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### Scientific and Technological Research

# Changes in the hemodynamic profile when establishing mechanical ventilation in patients with ischemic heart disease and coronary disease: Measurement with thoracic bioimpedance<sup>☆</sup>



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#### ABSTRACT

Breathing affects cardiac output on a cycle-by-cycle basis, through changes in pressure and intrathoracic volume of key components in cardiovascular function. Hence, heart-lung interactions affect cardiovascular functioning and the heart's ability to adapt. The heart-lung interaction is an area of applied physiology broadly studied but in Colombia, this is the first trial ever done with a thoracic bioimpedance monitor. The hemodynamic profiles of 38 patients scheduled for myocardial revascularization were measured at the Fundación Clínica Abood Shaio using thoracic bioimpedance monitor, which provided ventricular volume and cardiac output measurements. The ventilator volumes and pressures with which corrections were made to interpret the effects of mechanical ventilation were recorded.

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## Cambios en el perfil hemodinámico al instaurar la ventilación mecánica en pacientes con cardiopatía isquémica y enfermedad coronaria. Medición con biorreactancia torácica

### RESUMEN

#### Palabras clave:

Respiración  
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Anestesia

La respiración afecta el rendimiento cardiaco, ciclo a ciclo, a través de los cambios en la presión y el volumen intratorácicos sobre las determinantes de la función cardiovascular. De esta manera, las interacciones corazón-pulmón afectan el funcionamiento cardiovascular y la capacidad del corazón para adaptarse. La interacción corazón-pulmón es un área de la fisiología aplicada ampliamente estudiada, pero en Colombia es el primer estudio que se realiza con un monitor de biorreactancia torácica. Se midieron los perfiles hemodinámicos de 38 pacientes programados para cirugía de revascularización miocárdica en la Fundación Clínica Abood Shaio utilizando un monitor de biorreactancia torácica, con el cual se obtuvieron medidas de volúmenes ventriculares y gasto cardiaco. Se registraron los volúmenes y presiones ventilatorias con las que se hicieron correlaciones para interpretar los efectos de la ventilación mecánica.

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### Introduction

Spontaneous natural breathing that involves the integrity of the respiratory system begins with inspiration through the action of muscles that expand the chest volume, generating a negative pressure in the inter-pleural space that also allows for an increased pulmonary volume and airflow into the alveolar zone. Simultaneously, negative pressure trough a pressure gradient facilitates the inflow of blood to the chest and the heart for a natural venous return. During this phase, an enhanced right ventricle filling promotes a higher right systolic volume and blood flow through the pulmonary artery that increases the capillary refill to facilitate hematosis. During expiration, the mechanical inversion of forces produces divergent effects; but, according to Frank Starling's phenomenon, the left ventricle will receive more blood with enhanced stroke volume at this stage.

Pulmonary or cardiac disease that affects the blood flow dynamics or the gas exchange demands the use of methods and systems that temporarily support a compromised function. Usually these are based on external pulmonary insufflation using the Positive Pressure principle. Mechanical ventilation is one of the most commonly used and important aids for the comprehensive management of the critical patient. Intrathoracic positive pressures have beneficial effects on the respiratory function that are directly related with gas exchange but, on the other hand, lead to adverse effects on the lungs and the heart that have to adapt their function to the pressure forces and vectors.

Positive intrapulmonary pressures during mechanical ventilation bring about changes in the heart-lung interaction that may alter directly or indirectly the regulation of the cardiorespiratory system. The intensity of the effects depends on several factors: the severity of the involvement of the lung parenchyma, the integrity of the intrapleural space, the strength of positive pressures, the volemic status, and heart failure. However, the effects of mechanical ventilation (MV) over the composition of blood gasses will depend on the underlying pulmonary disease and the peripheral perfusion.

During the last few years, clinical research has been focusing on non-invasive monitoring methods because of the adverse events resulting from invasive devices in the ICUs. These new devices allow for a continuous evaluation of the hemodynamic variables, of any acute changes in the respiratory cycle and immediate response to treatment, hence making some headway toward achieving the management objectives.

In order to analyze the changes in the heart-lung interaction, a research protocol was designed to take measurements in patients with ischemic heart disease scheduled for myocardial revascularization surgery. First, because mechanical ventilation may then be initiated in a programmed manner, and second, because the hemodynamic changes associated with mechanical ventilation could be potentially evaluated early.

### Materials and methods

This research protocol was approved by the Ethics Committee of the School of Medicine of the National University of Colombia and by the Ethics Committee of the Fundación Clínica Abood Shaio, in keeping with the Declaration of Helsinki.

This was a pre-experimental trial with a pre-test and post-test single group design.<sup>1</sup> The study took place during the second and third quarter of 2011, at the Fundación Clínica Shaio. Three time periods were used:

1. Informed consent and baseline pre-anesthetic evaluation.
2. Induction of anesthesia – the same anesthetic induction protocol was followed in every patient: Midazolam 0.1 mg/kg, Fentanyl 4 mcg/kg, Cisatracurium 0.1 mg/kg and Sevoflurane initial dose 4% and 2% maintenance dose.
3. Mechanical ventilation – the following parameters were applied: volume controlled ventilation, RR 12–14 rpm, PEEP 5 cmH<sub>2</sub>O, CV 8 ml/kg approximately, FIO<sub>2</sub> 100%.

The trial included both male and female patients with the following characteristics:

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