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Mechanical Ventilation for Patients with COPD

Ozlem Ediboglu

Abstract

Mechanical ventilation is a lifesaving therapy in patients who have acute respiratory failure due to chronic obstructive pulmonary disease (COPD). Mechanical ventilation either invasive or non-invasive has an important role in the management of acute exacerbation of COPD (AECOPD). AECOPD required hospitalization had increased mortality and poor prognosis. Ventilatory management success related to understanding pathophysiology of the disease. Clinicians must be aware of deterioration of clinical signs of COPD patients. The most appropriate treatment should be performed at optimal time. Some COPD patients are at high risk for prolonged mechanical ventilation due to COPD is a progressive disease.

Keywords: mechanical ventilation, COPD, respiratory failure

1. Introduction

Chronic obstructive pulmonary disease (COPD) is a major global health problem which has high morbidity and mortality [1]. COPD is characterized by chronic inflammation of the airways and lung parenchyma. The most important physiologic abnormality is worsening of expiratory airflow limitation due to increased airway resistance and decreased elastic recoil [2]. Patients who have expiratory airflow limitation cannot breathe normally and due to dynamic hyperinflation increase work of breathing. These physiologic changes are deteriorated unless avoid risk factors because of COPD is a progressive disease and can be complicated with different severity of acute exacerbation [1–4].

Acute exacerbation of chronic obstructive pulmonary disease (AECOPD) is described as an acute worsening of the clinical condition of the COPD patient [5]. Clinical features are highly variable and AECOPD has a negative impact on patients' health status and outcomes [1, 6–8]. The reported mortality associated with AECOPD is variably at 11% to 32% [9]. The mortality rate and costs are much higher in some patients requiring mechanical ventilation [10, 11]. In severe AECOPD, it is crucial to recognize acute respiratory failure (ARF) immediately and to decide appropriate treatment. ARF is defined as the inability to maintain the delivery of oxygen and/or removal of carbon dioxide acutely. Worsening gas exchange and consequently hypercapnia and/or hypoxemia occur in arterial blood gas sample (ABG) analysis [12].

2. Non-invasive ventilation

Mechanical ventilation either invasive or non-invasive is lifesaving treatment for acute respiratory failure. It is targeted by non-invasive ventilation (NIV)

to minimize risks of mechanical ventilation and maximize patients' safety and comfort. Hence NIV is successful to provide alveolar ventilation and gas exchange as invasive mechanical ventilation (IMV); NIV accepted widely as the first choice in treating AECOPD patients with ARF [13–24]. NIV therapy success is related to appropriate patient selection and early application [14, 25–27]. The appropriate patient means that is alert, co-operative, compliant and has no contraindications [28].

NIV is applied after initial treatment if the pH remains <7.30 and after exclusion of reversible precipitating causes such as a pneumothorax, the depressant effect of uncontrolled oxygen therapy, or the excessive use of sedatives [29–31]. According to GOLD guide, NIV is considered at least one of these conditions; respiratory acidosis, weakness of respiratory muscles, severe dyspnea, increased work of breathing, accessory muscle using, intercostal retraction, paradoxal breathing and persistent hypoxemia with oxygen therapy [32]. Main determinants are experience of the clinician, place of the NIV therapy, clinical condition and therapeutic requirement of patient [33, 34].

NIV can be applied with all ventilators used in IMV support [35]. It's important to know technical specialties and settings by clinician. Portable ventilators, intermediate ventilators and ICU ventilators have been used [33, 36]. Portable ventilators are named according to targeted parameter as volume and pressure ventilators. The synonym name is portable device is bilevel or BiPAP (Bilevel positive airway pressure) ventilator. Clinicians must be aware of difference between settings of the two devices: While adjusting IPAP (inspiratory positive airway pressure), EPAP (expiratory positive airway pressure) levels setting in BiPAP device, pressure support (PS = IPAP - EPAP) and EPAP levels in ICU ventilators [33, 37]. Bi-level pressure support ventilators are simpler to use, cheaper, and more flexible than other types of ventilator currently available. ICU ventilators have full monitoring and alarm capability and can be given up to 100% FiO₂ when needed [30, 33]. Whole appropriate equipment must be ready to initiate the NIV therapy as single/double lumen circuit, nasal/oronasal NIV mask by different size [38]. Mask selection is more important than ventilator. In acute setting, oronasal mask is well tolerated and preferred by many clinicians [14, 38, 39].

