International Journal of Physical Medicine & Rehabilitation

Tomazini Sombrio RLW et al., Int J Phys Med Rehabil 2018, 6:6
DOI: 10.4172/2329-9096.1000493

Research Article Open Access

Mechanical Insufflation-Exsufflation as Bronchial Hygiene Technique in Critical Care Patients: Systematic Review

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Received date: September 17, 2018; **Accepted date:** November 19, 2018; **Published date:** November 21, 2018

Abstract

The bronchial hygiene of intubated patients, there is no closure of the glottis, but the increased expiratory flow is determinant to the passive expulsion of secretions in the presence of endotracheal tubes. Methods aimed at improving the effectiveness of cough are important because they facilitate weaning from mechanical ventilation and improve functional outcomes for patients. This study aimed to systematically review the outcomes enabled by the respiratory therapy using the mechanical insufflation-exsufflation in critically ill patients admitted to the intensive care unit. Trials were included from 1993 to 2015, through a systematic literature review. The databases involved were LILACS, SciELO and PubMed using the keywords "mechanical ventilation", "physiotherapy", "cough", "secretion" "mechanical insufflation-exsufflation" and "device". Two independent researchers carried out the screening of articles and included studies using the mechanical insufflation-exsufflation in critically ill patients. Initially 52 potentially relevant articles were found, only 3 (5.7%) contemplated the inclusion criteria and addressed the mechanical insufflation-exsufflation in critically ill patients. The articles analyzed, all showed significant benefits in the use of mechanical insufflation-exsufflation regarding the improvement of peripheral oxygen saturation, increased of peak expiratory flow and a decrease in the rate of re-intubation. The studies demonstrated if the mechanical insufflation-exsufflation improves bronchial hygiene when used in critically ill patients, proving to be effective equipment. The level of evidence about the theme addressed is still considered low, making necessary new studies.

Keywords: Physical therapy; Equipment; Secretion; Cough; Mechanical ventilation

Introduction

Mechanical ventilation is considered a supportive method; however, in addition to causing respiratory muscle weakness, it can impair airway clearance in critically ill patients. The use of the endotracheal tube prevents closure of the glottis, which is essential for cough efficacy, protecting the respiratory tract against possible infections [1,2]. Care in this type of patient includes aspiration of the airways, applied through the endotracheal tube, which maintains the hygiene of only a small portion of the airway. This procedure is ineffective and leaves the patient hygiene-dependent through mucociliary beats instead of the cough mechanism [3-5].

Mechanical insufflation-exsuflation (IE-M) equipment can be described as an efficient technique in patients with chronic muscular weakness [6,7]. It is the application of positive pressure followed by negative pressure in the airway (central and peripheral portions), whose main objective is to increase the expiratory flow to displace the secretion towards the glottis, facilitating its removal [1,2,6,8-11]. This equipment has provided mechanical assistance to compensate for deficits in both the inspiratory and expiratory phases of coughing in patients with changes in respiratory muscles. Generally associated with non-invasive mechanical ventilation (NIV), it has been offering assistance in bronchial hygiene during physiotherapeutic care [9,10,12] and is used in patients of different age groups. This would require the active participation of the patient who, although with respiratory muscle changes, should perform the cough maneuver to close the glottis; In this case the equipment will amplify the cough. In contrast, when connected in an invasive interface, patient participation is not necessary, thus, the equipment will simulate coughing, even in unconscious and sedated patients [13].

IE-M increases the flow of cough more than other methods possibly used. Therefore, methods that aim to improve cough efficacy are important because they facilitate the weaning of mechanical ventilation and improve the functional outcomes of patients [14]. A number of invasive and non-invasive techniques are currently used to facilitate the removal of bronchial secretions, including tracheal aspiration, bronchoscopy, manually assisted coughing, with or without air stacking, percussion, and postural drainage. IE-M therapy is an additional noninvasive tool that increases inspiratory and expiratory flow to improve secretion mobilization [15,16].

Thus, the present study aimed to systematically review the literature regarding the outcomes provided by the performance of respiratory physiotherapy with the use of IE-M in critically ill adult patients admitted to an intensive care unit.

Material and Methods

Identification and selection criteria

The search for articles involving the intended clinical outcome was carried out in the Latin American and Caribbean Literature in Health Sciences (LILACS), Scientific Electronic Library Online (SciELO) and Medical Literature Analysis and Retrieval Sistem Online (MedLine/PubMed). The criteria for inclusion of articles were the use the following keywords: mechanical ventilation, physiotherapy, cough,

secretion, mechanical insufflation and device. The search for references was limited to articles written in Portuguese, English, Dutch, French or Spanish, and published in the last 22 years (1993 to 2015). We included at the end of the analysis only the clinical trials that addressed the performance of respiratory physiotherapy with the use of IE-M in critical adult patients. The exclusion criteria were published as letters, abstracts, dissertations, theses and case reports.

