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Insights into Prehospital Mechanical Ventilation

1 Introduction

Emergency Medical Services (EMS) providers frequently deal with airway emergencies and respiratory failure, which present complex challenges. Traditionally, patients requiring advanced airway management in the prehospital setting are ventilated manually. This manual method, however, carries significant risks, such as inconsistent tidal volumes, hypo- and hyperventilation, and barotrauma, due to the lack of precise control over ventilation parameters. Mechanical ventilation, essential for managing intubated patients in-hospital and during medical transport, ensures consistent, efficient, and controlled ventilation, thereby reducing these risks. As a result, there is increasing interest among EMS providers and agencies in adopting portable ventilators for prehospital care.

2 Current Usage Statistics

In the United States, mechanical ventilation is used in about 4% of EMS activations each year. The data on prehospital care for critically ill patients, including both interfacility transports and emergency scene calls, remains limited. Studies indicate that 73-83% of these patients are managed with volume control ventilation, with only a smaller proportion benefiting from more advanced ventilation modes.

3 The Use of Mechanical Ventilation in EMS

According to the National Association of EMS Physicians (NAEMSP), EMS providers should consider mechanical ventilation during emergency responses and interfacility transports following advanced airway insertion, especially for the following cases:

- Hypoxic Respiratory Failure
- Hypercapnic Respiratory Failure
- Airway Protection

These conditions are frequently encountered during initial emergency ambulance responses and interfacility transfers managed by critical care teams.

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4 Clinical Significance

The National Association of EMS Physicians (NAEMSP) supports the use of mechanical ventilation following advanced airway insertion in prehospital care due to several key benefits:

1. Consistency in Ventilation Parameters:

• Mechanical ventilators offer controlled and consistent ventilation support, which is crucial for effective patient management during transport. This precision ensures reliable ventilation parameters.

2. Maximizing Oxygenation and Carbon Dioxide Elimination:

• Mechanical ventilators optimize oxygenation and carbon dioxide elimination by maintaining constant ventilation parameters, thereby stabilizing the patient's respiratory status more effectively than manual methods. For example:

- Precise delivery of Fraction of Inspired Oxygen (FiO2) optimizes oxygenation in hypoxic patients.
- Proper Positive End-Expiratory Pressure (PEEP) settings maintain alveolar stability, enhance oxygenation, and prevent atelectasis.
- By controlling minute ventilation (Tidal Volume X Respiratory Rate), ventilators effectively manage carbon dioxide levels, addressing hypercapnia.

3. Limiting Airway Pressures and Preventing Complications:

• Mechanical ventilation helps regulate airway pressures, reducing the risk of complications such as barotrauma, gastric distention, and hypotension, which are common with manual ventilation techniques. Consistent monitoring of airway pressures helps avoid excessive pressures that can cause these complications.

4. Allowing Focus on Comprehensive Patient Care:

• Using transport mechanical ventilators allows EMS providers to focus on other critical aspects of patient care during transport. The ventilator autonomously manages the patient's respiratory needs by providing consistent and adjustable ventilation settings, freeing providers to concentrate on other vital tasks.

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5 Challenges with Manual Ventilation:

Due to the unavailability of transport ventilators for many intubated patients, manual bag-valve-mask resuscitators (BVMs) are frequently used during patient transport. EMS training traditionally highlights the visible chest rise to confirm effective manual ventilation. However, BVMs do not offer feedback on the exact volumes delivered, minute ventilation, or other crucial parameters, leading to variable volumes and potential injurious ventilation.

- **Inconsistent Volume Delivery:** Bag-valve devices rely on the provider's manual compression to deliver breaths. This manual method can result in significant variability in the delivered tidal volumes due to differences in hand strength, fatigue, and technique.

- **Risk of Injurious Ventilation:** The use of BVMs can result in variable delivered volumes, potentially leading to injurious ventilation. Inconsistent volumes can cause both under- and over-inflation of the lungs, contributing to barotrauma or inadequate oxygenation.

- **High Tidal Volumes and Pressures:** Studies have shown that manual bag ventilation is often associated with high tidal volumes and pressures. An adult-sized bag provides a mean tidal volume of approximately 800 mL, exceeding the upper limit tidal volume of 560 mL for a 70 kg patient. Almost all participants in a manikin ventilation study exceeded this threshold when using an adult bag, increasing the risk of lung injury. Due to these large tidal volumes, lung injury can develop in around 20 minutes of ventilation.

- **Hyperventilation:** Manual ventilation can lead to higher-than-intended respiratory rates, causing hypocapnia and associated poor outcomes. Providers may unintentionally ventilate too rapidly, especially in stressful situations, leading to decreased CO2 levels and potential complications.

REFERENCES

The insights presented on this topic are derived from the following article. For a comprehensive review and more detailed information on this topic, please refer to the original text:

Baez, A. A., Qasim, Z., Wilcox, S., Weir, W. B., Loeffler, P., Golden, B. M., … Levy, M. (2022). Prehospital Mechanical Ventilation: An NAEMSP Position Statement and Resource Document. Prehospital Emergency Care, 26(sup1), 88–95. https://doi.org/10.1080/10903127.2021.1994676

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