Research Article
Volume 09:02, 2023

Journal of Clinical Respiratory Diseases & Care: Open Access

ISSN: 2472-1247 Open Access

Effectiveness of Incentive Spirometry to Reduce Pulmonary Complications and Improve Respiratory Parameter after Coronary Artery Bypass Graft Surgery: A Narrative Review

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Abstract

Background: Coronary artery bypass graft (CABG) surgery is a surgical procedure to restore normal blood flow to the heart by bypassing obstructed coronary arteries. The goal of coronary artery bypass graft (CABG) surgery is to bypass clogged coronary arteries and return normal blood flow to the heart. Incentive Spirometry is used frequently as a component of postoperative pulmonary management and rehabilitation purpose. This study aimed to explore the effectiveness of Incentive Spirometry by reviewing of the article. Five articles were reviewed in order to fulfil the purpose of this study. With a PEDro score ranging from 5 to 7, randomized controlled trial was used. Studies compared or combined with Incentive spirometry, DBE, ACBT, expiratory positive airway pressure and conventional physiotherapy. From the review it is found out that Incentive spirometry improved arterial oxygenation, functional capacity, oxygen saturation, inspiratory muscle strength and prevention of atelectasis among patients undergone Coronary artery bypass graft (CABG) surgery. Therefore, it is convenient to conclude from the overall review that Incentive Spirometry (IS) is not superior to other conventional physiotherapy techniques, but when used in combination, it can be used as the most effective treatment technique for patients who have undergone coronary artery bypass grafting.

Keywords: CABG • Respiratory physiotherapy • Incentive spirometry

Abbreviations

CABG: Coronary Artery Bypass Graft

IS: Incentive Spirometry

DBE: Deep Breathing Exercise

MRP: Maximal Respiratory Pressures

ACBT: Active Cycle of Breathing Technique

FVC: Forced Vital Capacity

FEV1: Forced Expiratory Volume in one Second

Introduction

Coronary artery bypass graft (CABG) surgery is a surgical procedure to restore normal blood flow to the heart by bypassing obstructed coronary arteries [1]. The goal of coronary artery bypass graft (CABG) surgery is to bypass clogged coronary arteries and return normal blood flow to the heart. The rate of postoperative pulmonary complications (PPCs), such as atelectasis, pleural effusion, pneumonia, and pneumothorax following CABG surgery, has not improved as much and remains a challenge [2,3], despite significant advancements in surgical methods, anesthesia procedures, and postoperative care [3]. In the postoperative phase of CABG, respiratory physiotherapy has been suggested to advance lung functioning and prevent or treat pneumonic problems. As of right now, incentive spirometry (IS) is being used to predict PPC [4]. Prior studies have evaluated the effects of various respiratory physiotherapy interventions on PPC following CABG, including breathing and coughing exercises, incentive spirometry, and expiratory positive airway pressure (EPAP) [5]. The risk of developing pulmonary problems, such as atelectasis, pneumonia, and pleural effusion, is normally high in patients after CABG. When mortality is taken into account, these issues lengthen hospital stays and increase the need for financial resources [6]. Transpiratory factors that influence the development of aspiratory problems include common anesthetic, pulmonary modifications following extracorporeal circulation, use of the inner mammary route, and postoperative discomfort therefore, over the past ten years, efforts have been undertaken to identify patients who are more likely to have difficulties and to identify ways to foresee these complications [7].

In the first few days following open heart surgery, patients receiving chest physiotherapy treatment in the intensive care unit (ICU) are frequently attached. The goals of physiotherapy are to lessen pain, reduce the accumulation of aspiratory discharges, pneumonia, and atelectasis, maintain aspiratory volume, adjust ventilation and perfusion ratios, reduce aviation route resistance, advance respiratory and peripheral muscle quality, reduce postoperative complications, shorten hospital stay, and reduce quiet horror and mortality [8].

