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Protective Mechanical Ventilation Modes in the ICU: Contemporary Approaches, Clinical Applications and their Association with Infections

Yoğun Bakım Ünitesinde Koruyucu Mekanik Ventilasyon Modları: Çağdaş Yaklaşımlar, Klinik Uygulamalar ve Enfeksiyonlarla İlişkisi

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ABSTRACT
In patients with respiratory failure, mechanical ventilation is the most basic treatment for intensive care patients. This treatment management is indispensable to ensure normal oxygen and carbon dioxide levels. If appropriate ventilation parameters are not used, possible lung damage is an inevitable consequence. Protective mechanical ventilation strategies have been developed to prevent such damage. Despite all these strategic approaches, the risk of lung infection may increase. This article seeks to explore how protective ventilation strategies influence infection risks and discusses the optimal application of these strategies in clinical practice.

Keywords: Protective mechanical ventilation, Intensive care ünit, Ventilator-induced lung injury

ÖZ
Solunum yetmezliği olan hastalarda mekanik ventilasyon yoğun bakım hastalarına yönelik en temel tedavi yönetimidir. Bu tedavi yönetimi normal oksijen ve karbondioksit düzeylerinin sağlanması için vazgeçilmezdir. Eğer uygun ventilasyon parametreleri kullanılmazsa olası akciğer hasarı kaçınılmaz bir sonuçtur. Bu hasarları önlemek için koruyucu mekanik ventilasyon stratejileri geliştirilmiştir. Tüm bu stratejik yaklaşımlara rağmen akciğer enfeksiyonu riski artabilmektedir. Bu makale, koruyucu ventilasyon stratejilerinin enfeksiyon risklerini nasıl etkilediğini araştırmayı amaçlamakta ve bu stratejilerin klinik uygulamada en uygun şekilde uygulanmasını tartışmaktadır.

Anahtar Kelimeler: Koruyucu mejanik ventilasyon, Yoğun bakım ünitesi, Ventilasyon ilişkili akciğer hasarı

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Introduction

Mechanical ventilation (MV) is a crucial intervention within intensive care units (ICUs) for patients experiencing critical respiratory failure. This therapeutic modality is paramount in ensuring adequate oxygenation as well as facilitating carbon dioxide removal. Nonetheless, it is important to recognize that mechanical ventilation carries the potential risk of lung injury, particularly when inappropriate ventilatory parameters are employed. This can result in ventilator-induced lung injury (VILI), and the prolonged use of mechanical ventilation may further complicate a patient’s recovery (Pearson et al., 2022).

To mitigate such risks, protective ventilation strategies have been formulated. These strategies are designed to safeguard lung function by implementing lower tidal volumes, judicious application of positive end-expiratory pressure (PEEP), and maintaining plateau pressure within safe limits. However, the utilization of these ventilation strategies may also have implications for infection risk. The procedures associated with mechanical ventilation can elevate the likelihood of infections, leading to significant complications during patient management. This article seeks to explore how protective ventilation strategies influence infection risks and discusses the optimal application of these strategies in clinical practice (Banavasi et al., 2020; Pearson et al., 2022) .

Mechanical Ventilation Modes and Protective Strategies

Mechanical ventilation is a therapeutic intervention aimed at supporting the respiratory functions of critically ill patients. This treatment must not only assist respiratory function but also minimize potential lung harm. Among the most commonly utilized ventilation modes and protective strategies in intensive care today are (Banavasi et al., 2020; Pearson et al., 2022; Van Kaam et al., 2021).

Low tidal volume ventilation

Low tidal volume ventilation has become a standard approach for managing patients with acute respiratory distress syndrome (ARDS) and other lung conditions. Setting tidal volumes at 6 mL/kg of ideal body weight limits excessive lung expansion and decreases the risk of ventilator-induced lung injury (VILI). This method enhances oxygenation and is associated with reduced mortality in ARDS patients (Banavasi et al. 2020; Kadado et al., 2022; Van Kaam et al., 2021).

Positive end-expiratory pressure (PEEP)

PEEP plays a vital role in preventing the collapse of alveoli, which in turn improves oxygenation. By maintaining open alveoli, PEEP facilitates more effective oxygen transfer into the bloodstream. However, it is important to carefully regulate PEEP levels, as excessive use can lead to cardiovascular complications or lung distension (Santa Cruz et al., 2021).

Plateau pressure and lung protection

Plateau pressure, defined as the maximum pressure exerted during mechanical ventilation, should be maintained below 30 cm H_2O to avert barotrauma or volutrauma. Protective ventilation strategies aim to restrict plateau pressure to prevent lung damage (Diaz et al., 2024).

