Mechanical ventilation

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Method to mechanically assist or replace spontaneous breathing. This may involve a ventilator machine or the breathing may be assisted by a registered nurse, physician, respiratory therapist, paramedic, or other suitable person compressing a bag or set of bellows. There are two main divisions of mechanical ventilation: invasive ventilation and non-invasive ventilation.

There are two main modes of mechanical ventilation within the two divisions: positive pressure ventilation, where air (or another gas mix) is pushed into the trachea, and negative pressure ventilation, where air is, in essence, sucked into the lungs.

Among a nationally representative sample of hospitalizations, nearly one-in-six patients had prolonged mechanical ventilation after EVT. Heart failure and diabetes were significantly associated with prolonged mechanical ventilation following endovascular treatment (EVT). Prolonged ventilation was associated with a significant increase in in-hospital mortality and morbidity [1).].

Prolonged fever is the common complication in neurosurgical patients. The risks of prolonged fever in patients are attributed to antibiotic therapy, use of central venous catheter and prolonged mechanical ventilation. Indicators of prolonged fever are helpful for better identification of high-risk patients and fever control [2)].

Reusser et al. studied prospectively 40 critically ill neurosurgical patients who required prolonged mechanical ventilation to determine the current incidence of stress-related gastroduodenal erosions and ulcers, and to assess endoscopically the efficacy of acid-reducing prophylactic treatment. Nineteen patients were randomized to receive ranitidine plus antacids if necessary to maintain gastric pH at greater than or equal to 4. The remaining 21 patients were given no drug prophylaxis. Gastric pH was significantly (p less than .001) higher in the treated group: 78% of pH readings were at greater than or equal to 4 as compared to 32% in the control group. However, after five study days, incidence and severity of stress lesions were similar in the two groups: nine patients in each group had more than five erosions, one treated patient had a gastric ulcer, and one control patient had duodenal ulcerations. No patient experienced clinically relevant upper GI bleeding. The lack of severe stress bleeding and the low ulcer rate contrast with results from earlier reports on similar patient populations. Furthermore, drug prophylaxis had no detectable benefit, as assessed endoscopically. These findings suggest that routine stress lesion prophylaxis may not be necessary in critically ill patients with comparable risk factors [3].

Indications

Mechanical ventilation is used to support or replace spontaneous breathing in patients who are unable to breathe adequately on their own. Indications for mechanical ventilation can be broadly categorized into:

Respiratory Failure:

Hypoxemic Respiratory Failure (Type I):

Arterial oxygen tension (PaO2) is less than 60 mmHg despite supplemental oxygen.

Causes: Acute respiratory distress syndrome (ARDS), pneumonia, pulmonary edema, and pulmonary embolism.

Hypercapnic Respiratory Failure (Type II):

Elevated carbon dioxide levels (PaCO2 greater than 50 mmHg) with a pH less than 7.3.

Causes: Chronic obstructive pulmonary disease (COPD) exacerbations, drug overdose, and neuromuscular disorders.

Airway Protection:

In patients who are unable to maintain an airway or protect it from aspiration (e.g., coma, stroke, or trauma).

Severe Respiratory Distress:

Severe dyspnea with significant effort to breathe, and when non-invasive ventilation methods (like CPAP or BiPAP) fail.

Post-Operative Recovery:

For patients under general anesthesia who require prolonged ventilation after surgery due to respiratory depression or sedation.

Neuromuscular Disorders:

Conditions that impair respiratory muscle function, such as Guillain-Barré syndrome, myasthenia gravis, or spinal cord injury.

Cardiac Arrest or Severe Shock:

In patients with insufficient circulation and ventilation during resuscitation or shock.

Metabolic Disturbances:

Respiratory acidosis (high CO_2) or alkalosis (low CO_2) that cannot be corrected through other means. The decision to initiate mechanical ventilation is guided by clinical signs, laboratory results, and the underlying cause of respiratory insufficiency

Flow-controlled ventilation

Flow-controlled ventilation (FCV) is a mode of mechanical ventilation where the ventilator delivers a constant flow of gas to the patient over a set period of time, rather than targeting a specific pressure or volume. In FCV, the flow rate of the gas is maintained constant throughout the inspiratory phase, which can help ensure that the volume delivered to the lungs is consistent, particularly in cases where lung compliance or resistance may vary.

Key Characteristics of Flow-Controlled Ventilation: Constant Flow:

The ventilator delivers a constant flow of gas to the lungs during the inspiratory phase, rather than adjusting flow based on pressure or volume. Pressure and Volume Variation:

Because the flow is constant, the pressure and volume delivered can vary depending on the patient's lung compliance and airway resistance. The pressure might rise in cases of decreased lung compliance (e.g., ARDS) or higher airway resistance. Advantages:

Predictable Tidal Volume: Since the flow is constant, the volume delivered can be more predictable in terms of meeting the patient’s needs, especially when lung compliance is variable. Smoother Ventilation: This can reduce mechanical strain on the lungs and minimize the risk of barotrauma (lung injury due to high pressure). Less Patient-ventilator Asynchrony: FCV can improve synchrony between the ventilator and the patient’s breathing effort, particularly in patients with variable lung mechanics. Clinical Uses:

ARDS (Acute Respiratory Distress Syndrome): FCV can be beneficial in conditions like ARDS where lung compliance is low and unpredictable. Patient with Variable Respiratory Resistance or Compliance: It may be suitable for patients with obstructive lung disease, or those with high variability in airway resistance (e.g., asthma or COPD exacerbations). Monitoring and Adjustments: Since pressure and volume are not directly controlled in FCV, continuous monitoring of both tidal volume and airway pressure is essential to ensure the patient’s lungs are not overinflated (leading to barotrauma) or underinflated. In summary, flow-controlled ventilation is a technique that emphasizes a fixed flow of air to optimize ventilation in certain patients with variable lung mechanics or respiratory conditions.

A study investigates the effects of flow-controlled ventilation (FCV) using negative end-expiratory pressures (NEEP), on cerebral hemodynamics in a swine model of intracranial hypertension.

A model of intracranial hypertension involving bilateral trepan bolt holes was performed in 14 pigs. Pressure-controlled volume-guaranteed ventilation (PCV-VG) with PEEP and FCV using PEEP and then NEEP were applied. Intracranial pressure and oxygenation, as well as systemic hemodynamics and gas exchange parameters, were continuously monitored. Data were collected at baseline and at varying PEEP levels for both PCV-VG and FCV ventilation modalities. Following this, FCV ventilation and NEEP levels of -3, -6 and -9 cmH2O were applied.

ICP remained stable with low PEEP levels but significantly decreased with NEEP. Lower ICP following NEEP improved cerebral perfusion pressure and cerebral tissue oxygenation ($p < 0.05$ for all). FCV with NEEP at EEP-6 and EEP-9 significantly improved cardiac output and mean arterial pressure (MAP), compared to PCV-VG and FCV using PEEP ($p < 0.05$, respectively). There were no significant differences in gas exchange parameters between modalities (PCV-VG vs FCV), and between the application of PEEP or NEEP. No significant correlations were observed between ΔICP and ΔMAP.

The application of FCV with NEEP appears to be a safe ventilation mode and offers an additional tool for controlling severe intracranial pressure episodes [4].

This study presents promising findings on the use of FCV with NEEP in managing intracranial hypertension in a swine model. While the results are statistically significant, the study's methodological limitations, including a small sample size and lack of detailed statistical analysis, temper the strength of the conclusions. Nonetheless, the findings suggest that NEEP could be a valuable addition to the management strategies for ICH and warrant further investigation in both animal and clinical studies.

1)
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