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Effect Of Incentive Spirometer On Breathing Holding Time After Coronary Artery Bypass Graft

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Abstract: *The incidence of postoperative pulmonary complications (PPCs) following coronary artery bypass grafting (CABG) is between 30% and 60% and are the most significant contributor to morbidity, mortality, and expenses associated with the hospitalization. Chest physiotherapy as incentive spirometer is the fundamental component in post-operative physiotherapy. This article review represents the critical role of incentive spirometer on holding time after coronary artery bypass grafting. As holding time is a good indicator for optimal hung expansion and better oxygenation and absence of pulmonary complications. The results showed a significant effect of incentive spirometer and stress its advantage as it safe, easy to use and accessible.*

Key words: *incentive spirometer, breathing holding time, coronary artery bypass graft.*

Introduction

Background:

Coronary artery bypass graft ([1]CABG) is a surgical procedure to restore normal blood flow to the heart by bypassing the blocked coronary arteries. Although surgical procedures, anesthesia, and postoperative care have improved dramatically, postoperative pulmonary complications, including atelectasis, pneumonia, and pneumothorax, have not improved significantly after CABG and remain a challenge. The incidence of these complications in patients undergoing CABG surgery is significant and has been reported between 30% and 60%, so that pulmonary complications should be expected for any patient who undergoes CABG surgery. Pulmonary complications lead to impaired oxygen delivery and gas exchanges (Manapunsopee et al., 2020; Almashrafi et al., 2016; Mullen-Fortino et al., 2009).

Several measures have been proposed to reduce these complications and improve arterial blood gas parameters and hemodynamic indices. However, there is no agreement on a specific method. Among these methods, the use of incentive spirometry is common method that can be used easily and without complications for patients and are also low-cost methods. Incentive spirometry, with the aim of encouraging the patient to breathe deeply and create maximum dilation in the bronchi and create an effective cough, to improve lung volume in

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order to improve oxygen delivery and proper ventilation through visual feedback based on tolerance, motivation, will, and cooperation of the patient. Moreover, this prevents a decrease in lung function and atelectasis, which in turn improves the ventilation/perfusion ratio and ultimately improves gas exchange and oxygen delivery (Zerang et al., 2022; Renault et al., 2009).

Aim of the study:

- Highlight the role of incentive spirometer on breathing holding time and respiratory parameters for patients post coronary artery bypass grafting.

Review of literature:

Cardiovascular diseases, which are very common in developed and developing countries, are one of the leading causes of mortality and morbidity. It is possible to extend the life expectancy and increase the quality of life of patients with open heart surgery. CABG surgery is one of the most common methods of open heart surgery (Martínez-González et al., 2017). Angina, dyspnea and patient's fatigue is reduced, health-related quality of life is improved, especially in terms of mental and physical functions with CABG. However, as in all surgeries, some complications may develop from this surgery. Conditions such as anaesthesia, type of surgery and previous health problems can cause a decrease in lung volume and compliance, inadequate cough strength, respiratory muscle weakness and phrenic nerve dysfunction after CABG surgery (Ghavami et al., 2018; Kotta & Ali., 2021).

Incentive spirometer (IS) devices being either flow-oriented or volume-oriented. Flow oriented devices involve three chambers connected with columns settled with lightweight plastic floats. The chamber is linked to an elastic tube with a mouthpiece used to inhale breath, the aim being to elevate the floats throughout the inspiratory flow, which is initiated by negative intrathoracic pressure. Volume-oriented IS devices involve an elastic pipe including a mouthpiece linked to a visual numeral chamber that shows the volume level. Once the patient takes a breath, the piston in the chamber upswings to the maximum level of air shifted. Evidence guidelines recommend that volume-oriented spirometers are desirable because they reduce the enforced work/effort of breathing (Eltorai et al., 2018; Sweity et al., 2021).

Incentive spirometry, described as a continual maximum inspiration, is reached via using a device that gives visual light feedback when the patient inhales at a fixed flow or volume then holds the inflation for at least 5 s. Then the patient is taught to sustain the spirometry in an upright position, normally exhaling and then placing the lips tightly around the mouthpiece. The subsequent action is a slow inhalation to elevate the ball or the piston/ plate in the chamber to the appointed target. At maximum inhalation, followed by a breath hold and then exhaling normally and the mouthpiece may be removed if preferable,. Instruction in the practices of IS by a close relative and health-care provider may assist the patient in using the IS correctly in practice and support adherence to the treatment through encouragement (Sweity et al., 2021).

