



Review Article

Immediate Effect of Incentive Spirometer, Breathing Exercise and Active Cycle of Breathing Technique in CABG Patients: A Narrative Review

Anshu Kumari¹, Dr. Dimple Choudhry², Dr. S.S. Lohchab³,
Dr. Gitanjali Sikka⁴, Manshi⁵

¹PG Student, College of Physiotherapy, Pt. B.D. Sharma UHS, Rohtak, India

²Assistant Professor, College of Physiotherapy, Pt. B.D. Sharma UHS, Rohtak, India

³HOD Cardio Thoracic & Vascular Surgery, Pt. B.D. Sharma UHS, Rohtak, India

⁴Assistant Professor, College of Physiotherapy, Pt. B.D. Sharma UHS, Rohtak, India

⁵PG Student, College of Physiotherapy, Pt. B.D. Sharma UHS, Rohtak, India

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Corresponding author: Dr. Dimple Choudhry

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Abstract:

Background: Coronary artery bypass surgery is one of the widely used treatment as every year more than 1 million coronary artery bypass surgery procedure are performed around the world. The patients who have CABG are prone to pulmonary complications. Pulmonary complications are highly common after the CABG and the incidence is between 30% and 60%. These complications are the most significant contributor to morbidity, mortality and expenses associated with the hospitalization. Development of pulmonary complication is associated with impaired oxygenation and inconsistencies in gas exchange. Respiratory physiotherapy plays a vital role in postoperative CABG status. The interventions such as postoperative breathing exercises, effective coughing techniques, incentive spirometer and active cycle of breathing technique are used to limit lung volume decreases and atelectasis and to increase oxygenation after surgery.

Objective: To find out the immediate effect of incentive spirometer, breathing exercise and active cycle of breathing technique on respiratory parameters and postoperative pulmonary complications in CABG patients.

Study selection: This narrative review is conducted on databases from Pub med, Google scholar, ResearchGate and Cochrane library in Nov 2022. This review included 10 studies on the effect of incentive spirometer, breathing exercise and active cycle of breathing technique after CABG.

Conclusion: It is concluded that incentive spirometer, breathing exercise and active cycle of breathing technique are effective in reducing postoperative pulmonary complications. But there are less studies which compares the two different type of spirometer i.e. flow incentive spirometer and volume incentive spirometer in CABG patients and also there is no specific treatment protocol for CABG patients. Hence, in order to establish a definitive protocol in patients with CABG, there

is need to compare the effect of flow incentive spirometer and volume incentive spirometer along with breathing exercise and active cycle of breathing technique.

Introduction

Coronary artery disease (CAD) is the leading cause of death and disability worldwide. Therefore, coronary artery bypass grafting (CABG) is indicated for patients with angina and suitable coronary anatomy, especially those with stenosis of the left main coronary artery or patients with the multivessel disease. Coronary artery bypass surgery is one of the widely used treatments as every year more than 1 million coronary artery bypass surgery procedures are performed around the world¹. The Global Burden of Disease study estimate of age-standardized CVD death rate of 272 per 100000 population in India is higher than the global average of 235 per 100000 population. Coronary artery disease has reached an epidemic proportion in South East Asia especially India in the recent few years. Cardiovascular Outcomes after Acute Coronary Syndrome are unpredictable. The patients who have coronary artery bypass graft (CABG) are prone to pulmonary complications. Pulmonary complication is highly common after the coronary artery bypass surgery and the incidence is between 30% and 60%. These complications are the most significant contributor to morbidity, mortality, and expenses associated with the hospitalization. Development of pulmonary complication is associated with impaired oxygenation and inconsistencies in gas exchange². Postoperative pulmonary complications (PPCs) are a frequent incident following cardiac, thoracic, and abdominal surgeries. PPCs are widespread following CABG surgery, and the incidence is between 30 and 60%. PPC complications contribute significantly to morbidity, mortality, and hospitalization costs. These complications include atelectasis, pulmonary infections such as pneumonia and bronchitis, pleural effusion,

