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بالرسالة صفحات لم ترد بالأصل

Effect of applied positive end expiratory pressure (PEEP) on the auto PEEP in chronic obstructive pulmonary disease patients

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CHAPTER I

INTRODUCTION

HYPERINFLATION AND DYNAMIC AUTO POSITIVE END EXPIRATORY PRESSURE

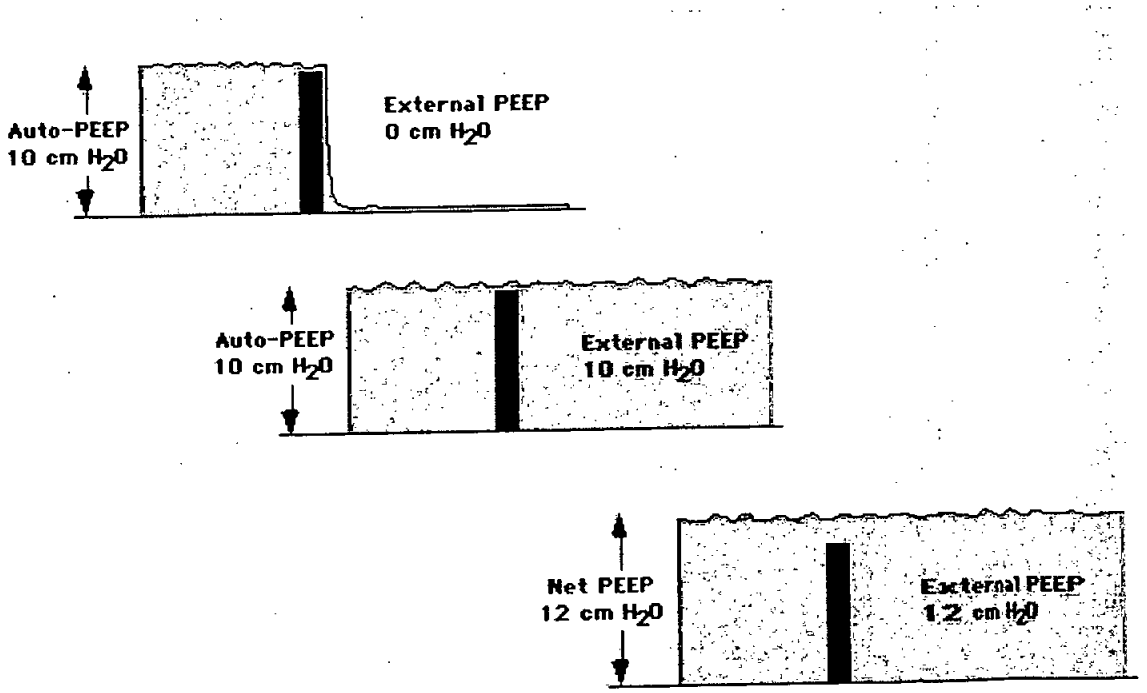
The approach to mechanical ventilation of critically ill patients may vary according to the pathophysiologic events underlying the development of acute respiratory failure. In that regard, it is useful to classify acute respiratory failure into two major categories: type1, or hypoxemic respiratory failure, and type 2, or hypercapnic ventilatory failure [1,2]. The former category, exemplified by the acute respiratory distress syndrome, is characterized by severe hypoxemia, generally caused by alveolar or interstitial pulmonary edema or alveolar collapse. In contrast, hypercapnic ventilatory failure corresponds to acute ventilatory failure (AVF) and is characterized by the inability of a failing respiratory pump to provide a level of alveolar ventilation sufficient to meet the required metabolic demands [2,3]. Although this may be caused by central depression of respiratory drive, neuromuscular disorders, or chest wall abnormalities, perhaps the most comman cause in the ICU setting is an exacerbation of severe underlying chronic obstructive pulmonary disease (COPD). Mechanical ventilation therefore provides an appropriate level of alveolar ventilation while allowing for improved pulmonary function and recovery from respiratory muscle fatigue. In this setting, positive end-expiratory pressure (PEEP) has been considered unhelpful and contraindicated, for the following reasons: (1) the level of hypoxemia in patients with COPD generally is mild and responds readily to low level of supplemental oxygen (O2), (2) Severe COPD is characterized by augmentation of lung volume, a further increase in lung volume eventually induced by application of PEEP would impair respiratory muscle efficiency and enhance risk of barotrauma and hemodynamic depression.