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Received: 03 November, 2022, Manuscript No. jcrdc-22-80421; **Editor Assigned:** 05 November, 2022, Pre QC No. P-80421; **Reviewed:** 07 April, 2023, QC No. Q-80421; **Revised:** 21 April, 2023, Manuscript No. R-80421; **Published:** 28 April, 2023, DOI: 10.37421/2472-1247.2023.9.244

Patients undergoing open heart surgery are frequently advised to undergo various forms of chest physiotherapy and breathing exercises with or without mechanical devices to prepare for or lessen the frequency of impaired lung function. Positioning, incentive spirometry (IS), early mobilization, expiratory positive airway pressure, respiratory muscle training, cough support, deep breathing exercises, and active cycle of breathing methods (ACBT) are a few of them [9].

Materials and Methods

This narrative review was done following the methodology described [10].

Search strategy

A comprehensive search was conducted on PEDro, Pubmed and google scholar including Medical Subject Headings (MeSH) terms identified as "Incentive Spirometry", "exercise", "chest physiotherapy", "coronary artery bypass graft", "pulmonary complication", "respiratory exercise". Inclusion criteria were randomized controlled trial with a PEDro score of >4.

Result and Discussion

The immediate aftermath of coronary artery bypass grafting (CABG), pulmonary problems are a cause of morbidity. According to studies, patients who already have lung disease are more likely to experience difficulties after surgery 13. Chest physical therapy improves respiratory muscle performance and increases inspiratory volume, both of which reduce the risk of pulmonary problems following CABG surgery. Therefore, a study conducted on CABG surgery where they explored the effect of postoperative combined incentive spirometry and DBE *vrs.* DBE alone on inspiratory muscle strength following CABG. Ninety (90) patients were included, with 47 and 43 patients alloted to the study and control groups. The study group received incentive spirometry and DBE, and the control group received DBE only. Maximal inspiratory pressure (MIP) before surgery and at day 4 after surgery was assessed by a respiratory pressure meter. Secondary outcomes, including postoperative pulmonary complication and duration of postoperative hospitalization, were obtained from the medical records. Patients in the study group had significantly better recovery of inspiratory muscle strength on day 4 post- CABG than patients in the control group. There was no significant difference between groups for either postoperative pulmonary complications or length of hospital stay [11] (Table 1).

It is not well established how to employ expiratory positive airway pressure (EPAP) in conjunction with incentive spirometry (IS) to prevent postoperative pulmonary complications (PPC) following coronary artery bypass graft (CABG). There is a study conducted where they determine the paraphernalia of Incentive spirometry with expiratory positive airway pressure (IS + EPAP). In that study Thirty-four patients enduring CABG were randomly assigned to case and control group. Outcome measure are Maximal respiratory pressures, pulmonary function test, 6-minute walk test and chest x-ray. After 1 month in patients undergoing CABG, IS + EPAP results in improved pulmonary function rather than control group [12].

There is controversy whether chest physiotherapy is more superior than IS. There is a study where it was to determine whether the addition of incentive spirometry (IS) to postoperative pulmonary physical therapy is more effective than physical therapy alone in reducing postoperative pulmonary complications in high-risk patients after coronary artery bypass grafting (CABG) Patients with chronic airflow limitation following CABG (N=185) participated. They were randomly assigned to receive either postoperative pulmonary physical therapy (breathing exercises, secretion removal, mobility) or physical therapy combined with IS. Incentive spirometry combined with physical therapy is no more effective than postoperative physical therapy alone in reducing atelectasis for this population [13].

IS and ACBT are commonly used techniques for the prophylaxis and treatment of respiratory complications in post-surgical patients [14]. A patient with various states can simply undergo ACBT. It can be used independently, either with manual approaches included or not. It works well to increase oxygenation, airway clearance, and pulmonary function [15]. Evaluations of the ACBT's efficacy may be found in acute respiratory failure, chronic obstructive lung illness, and stable cystic fibrosis. There is no information about its use in CABG surgery patients, though. A study conducted where they evaluated the efficacy of incentive spirometer (IS) and active cycle of breathing techniques (ACBT) following coronary artery bypass graft (CABG) surgery. This prospective randomized trial comprised 60 male CABG patients, aged 41 to 75.