pulmonary edema, and respiratory insufficiency. Atelectasis is a highly prevalent complication following coronary artery bypass graft (CABG) surgery³. There is no clear cause yet for atelectasis, but several factors may contribute, such as impairment in the function of the diaphragm, general anaesthesia 'abdominal distension, chest wall shift, pain, and pleural effusions. The pain and postoperative fear associated with changes in lung mechanics resulting from the surgery affect the performance of periodic deep inspiration and effective cough, allowing the accumulation of secretion, alveolar collapse, and changes in gas exchange⁴. Three factors play a major role: the extracorporeal circulation, the anesthesia and surgical technique which can cause a systemic inflammatory response following the use of cardiopulmonary bypass (CPB), entrapment of neutrophils in the pulmonary capillaries due to endotoxins, and the release of several pro-inflammatory agents. Its clinical manifestations range from transient hypoxemia to severe pulmonary injuries (ALI) and acute respiratory distress syndrome⁵.

Respiratory physiotherapy is routinely used in the prevention and treatment of post-operative pulmonary complications after cardiac surgery. The goals of physiotherapy are to improve ventilation perfusion matching, increase lung volume, enhance mucociliary clearance, and decrease pain. Post-operative physiotherapy techniques include early mobilization, change of position, breathing exercises, cough, huffing, active cycle of breathing techniques (ACBT) and various mechanical devices such as incentive spirometer (IS), positive expiratory pressure mask therapy and continuous positive airway pressure⁶. IS and ACBT are commonly used techniques for the

prophylaxis and treatment of respiratory complications in post-surgical patients⁶.

Diaphragmatic breathing exercises (DBE) are performed to initiate diaphragmatic descent during inhalation and diaphragmatic ascent during exhalation. When performing diaphragmatic breathing the patient inhales, the air reaches the alveoli, it reverses the post-operative hypoxemia which is the result of the anesthesia, improves the ventilation and oxygenation, reduces the work of breathing as the muscles of the neck and the shoulders relax, and also increases the excursion of the diaphragm⁷.

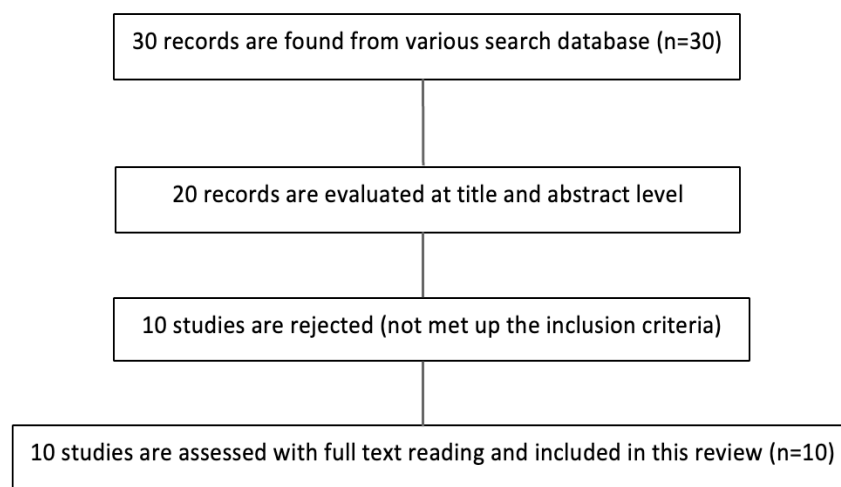
Incentive spirometry (IS) is a mechanical breathing device in which the patient is expected to take long, slow deep breaths imitating natural sighing which also gives a positive visual feedback. Incentive spirometers are accessible either by volume of inspiration (volume-oriented) or flow rate (flow-oriented). A typical flow-oriented Incentive Spirometer (FIS) (Tri flow device) consists of three chambers in a series each of which consists of a ball. The ball rises in the chamber as the patient sucks in the air and generates a sub atmospheric pressure above the ball. When an inspiratory flow of 600 mL/s is achieved then the ball in the first chamber rises, an inspiratory flow of 900 mL/s raises the ball in the second

column and an inspiratory flow of 1200 mL/s raises the ball in the third chamber. A typical volume-oriented Incentive Spirometer (VIS) is a compact device of 4000 mL capacity and has a one way valve to prevent exhalation into the unit, it consists of a corrugated large-bore breathing hose and mouthpiece that connects the patient to a flexible plastic bellow. When the patient inspires in through the breathing hose, the bellow raises, which indicates the volumetric displacement via an indicator present on the device enclosure⁷.

