Optimizing Oxygenation in the Mechanically Ventilated Patient

Nursing Practice Implications

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KEYWORDS

• Critical care nursing • Mechanical ventilation • Oxygenation • Patient safety
• Hypoxia

KEY POINTS

- Critical care nurses must possess advanced knowledge, skill, and judgment when implementing and evaluating oxygenation improvement strategies with mechanically ventilated patients.
- Effectively communicating findings of the nursing assessment and patient response to oxygenation interventions are integral to informing ongoing patient treatment decisions.
- Nurses in the intensive care unit are well-positioned to anticipate, monitor, and prevent complications related to invasive and potentially risky oxygen improvement therapies.

INTRODUCTION

Most critical care interventions target the optimization of end organ oxygenation to some degree. Hypoxia is frequent grounds for admission to the intensive care unit (ICU), carrying with it high patient acuity and demands for complex interventions such as positive pressure mechanical ventilation.[1] When hypoxic patients are admitted to the ICU, critical care nurses maintain a continuous therapeutic presence with them and mounting literature suggests that these nurses are playing an increasingly active role specific to oxygenation and mechanical ventilation.[2,3] Recent studies

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highlight the need to more critically evaluate the overall risk–benefit associated with oxygen improvement strategies, and that potentially the hypoxia problem is being overtreated.[4,5] In their role, ICU nurses not only require knowledge to appropriately implement oxygen treatment measures, they also demand competent skill and judgment to anticipate, monitor, and intervene when complications arise.

Improving oxygenation in the ventilated patient is widely studied; however, this literature rarely targets a nursing practice audience.[6] Furthermore, terms used to quantify and communicate clinical oxygenation parameters can be confusing, complicated, and controversial.[7] Given requirements for clinical information that is clear and consistent, it is essential that ICU nurses possess the communicative capacity required to best relay their holistic knowledge related to patient oxygenation status.

This article provides insight into several best practice nursing considerations for optimizing oxygenation in ventilated patients. We first situate the topic by providing an overview of relevant principles pertaining to gas exchange and measurement. We then clarify some frequently used clinical terms. Common rescue therapies used to optimize oxygenation in ventilated patients are described, including patient positioning, ventilatory strategies, and pharmacologic measures. Informed by our recent review of the literature, discussion in this article emphasizes findings of practical relevance for ICU nurses, specifically direct nursing care implications for patients receiving these therapies, particularly where they intersect with issues related to patient safety.

UNDERSTANDING AND COMMUNICATING OXYGENATION PRINCIPLES

Nearly 3% of hospital stays in the United States involve mechanical ventilation[8] and the primary reason for both adult and pediatric ICU admission is complex respiratory support.[9] Knowledge of pulmonary gas exchange and indices used to measure it are fundamental to the critical care nursing role. Oxygenation is facilitated through inspiration or positive pressure ventilation when intubated as air is dispersed through pressure and laminar flow from central airways out to the alveoli.[10] Here, in the lung's functional units gas is dissolved into blood as available oxygen molecules diffuse rapidly through a thin complex interface of alveolar epithelium and surrounding pulmonary capillaries. Red blood cells flowing tightly through these capillaries also bind to oxygen as the prime delivery mechanism for transport throughout the body.[10] Preventing hypoxemia (impaired pulmonary gas exchange) relates directly to ensuring sufficient alveolar O_2 supply is available for diffusion and also that sufficient capillary blood volume and flow at this exchange interface is maintained.

Basic oxygenation measures such as PaO_2, SaO_2, and SpO_2 are often discussed but can be used erroneously in clinical dialogue. It is therefore important to define and highlight distinctions between these common terms often used to quantify oxygenation status. These measures often serve as endpoints determining whether interventions to improve oxygenation are successful; however, these indices merely reflect effectiveness of pulmonary gas exchange and oxygen available for delivery rather than providing direct measure of appropriate oxygenation at the tissue level.[11]

PaO_2 refers to a global measurement specific to the partial pressure of oxygen dissolved in blood plasma. The normal range of PaO_2 is 80 to 100 mm Hg.[12] Conversely, SaO_2 is a measurement expressed as percentage of available oxygen bound to hemoglobin with a normal range of 95% or greater to 100%.[12] Nearly 98% of oxygen available for tissue delivery is found bound to hemoglobin with the remaining 2% dissolved in blood plasma.[10] Ellstrom (2006) notes that "[a]rterial oxygenation is considered compromised when [hemoglobin] saturation is less than 88% (PaO_2 [less than]