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## Positive-Pressure Mechanical Ventilation in the Management of Acute Respiratory Failure

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# Positive-Pressure Mechanical Ventilation in the Management of Acute Respiratory Failure

## INTRODUCTION

Mechanical ventilation imposes an artificial pattern of ventilation on a patient's natural breathing rhythm. In placing patients with acute respiratory failure on mechanical ventilation, physicians have an obligation to ensure that respiratory needs are met, that complications are avoided, and that the process remains as comfortable as possible. Inappropriate initial ventilator settings and failure to modify these settings based on a patient's response and changing physical condition can increase the work of breathing, worsen gas exchange, and lead to harmful sequelae.

**Table 1** summarizes the physiologic and clinical goals of mechanical ventilation, as determined by the 1994 American College of Chest Physicians' Consensus Conference on Mechanical Ventilation.<sup>1</sup> In cases of acute respiratory failure, the basic goal of mechanical ventilation is to support gas exchange and/or assist the respiratory pump while minimizing adverse effects.

This review will address current concepts involving positive-pressure ventilation (PPV) delivered through an endotracheal tube, specifically as they concern patients with acute respiratory failure. Current modes of mechanical ventilation, necessary steps in the monitoring of patients being mechanically ventilated, potential complications of mechanical ventilation, and methods of weaning patients from mechanical ventilation will be discussed.

## INDICATIONS AND MODES

The respiratory and nonrespiratory indications for instituting invasive mechanical ventilation in patients with acute respiratory failure are listed in **Table 2**. Although these general guidelines exist, the precise timing of intubation and initiation of mechanical ventilation depends on an individual physician's assessment, as does the precise type of mechanical ventilation used.

### STANDARD MODES

The greater complexity of today's mechanical ventilators has increased the number of variables that define a specific mode. In the case of PPV, the term *mode* can

refer to the way of delivering tidal volume ( $V_T$ ), or the degree of patient participation, or the cycling mechanism of the ventilator. **Table 3** summarizes the most commonly used modes of mechanical ventilation and their different features.

### Way of Delivering Tidal Volume

*Volume-targeted modes* deliver a preset  $V_T$  with each breath. The inspiratory flow rate and  $V_T$  are fixed, and the airway pressures are variable. In *pressure-targeted modes*, the ventilator applies a preset pressure level throughout inspiration. The inspiratory airway pressure is fixed, and the flow rate and  $V_T$  are variable.

### Degree of Patient Participation

In *assisted modes* of mechanical ventilation, patients can initiate or trigger breaths above the rate preset by the machine. In *controlled modes*, the machine delivers all breaths at a preset rate. Controlled modes are used in situations such as anesthesia, paralysis, or deep sedation that involve apnea. Assisted or controlled modes can be volume- or pressure-targeted. In *supported modes*, the patient's efforts determine the respiratory rate (RR) and  $V_T$ , and the machine assists or augments each effort.

### Cycling Mechanism

There are various ways of switching from inspiration to expiration in a ventilator. *Volume-cycled modes* end inspiration after a predetermined volume of gas is delivered. *Time-cycled modes* end inspiration after a predetermined time has elapsed (eg, in pressure-control ventilation [PCV]). *Flow-cycled modes* end inspiration after airflow has decreased to a predetermined level preset in the ventilator; this predetermined level is usually 25% of the peak flow achieved during inspiration, or 5 L/min (eg, in pressure-support ventilation [PSV]).

### ALTERNATE MODES

On occasion, oxygenation or ventilation cannot be achieved without high minute volumes, high inflation pressures, or lung overdistention. Less conventional modes of mechanical ventilation can be useful in these situations. Some of these modes include inverse-ratio ventilation, high-frequency ventilation, airway pressure release ventilation, and prone ventilation. Whereas