Validity of the study

The articles identified in the search strategy had their title and abstracts evaluated by two researchers independently and blindly. The studies that met the inclusion criteria were evaluated by the Physiotherapy Evidence Database (PEDro) scale. PEDro is a specific database for studies investigating the efficacy of interventions in physical therapy. This database was created in 1999 by a group of Australian physiotherapists from the Center for Evidence-Based Physiotherapy at the University of Sydney to maximize the effectiveness of physiotherapy services and to facilitate the practical application of the best existing evidence [17].

This scale evaluates the trials by means of 11 pre-established items. The first item is an additional criterion and represents the external validity (or "generalization potential" or "applicability" of the clinical study), not being included in the total scale score. The other items analyze two aspects of article quality: internal validation (items 2 to 9) and if the article contains sufficient statistical information so that the results can be interpreted (items 10 and 11). These items qualify as "applicable" or "not applicable", generating a total score ranging from 0 to 10 points [18]. For each criterion defined in the scale, a point (1) is attributed to the presence of indicators of the quality of evidence presented, and zero point (0) is attributed to the absence of these indicators [19]. The PEDro scale score was not used as a criterion for inclusion or exclusion of articles, but rather to verify the methodological quality.

Results

After the analysis carried out by two researchers, 53 articles were excluded because they did not present the methodological design and sample profile required. Three clinical trials were included that addressed the use of IE-M respiratory therapy in critical adult patients.

Table 1 contains information on the scores obtained by clinical trials on the PEDro scale. As we can see, all the studies used showed eligibility criteria, initial similarity between the groups, adequate follow-up, intergroup comparison and precision and variability measures. As to classification in the PEDro scale, the three studies scored higher than 4, being classified as "high quality", according to the criteria of Van Peppen et al. [20].

PEDro Scale	Sancho et al. [21]	Gonçalves et al. [15]	Pillastrini et al. [22]
Eligibility criteria	Sim	Sim	Sim
Random distribution	0	1	1
Secret Allocation of Subjects	0	1	0
Initial similarity between groups	1	1	1
Subject blindness	0	1	0
Therapists blinding	0	1	0
Evaluators' blinding	0	1	0
Appropriate monitoring	1	1	1
Analysis of intention to treat	1	1	0
Intergroup comparisons	1	1	1
Measures of precision and variability	1	1	1
Total score	5/10	9/10	5/10

Table 1: Classification of clinical trials according to PEDro Scale.

The three studies used used IE-M for bronchial hygiene in critically ill patients (Table 2). The sample size ranged from 6 to 75 subjects, of both genders, with mean age ranging from 31 to 64 years of age and who underwent IE-M for bronchial hygiene.

Author	Sample (N)	Sample Characteristic	Intervention	Intervention time	Main variables evaluated	Outcome
Sancho et al. [21]	G1:6 G2:6 G3:6	Patients submitted to mechanical ventilation with a tracheostomy tube with a diagnosis of	G1: Baseline data. G2: Tracheal aspiration with pressure of -80 cmH2O.	While the patients had pulmonary infection.	SpO2, inspiratory pressure peak (PIP), mean airway pressure, ventilatory work by the mechanical ventilator	Ventilatory work performed by the mechanical ventilator decreased significantly after tracheal aspiration. PIP, SpO2

		Amyotrophic Lateral Sclerosis (ALS), and pulmonary infection, with a mean age of 64 years.	G3: 5 cycles of IE-M +40/-40 cmH2O followed by tracheal aspiration.		(WOB) and volume of secretion.	and mean airway pressure improved significantly after IE-M.
Gonçalves et al. [15]	Control group: 40 Study group: 35	Patients submitted to mechanical ventilation for more than 48 hours and who tolerated the spontaneous breathing test, with acute hypoxemia and / or respiratory failure, with a mean age of 61.8.	Control group: They received standard medical treatment (supplemental oxygenation, physiotherapy, bronchodilators, antibiotics) after extubation. Study Group: They received the same standard medical treatment with addition of IE-M before and after extubation.	During the first 48 hours after extubation.	Total period of mechanical ventilation, re-intubated patients, ICU stay.	The duration of mechanical ventilation and length of stay in the ICU were significantly lower, and the re-intubation rate was significantly lower in the study group.
Pillastrini et al. [22]	GC: Control group GE: Experimental group	Cervical spinal cord lesion (C1-C7) with grade A classification (ASIA), tracheostomy and bronchial hypersecretion. GC 50% in spontaneous breathing and 50% in mechanical ventilation. GE 80% in spontaneous breathing and 20% in mechanical ventilation.	GC: They received methods of bronchial clearance that consist of postural drainage, assisted cough, manual hyperinflation, endoscopic bronchoaspiration. GE: They received the same methods with addition of IE-M.	Each patient received 10 treatments, except two patients in the control group (CG), who received six and nine treatment sessions, respectively.	Forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), FEV1/FVC, peak expiratory flow (PEF), partial oxygen pressure (PaO2), partial pressure carbon dioxide (PaCO2), pH and peripheral saturation of O2.	At the end of treatment associated with IE-M, the EG showed a significant increase in FVC, FEV1 and PEF.

