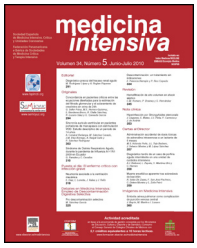
Med Intensiva. 2014;38(4):249–260

medicina intensiva

www.elsevier.es/medintensiva



UPDATE IN INTENSIVE CARE MEDICINE: MECHANICAL VENTILATION

New modes of assisted mechanical ventilation☆

F. Suarez-Sipmann*, in representation of the Acute Respiratory Failure Working Group of the SEMICYUC

Department of Intensive Care Medicine, Uppsala University Hospital, Hedenstierna Laboratory, Department of Surgical Sciences, University of Uppsala, Uppsala, Sweden

KEYWORDS
Patient–ventilation synchrony;
Assisted mechanical ventilation;
Work of breathing

Abstract Recent major advances in mechanical ventilation have resulted in new exciting modes of assisted ventilation. Compared to traditional ventilation modes such as assisted-controlled ventilation or pressure support ventilation, these new modes offer a number of physiological advantages derived from the improved patient control over the ventilator. By implementing advanced closed-loop control systems and using information on lung mechanics, respiratory muscle function and respiratory drive, these modes are specifically designed to improve patient–ventilator synchrony and reduce the work of breathing. Depending on their specific operational characteristics, these modes can assist spontaneous breathing efforts synchronically in time and magnitude, adapt to changing patient demands, implement automated weaning protocols, and introduce a more physiological variability in the breathing pattern. Clinicians have now the possibility to individualize and optimize ventilatory assistance during the complex transition from fully controlled to spontaneous assisted ventilation. The growing evidence of the physiological and clinical benefits of these new modes is favoring their progressive introduction into clinical practice. Future clinical trials should improve our understanding of these modes and help determine whether the claimed benefits result in better outcomes.

PALABRAS CLAVE
Sincronía paciente–ventilador;
Ventilación mecánica asistida;
Trabajo respiratorio

Nuevos modos de ventilación asistida

Resumen Los mayores avances en ventilación mecánica de los últimos años se han producido en el desarrollo de nuevos modos de ventilación asistida. En comparación con los modos tradicionales como la ventilación controlada-asistida o la presión de soporte, ofrecen una serie de ventajas fisiológicas así como un mayor control sobre el ventilador por parte del paciente. Basados en la utilización de algoritmos de control de asa cerrada que incorporan información de la mecánica, la actividad de la musculatura respiratoria y del estímulo respiratorio, estos modos están diseñados específicamente para mejorar la sincronía paciente-ventilador y reducir el trabajo respiratorio. Dependiendo de las características de funcionamiento

☆ Please cite this article as: Suarez-Sipmann F, por el Grupo de Trabajo de Insuficiencia Respiratoria Aguda de la SEMICYUC. Nuevos modos de ventilación asistida. Med Intensiva. 2014;38:249–260.

* Corresponding author.
E-mail address: fsuarez.sipmann@surgsci.uu.se

2173-5727/$ – see front matter

específicas de cada modo, estos pueden ayudar en los esfuerzos respiratorios espontáneos del paciente de forma sincronizada en tiempo y magnitud, adaptarse a sus demandas, realizar protocolos automatizados de reducción del soporte y devolver al patrón respiratorio una variabilidad más fisiológica. El clínico tiene ahora a su disposición modos que permiten individualizar y optimizar la asistencia ventilatoria mecánica en la compleja transición de la ventilación controlada a la ventilación espontánea-asistida. La creciente evidencia de las ventajas fisiológicas y clínicas de estos nuevos modos así como las nuevas posibilidades de monitorización que ofrecen, están llevando a su paulatina introducción en la práctica diaria. Futuros estudios permitirán aumentar nuestro conocimiento acerca de estos modos y deberán determinar si sus beneficios se traducen en mejores resultados clínicos.

Introduction

Mechanical ventilation (MV) is a life support measure that is used when the respiratory system of the patient is unable to meet the metabolic demands of the body. The indications of MV range from disease processes that affect gas exchange to simple ''switching off'' of the respiratory control system during anesthesia. Mechanical ventilation is usually started with a controlled ventilation phase during which the clinician takes full control of the ventilatory process, ensuring a minimum level of gas exchange and adequate muscle rest. Once the underlying disease condition has been corrected, a transition phase is started in which the patient gradually begins to participate in the ventilatory process. In this phase, which is referred to as assisted ventilation, the aim is to provide ventilatory support synchronized in time and magnitude with the inspiratory effort of the patient as the level of mechanical ventilation is gradually reduced.

The greatest advances in MV correspond to the development of new assisted ventilation modes. Impulsed by important technical innovations, these new modes offer theoretical advantages with respect to the traditional assisted ventilation modes such as assisted-controlled ventilation or pressure support ventilation. However, their slow introduction to clinical practice and the fact that their superiority in terms of clinical outcomes has not yet been firmly established have caused the traditional modes to remain the most widely used techniques.[1]

The present review describes new assisted ventilation modes that have been grouped as follows: (1) modes that adapt to the instantaneous inspiratory effort of the patient, such as proportional assist ventilation (PAV) and neurally adjusted ventilatory assist (NAVA); (2) automated modes that can be adapted to the patient demands, such as adaptive support ventilation (ASV) and the NeoGanesh system marketed as SmartCare™; and (3) modes that introduce biological variability in the ventilatory pattern, such as variable pressure support ventilation (V-PSV) or ''noisy ventilation''.

The challenges of assisted ventilation

Assisted ventilation has the difficult task of harmonizing the operation of two complex systems, i.e., patient and ventilator–each with its own control center and ventilatory pump (Fig. 1). The respiratory control system (RCS) is composed of an automatic system and a voluntary system. The former integrates information from neurological and chemical peripheral afferents at brainstem level, while the voluntary or behavioral system in turn is located in supramedullary and cortical structures. In healthy individuals, the respiratory stimulus has three main origins: (1) chemical, mediated by changes in PaO_2, PCO_2 and pH; (2) metabolic, mediated by less well known mechanisms; and (3) a conscious origin that disappears during sleep phases.[2] In effect, during sleep, the respiratory pattern is almost exclusively conditioned by chemical stimuli, which for example explains the apneas seen in response to minor changes in PCO_2 in sedated patients.[3] During the waking state, the voluntary control system is activated and influences the respiratory patterns in a variable and often unpredictable manner. As a result, patients subjected to assisted ventilation can develop complex respiratory patterns that affect interaction with the ventilator, thereby complicating mechanical assist.

In order to activate the muscle pump, the automatic control system transmits the respiratory impulses along the efferents (motor neurons). The voluntary system not only interacts directly with the automatic system, but also has efferents that can directly activate the muscle pump without passing through the automatic control filter[2] (Fig. 1). The difficulty of harmonizing the respiratory cycle generated by this complex RCS with the mechanical cycle of the ventilator is reflected by the fact that both are in manifest asynchrony in approximately 25% of all patients.[4] An element that contributes to this situation is the fact that the traditional ventilation modes are rigid–delivering prefixed volumes or pressures without taking into account the frequent changes in patient demands or the changes between the sleeping and waking states. Moreover, in the case of assisted-controlled ventilation, the clinician assigns a fixed inspiratory time that rarely coincides with the physiologically variable time set by the respiratory control center (neural time).

Assist modes adapted to the instantaneous inspiratory effort of the patient

These modes are represented by PAV and NAVA, and have opened a new range of possibilities for assisted ventilation. Based on solid physiological principles, these techniques offer a series of theoretical advantages that make them particularly attractive for improving patient–ventilator