Future of Positive Airway Pressure Technology

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KEYWORDS

• Positive airway pressure • Obstructive sleep apnea • Central sleep apnea • Noninvasive ventilation

KEY POINTS

- Further technological improvements in positive airway pressure (PAP) technology will allow for smaller and more energy-efficient machines to improve tolerance and battery-powered options for travel and for countries without reliable power.
- Personalized PAP through machine learning and adjustable algorithms may improve treatment and tolerance to PAP.
- Incorporating data from other medical devices, such as insulin pumps and pacemakers, and with embedded or external sensors, such as ECG and oximetry, could increase understanding about the effects of PAP and which patients will benefit most and drive algorithms to improve treatment.
- Cross-platform integration of PAP data into electronic health record may enhance PAP utilization and optimization, provider documentation and research opportunities.
- The largest limitation of PAP technology may be not understanding the psychosocial issues that have so far prevented many patients from using it for the full 7 hours to 8 hours they need to sleep free of obstructive sleep apnea.

INTRODUCTION

Continuous positive airway pressure (CPAP) has been around for 37 years. When first proposed, many suspected that its use in the clinical arena would be a transient phenomenon, because few people believed patients would be ready to accept a nasal mask for nightly use. To date, however, no therapy has come close to PAP's physiologic success for treating obstructive sleep apnea (OSA). Thus, it is widely used as a benchmark of physiologic research that requires reversal of upper airway obstruction in sleep; clinically, PAP remains the most widely recommended therapy for OSA. Despite many technological advances in mask therapy, blower algorithms, and accessories like humidifiers, however, it is increasingly recognized that a major limitation of CPAP has been suboptimal adherence by a substantial minority of patients. This, rather than enhancing the effect on OSA physiology, has become the major focus for investigation and it is likely that the future of PAP technology will depend on addressing (or accepting) this limitation. Several areas of investigation are actively being pursued and others are being discussed.

This article discusses the future of PAP technology. The focus is on (1) technology improvements in the delivery of PAP; (2) improvements in PAP

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algorithms; and (3) improvements in PAP informatics. Current limitations of PAP technology and whether technological improvements are sufficient to improve PAP beyond where it is today are discussed.

TECHNOLOGY IMPROVEMENTS IN THE DELIVERY OF POSITIVE AIRWAY PRESSURE

Blower Technology

Currently most PAP systems use direct current (DC) brushless motor blower technology, which limits the size and energy efficiency of current machines. Fig. 1 shows several blower options studied for use in PAP technology.

Multistage DC brushless motors have multiple impellers to allow for higher flow at lower motor speeds, allowing for quieter motors that can achieve desired speeds more rapidly.[1]

Three-phase torque motors, such as the switch reluctance motor, work by cycling through 3 phases—1 negative current, 1 positive current, and 1 nonenergized—creating rotational torque.[2] Similar effects can be achieved with 3-phase electric motors using high-efficiency permanent magnets.[3]

A Roots-type blower is a multilobed positive displacement pump that works by trapping air in pockets to move it forward.[4] A bias valve closes the exhalation valve at the start of inspiration and regulates the positive end-expiratory pressure during exhalation. Power consumption is minimized when the bias pressure is able to be low and constant allowing for smaller, more efficient, battery-powered devices.

Microelectromechanical system (MEMS) technology is currently used in several medical devices, including hearing aids and insulin pumps. This technology is being developed by Marsh[5]

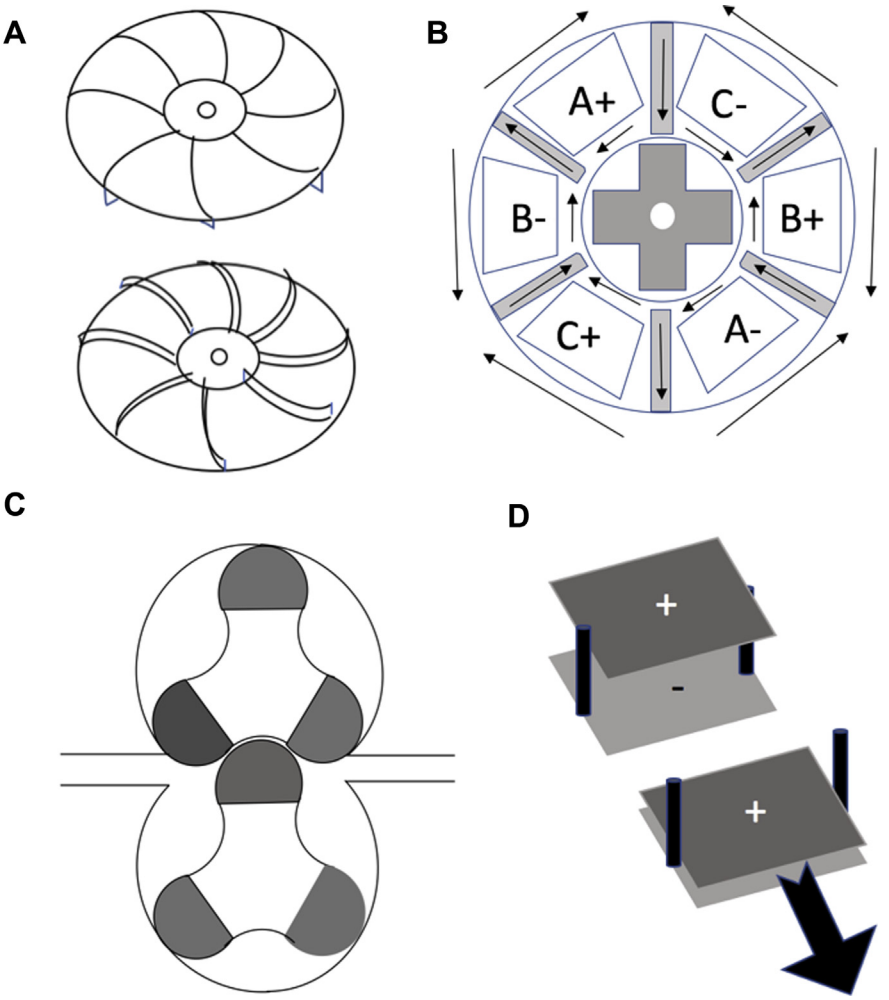

Fig. 1. Blower technology. (*A*) DC brushless multistage blower. (*B*) Three-stage torque motor. (*C*) Roots 3-lobed blower. (*D*) Electrostatic micro–air pump.