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REVIEW

Ineffective cough and mechanical mucociliary clearance techniques[☆]

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Received 27 February 2017; accepted 5 May 2017

KEYWORDS

Cough assist;
Intrapulmonary
percussive
ventilation;
Mucociliary clearance

Abstract Cough is a fundamental defense mechanism for keeping the airway free of foreign elements. Life-threatening situations may arise when cough proves ineffective as a result of muscle weakness or altered mucociliary function.

When a patient is unable to cough effectively, techniques are required to either reinforce or replace cough capacity. The use of mechanical systems that facilitate or substitute cough function is increasingly common in Intensive Care Units, where it is relatively frequent to find situations of ineffective cough due to different clinical causes.

This review examines the current clinical practice recommendations referred to the indication and use of mechanical cough assist and intrapulmonary percussive ventilation systems.

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PALABRAS CLAVE

Tos asistida;
Tos mecánica;
Ventilación percutora
intrapulmonar;
Aclaramiento
mucociliar

Tos ineficaz y técnicas mecánicas de aclaramiento mucociliar

Resumen La tos es un mecanismo de defensa fundamental para mantener la vía respiratoria libre de elementos extraños. Cuando la tos es ineficaz, por debilidad muscular o por alteración del normal funcionamiento del sistema mucociliar, se puede dar lugar a situaciones que pongan en riesgo la vida.

Cuando un paciente no es capaz de producir tos eficaz es cuando está indicada la aplicación de técnicas que, o bien potencien la tos del paciente, o bien la sustituyan. Actualmente el uso de sistemas mecánicos facilitadores o sustitutivos de la tos es creciente en las unidades de cuidados intensivos, donde con relativa frecuencia encontramos pacientes en esta situación por diversas causas clínicas.

[☆] Please cite this article as: Fernández-Carmona A, Olivencia-Peña L, Yuste-Ossorio ME, Peñas-Maldonado L y Grupo de Trabajo de Unidad de Ventilación Mecánica Domiciliaria de Granada. Tos ineficaz y técnicas mecánicas de aclaramiento mucociliar. Med Intensiva. 2017. <https://doi.org/10.1016/j.medin.2017.05.003>

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Esta revisión se centra en las recomendaciones de práctica clínica actuales con respecto a la indicación y aplicación de la tos asistida mecánica y de la ventilación percutora intrapulmonar. © 2017 Elsevier España, S.L.U. y SEMICYUC. Todos los derechos reservados.

Introduction

“Cough” (in Latin: *tussis*): the voluntary or reflex sudden, sharp and noisy expulsion of air from the lungs.

Cough is a defense mechanism with two basic functions: to keep the airway free of foreign elements, and to expel secretions that are produced in excess or under pathological conditions. Ineffective cough is defined as cough unable to adequately perform these functions. Cough can also manifest in acute or chronic form as a symptom of many disease conditions, drug side effects, etc.^{1,2}

Many diseases can severely affect the cough reflex and result in ineffective cough, particularly disorders that cause muscle weakness, alterations in bronchial secretion characteristics and clearance, and a decrease and/or abolition of cough stimulation. The disorders that produce ineffective cough result in a tendency to retain bronchial secretions, with alteration of the normal ventilation/perfusion (v/Q) ratio, and an increased risk of respiratory infectious problems. On the other hand, in the presence of a significant amount of secretions in the upper airway that are not expelled correctly, patients experience excessive muscle labor, with a risk of muscle fatigue.¹⁻⁴

When a patient is unable to cough effectively, techniques that either reinforce cough or replace it are indicated with the aim of improving inspiratory capacity or mobilizing the secretions to where they can be cleared by the patient or by physical means.⁵⁻⁷

Ineffective cough has been widely studied in patients with disorders causing muscle weakness, such as neuromuscular disease. In critical patients, the deficient management of secretions is a determining factor of respiratory failure, failed weaning from invasive mechanical ventilation, and failure of noninvasive mechanical ventilation.^{3,8-10}

Although there is currently no solid scientific evidence warranting the systematic use of mechanical mucociliary clearance systems in the Intensive Care Unit (ICU) (the studies involving critical patients being few and heterogeneous), and the recommendations are practically based only on expert opinion, such systems are increasingly used in critical care – often in patients with spinal cord injuries or neuromuscular diseases, but also in situations of muscle weakness or difficult weaning from mechanical ventilation. Special mention must be made of the recent study published by Gonçalves et al., which demonstrates the benefits of these techniques when included in the mechanical ventilation weaning protocols in critical patients, affording lower reintubation rates and shorter ICU stays.¹⁰⁻¹³

The present review offers a brief description of the pathophysiology of cough and comments on the current clinical practice recommendations regarding mechanical mucociliary clearance techniques and their application, including: intrapulmonary percussive ventilation (IPV) and mechanical

insufflation–exsufflation therapy (MI–E) or mechanical cough assist (MC).

Assessment of cough efficacy

Clinical assessment

Assessment always should include the patient antecedents and updated clinical history. Special attention should focus on the duration of mechanical ventilation and on whether the patient has an artificial airway or not; the presence of neuromuscular disease; high spinal cord injury; diaphragmatic dysfunction (Table 1); chronic bronchial disease; or disease conditions altering the characteristics of the bronchial secretions, such as cystic fibrosis.

In addition to the usual physical examination, quantification and evaluation of the characteristics of the bronchial secretions are required, along with assessment of the patient capacity to mobilize and expectorate the secretions, and the need for specific care measures such as cough incentivizing, tracheal aspiration (through the natural or artificial airway), auscultation and respiratory inspection.^{2,3,6-8}

Consideration is also required of phonation and swallowing alterations, as well as of the capacity to perform an effective Valsalva maneuver – this being of great importance for spontaneous cough and for non-mechanical cough assist maneuvers.

Complementary tests are to be added to the physical examination.

Functional assessment

A number of determinations have been used for the functional assessment of cough. Such measurements can be made both in patients with a natural airway and in those who are intubated or subjected to tracheostomy not dependent upon mechanical ventilation:

- *Peak expiratory pressure (PE_{max})*: This parameter measures the maximum pressure generated by the expiratory muscles. The measurement is made following a maximum inspiration coming as close as possible to total lung capacity. However, consensus is lacking regarding the cut-off point of this parameter in defining whether cough is effective or not. On the other hand, peak expiratory pressure has limitations resulting from the measuring process used.^{2,7,14}
- *Gastric pressure during cough maneuvering (PGA-cough)*: This parameter estimates the force generated by the expiratory muscles in the expulsive phase; the normal values for adults are >175 cmH₂O in men and > 100 cmH₂O in women. The technique is invasive, however, and there

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