Table 2: Analysis of selected clinical trials, published between 2003 and 2012, using mechanical insufflator-exsuflator.

The clinical trials studied showed divergence in the use of IE-M for pressure, cycle and pause. Each study used a pause time in each different cycle: one second [21], three seconds [15] and 0.5 seconds (Table 3) [22].

Mechanical insufflator-exsuflador	Sancho et al. [21]	Gonçalves et al. [15]	Pillastrini et al. [22]
Used pressure	Pressures 40 cmH_2O for insufflation and -40 cmH_2O for exsuflation.	Pressures set at 40 cmH_2O for insufflation and -40 cmH_2O for exsuflation.	Minimum of 15 cmH_2O, maximum 45 cmH_2O, always from the minimum pressure, in order to allow time for the patient to adjust to the instrument.
Cycles	Five cycles of IE-M.	Eight IE-M cycles.	Five cycles of IE-M.
Inspiration and expiration	2 - 3 s respectively	2 - 3 s respectively	2 - 3 s respectively
Pause	1 s	3 s	0.5 s
Mode	Automatic.	Automatic.	Automatic.

Table 3: Characteristics of the mechanical insufflator-exsuflador in the clinical trials analyzed.

Discussion

The endotracheal tube hinders the entry and exit of air in patients hospitalized in the intensive care unit and mechanically ventilated, as it increases the resistance to the flow of the same. The smaller the diameter of the tube, the greater the resistance to air flow [14,23]. Moreover, in invasive mechanical ventilation, secretion retention, together with changes such as respiratory acidosis, hypoxemia and low respiratory work, contribute to extubation failure [24].

Currently, the vast majority of studies use IE-M in patients with neuromuscular diseases. However, it can be used in any patient with airway secretion and/or ineffective cough who needs assistance and should expand the use of this device [12].

Cough is the main component of airway clearance 1 its efficiency is related to its peak flow [26]. Increasing the efficacy of cough with the use of mechanical equipment is the main therapeutic objective in several clinical conditions in which this mechanism is weakened, being this equipment widely used in some European countries [25].

Gonçalves et al. [15] used the IE-M in 35 patients with chronic obstructive pulmonary disease (COPD), congestive heart failure, thoracic surgery, chest trauma, sepsis and under mechanical ventilation for more than 48 hours. In the study group, prior to extubation, all patients underwent IE-M (three sessions) through the endotracheal tube with pressures set at 40/-40 cmH_2O. IE-M was also used in conjunction with standard medical treatment (supplemental oxygenation, physiotherapy, bronchodilators, and antibiotics). During the first 48 h after extubation, each patient received three daily treatments with IE-M through an oronasal mask. The treatments (three sessions each) were divided between morning, afternoon and night, for a total of nine sessions (one before extubation and the other after extubation). The control group received only standard medical treatment. The aim of the study was to evaluate the efficacy of IE-M in preventing re-intubation in these patients. Compared with the control group, the duration of mechanical ventilation and length of stay in the ICU were significantly lower, around six days ($p<0.05$), and the re-intubation rate was significantly lower (17% versus 48 %) in the intervention group.

The study by Gonçalves et al. [15] presented some limitations. Twenty patients (50%) from the control group and 14 patients (40%) from the study group used NIV. All patients in both groups for whom NIV failed, according to the criteria, were re-intubated. Considering this subgroup of patients, re-intubation rates related to NIV failure were significantly lower in the intervention group when compared to controls; Two patients (6%) versus 13 (33%), respectively. Although there were no significant differences in the baseline characteristics between the groups, hypoxemic respiratory insufficiency was slightly more frequent in the control group and consequently the rate of re-intubation was higher in this group, since NIV is not considered effective as a rescue method and re Intubation may be required in the presence of severe hypoxemia [27].