NIV is contraindicated in these situations; respiratory or cardiac arrest, hemodynamic instability, inability to use mask, excessive secretion, high risk for aspiration, and uncooperative patient.

Initially it is begun with low pressure levels as IPAP 8–10 cm H₂O and EPAP 4–5 cm H₂O. According to patient's clinical status, pressure levels can be increased. Monitorization of clinical signs, parameters of mechanical ventilation and gas exchange at the bedside are very important. Especially clinician must follow and record subjective symptoms like anxiety, consciousness, delirium, agitation, sedation, analgesia, patient comfort, dyspnea, tolerance of mask. All the time NIV therapy, physiological response like respiratory rate (RR), using accessory muscle, heart rate (HR) and rhythm, blood pressure (BP) must be recorded. After the first 1–2 hours ABG must be done. We must consider intubation, if no improvement in ABG, deterioration in level of consciousness, NIV poorly tolerated, and inadequate secretion clearance [1, 7, 21, 40].

NIV failure is associated with hospital mortality, length of hospital and ICU stay [41]. NIV failure indicators are found as initial pH <7.25 , Glasgow Coma Scale (GCS) <10 , Acute Physiology and Chronic Health Evaluation (APACHE) II score >25 , severe comorbidity, asynchrony, leaks [7, 42], existing pneumonia, and bad initial response (no change RR, pH and paCO₂) [14, 43]. The potential causes NIV failure are defined that poor patient selection, progression of the underlying disease, wrong interface, wrong ventilator, inappropriate ventilator settings

and clinician's inexperience [44]. In a study, HACOR scores (heart rate, acidosis, consciousness, oxygenation, respiratory rate) be defined as a potential tool for clinical physicians to identify NIV failure earlier [45]. Patient tolerance to NIV is a critical factor determining its success in avoiding endotracheal intubation [46]. The most important point of the tolerance to NIV is optimal synchrony between the patient's spontaneous breathing activity and the ventilator's set parameters, known as "patient-ventilator interaction" [47]. Clinician can detect an asynchrony index (AI) (%) via visual inspection of asynchrony events (ineffective triggering, auto-triggering, premature cycling, double triggering and delayed cycling). AI is identified as number of asynchrony events/total RR X 100% and above 10% was accepted as severe asynchrony [44]. In a multicenter study, severe asynchrony was found 43% [48]. The level of pressure support and the existing of leaks were found independent predictive factors of severe asynchronies and severe asynchronies were detected 30% of patients [49]. Patient-ventilator synchrony is related to better success of NIV. For this reason, in case of asynchrony, the most appropriate strategies should be followed to improve synchronization with NIV [44].

3. Invasive mechanical ventilation

Endotracheal intubation should be done any one of the following criteria immediately: respiratory arrest, loss of consciousness, psychomotor agitation requiring sedation, hemodynamic instability with a systolic BP less than 70 or greater than 180 mmHg, HR less than 50 beats/minute with loss of alertness, gasping for air. These criteria are named major criteria. Intubation was suggested any two of the following criteria also named minor criteria; RR >35 breath/min, worsening acidemia or pH < 7.25, $\text{paO}_2 < 40$ mmHg or $\text{paO}_2/\text{FiO}_2 < 200$ despite oxygen therapy, decreasing level of consciousness [50]. Before intubation pre-oxygenation is essential. Intubation with the rapid sequence induction and cricoid pressure to reduce the risk of aspiration should ideally be performed by an experienced clinician [51].