Deviation of end- expiratory lung volume (EELV) from the elastic equilibrium volume i.e. relaxation volume (Vr) of the respiratory system is recognized as a cardinal feature in mechanically ventilated patients with severe COPD and AVF. The presence of dynamic hyperinflation implies that alveolar pressure remains positive throughout expiration. At the end of expiration, this positive pressure is termed auto [4] or intrinsic PEEP [5].

A PEEP and dynamic hyperinflation have been described in mechanically ventilated COPD patients in whom expiratory flow limitation occurred as consequence of dynamic airway compression. Recent work has suggested that, in COPD patients with expiratory flow limitation, application of external PEEP during assisted mechanical ventilation [6] or the use of continuous positive airway pressure (CPAP) in spontaneously breathing patients [7] can counterbalance and reduce the inspiratory threshold load imposed by auto-PEEP without causing further hyperinflation under these circumstances, application of PEEP may facilitate weaning from mechanical ventilation by reducing the work of breathing and dyspnea without increasing further hyperinflation [6-8].

AUTO-POSITIVE END-EXPIRATORY PRESSURE AND DYNAMIC HYPERINFLATION WITH FLOW LIMITATION

Flow limitation usually occurs in normal subjects only with maximal forced expiratory maneuvers. Auto-PEEP and dynamic hyperinflation in patients with flow limitation are a direct result of critical closure of the airways[9]. The physiology of critical closure of the airway originally was described by analogy of a waterfall[10,11] see figure(1).



External PEEP with auto-PEEP The use of external PEEP in the setting of auto-PEEP may be conceptualized by the "waterfall over a dam" analogy. In this analogy, the presence of dynamic hyperinflation and 10 cmH2O of auto-PEEP is represented in the top panel by the reservoir of water trickling over the dam represented by the solid block. In the middle panel, as long as the external PEEP is less than or equal to the amount of auto-PEEP, the amount of water in the upstream reservoir, representing dynamic hyperinflation, does not increase. However, once the amount of water in the reservoir does increase (bottom panel), dynamic hyperinflation worsens. Additional experimental studies done by others suggest that this effect occurs once the external PEEP is greater than approximately 85 percent of the amount of auto-PEEP. (Redrawn from Tobin, MJ, Lodato, RF, Chest 1989; 96:449.)

Figure(1)

The characteristic of this phenomenon is that increasing the pressure downstream (applied PEEP) from the site of critical closure (the waterfall) has no influence on the expiratory flow or the pressure upstream of the site critical

closure (auto-PEEP) [10,11]. The waterfall analogy assumes auto PEEP to be the same as the critical closing pressure of the airway. The transpulmonary pressure at which expiratory flow limitation occurs, however, must be somewhat less than the total elastic recoil pressure available because of the resistive pressure losses across the upstream segment proximal to the point of dynamic air-way collapse[10]. Furthermore, McNamara et al [12] have shown, through direct measurements of regional alveolar pressure in animals, that significant heterogeneity may occur in the presence and the magnitude of expiratory flow limitation among regional lung units. On that basis, the simple waterfall analogy to describe the flow limitation phenomenon may not be accurate, and a more complex system with marked heterogeneity of regional mechanical properties has to be considered [8]. The presence of auto-PEEP implies that the inspiratory muscles have to produce an initial effort to overcome the opposing recoil pressure before inspiratory flow can begin. In that respect, auto-PEEP acts as an inspiratory threshold load and represents additional impedance the respiratory muscles have to face. Under these circumstances, application of external PEEP (during mechanical ventilation) or CPAP (during spontaneous breathing) may reduce the gradient between alveolar and airway opening pressure, thereby counterbalancing the inspiratory threshold load caused by auto-PEEP. Confirming that hypothesis, Smith [6] and Petrof [7] found that, in patients with COPD during AVF, the application of PEEP within the measured levels of auto-PEEP decreases the inspiratory work of breathing by reducing the inspiratory mechanical load caused by auto-PEEP. Further hyperinflation was observed when the applied PEEP was higher than the measured auto-PEEP [7]. Nave and coworkers [9] recently showed that during assisted modes of mechanical ventilation such as pressure support (PSV), auto-PEEP may cause ineffective