Sancho et al. [21] compared in their study the effects of IE-M with tracheal aspiration in six patients with Amyotrophic Lateral Sclerosis, who developed pulmonary infections and required invasive mechanical ventilation through tracheostomy in an ICU. The pressure used by the authors was 40/-40 cmH_2O. The inspiratory pressure peak (PIP), the mean airway pressure, the oxygen saturation (SpO2), the ventilatory work performed by the ventilator and the volume of secretion were analyzed. Aspiration was indicated and performed when SpO_2 was less than 94%, peak inspiratory pressure increased 5 cmH_2O or the patient requested aspiration. Baseline SpO2 values were measured in ambient air. The checks were performed before and repeated 5 and 30 minutes after application of the technique. Compared with the baseline data, the ventilatory work performed by the mechanical ventilator decreased significantly after tracheal aspiration ($p<0.05$). The inspiratory peak pressure (PIP), SpO_2 and mean airway pressure showed significant improvement after IE-M compared to the baseline data. IE-M and aspiration, alone, were able to eliminate more than 0.5 ml of secretions from the respiratory tract. This limit value was considered in previous studies as the standard for the elimination of effective secretion [28,29].

The limitations presented in the study by Sancho et al. [21] include the small sample size and the lack of randomization of the procedures performed, the authors chose to use aspiration always as the first technique.

In their study, Pillastrini et al. [22] aimed to establish if the use of IE-M had a greater effect on pulmonary volumes and flows compared to manual bronchial clearance in patients with cervical cord injury (C1-C7) with the classification of Degree A (complete lesion) of the American Spine Injury Association (ASIA) [31], tracheostomized and with bronchial hyper secretion. Each patient received 10 treatment sessions, except for two patients in the control group (CG), who received six and nine treatment sessions, respectively. Methods of bronchial clearance consisted of postural drainage, assisted cough, manual hyperinflation and endoscopic bronchoaspiration. In addition to using the same GC methods, the IE-M was also used in the semi-seated position (35-40°) with a minimum pressure of +15/-15 cmH_2O and a maximum of +45/-45 cmH_2O. Before the first treatment and at the end of the last treatment session, the arterial blood analysis of each patient was performed to verify the value of partial pressure of oxygen (PaO_2), partial pressure of carbon dioxide ($PaCO_2$) and pH. The value of SpO_2 was measured before and after each treatment session using a pulse oximeter. Individuals also underwent three spirometries before and after each session in order to verify forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), FEV1/FVC and peak expiratory flow (PEF). In GE, two parameters increased significantly: FVC and FEV1, with respective percent increases of 24% (from 0.37-0.23 l to 0.46-021 l) and 33% (from 0.21 to 0.15 L for 0.28 0.14 GP = 0.0001). Another parameter that presented a significant increase ($p=0.0093$) was the PEF (from 0.24 0.19 L/s to 0.31 0.19 L/s). The optimization of PEF that can be provided by IE-M is usually the reason for its use [2,7,8,9,10]. However, it is possible that patients who have very low peak cough flow do not benefit from this equipment because, although it generates an increase in expiratory flow, it may still be insufficient to displace secretions prior to airway collapse [32]. In the Bach study30 46 patients with neuromuscular disease, FVC and FEF 25-75% increased significantly immediately after IE-M (11%, $p=0.008$, and 14%, $p=0.005$, respectively) and also a significant increase Peak expiratory flow ($p=0.0005$). There were other articles that addressed the use of IE-M in patients with cervical spinal cord injury (ICS) [33], where treatment with IE-M aided in the removal of secretion in individuals with acute cervical SCI. The authors reported that such equipment should be available in all acute rehabilitation centers that treat patients with SCI.

Although studies have shown that the use of IE-M seems to be a good alternative for increasing cough efficacy through increased expiratory flow and has described it as an efficient technique to avoid intubation [34] or facilitating extubation [35-37], there is a lack of studies that use this equipment in critically ill patients. One possible limitation of this study is related to the scarcity of studies that address the use of M-IE and critical patients. In this way, clinical studies that evaluate the capacity of use of this equipment are of extreme importance.

Conclusion

The methodological analysis performed in this study demonstrated that 3 studies address the effect of IE-M on the improvement of bronchial hygiene in critically ventilated critical patients. The device proved to be an effective strategy when used in critically ill patients, improving peripheral oxygen saturation, increasing peak expiratory flow and forced vital capacity, and decreasing re-intubation rate and duration of mechanical ventilation. The level of evidence on the subject is still considered low and new studies are needed.

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