,

BIS values ranged from 58.8 (95% CI: 48.6–69) for RSS score of 4 to 92.2 (95% CI: 90.1–94.3) for RSS score of 2. A significant correlation was observed between values obtained with BIS and those from the three scales, although the best fit was for RSS, followed by Glasgow and Richmond ($r=-0.757$, $r=0.701$, and $r=0.615$, respectively; P,0.001 for all). In the stable phase after discharge, BIS showed values considered as normal for a wake state (94.6; 95% CI: 91.7–97.9). It was concluded that BIS may be useful for the objective early detection and automatic monitoring of the intensity of hypercapnic encephalopathy in COPD exacerbation, facilitating the early detection and follow-up of this condition, which may avoid management problems in these patients.

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Anaesthetic Considerations in patients with COPD undergoing laparascopic surgeries:

In the study conducted by Ranjana Khetarpal et al, to review the various anesthetic options which can be considered for laparoscopic surgeries in the patients with the chronic obstructive pulmonary disease. Retrospective data were observed from various studies and case reports showed regional anesthesia (RA) to be valid and safer option in the patients who are not good candidates of general anesthesia like patients having obstructive pulmonary diseases. It showed better postoperative patient outcome with respect to safety, efficacy, postoperative pulmonary complications, and analgesia. So depending upon disease severity RA in various forms such as spinal anesthesia, paravertebral block, continuous epidural anesthesia, combined spinal epidural anesthesia (CSEA), and CSEA with bi‐level positive airway pressure should be considered.

Risk factors of postoperative pulmonary complications in patients with asthma and COPD:

In the study conducted by Takanori Numata et al, to evaluate postoperative pulmonary complications in patients with asthma and COPD and evaluation of perioperative management using new inhalant drugs in patients with obstructive pulmonary diseases. 346 adult patients with pulmonary diseases (257 asthma, 89 chronic obstructive pulmonary disease (COPD) who underwent non-pulmonary surgery except cataract surgery in hospital were taken. To analyze the risk factors for PPC, Retrospective evaluation of physiological backgrounds, surgical factors and perioperative specific treatment for asthma and COPD was done. It was found that 29 patients with pulmonary diseases (22 asthma, 7 COPD) had PPC. In patients with asthma, smoking index (≥ 20 pack-years), peripheral blood eosinophil count (≥ 200/mm3) and severity (Global INitiative for Asthma(GINA) STEP ≥ 3) were significantly associated with PPC in the multivariate logistic regression analysis [odds ratio (95% confidence interval) = 5.4(1.4–20.8), 0.31 (0.11–0.84) and 3.2 (1.04–9.9), respectively]. In patients with COPD, age, introducing treatment for COPD, upper abdominal surgery and operation time (≥ 5 h) were significantly associated with Post-operative pulmonary complications [1.18 (1.00–1.40), 0.09 (0.01–0.81), 21.2 (1.3–349) and 9.5 (1.2–77.4), respectively. It was concluded that asthma patients with a history of smoking or severe asthma had an increased risk of Post-operative pulmonary complications. Sufficiently and aggressively increasing Inhaled Corticosteroid can reduce the risk of Post-operative pulmonary complications in asthma patients with eosinophilia. Although aging, upper abdominal surgery and long operation times are risk factors for pneumonia and respiratory failure in COPD patients, introducing treatment for COPD significantly reduces the risk of PPC by improving pulmonary function.

III. CONCLUSION:

COPD presents a challenge to the anesthesiologist. The tools available to avoid and treat manifestations of COPD in the perioperative period can be deduced from the pathophysiological mechanisms of COPD. Anaesthetic management of patients with COPD requires proper insight into the patients condition. Objective methods, such as CPET are very useful in assessing the functional status non‐invasively. Intraoperative management involves taking proper measures to minimize airway manipulation, and prevention of air trapping and PEEPi during intraoperative ventilation. Recent evidences favour the use of regional techniques for anaesthetic and analgesic management in these patients. Thoracic epidural analgesia is shown to reduce the incidence of post‐operative complications in upper abdominal and thoracic surgeries in patients with COPD. BIS seems to adequately reflect the state of consciousness in patients with hypercapnic encephalopathy secondary to COPD exacerbation. This technique has no relevant drawbacks and maybe useful in monitoring critical respiratory patients. Broader studies are needed to confirm our findings and potentially extend our conclusions to other respiratory disorders. Regional Anaesthesia should be considered as a valid option for the patients who are poor candidates for GA like patients with advanced COPD as there is avoidance of the strong stimulation of intubation or the risk of bronchoconstriction on extubation, less risk of atelectasis, closing capacity, and FRC are less affected, pulmonary gas exchange is better maintained and it provides superior postoperative analgesia without risking respiratory depression, and so decreases the need for postoperative mechanical ventilation. History of smoking or severe asthma is a risk factor of PPC in patients with asthma, and age, upper abdominal surgery, or long operation time is a risk factor of PPC in patients with COPD. Adequate inhaled corticosteroids treatment in patients with eosinophilic asthma and introducing treatment for COPD in patients with COPD could reduce PPCs.

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