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Research Article

Bag Squeezing and Manual Hyperinflation: Different Techniques or Merely Synonyms?

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Keywords

- Physical therapy modalities; Inflation; Airway obstruction; Respiratory therapy; Critical care

Abstract

Objective: To describe procedures, indications and contraindications for bag squeezing and manual hyperinflation maneuvers and to propose an algorithm to optimize use of these techniques.

Methods: A narrative literature review based on searches in the SciELO, ScienceDirect, PubMed and PEDro databases as well as the SECAD online continuing education system. The following descriptors were used: physical therapy modalities, inflation, airway obstruction, respiratory therapy and critical care.

Bag squeezing: A physical therapy maneuver primarily for airway clearance and lung re-expansion. The maneuver is used with manual hyperinflation and compression of the chest followed by tracheal suctioning.

Manual hyperinflation: A physical therapy maneuver that can technically be performed by physicians and nurses to ensure bronchial hygiene. The maneuver is characterized by the use of a self-inflating bag and slow manual compression, with a plateau being maintained for 2 to 3 seconds before abrupt decompression.

Conclusion: Both bag squeezing (BS), and manual hyperinflation (MH), help with mechanical ventilation, oxygenation and airway clearance and re-expansion. However, BS is more effective than MH due to manual compression of the chest.

ABBREVIATIONS

MV: Mechanical Ventilation; BS: Bag Squeezing; MH: Manual Hyperinflation; PEF: Peak Expiratory Flow; PIF: Peak Inspiratory Flow; PEEP: Positive End Expiratory Pressure

INTRODUCTION

Physical therapy for critical patients on mechanical ventilation (MV), in an intensive care unit (ICU), is intended to avoid respiratory and motor complications [1,2]. Respiratory physical therapy uses specific maneuvers to keep the airways unobstructed by helping to remove pulmonary secretions and re-expand the lungs [3-5]. When patients requiring MV are admitted to an ICU, the physical Therapistperforms and adjusts maneuvers such as bag squeezing (BS), and manual hyperinflation (MH), both of which are frequently indicated for patients on MV [2,3,6].

Originally described in 1968 [7], BS involves the use of a bag to manually inflate the patient's lungs (Figure 1). After the bag is compressed slowly, a plateau is maintained for 1 to 2 seconds during the inspiratory phase. This is followed by the sudden release of pressure and compression or compression-vibration of the chest during the expiratory phase, which starts at the end of the inspiratory phase [6].

In 1972, Windsor, Harrison and Nicholson [6], described three fundamental principles on which the bag-squeezing technique is based: manual hyperinflation of the lungs to expand the alveoli; compression of the chest to increase the expiratory flow and so loosen and expel bronchial secretions; and removal of the secretions by tracheal suction. These stages simulate the cough reflex.

Manual hyperinflation is one of the three phases in the BS maneuver. A manual resuscitator or self-inflating bag can also be used, where the bag is compressed slowly, followed by a pause of approximately 2 seconds and rapid decompression [7-9]. With slow compression and rapid decompression of the bag, the elastic recoil of the lungs is increased, causing an increase in peak expiratory flow (PEF), and tidal volume and in turn