Thirty patients had ACBT, and another thirty underwent IS plus mobilization. The 6-minute walk test (6MWT), chest radiography, arterial blood gases, pulmonary function tests, and visual analogue scale for pain assessment were all used to

Assess patients. From the first postoperative day, both therapies increased arterial oxygenation. Functional ability was well preserved with the use of ACBT or IS after a 5-day treatment. On the rate of atelectasis, pulmonary function, and pain perception, both physiotherapy techniques exhibited comparable results [16] (Table 2).

There is a study which aimed to examine the effects of forced vital capacity (FVC), forced expiratory volume in one second (FEV1), maximal respiratory pressures (MRPs), and oxygen saturation in patients who had coronary artery bypass grafting (CABG) with the flow-oriented incentive spirometry (IS). 36 CABG postoperative patients were randomly divided into two groups, DBE (n=18) and IS (n=18), and had non-invasive ventilation for 30 minutes throughout the first 24 hours following extubation. The preoperative period and the seventh postoperative day were used to evaluate the spirometric variables (POD). With regard to the surgical and demographic factors, the groups were thought to be homogeneous. Between the preoperative period and the seventh POD, it has been seen that FVC and FEV1 values have decreased, but there were no appreciable variations between groups. Although there was a progressive and partial recovery up until the seventh POD and no significant differences between groups, the peak respiratory pressures decreased in the

Table 1. Patient preference for treatment.

Author	Participants	Interventions	Preference
Manapunsopee et al, 2020 [13]	90	IS+DBE DBE only	Incentive Spirometry is preferable
Haeffener et al, 2008 [14]	34	IS + EPAP coughing technique, early mobilization, and deep breathing exercises	MIP increased in (IS + EPAP) group
Crowe, & Bradley, (1997) [15]	185	IS + Mobility exercise and secretion removal breathing exercises, secretion removal, mobility	Not measure
Savci, Sema, et al, (2006) [11]	60	IS combined with mobilization. ACBT	Both method preferable
Renault, Julia Alencar, et al, (2009) [12]	36	IS DBE	Not measure

Table 2. Article summary.

Author	Title	Design	Outcome measure	PEDro score (0-10)
Manapunsopee et al., 2020[13]	Effectiveness of Incentive Spirometry on Inspiratory Muscle Strength After Coronary Artery Bypass Graft Surgery	randomized clinical trial	Respiratory pressure meter, numeric pain rating scale, 6-minute walk test	7
Haeffener et al., 2008 [14]	Incentive spirometry with expiratory positive airway pressure reduces pulmonary complications, improves pulmonary function and 6-minute walk distance in patients undergoing coronary artery bypass graft surgery	prospective, controlled, randomized clinical trial	Pressure transducer, spirometric computerized test, Six-minute walk test, Chest x-ray.	6
Crowe, & Bradley, (1997) [15]	The Effectiveness of Incentive Spirometry with Physical Therapy for High-Risk Patients After Coronary Artery Bypass Surgery	randomized clinical trial	chest radiography, pulse oximeter, spirometer, vitalograph	6
Savci, Sema, et al, (2006) [11]	Active cycle of breathing techniques and incentive spirometer in coronary artery bypass graft surgery	prospective randomized clinical trial	Spirometer, 6-minute walk test (6MWT), Polar heart rate monitor, chest radiography, visual analogue scale (VAS),	6
Renault, Julia Alencar, et al, (2009) [12]	Comparison between deep breathing exercises and incentive spirometry after CABG surgery	prospective, experimental, randomized study	Spirometer, pulse oximeter	5

Table 3. Interventions summary.