The common cycle of ACBT involves breathing control, expansion training, breathing control, and huffing technique. The number and frequency of each ACBT component can be changed, but all the components of the cycle must be applied and vary with the control of respiration⁵.

Method

Studies are search from the following search engine Pubmed, Google scholar, ResearchGate and Cochrane library to review the literature. Studies include that investigate respiratory parameters, SPO₂ and postoperative pulmonary complications. Key words used to search studies are incentive spirometer, breathing exercise, active cycle of breathing technique, CABG.



Several studies have shown that incentive spirometer, breathing exercises and active cycle of breathing technique helps in preventing postoperative pulmonary complications, improves respiratory parameters, pulmonary function and quality of life.

Authors Journal Year	Objective	Design	Characteristics of participants Sample size	Methods	Outcome measures	Results
Westerdahl E et al. Chest journal 2005 ⁸	To investigate the effects of deep breathing exercises on pulmonary function, atelectasis and arterial blood gas level after CABG	Randomized clinical trial	N=115 patients undergoing CABG. Patients who had previous cardiac surgery, severe renal dysfunction were not included.	Control group (n=42) performed no breathing exercise. Experimental group (n=48) perform deep breathing exercise consist of 30 slow, deep breaths performed with a positive expiratory pressure blow bottle device.	Pulmonary function test, atelectasis by spiral CT, arterial blood gas analysis	Patient performed deep breathing exercises after CABG surgery showed a significantly smaller amount of atelectasis and better pulmonary function on 4 th postoperative day compared to control group.
Savci S et al. Fizyoter Rehabil. 2006 ⁶	To evaluate the efficacy of incentive spirometer and active cycle of breathing technique following CABG	Prospective randomized study	N=60 patients included were elective CABG, age more than 18 years and ejection fraction above 50%.	ACBT Group (n=30)- consist of 1-2 breathing control breaths, 3 thoracic expansion exercises followed by a 3 sec breath hold and the forced expiration technique including 1-2 breathing control breaths combined with 1-2 huffs. Incentive spirometer (n=30)- 3 deep breaths followed by a 3 sec breath hold at the end of deep inspiration after that 1-2 huffs with 1-2 breathing control. For both group- 1 st and 2 nd postoperative days- treatment was applied twice a day, 15 min/session For 3 rd day, it was applied once a day for 15 min.	VAS for pain, arterial blood gas analysis, 6-minute walk test, pulmonary function test	Both group improved arterial oxygenation from the first day of CABG. After 5 th day, rate of atelectasis decreased. Similar effects on pulmonary function and pain perception were found.
Renault J et al. Brazilian Journal of cardiovascular surgery. 2009 ⁹	Comparison between deep breathing exercises and incentive spirometry after CABG	Prospective, experimental, randomized study	N=36 patients hospitalized at SCMBH were assessed in preoperative of elective CABG, with normality standard or mild ventilatory disorder on spirometry.	Deep breathing exercise group (n=18)- performed 3 series of 10 DBE, mainly diaphragmatic breathing through a slow and uniform nasal inspiration from residual capacity, assisted cough and huffing and early mobilization exercises were also performed. Incentive spirometry group (n=18)- underwent the same protocol with slow inspiration from FRC until achievement of the desired level marked in the spirometer cylinder, by maintaining therefrom the inspiration sustainance.	Pulmonary function test- FVC, FEV1, pulse oximeter-oxygen saturation, Wika manovacuometer- maximal inspiratory pressure and maximal expiratory pressure	There was no significant difference in maximal respiratory pressure, spirometric variables and oxygen saturation in patients undergoing DBE and incentive spirometry in the post CABG.
Jain K et al. JMGUMST 2017 ¹⁰	Comparative study on effects of ACBT and manual chest physical therapy after uncomplicated CABG	Comparative study	N=30 Age range of 30 to 65 years undergo CABG	Group 1 (n=15): recieved ACBT and IS. Instruction given to the patients regarding incentive spirometer and ACBT. 2 sessions were performed on 1st, 2nd and 3rd postoperative day i.e. 6 sessions of treatment. Group 2 (n=15): recieved MCPT and IS. Instruction were same as in group 1.	Pulse oximeter- for SPO2, oxygen flow meter regulator- for FiO2, respiratory rate, ABG analysis, breath holding time	Both ACBT and MCPT techn were effective along with IS in postoperative pulmonary function, specifically MCPT was more effective for SpO2 and PaO2 while ACBT was more effective with breath holding time, respiratory rate and PaCO2.