After intubation, its targeted to improve gas exchange abnormality and to avoid auto-PEEP (PEEP_i) [7, 52]. Dynamic hyperinflation (DHI) may exist before intubation or induced by mechanical ventilation. The minute volume (MV) should be adjusted to pH and not to the PaCO_2 levels. Clinicians should avoid overventilation and paCO_2 levels should decreased gradually. It is important to provide lower MV (RR x tidal volume (TV)) and higher inspiratory flow rate which has allow longer expiratory time. Any mode can be used, either assist control (AC), synchronized intermittent mandatory ventilation with either volume or pressure target (SIMV-VS, SIMV-PS), or pressure support ventilation (PSV). Clinician's experience is the most important determinant of mode selection. Initial ventilator settings are recommended like that; TV: 6–10 ml/kg, FiO_2 : 1.0, RR: 10–14 breaths/minute, no PEEP, inspiratory flow rate: 80–100 liter/minute with square waveform [1, 2, 4]. Monitoring the lung mechanics on ventilator graphic screen continuously and detecting any sign of DHI or PEEP_i are very important. The clinicians should be followed existing any clinical signs to avoid the complications of DHI. The most important complications of DHI are hypotension, hemodynamic collapse, barotrauma and increased work of breathing (WOB) [51, 53]. Therefore, that strategies must be applied by clinicians to reduce auto-PEEP; providing the longest expiratory phase that is possible, reducing patient ventilatory demand and MV, and reducing airflow resistance by bronchodilators and steroids [1].

Barotrauma is an important risk at the COPD patients. Elevated peak inspiratory pressure (PIP) does not reflect the alveolar pressure in patients with bronchospasm.

Alveolar pressure can be detected with plateau pressure (P_{plat}) and suggested $\text{PIP} < 50 \text{ cmH}_2\text{O}$, $P_{\text{plat}} < 30 \text{ cmH}_2\text{O}$ to avoid barotrauma [1].

Quantifying PEEP_i is a difficult and favored process. PEEP_i amount of proportionated with degree of bronchial obstruction. Different techniques can be used to calculate PEEP_i . Clinicians can directly measure by occluding the expiratory port for 1–3 seconds at end expiration or by using expiratory hold maneuver on new ventilators. Static PEEP_i can be measured in this way only in sedatized patients without active respiratory effort. The PEEP_i can then be calculated by subtracting the external PEEP from the total PEEP. If there is spontan respiratory effort of the patient, dynamic PEEP_i can be determined by simultaneously recording esophageal pressure and airflow tracings. It is measured at end expiration as the negative deflection of esophageal pressure to the point of zero flow. The dynamic PEEP_i is usually measured lower than static PEEP_i by reason of different longer of time constant [1, 2, 4, 53, 54]. While PEEP_i is determined extrinsic PEEP (PEEP_e) at 80% of PEEP_i should be added to reduce patient triggering effort. Ventilator trigger sensitivity must be justify minimal [1, 4, 6, 51, 55, 56].

Weaning should begin once the cause of the exacerbation is adequately treated and the patient is hemodynamically stable. Physiologic parameters must be followed intensively. It's targeted $\text{MV} < 15 \text{ L}$, $\text{RR} < 30 \text{ breaths/minute}$, $\text{TV} > 325 \text{ ml}$, rapid shallow breathing index (RSBI) < 105 , maximum inspiratory pressure (MIP) < -15 . Although the superiority did not found among each other, different strategies were used to weaning. Daily spontaneous breathing trail (SBT) is one way of identifying patients stable to wean and it may reduce the number of ICU days. While decreasing gradually of PS has not been shown to be superior to SBT, PSV is preferable by many clinicians. Using NIV to facilitate weaning is accepted by multiple RCT [14, 15, 52, 57, 58].

4. High flow oxygen therapy

Long term oxygen therapy (LTOT), is used mainly in COPD patients with chronic hypoxemia [32]. High flow oxygen therapy (HFOT) is a new technique for delivering oxygen. There are many studies using HFOT instead of conventional oxygen therapy (COT) recently. HFOT was well tolerated and was sensed as comfortable. By using this system, oxygen delivery trends provided to be lower, and paCO_2 levels could be measured significant decreased. HFOT could be accepted as an alternative treatment to NIV due to it generates a modest degree of positive pressure almost 5–6 cmH_2O . It provides a more physiological humidification and heating of the airways. In this settings, HFOT has been used with different aims, as an alternative to COT, and NIV [59–62].

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