Close supervision of each patient‟s use of incentive spirometry is not required once the patient has established mastery of the technique. However, intermittent reassessment is crucial to optimal performance (Eltorai et al., 2018) with regard to: observation of patient’s actions and utilization; rate of sessions; number of breaths; inspiratory volume; flow; breath-hold goals reached; effort and motivation; device within scope of patient to support acting without supervision (Savci et al., 2006).

The use of incentive spirometry after coronary artery bypass graft surgery is accompanied by severe postoperative incisional pain. Consequently, pain reduction and reducing the risk post-operative respiratory complications after cardiac surgery are considered the foremost postoperative care strategy. Various methods are administered to reduce or control pain effectively. One of these methods is cold application, which is considered a simple, cost efficient, and non-pharmacological pain relief method (AlOtaibi& El-Sobkey., 2015). Therefore, Seweid et al., (2021) conducting a crossover study aimed to determine the effect of cold application on incisional pain associated with incentive spirometry after coronary artery bypass graft surgery for 60 patients. All participants were subjected to the use of incentive spirometry with and without cold gel pack application. Subjective and objective pain assessments were under taken before and after the use of incentive spirometry with and without cold gel pack application for two consecutive days. Data analysis showed significant reduction in pain scores on pain intensity and pain distress, as well as the critical care pain observation tool ($P < 0.001$) after the cold gel application. The conclude that cold application reduces incisional pain associated with incentive spirometry in patients undergoing coronary artery bypass grafting.

Fayyaz et al. (2016) conducted a randomized control trial, comprising 170 patients at the Institute of Cardiology Multan. The authors‟ aim was to evaluate postoperative oxygenation status in patients following CABG surgery with and without preoperative IS. Two equal groups were randomly assigned by using a binary number generator system: Group I (incentive spirometry group) performed preoperative IS and Group C (control group) did not perform preoperative IS. The authors followed all patients to observe preoperative IS and postoperative improvement in oxygenation. The researchers revealed that the preoperative IS group had better postoperative oxygenation status and a decreased incidence of PPCs in patients undergoing CABG surgery, but the spirometry remarkable improved lung function as improved oxygenation. However, this study did not show decreases in hospital length of stay for either group, but did report a significant improvement in oxygenation status when preoperative incentive spirometry was used (Fayyaz et al., 2016).

Deep breathing exercises have been shown to improve postoperative lung expansion and reduce pulmonary complications. An incentive spirometer is a deep breathing exercises device that imitates continuous sigh-like maximal inspiration (Amin et al., 2021). From this background, Alwekhyan et al., (2022) conducting a research to assess the effect of nurse-guided use of incentive spirometer on postoperative oxygenation and pulmonary complications after coronary artery bypass graft surgery. They found that patients in the intervention group had a significantly lower mean number of hypoxic events with shorter duration and shorter length of stay in the hospital and the ICU. Patients in the intervention group also had greater postoperative forced expiratory volume in 1 second. They also conclude that nurse-guided use of the incentive spirometer reduces the risk of pulmonary complications and hospital length of stay after cardiac surgery.

Methodology:

To prepare this brief report, we systematically searched web of science, PubMed, and Google scholar databases to find articles related to coronary artery diseases, post cardiac surgeries complication and impact incentive spirometer as form of chest physiotherapy on holding time post coronary artery bypass grafting considering it as an indicator of absence or presence of respiratory complications. A number of 50 articles were collected. 26 of them are excluded for duplication and irrelevancy. 24 articles were reviewed, summarized and used. Publication in English in a peer-reviewed journal, including CABG, incentive spirometer and holing time,

which means that incentive spirometer is a safe, effective, accessible and easy to use maneuver. Articles discussed preoperative preparations and exercises or other types of surgeries are excluded.