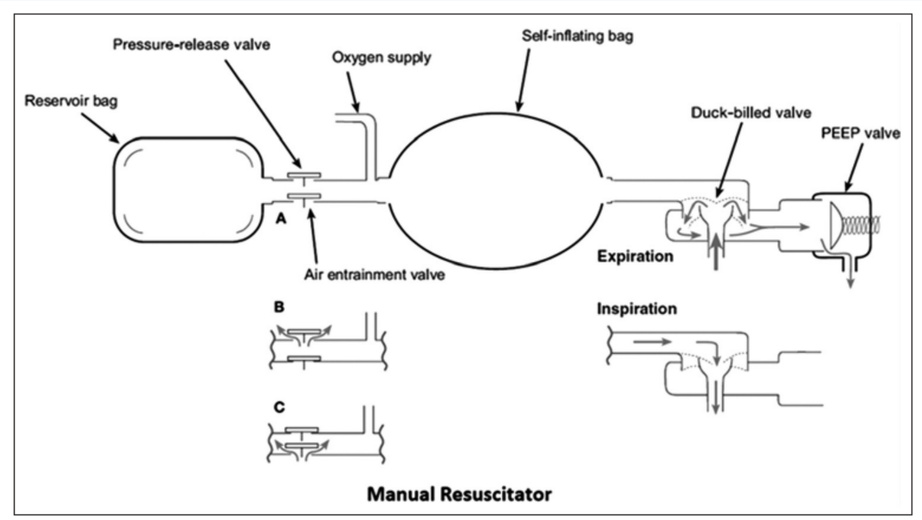

Figure 1 Parts of Self-inflating bags [17].

allowing mucus to be more easily moved. Some studies have shown that the maneuver is more effective when it is used with tracheal suctioning [2,10-12]. MH can be performed by physical Therapist, physicians and nurses who have been trained in the technique [6,13].

Although BS has been described in some studies as MH [14-16], the two maneuvers are different. While MH is an integral part of BS, the two maneuvers differ in the way they are performed and which professionals perform them. As there is a certain degree of conflict in the literature regarding the description of these two maneuvers, this study sought to describe the procedures, indications, contraindications and recommendations for BS and MH and to propose an algorithm to optimize use of these techniques [17].

METHOD

The study is based on a narrative literature review [18]. Articles identified in searches in the SciELO, ScienceDirect, PubMed and PEDro databases and the SECAD continuing distance education system were analyzed. The following descriptors were used: Physical therapy modalities, inflation, airway obstruction, respiratory therapy and critical care. Studies in which the descriptions of the techniques were different from the original descriptions were excluded.

LITERATURE REVIEW

Mechanical Ventilation and Mucociliary Activity

Mechanical ventilation is used to reduce respiratory effort in patients with acute respiratory failure. However, ventilatory support implies changes in both mucociliary activity and ventilation mechanics [19-21]. Critically ill patients and patients who are dependent on MV have reduced mucociliary activity, which is generally associated with an ineffective cough reflex. This leads to a build-up of secretions in the distal airways, favoring atelectasis and the development of nosocomial pneumonia [22,23].

Secretions move in the airways by two mechanisms: the expulsion of air and gas/liquid interactions. For air to be expelled, the glottis must be closed, as occurs during a cough or sneeze; however, this is not possible when the patient is intubated. For secretions to be moved, the gas/liquid interaction mechanism causes turbulence in the air in the lungs, leading to instability and breaking down the layer of secretion (liquid) and layer of mucus [11,24].

MANUAL HYPERINFLATION

Manual hyperinflation is performed with a manual resuscitator bag or self-inflating bag. To start the maneuver the patient must be disconnected from the mechanical ventilator and connected to the bag device with an oxygen supply with a flow rate of 5-15 L/min. The maneuver is started by compressing the self-inflating bag to produce an increase in the internal pressure in the bag. Compression is performed slowly until a plateau is reached. The pressure is then maintained for 2 to 3 seconds before being suddenly released. Airway suctioning is performed after secretions are moved [7,25,26].

The efficiency of MH depends on the person applying the maneuver and their understanding of the pressure limits and the duration of the inspiratory phase. Furthermore, even if the person applying the maneuver has been trained and the technique has been standardized, a PEF greater than the peak inspiratory flow (PIF), cannot be achieved. MH is therefore ineffective in either moving secretions or increasing tidal volume [27].

The use of chest compression with MH is known to lead to an additional increase in PEF and consequent movement of lung secretions [28]. The effects of MH in clinical practice depend on the PEF being greater than the PIF so that the tidal volume and flow is sufficient to ensure effective mucus clearance [29].

In addition to positioning and suctioning in mechanically ventilated patients, MH improves total pulmonary compliance and greatly removes pulmonary secretion. These results were achieved without adverse effects on hemodynamic stability (heart rate, mean arterial blood pressure) [30]. MH used with a positive end expiratory pressure (PEEP), valve on mechanically ventilated premature newborns, has not resulted in increase of lung pressure [16]. Pulmonary compliance, oxygenation and airway clearance also have improved [31].