Author	Mode	Frequency and Intensity	Duration	Result
Manapunsopee et al., 2020 [13]	incentive spirometry, DBE, early mobilisation, and titrated ambulation.	On the first postoperative day, patients were sitting out of bed and/or standing. On the second day, they stood and transferred to a chair. On the third day, they walked a short distance. Perform DBE10 times per waking hour. incentive spirometry 10 times per waking hour in a sitting position	4 days	Patients in the study group had significantly better recovery of inspiratory muscle strength on day 4 post- CABG than patients in the control group.
Haeffener et al., 2008 [14]	IS + EPAP breathing exercises, instructions about coughing technique, early mobilization, and deep breathing exercises.	intervention group exercised twice a day for 15 to 20 minutes under the direction of a physical therapist. maintain diaphragmatic breathing throughout the IS + EPAP treatment at a rate of 12 to 18 breaths per minute. IS + EPAP group received their equipment to continue the protocol at home, twice each day, 15 minutes each session,	1 month	In patients undergoing CABG, IS + EPAP results in improved pulmonary function and 6-minute walk distance as well as a reduction in PPC.
Crowe, & Bradley, (1997) [15]	postoperative pulmonary physical therapy (breathing exercises, secretion removal, mobility) or physical therapy combined with IS.	lung expansion techniques (supported/assisted coughing) and secretion removal techniques (bed motion and continuous maximal inspiration). The physical therapist offered this management once or twice each day. Chest wall vibrations and percussions and suctioning were also done. Patients were treated by the physical therapist more than once per day. On the second postoperative day, thoracic mobility and shoulder range-of-motion exercises were started and ambulation, this was usually on the third postoperative day	3 days	No difference was found between the two groups in atelectasis, spirometry, oxygen saturation, pulmonary infection, or hospital stay. The effectiveness of the spirometer cannot be fully evaluated.
Savci, Sema, et al, (2006) [11]	Breathing exercises, IS instructions in huffing and coughing techniques, mobilization, Active range of motion exercise, ACBT, thoracic expansion exercises	basic post-operative respiratory physiotherapy including breathing exercises, instructions in huffing and coughing techniques, mobilization, and active exercises of the upper limbs and thorax performed 1st operative day (2-3 times). On the second day, patients moved around the room or a short distance in the hallway (5-minute stroll every two hours from morning [8:00] until evening [20:00]). ACBT and IS The treatment was administered twice daily for 15 minutes on the first and second post-operative days. It was applied once daily for 15 minutes starting on the third day after surgery.	5 days	When compared to pre-operative values on the fifth postoperative day, pulmonary function metrics were similarly but significantly lower in both groups (vital capacity reduced 15% and 18% in ACBT and IS, respectively). Within and between the ACBT and IS groups, there was no discernible change in 6MWT distance measured before and on the fifth day after CABG operation.
Renault, Julia Alencar, et al, (2009) [12]	DBE, IS, early mobilization, assisted cough and/or huffing,	Patients received PO PT twice every day while they were in the ICU and once per day when they were in the hospital. ten DBE that gave diaphragmatic breathing priority. IS done by preserving the inspiration sustenance from the FRC, gradual inspiration is performed until the target level is reached that noted on the spirometer cylinder.	7 days	Between the preoperative period and the seventh POD, it has been seen that FVC and FEV1 values have decreased, but there were no appreciable variations between groups. Although there was a progressive and partial recovery up until the seventh POD and no significant differences between groups, the peak respiratory pressures decreased in the first POD. On the seventh POD, the oxygen saturation was the sole variable with a full recovery and no discernible group differences.

first POD. On the seventh POD, the oxygen saturation was the sole variable with a full recovery and no discernible group differences [17] (Table 3).

Conclusion

Patients in combination with IS, DBE, ACBT, breathing exercises, chest expansion exercises, active range of motion exercises and early mobility had shown its effectiveness to minimize pulmonary complication, improve vital capacity, maximal respiratory pressures (MRPs), FVC, after coronary artery bypass graft surgery. It also prevents the length of hospital stay for patients undergone coronary artery bypass graft surgery.

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How to cite this article: Fazal, Abdullah Ibn Abul, Kaniz Fatema, Md Waliul Islam and Suraiya Salek, et al. "Effectiveness of Incentive Spirometry to Reduce Pulmonary Complications and Improve Respiratory Parameter after Coronary Artery Bypass Graft Surgery: A Narrative Review." *J Clin Respir Dis Care* 9 (2023): 244.