Results:

As a complementary therapy, physiotherapy, in addition to medical treatment, isrecommended in the early period to prevent and treat the complications. Respiratory physiotherapy methods, such as deep breathing exercises, bronchial hygiene techniques, forced expiration techniques, manual hyperinflation, percussion, incentive spirometer, intermittent positive pressure breathing (IPPB), continuous positive airway pressure (CPAP) and early mobilization, walking training and active/assistive exercises of the lower and upper extremities are applied in the early postoperative period of cardiac and abdominal surgery (Patman et al., 2017). Eltorai et al., 2019 stated that IS was improved the patient adherence, atelectasis severity, noninvasive positive pressure ventilation use, ICU and length of stay. In a review aimed to compare the effects of IS for preventing postoperative pulmonary complications in adults undergoing coronary artery bypass graft surgery stated that despite its widely used of IS in CABG studies have been unable to demonstrate the superiority of IS over other techniques and also high methodological trials are needed to determine effects of IS (Freitas et al., 2007)

On the other hand, Hüzmeli et al., 2021 conducting a study to investigate the effects of incentive spirometer on respiratory muscle strength, exercise capacity and hemodynamic responses after CABG surgery. Patients were divided into incentive spirometer (IS) group and physiotherapy (PT) group. All patients in this study received standard physiotherapy postoperatively. In addition, IS group received volume-oriented incentive spirometer. Respiratory muscle strength (mouth pressure device) on 2nd and 5th postoperative day, exercise capacity (6-min. walking test (6-MWT)) on 3rd postoperative day, before and immediately after physiotherapy on the first postoperative day blood gases were assessed. They found that respiratory muscle strength was improved and blood gas values were maintained in both groups. There was no superiority of IS combined with PT in increasing respiratory muscle strength and in maintaining arterial blood gas results after CABG surgery. IS combined with physiotherapy could be used safely from the early period after cardiac surgery due to the nonappearance of adverse effects

Zerang et al., 2022 results showed that incentive spirometry has a greater effect on hemodynamic indices of patients undergoing CABG compared to deep breathing exercises, hence, it is recommended to use incentive spirometry to improve hemodynamic indices in these patients.

Afshan et al., (2020) added that pulmonary complications are the main cause of mortality and morbidity after cardiac surgery. In postoperative care, chest physiotherapy is frequently used to avoid pulmonary complications such as reduced respiratory volumes, atelectasis, pneumonia and collapsed lung. Cardiac surgical patients are more prone to Post Pulmonary Complications (PPC). Factors associated with PPC are chronic obstructive lung disease, obesity, age, diabeties, smoking, chronic heart failure and immobility. Improvements in breathing, such as Breath-Holding Time and Breathing patterns, have been associated with beneficial therapeutic effects in patients treated with different kind of breathing techniques. A study was done to compare the effects of both Breathing techniques, buteyko breathing technique and incentive spirometer on breath control pause or holding time among post cardiac surgery. They found that there was significant variation in control pause (breath holding time) of post-cardiac surgery patients after using Incentive Spirometer when compared to the

Buteyko breathing technique. Incentive spirometer was better than Buteyko breathing technique for improving control pause in Post-operative cardiac patients.

Coronary artery bypass grafting (CABG) surgery is aimed at reducing the symptoms related to coronary artery disease, preventing possible complications, and improving the quality of life (QoL) of the patients. On the other hand, CABG is a major surgery that might lead to vital complications. Postoperative pulmonary complications (PPCs), a well-reported group of complications following cardiac surgery, are associated with a 4-time increase in mortality, extended intensive care unit and hospital stay, and over $20,000 institutional cost per case (Stevens et al., 2021; Montrief et al., 2018; Moradian et la., 2017). In this respect, Girgin et al., (2021) Examining the effects of a pulmonary rehabilitation (PR) program applied to patients undergoing coronary artery bypass grafting (CABG) surgery with open heart technique on respiratory functions, functional capacity, and quality of life (QoL). The results of this study revealed that pulmonary rehabilitation applied to patients who have undergone coronary artery bypass graft recover their functional capacity faster.

In relation to arterial blood gases and the risk for post CABG hypoxemia, Yazdannik et al., (2016) Reported that after coronary artery bypass surgery, pulmonary complications and oxygenation disorders are common, which have an important role in mortality and morbidity. Different methods are used for the improvement of pulmonary function and oxygenation, of which incentive spirometry (IS) has been investigated here. Their study aimed to evaluate the effects of IS on arterial blood gases after coronary artery bypass graft (CABG) and showed that using incentive spirometer is significantly effective in the improvement of blood arterial gas parameters.

Conclusion and recommendations:

There was significant improvement in breath holding time (control pause), respiratory functions of post-cardiac surgery patients as coronary artery bypass grafting after using incentive spirometer when compared to the chest physiotherapy exercises an Buteyko breathing technique, deep breathing and coughing exercises, in favor of incentive spirometer. To avoid postoperative pulmonary complications, it is recommended that incentive spirometry be used with deep breathing exercises and early mobilization.

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