ORIGINAL ARTICLE

IJPHY

# COMPARATIVE STUDY ON THE IMMEDIATE EFFECTS OF DEEP BREATHING EXERCISES WITH PEP DEVICE VERSES INCENTIVE SPIROMETRY WITH EPAP ON PREVENTING PULMONARY COMPLICATIONS FOLLOWING CABG

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## ABSTRACT

***Background:*** The initial days following CABG is a crucial period as it imposes a high risk of pulmonary complications and morbidity. In an effort to increase lung volume following surgery, various deep breathing manoeuvres have been implemented as a main component in the care of the postoperative patient. The rationale for Deep Breathing Exercises with PEP and Incentive Spirometry is that they prevent postoperative complications (PPC), thereby improving cardiorespiratory function. Various studies to substantiate the effectiveness of Deep Breathing Exercises with PEP devices and Incentive Spirometry on preventing pulmonary complications following CABG surgery have been done. The need to study immediate effects of both techniques is yet to be studied.
***Methodology:*** 30 subjects undergoing CABG and fulfilling the inclusion criteria were selected for the study. They were randomly assigned into two groups: Group A and Group B having 15 subjects each. Group A received Deep Breathing Exercises with a positive expiratory pressure (PEP) device and Group B received Incentive Spirometry with Expiratory Positive Airway Pressure (EPAP).
***Results:*** The value of F = 45.729 to find the difference in PEFR in Group B is significant (p=0.00). It has been found that PEFR increased significantly after application of incentive spirometer with EPAP to the patients after 4th day. On Day 4, t = 3.750, which is significant (p = 0.001) implying that deep breathing exercise with PEP device is more effective to increase PEFR as compared to incentive spirometer with EPAP.
***Conclusion:*** PEP device is more effective than Incentive Spirometry with EPAP in preventing postoperative complications following CABG surgery. It can be inferred that deep breathing exercise with PEP device is more effective than incentive spirometer with EPAP in improving SPO2 and PEFR in both the groups.
***Keywords:*** Complications of CABG, Positive expiratory pressure device, Expiratory Positive Airway Pressure device.

Received 25th December 2015, revised 14th January 2016, accepted 07th February 2016

www.ijphy.org

10.15621/ijphy/2016/v3i1/88929

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## INTRODUCTION

CABG is the routine procedure for the treatment of patients who present with symptoms of myocardial ischemia, and expenditure accounts for more resources in cardiovascular medicine than any other single procedure [1].

CABG is performed daily on a worldwide basis in patients with coronary artery disease [2]. A majority of cardiac surgeries are performed for ischemic coronary artery disease. CABG is commonly performed via median sternotomy. The procedure is done by taking a graft from the saphenous vein or internal mammary artery (IMA) and placed proximal and distal to the lesion [3]. With advanced research and technologies available in the healthcare system, complex cardiovascular disorders are treated and managed better.

Pulmonary complications such as atelectasis and pleural effusion occurring after cardiac surgery is a major problem and a significant cause of postoperative morbidity [4]. Patients undergoing CABG often develop atelectasis and severe reduction in lung volumes and oxygenation in the early postoperative period [5,6]. The initial postoperative phase is the most vulnerable period, but decrease in pulmonary function persists for several months after surgery [7,8].

Impaired ventilator mechanics [9,10], decreased lung compliance and increased effort of breathing is prominent [11]. The significantly reduced lung volumes contribute to impaired gas exchange. Various studies have documented arterial hypoxaemia [12] and decreased diffusion capacity [13] in the early postoperative period.

The postoperative complications increase with age, obesity, smoking and pre-existing lung diseases. The other factors such as site of surgery, duration of anaesthesia and postoperative risk factors, such as immobilization, analgesia, emergency procedures and inadequate preoperative education are also reported to contribute to an increased risk [14, 15].

Mucociliary clearance is adversely affected after surgery by the effects of general anaesthesia, intubation and analgesia. Expiratory flow rate is directly related to lung volume and therefore when lung volumes are decreased, as in the postoperative period, coughing will be less effective [16, 17]. Insufficient breathing as well as the absence of a normal sigh mechanism and coughing technique, immobilization and inadequate patient cooperation may affect the pulmonary function [18, 19]. The absence of sigh has been suggested to lead to alveolar collapse within one hour [20, 21]. Pain, discomfort and fear contribute to the pulmonary impairment.

Chest physiotherapy has long been a standard component of postoperative care, with the aim of preventing or reducing complications such as impaired pulmonary function, atelectasis, pneumonia, sputum retention and gas exchange impairments [22, 23].