Manual hyperinflation and BS maneuvers change the airflow in airways [21,29]. It is assumed that when the increase in PEF exceeds the increase in PIF, lung elastic recoil increases, expelling mucus from distal to proximal airways [15,24,32]. MH in conjunction with chest compression-vibration lead to a greater increase in PEF than MH only [21] (Figure 2).

BAG SQUEEZING

Bag squeezing consists of three phases. In the first, the patient is disconnected from the MV and connected to a self-inflating bag or manual resuscitator. The self-inflating bag should be connected to an oxygen supply at 5-15 L/min depending on the amount of oxygen required by the patient. The bag should be compressed slowly for 1 to 1.5 seconds and an alveolar pressure plateau should then be maintained approximately 2 to 3 seconds to re-expand collapsed alveoli. In the second phase, the patient's chest is compressed just before the pressure in the manual resuscitator is suddenly released. The patient's chest is compressed continuously and firmly until the end of expiration to increase the expiratory flow. Compression or vibration of the chest is performed to loosen and move secretions from the walls of the alveolar sacs. Chest compression by the physical therapist should increase expiratory flow and depends on variables such as patient age, weight, sex and overall condition. Airway or tracheal tube suctioning is the third phase and involves removing

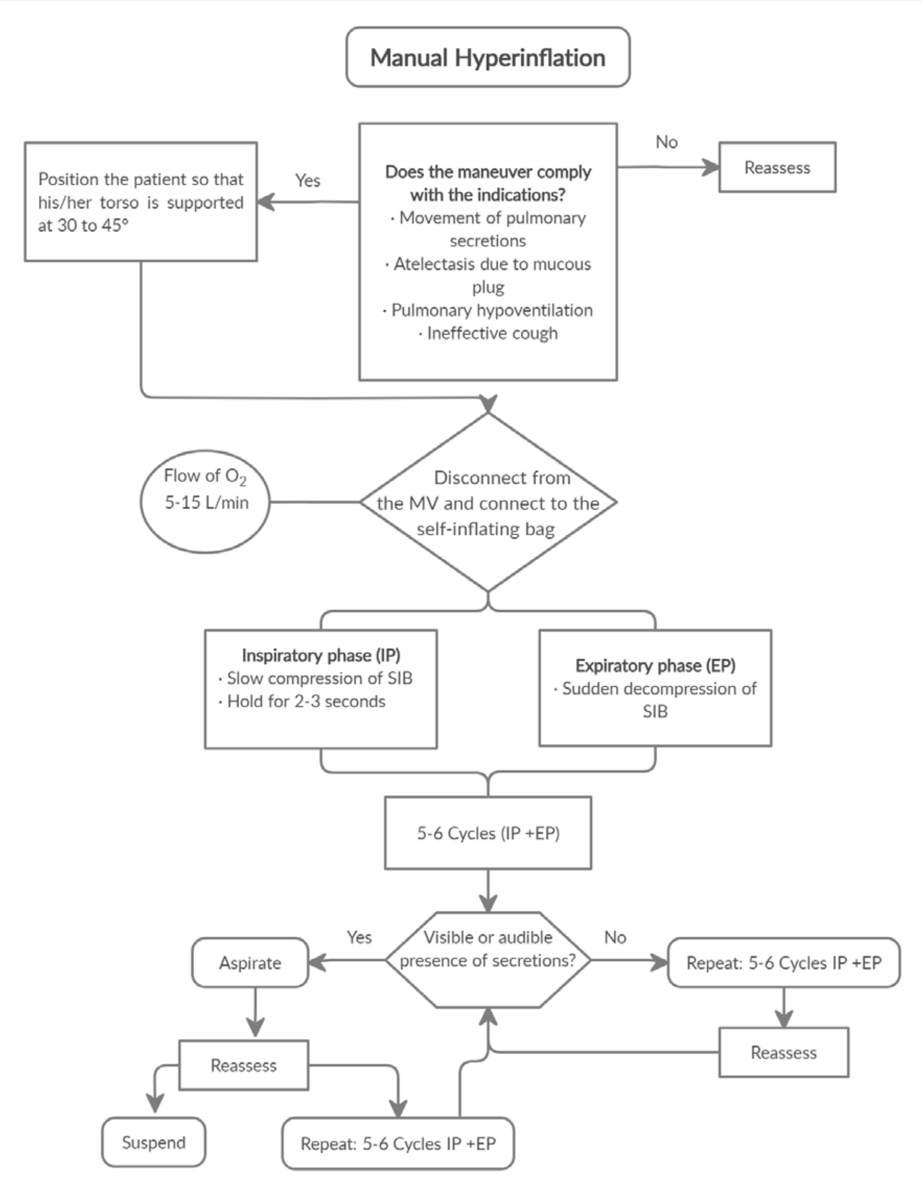

Figure 2 Flowchart 1. Algorithm for using manual hyperinflation.