Khan S et al. IJCBR 2018 ¹¹	Immediate effect of incentive spirometry on ABG analysis after CABG	Interventi on study	N=30 patients underwent CABG, have no mental or neuromuscular disorder and mechanical ventilation should be less than 24 hour.	Incentive spirometer was given 10reps and 3 sets. Patient was prop up 30-40 degree. Romsons tri.co.our volume spirometry was used. Ball in the incentive spirometry will go up ask the patient to hold or rise the ball as high as possible and hold it for 3 or 5 second and then slowly exhale. This was done for 10 to 15 times.	Arterial blood gas analysis- PaO ₂ , PaCO ₂ and SaO ₂	There was immediate effect of incentive spirometry on ABG analysis in CABG surgery.
Derakhtanja ni A et al. Anesth Pain Med. 2019 ⁵	Comparison the effect of ACBT and routine chest physiotherapy on pain and respiratory parameters after CABG	Randomiz ed clinical trial	N=70 Age within 18-60 years, undergoing non-emergency CABG surgery, having cognitive speaking and hearing ability, no history of open heart surgery, no pulmonary disease	ACBT group (n=35)- it was performed on the 2 consecutive days after operation, each day one session, each session 3 courses and each course for 10 min with 15 min ofrest between them. Routine physiotherapy (n=35)- it includes chest wall vibration and manual percussion. Vibration and percussion were done on a bed sheet. Manual percussion was performed 25 times in 10 seconds for 2 min. Then patients was encouraged to do effective coughs	VAS- for pain, ABG analysis - PaO ₂ , PaCO ₂ , pH and HCO ₃ , pulse rate, respiratory rate	Both method increased the pain perception to a mild level and heart rate in normal range.
Chaudhary S et al. Int J Cur Res Rev. 2020 ¹	The immediate effect of breathing exercise with acapella and incentive spirometer on preventing early pulmonary complications following CABG.	Randomiz ed clinical trial.	N=30 who were having stable vital following CABG, age between 40-70 years, male and female and not having any existing pulmonary complication.	Group 1 (breathing exercises with acapella)- includes 3 sets of deep breaths, each set includes 30 reps which were followed by 30 to 60 secs pause in between. Subjects were instructed to performed slow maximal inspiration while expiration was done through acapella in a prolonged forceful manner. Acapella device, resistance was increased continuously on each successive day. Group 2 (breathing exercise through incentive spirometer)- the session lastec for 15-20 min. Breathing exercise were performed through IS with 30 reps , rest was given for 30-60 secs in between each set, total 3 sets/session were given each day for the next 3 consecutive days. The breath was asked to hold for 2,3,4,5 sec in between inspiration and expiration each successive day.	SpO ₂ , peak expiratory flow rate and numerical rating scale	Breathing exercise through acapella and incentive spirometry were effective in preventing early PPCs followed by CABG improving PEFr, SpO ₂ leve, and reduction of shortness of breath.
Amin R et al. 2021 ⁷	Effects of three pulmonary ventilation regimes in patients undergoing CABG	Randomiz ed clinical trial	N=72 patients underwent CABG.	Group 1 (n=24)- it includes flow incentive spirometer. Group 2 (n=24)- it includes volume incentive spirometer. Group 3 (n=24)- diaphragmatic breathing exercise.	PFT- pulmonary function, 6MWT- functional capacity and functional difficulties questionnaire	Volume incentive spirometer was more beneficial in improving the pulmonary function (FVC), functional capacity and functional difficulties questionnaire.