The Relationship Between Protective Ventilation and Infection Risk

In the context of mechanical ventilation, the risk of infection is predominantly associated with ventilator-associated pneumonia (VAP) and other respiratory complications. VAP is a common and serious infection in critically ill patients reliant on prolonged mechanical ventilation, typically arising when microorganisms infiltrate the lungs via endotracheal tubes (Diaz et al., 2024; Papazian et al., 2020).

VAP and protective ventilation strategies

The management of ventilator-associated pneumonia (VAP) poses a significant challenge in the application of protective ventilation strategies. While PEEP is effective in preventing alveolar collapse, elevated levels of PEEP can increase the potential for microaspiration, thereby raising VAP risk. Consequently, it is crucial to carefully adjust PEEP settings to mitigate infection risks. Furthermore, maintaining low tidal volumes aids in minimizing VAP risk by preventing lung over-distension (Diaz et al., 2024; Papazian et al., 2020).

Mechanical ventilation and other infection risks

Mechanical ventilation can serve as a conduit for microorganisms to enter the respiratory tract. Invasive devices, such as endotracheal tubes and tracheostomy cannulas, when utilized for extended periods, significantly heighten the risk of infections. Therefore, regular maintenance and stringent hygiene practices for these devices are imperative in preventing such infections (Diaz et al., 2024; Papazian et al., 2020).

Antibiotic resistance and infections

The increasing prevalence of antibiotic resistance in intensive care units has become a concerning issue. Resistant bacterial strains are more likely to be encountered during prolonged mechanical ventilation, complicating infection management and extending recovery times. Addressing the rise of antibiotic resistance calls for careful infection management and prompt treatment initiation. Early diagnosis and appropriate antibiotic therapy are crucial elements in preventing severe complications (Despatovic et al., 2020; Vincent et al., 2020).

Infection Management through Enhanced Ventilation Techniques

As the risk of infections rises, it is crucial to modify ventilation strategies to enhance patient care. The management of conditions such as ventilator-associated pneumonia (VAP) requires precise adjustments to ventilator settings (Despatovic et al., 2020; Vincent et al., 2020).

Implementing early mobilization and preventive measures

Early mobilization serves as an effective technique to minimize the duration of mechanical ventilation, thereby lowering the risk of developing infections. Reducing the time on ventilation can enhance patient outcomes and diminish infection rates. Furthermore, as patients show signs of recovery, transitioning to non-invasive ventilation methods should be considered to further mitigate infection risks (Despotovic et al., 2020; Diaz et al., 2024; Papazian et al., 2020).

Protocols for hygiene and ınfection prevention

The enforcement of strict hygiene protocols in intensive care settings is crucial in combating infections, particularly VAP. Proper care and sanitation of ventilators and endotracheal tubes play a significant role in lowering infection prevalence. It is important to routinely replace tracheal tubes and cannulas, and to provide healthcare workers with thorough training in infection prevention techniques (Despatovic et al., 2020; Vincent et al., 2020).

Timely intervention and management of infection risks

The swift identification of infections can greatly enhance patient recovery times. Ventilator-associated pneumonia (VAP) and similar infections need to be recognized and treated without delay. In certain instances, preemptive antibiotic regimens may be employed to stave off infections. The prompt initiation of antibiotic treatment can help avert complications that may arise from extended periods of ventilation (Diaz et al., 2024; Papazian et al., 2020).

Innovations and Future Directions

Recent technological advancements have yielded new ventilatory systems and monitoring equipment designed to enhance protective ventilation and minimize infection risks. Smart ventilation technologies enable continuous monitoring of patients, allowing for real-time adjustments to ventilatory parameters. Furthermore, the introduction of antimicrobial coatings on ventilator components aims to lower the likelihood of infections.

Conclusion

Protective mechanical ventilation in intensive care units is vital for supporting patient recovery while reducing the potential for ventilator-induced lung injury (VILI). However, extended mechanical ventilation raises the risk of infections, particularly VAP. It is essential to integrate protective ventilation strategies with robust infection control measures to improve patient outcomes. To mitigate infection risks, employing early mobilization practices, adhering to stringent hygiene protocols, and addressing antibiotic resistance are essential steps. Anticipated advancements in technology and more efficient ventilation techniques are likely to enhance both protective ventilation and infection management in the future, enabling faster and more effective patient recovery in intensive care environments. This article discusses the various protective mechanical ventilation approaches and their association with infection risks, highlighting contemporary practices and the impact of technological innovations on improving patient outcomes.

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