secretions that have been loosened and moved. Suctioning can be performed after five or six cycles of hyperinflation and compression during the expiratory phase or when the secretions are visible in the endotracheal tube [6,7,33].

For safety reasons, it is advisable to monitor peak airway pressure with a manometer. The pressure in the self-inflating bag should be limited to 40 cmH_2O to prevent barotraumas [30,34,35].

Gregson et al. (2007) [36], evaluated the use of BS in mechanically ventilated children up to the age of 16 years. The authors found that lung elastic recoil increased as a result of increased tidal volume and peak inflation pressure, facilitating the clearance of secretions. This movement was even greater upon chest compression-vibration.

Ventilatory mechanics after BS increased dynamic lung compliance, total tidal volume and peripheral oxygen saturation, and reduced airway resistance. These findings were observed immediately after the maneuver and for up to one hour afterwards [28].

Bag squeezing leads to greater reduction in airway resistance than tracheal suctioning [37]. Ventilatory and hemodynamic changes can be explained by airway clearance and alveolar recruitment [20,22,38]. Moreover BS reducedthe time for which MV was needed, faster weaning, a less extensive pulmonary lesion and a shorter stay in intensive care [39].

However, Dias et al. (2011) [15], reported that although safe in hemodynamics, BS was not superior to suctioning,in the optimization of oxygenation and respiratory mechanics or secretion clearance. A similar result was found in a randomized clinical trial by Battner et al. (2017) [40], who compared BS