Sweity E et al. J Cardiothorac Surg. 2021 ³	Preoperative incentive spirometry for preventing postoperative pulmonary complications in patients undergoing CABG.	A Prospective, randomized controlled trial	N=80 patients 18 years or older, schedule to have CABG.	Group 1 (n=40)- incentive spirometer, 10 breaths, 6 times per day for a period of 10 min in every session with a breathing technique for 2 days preoperative. Group 2 (n=40)- no IS preoperative, only IS postoperatively.	Atelectasis, pneumonia, pleural effusion, pneumothorax, hospital length of stay, mechanical ventilation duration, oxygenation status and SaO ₂ and pain control.	Preoperative IS along with DBE, assisted coughing and early ambulation after CABG prevent and lower incidence of atelectasis, hospital length of stay, duration of mechanical ventilation and improved SpO ₂ .
Fatima A et al. KMJ. 2021 ⁴	Comparison of effects of incentive spirometry and deep breathing exercises on pulmonary function after CABG.	Quasi-experimental study	N=40 patients from both genders aged 35-60 years, undergoing CABG.	Group A (n=20)- patients received incentive spirometry. Group B (n=20)- patients treated with deep breathing exercise, 3 sets of 10 deep breaths.	SaO ₂ by pulse oximetry, PaCO ₂ and PaO ₂ by arterial blood gases.	There was an improvement in ABGs and SaO ₂ after CABG in patients received chest physiotherapy intervention. Both techniques were equally effective in preventing and treating chest complications.

Discussion

The pulmonary function, respiratory parameters, pulmonary complications and shortness of breath after CABG can be improved by aid of deep breathing exercise, incentive spirometer and active cycle of breathing technique. The main objective of this review is to figure out the immediate effect of incentive spirometer, breathing exercise and active cycle of breathing technique after CABG. Anesthesia, intubation and surgical trauma contribute to changes in pulmonary mechanics, decrease in FRC and changes in production of surfactant on the post-operative of CABG surgery. These factors associated with immobility, pain and fear, favor the adoption of a monotonous breathing pattern without performing sporadic sighs to total lung capacity, promoting alveolar collapse. Also, damage to cough and bronchial hygiene lead to atelectasis development, causing a ventilation-perfusion disorder with changes in blood oxygenation and predisposing to occurrence of lung infection¹. Diaphragm dysfunction is caused due to injury to the phrenic nerve due to dissection of the internal mammary artery with electrocauterization and the insertion of chest tubes for pleural and mediastinal drainage after

and open heart surgery. This leads to reflex inhibition of the phrenic nerve causing functional disruption of the movement of the diaphragm⁷.

A study by Amin R et al, proven that volume incentive spirometry was more beneficial in pulmonary function, functional capacity and functional difficulties questionnaire as compared to flow incentive spirometer and deep breathing exercises. The possible reason might be that it is a mechanical device which opens the alveoli and maintain its patency upon the patients taking long deep breaths which again encourages the patient to breath until total lung capacity has been achieved⁷. Sweity E et al presented results that preoperative incentive spirometer for 2 days along with the exercise of deep breathing, encouraged coughing and early ambulation following CABG in connection with prevention and decreased incidence of atelectasis, hospital stay, mechanical ventilation duration and improved postoperative oxygenation with better pain control³. Furtherance, Renault J et al, presented results that no statistical differences were observed in maximal respiratory pressures, spirometric variables and oxygen saturation in patient undergone deep

breathing exercises and flow incentive spirometer after CABG⁹.

Through above studies, it is found that incentive spirometer, deep breathing exercises and active cycle of breathing technique, all three techniques are effective in preventing pulmonary complication, improves PaO₂, SaO₂, peak expiratory flow rate and decreased PaCO₂ and shortness of breath.

Conclusion

Breathing exercise, active cycle of breathing technique and incentive spirometry are effective methods for patients undergoing CABG. All the above mentioned studies have multiple limitations such as inadequate sample size, short intervention period, no comparison of preoperative and postoperative intervention, there was not even single study that suggests the supremacy of one therapy over another, no studies mentioned or suggested use of deep breathing exercise, active cycle of breathing technique and incentive spirometry as important treatment options. Very less studies are done on volume incentive spirometer and no study explained the exact protocol for patients underwent CABG preoperatively and postoperatively.

Hence, in order to establish a definitive protocol and to overcome all limitations, there is a need to compare flow incentive spirometer and volume incentive spirometer along with deep breathing exercise and active cycle of breathing technique on lung function parameters in patients undergoing CABG.

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