HOSPITAL PHYSICIAN®

CRITICAL CARE MEDICINE BOARD REVIEW MANUAL

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Noninvasive Positive Pressure Ventilation

Alan D. Betensley, MD, FCCP, and Rahul Kakkar, MD

INTRODUCTION

Primitive methods of noninvasive positive pressure ventilation (NIPPV) were first described in the medical literature centuries ago.[1,2] As a result of animal studies that revealed the risk of fatal pneumothorax with NIPPV, it was outlawed in Europe in the 19th century. Since then, great progress has been made in the fields of pneumatics, electronics, and physiology. The last century saw major advances in mechanical ventilation, marked by the success of noninvasive negative pressure ventilation during the polio epidemics in the United States and northern Europe. In the second half of the century, positive pressure ventilation with endotracheal intubation supplanted the use of noninvasive negative pressure ventilation. The improved design and material of endotracheal tubes, the emergence of large volume–low pressure cuffs, and advances in the design and technology of positive pressure ventilators proved invaluable in improving the efficacy and safety of mechanical ventilation. The resurgence of interest in NIPPV in the past 2 decades has been facilitated by the emergence of new technology, allowing better interface devices as well as improved algorithms for the delivery of the desired pressure and volume.

Mechanical ventilation utilizing an endotracheal tube exposes the patient to risks of barotrauma, tracheal injury, and, most importantly, nosocomial infection (**Table 1**).[3–6] Several randomized prospective trials have demonstrated that NIPPV not only effectively supports adequate respiration but also reduces complications associated with invasive mechanical ventilation. Randomized controlled trials have shown better outcomes in patients with acute respiratory failure due to chronic obstructive pulmonary disease (COPD), in patients with acute cardiogenic pulmonary edema, and in immunosuppressed patients presenting with bilateral pulmonary infiltrates.[7–14] This manual discusses the use of NIPPV in acute respiratory failure.

Important definitions pertaining to noninvasive ventilation are summarized in **Table 2**. Common modes for NIPPV include pressure support and assist-control ventilation. With pressure support, the physician sets the end-expiratory pressure and the driving pressure, while patient effort and respiratory system compliance determine the resulting tidal volume. With assist-control, the tidal volume is fixed by the physician. This mode has been found to be a less comfortable means of noninvasive ventilation.[15] In addition, bilevel positive airway pressure (PAP) is frequently used. Bilevel PAP is the application of a higher inspiratory positive airway pressure (IPAP) and a lower expiratory positive airway pressure (EPAP) in a spontaneously breathing patient on NIPPV. (Although commonly used in a generic sense, the term *BiPAP* is the proprietary name for bilevel PAP devices marketed by Respironics Inc. [Murrysville, PA].) Bilevel PAP is essentially equivalent to pressure support ventilation (Table 2) but with important differences in terminology. EPAP in bilevel PAP is analogous to positive end-expiratory pressure (PEEP) in pressure support ventilation. IPAP in bilevel PAP is equivalent to the sum of pressure support and PEEP in pressure support ventilation.

EQUIPMENT AND TECHNICAL ISSUES IN NIPPV

INTERFACES

An ideal interface should be lightweight, transparent, inexpensive, easy to clean, and nonallergenic and should provide an adequate seal. Masks are the most commonly used interfaces in acute settings. Although dead space remains a theoretical concern, the flow of gases is usually sufficient to flush the expired gases accumulated in the mask.[16,17] Nasal and full-face masks are equally effective.[18,19] **Table 3** summarizes the potential advantages and disadvantages of each.[20]

Many nasal masks have forehead spacers to adjust the pressure on the nasal bridge. However, nasal masks may be difficult to use in patients with nasal obstruction or mouth breathing. Dry air causes release of vasoactive amines and leukotrienes in nasal mucosa with resultant engorgement.[21,22] In addition, a mouth leak with nasal continuous positive airway pressure (CPAP) can increase nasal airway resistance.[23] The use of humidified air may sometimes overcome the resultant nasal congestion.[23,24] Use of a full-face mask better preserves

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