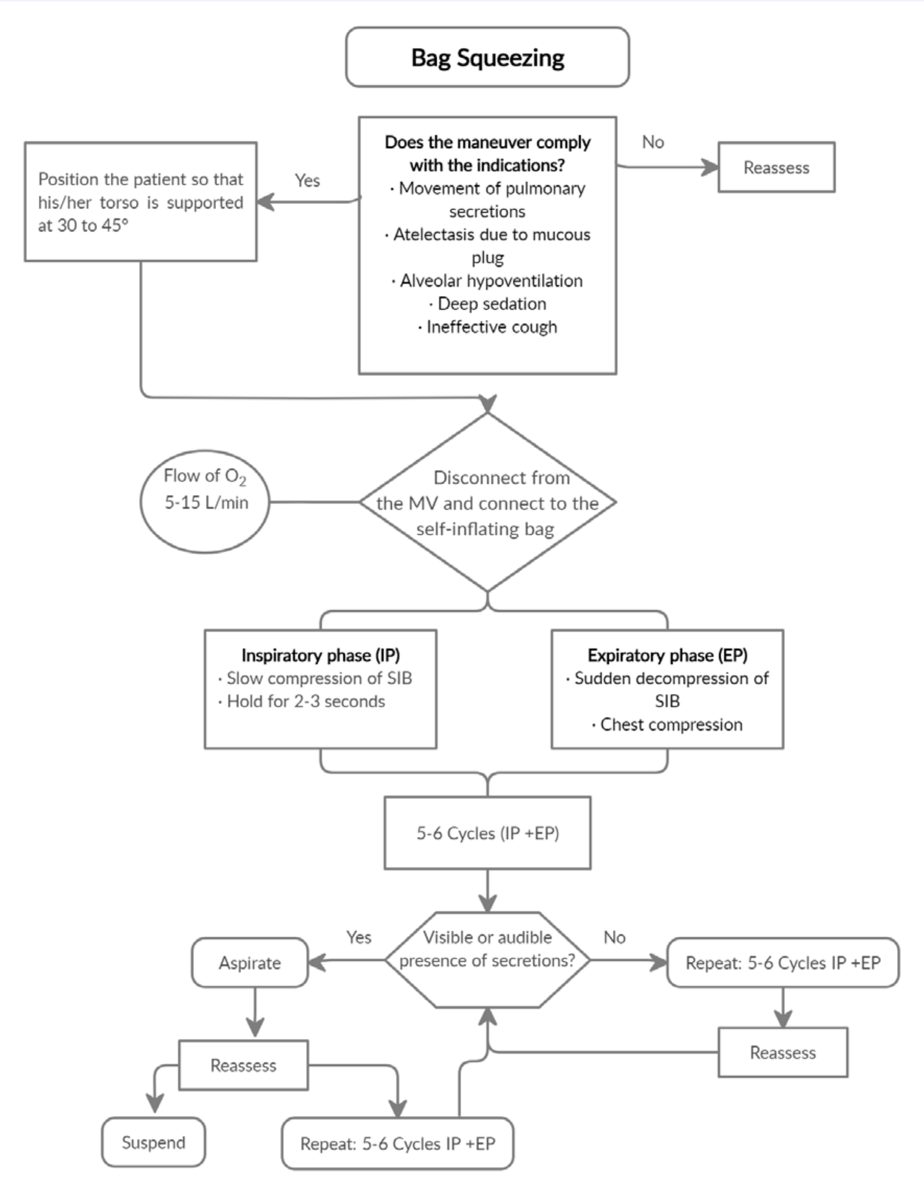

Figure 3 Flowchart 2. Algorithm for using bag squeezing.

with other physical therapy techniques routinely used in their unit. They reported no change in hemodynamic stability and an improvement in peripheral oxygen saturation (Figure 3).

BAG SQUEEZING VERSUS MANUAL HYPERINFLATION

It should be stressed that the use of manual chest compression together with positive pressure distinguishes BS from other maneuvers. BS leads to an approximately 40% increase in PEF over and above the level achieved with manual hyperinflation. This increase in PEF is directly related to the force applied to the chest, which increases the tidal volume and peak airway pressure [28].

When MH and BS are compared, the latter is significantly superior in resolving atelectasis. It has been suggested that treatment of atelectasis can be improved when adequate positioning of the patient is used with BS [44]. Another advantage of BS over MH is that the greater PEF can move secretions in the distal part of the airway to the periphery, where they can be more easily removed [28]. In pediatrics, chest compression with BS leads to increase in expiratory flow, causing secretions to move to more proximal airways, where they can be eliminated [28,36].

Bag squeezing should be used with caution in newborn because of the anatomical and physiological characteristics of this population. Chest compression can increase the risk of lung collapse as newborns have reduced lung compliance and increased chest compliance. As these characteristics contribute to a lower functional residual capacity being than the closing volume, chest compression increases the risk of alveolar collapse [33,45] (Table 1).

The disadvantages of such maneuvers include lung derecruitment when the patient is disconnected from the MV, the

Table 1: Indications and contraindications for bag squeezing and manual hyperinflation.

