But that life may be restored to the animal, an opening must be attempted in the trunk of the trachea, into which a tube of reed or cane should be put; you will then blow into this, so that the lung may rise again and take air.
— A. Vesalius, de Humani Corporis Fabrica, 1543

**Technology:** Mechanical ventilation

**Use:** Mechanical ventilation is the fundamental technique for life support in the intensive care setting. The greatest impetus for technological advancement followed the description of acute respiratory distress syndrome by Ashbaugh and colleagues in 1967. Initially, ventilator modalities and goals focused on normalizing pH and $P_{aCO_2}$ and on improving oxygenation. Tremendous advances have been made in the design, function and reliability of ventilators since then; computer microprocessors, improved gas-delivery systems, noninvasive methods to monitor gas exchange, sophisticated graphical displays of data, enhanced ventilation triggering, improved patient–ventilator synchrony and novel modes of ventilation have turned the simple ventilator into a sophisticated and daunting piece of equipment.

**History:** Interest in artificial ventilation dates back to the work of the Greek physician Galen (c. 129 to c. 200) and to that of Vesalius, who in the 16th century inserted a reed into a pig’s trachea so that he could gently inflate its lungs. In the 1700s bellows ventilation was used to resuscitate people who came close to drowning in canals.

Major progress in mechanical ventilation was made approximately 50 years ago at the time of a poliomyelitis epidemic. The application of negative pressure to the chest wall, which allowed for chest expansion and facilitated ventilation, dramatically reduced mortality from spinal poliomyelitis and led to the wide distribution of negative pressure ventilators (Figs. 1 and 2). Partly because of the obtrusive nature of negative pressure ventilators, positive pressure ventilators were eventually refined for clinical applications as well.

**Problems:** Mechanical ventilation itself can lead to derangements in the structure and function of the lung, a condition referred to as ventilator-induced lung injury. Indeed, it has been shown that mechanical ventilation can lead to biorauma and an increase in mediators (e.g., cytokines) in the lung and systemic circulation; this, in turn, can potentially contribute to distal organ failure, the major cause of death in patients with acute respiratory distress syndrome. Thus, in an attempt to limit ventilator-induced lung injury, the goal of therapy for patients with acute respiratory distress syndrome has shifted away from preserving “normalcy” to that of accepting higher levels of $P_{aCO_2}$ (permissive hypercapnia) and lower levels of oxygen.

**Promise:** A number of innovative, nonconventional approaches have been developed in an attempt to abrogate this injury in patients with acute respiratory distress syndrome (Table 1). For example, studies have evaluated the role of high frequency ventilation and partial liquid ventilation; during high frequency ventilation breaths are delivered at rates up to 1000 breaths/min and swings in lung volume are reduced. With partial liquid ventilation perfluorocarbon, which has a very high
solubility for oxygen, is poured into the lung in an attempt to improve oxygenation. To date, however, a strategy that employs smaller volumes to reduce lung overdistention has been the most successful. A recently completed and as yet unpublished American trial coordinated by the National Institutes of Health demonstrated 25% fewer deaths among patients with acute respiratory distress syndrome who received low tidal volumes (6 mL/kg) of air than among those who received a larger volume of 12 mL/kg (see http://hedwig.mgh.harvard.edu/ardsnet/). These observations support the results of an earlier small study using a somewhat different strategy. 

**Prospects:** The Acute Respiratory Distress Syndrome Network Study of Ventilator Management, in addition to being the first large multicentre randomized clinical trial in mechanical ventilation to show a significant reduction in mortality, also stands to challenge current practice and stimulate further study. At present, the role of prone positioning, high frequency oscillation and partial liquid ventilation and the importance of maintaining alveolar patency among patients with the syndrome are being evaluated. It is perhaps ironic that in the face of greater ventilator sophistication, it was not the advancement in technology that has led to better survival rates but rather a better understanding of the pathophysiology of the syndrome and basic ventilation principles. It serves to emphasis the need for continual reevaluation of the technologies in use as our understanding of the pathophysiology of disease improves.

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**References**