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UPDATE IN INTENSIVE CARE: MECHANICAL VENTILATION

# Monitorization of respiratory mechanics in the ventilated patient☆

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**KEYWORDS**
Mechanical ventilation;
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**Abstract** Monitoring during mechanical ventilation allows the measurement of different parameters of respiratory mechanics. Accurate interpretation of these data can be useful for characterizing the situation of the different components of the respiratory system, and for guiding ventilator settings. In this review, we describe the basic concepts of respiratory mechanics, their interpretation, and their potential use in fine-tuning mechanical ventilation.


**PALABRAS CLAVE**
Ventilación mecánica;
Mecánica respiratoria;
Mecánica de la pared torácica;
Deformación pulmonar

**Monitorización de la mecánica respiratoria en el paciente ventilado**

**Resumen** La monitorización durante la ventilación controlada permite la determinación de diferentes parámetros de mecánica respiratoria. La interpretación adecuada de estos datos puede ser de utilidad para conocer el estado de los diferentes componentes del sistema respiratorio del paciente, así como para guiar los ajustes del ventilador. A lo largo de esta revisión se describen los conceptos básicos de mecánica respiratoria, su interpretación y su potencial para el ajuste fino de los parámetros de ventilación mecánica.


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## Introduction

A large percentage of critically ill patients require invasive mechanical ventilation (MV)—a technique that is often essential for patient survival, but which is not harmless or without risks. Growing concern about the so-called ventilator-associated lung injury (VALI) has led to attempts to develop ventilation strategies capable of reducing such injury and of avoiding its consequences at both pulmonary and systemic levels.[1]

Although the response to ventilation is ultimately of a biological nature, the triggering factor is mechanical.[2] The application of a volume of gas to the respiratory system results in a more or less complex series of pressures and flows, depending on the components that come into play. In this sense, the response depends on whether ventilation is active or not, the characteristics of the airway, the lung parenchyma, the properties of the chest wall, and activation of the respiratory muscles. Monitorization of the ventilated patient is thus the end result of the interactions among all the above-mentioned elements.

Conversely, we can try to deduce the condition of each of the elements intervening in respiratory mechanics from the end result reflected by monitorization. In the same way that a series of equations are needed to clarify certain aspects, we need different variables—sometimes measured under different conditions—in order to know the condition of each of the pieces in this puzzle. Fig. 1 schematically represents some of these variables and their main relationships.

In the end, we will need an analysis of different results to transform the data obtained into knowledge of relevance for patient management. The present review describes the main elements of ventilatory mechanics and their interactions, with the aim of establishing the necessary bases for correct interpretation of the data.

## Equation of motion

The equation of motion refers to the relationship between the time course of one or more variables and the physical state of the system to which they belong. In application to our study, the equation of motion of the respiratory system refers to the relationship between the pressure in the system and the volume, flow and convective flow values.[3] This equation and its components are shown in Fig. 2. The equation indicates that at each point in time, the pressure in the respiratory system has an elastic component needed for distension of the lung parenchyma, a resistive component needed for the air flow to advance against the resistances of the airway, and an inertial component due to the changes in the lung parenchyma caused by volume acceleration. It is accepted that at respiratory frequencies of under 1 Hz (60 rpm), the component due to the inertia of the system is negligible, and is therefore usually not taken into account.[4]

Based on the equation of motion, we can establish the conditions required to conduct an adequate study of respiratory mechanics. In order to facilitate interpretation of the data, the patient must not make any respiratory effort, as a result of which pressure due to muscle effort (Pmus) = 0. If we obtain a pressure value under zero flow conditions (referred to as static conditions), the resistive component of the pressure is canceled. In this situation, we can calculate the compliance of the respiratory system, as will be explained further below. To this effect, we require inspiratory and expiratory pauses that cause the flow in the airway to be zero, with a view to measuring some of the mechanical parameters. Likewise, we can obtain measures under conditions of very low inspiratory flow rates (<9 l/min) that cause the resistive component of the pressure to be negligible.[5] In this case we speak of ''quasistatic'' conditions. Lastly, dynamic conditions are referred to when the air flow in the airway is not zero. One same parameter such as compliance

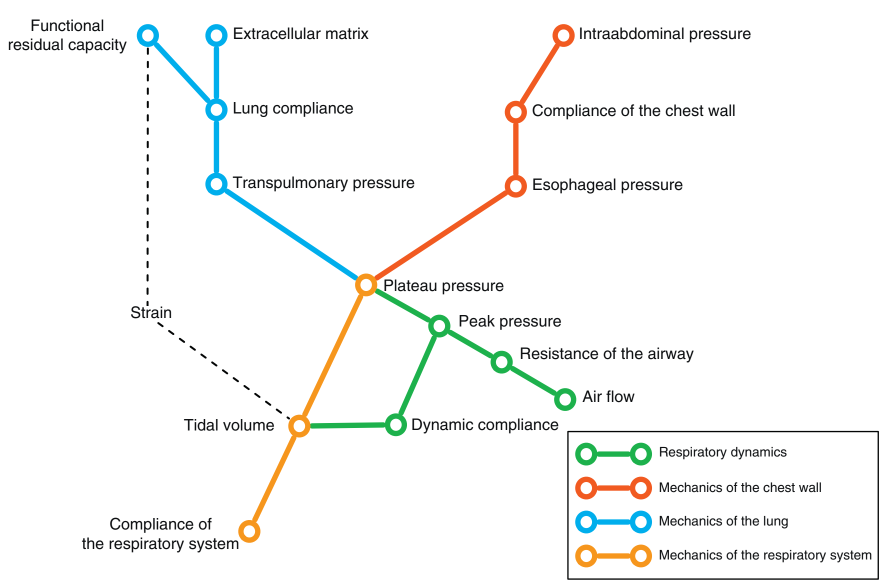


**Figure 1** Schematic representation of different parameters of respiratory mechanics and their main relationships.