	Bag Squeezing[46–48]	**Manual Hyperinflation**[2,47–49]
Indications	Movement of pulmonary secretions	Movement of pulmonary secretions
	Atelectasis due to mucous plug	Atelectasis due to mucous plug
	Alveolar hypoventilation	Ineffective cough
	Deep sedation and/or neuromuscular blocking	
	Ineffective cough	
	Alveolar recruitment	
	Pulmonary re-expansion	
Absolute contraindications	Undrained pneumothorax	Undrained pneumothorax
	Poor circulation and low cardiac output	Severe bronchospasm
	Low hemoglobin	Bronchopleural fistula
	Bronchospasm	Extremely premature newborns less than 72 hours old
	Bronchopleural fistula	Increased intracranial pressure
	Less than 72 hours old (extremely premature newborns)	Pulmonary hemorrhage
	Increased intracranial pressure	Periventricular/intraventricular hemorrhage (grades III and IV)
	Pulmonary hemorrhage	Osteopenia of prematurity
	Periventricular/intraventricular hemorrhage (grades III and IV)	Hypoxic-ischemic encephalopathy in the first 72 hours of life
	Osteopenia of prematurity	Platelet count less than 50,000
	Hypoxic-ischemic encephalopathy in the first 72 hours of life	Hemodynamic instability
	Platelet count less than 50,000	
	Hemodynamic instability	
Relative contraindications	Fractured ribs	PEEP > 10cmH_2O
	Hypotension	Hypoxia
	Hypoxia	PEEP > 15cmH_2O
	PEEP > 10cmH_2O	Very-low-weight newborn < 1500g
	Very-low-weight newborn < 1500g	
	Thoracic cage instability	

Abbreviations: PEEP: positive end expiratory pressure.

risk of airway contamination and pneumonia associated with MV as well as the risk of barotraumas [31].

Lobo et al. compared bag squeezing and the technique known as PEEP-ZEEP, and found that both techniques resulted in effective bronchial secretion clearance and did not have any significant adverse hemodynamic effects [50]. The PEEP-ZEEP maneuver involves increasing PEEP to about 15 cmH_2O in the MV, maintaining the pressure at this level for five respiratory cycles and then reducing PEEP suddenly to zero followed by manual compression-vibration in the expiratory phase. Both techniques resulted in increase of PEF. However, PEEP-ZEEP allows better control of respiratory mechanics, such as resistance, compliance and PIF and PEF, because depressurization does not occur whether the patient is not removed from ventilator[51].

MEASUREMENTS AND SAFE PRESSURE LEVELS

Because both techniques use manual positive pressure and can thus lead to barotrauma and/or volutrauma, care should be taken when administering BS and MH [49]. It is recommended that the pressure be monitored with a manometer and that the maximum pressure, which should be controlled with a pop-off valve, be kept within safe limits: up to 40 cm H_2O for adults [49]; up to 30 cm H_2O for term newborns and children [48], and up to 20 cm H_2O for premature or very-low-weight (<1500g) newborn [48,52].

The size of the self-inflating bag or manual resuscitator should be selected based on the patient's lung volume: adults - 1500 to 1000 mL; children - 600-450 mL; and newborns - 220 to 140 mL. The capacity of the self-inflating bag varies among companies and should likewise be selected based on the patient's weight [52,53].

FINAL CONSIDERATIONS

Manual hyperinflation is one element of the BS maneuver. They are different techniques and should not be confused, particularly by physical therapists. Their effects on pulmonary compliance (alveolar expansion) and the airways (clearance) depend on the practitioner's performance and his/her knowledge of the theory and practice underlying each maneuver. However, the significant effects described in the literature and attributed to BS can be explained by the use of chest compression. The resulting increase in PEF allows greater airway clearance than obtained with MH (Table 2).

Table 2: Top five recommendations for the bag squeezing maneuver.
Position the patient in the supine position with his/her torso supported at 30°- 45°;
Use a manometer with the manual resuscitator to monitor the pressure;
Follow the steps in the chosen maneuver correctly;
Limit peak pressure to 40 cmH_2O for adults; 30 cmH_2O for term newborns and children; and 20 cmH_2O for premature or very-low-weight (<1500g) newborns.
Monitor vital parameters such as heart rate, respiratory rate, peripheral oxygen saturation and blood pressure before, during and after the procedure.

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