Post-operative physiotherapy techniques include early mobilization, positioning, deep breathing exercises, effective huffing and coughing technique, active cycle of breathing technique (ACBT) and use of various mechanical devices such as incentive spirometer (IS), positive expiratory pressure (PEP) and continuous positive airway pressure (CPAP). Early mobilization is important in the prevention and treatment of pulmonary impairments. The aim of the technique is to increase pulmonary volume, prevent or diminish atelectasis, assist in sputum clearance and subsequently increase arterial hypoxaemia. Positive Expiratory Pressure (PEP) technique was developed in Denmark in the 1970s for the primary purpose of mobilising secretions. It helps to slow the emptying of lungs and increases lung volume, prevents or reduces alveolar collapse, mobilizes secretions, favours expectoration and may help in improving inspiratory muscle strength.

The use of PEP in postoperative care is mostly intended to increase pulmonary volume and facilitate the release of pulmonary secretions. This device is considered to allow more air to enter peripheral airways via collateral channels, to allow pressure air to go behind secretions, moving them towards larger airways where they can easily be expelled and to prevent the alveoli from collapsing [24]. The physiological explanation of how the technique is supposed to improve trans pulmonary function is unknown, although PEP is believed to increase pulmonary pressures resulting in an increased functional residual capacity (FRC).Various PEP devices have been developed, for example the PEP/respiratory muscle training (PEP-RMT) mask (Astra Tech, Denmark). In an early study by Falk et al., it is shown that the use of PEP increased mucus expectoration in patients with cystic fibrosis. Since then, various PEP devices have been developed and physiotherapists have used the PEP system for various purposes.

Incentive spirometry (IS), also referred to as sustained maximal inspiration (SMI), is a component of bronchial hygiene therapy. Incentive spirometry is designed to mimic natural sighing or yawning by encouraging the patient to take long, slow, deep breaths. This is accomplished by using a device that provides patients with visual or other positive feedback when they inhale at a pre determined flow rate or volume and sustain the inflation for a minimum of 3 seconds. The objective of this technique is to increase pulmonary volume, prevent or diminish atelectasis, assist in sputum clearance and subsequently increase arterial hypoxaemia. Incentive Spirometry is a widely used technique for the prophylaxis and treatment of respiratory complications in postsurgical patients.

The rationale for Deep Breathing Exercises with PEP and Incentive Spirometry is that they prevent postoperative complications (PPC) in Coronary artery Bypass Grafting (CABG) patients and thereby improves and facilitates cardio respiratory function. Various studies to substantiate the effectiveness of Deep Breathing Exercises with PEP devices and Incentive Spirometry on preventing pulmonary complications following CABG surgery have been done.

## METHODOLOGY

30 subjects undergoing CABG and fulfilling the inclusion criteria were selected for the study. They were randomly assigned into two groups namely Group A and Group B consisting of 15 subjects in each group. All the subjects were preoperatively explained about the purpose of the study and were educated about the respective treatment procedures. A prior written consent was obtained. Ethical clearance was attained. Detailed subjective assessment of the subjects were done preoperatively to rule out any other abnormalities. Patients between 41 to 75 years age and with low surgical risk were included in this study. The exclusion criteria for this study were unstable cardiac status, patients with artificial ventilation for more than 24 hours, patients who had an emergency CABG, severe renal dysfunction requiring dialysis, patients with previous open heart surgery, patients with haemodynamic instability and uncooperative patients.

## PROCEDURE

All the subjects received basic postoperative respiratory physiotherapy including breathing exercises, instructions in huffing and coughing techniques, mobilization and active exercises of the upper limbs and thorax.

Patients were mobilized as early as possible by the nursing staff according to the hospital protocol. The patients were instructed to sit out of bed and stand up on the first postoperative day, walk in the room or a short distance in the corridor on the second day, and increase the distance of walking on the third postoperative day.

**For Group A: DBEs with PEP device:**

1. The subjects in this group were informed and practiced the breathing technique preoperatively.
2. The exercises were started approximately 1 hour after extubation and the subjects were encouraged to perform 30 deep breaths once per hour till Day 3.
3. The exercise included 3 sets of 10 deep breaths with a 30 to 60 seconds pause between each set. If needed, the patients were asked to huff/cough during the pause to mobilize secretions.
4. The patients were instructed to perform the deep breathing in the sitting position, if possible.
5. A PEP device is used to create an expiratory resistance of +10 cm of $H_2O$. Subjects were instructed to perform slow maximal inspirations, while expiration was aimed to end approximately at FRC to minimize airway closure and alveolar collapse.

**Figure 1:** Subject performing breathing exercises

**For Group B: Incentive Spirometry with EPAP:**

1. The exercises were started approximately 2 hours after extubation. The protocol consisted of breathing exercises using an incentive volumetric spirometer associated with EPAP simultaneously.
2. The subjects were trained twice a day with each session lasting for 15 to 20 minutes till Day 3. During the session, the subjects were instructed to perform diaphragmatic breathing at a rate of 12-18 breaths per minute. The expiratory pressure was increased progressively: Day 1- 400ml; Day 2- 500ml; Day 3- 600ml and Day 4- 800ml respectively.

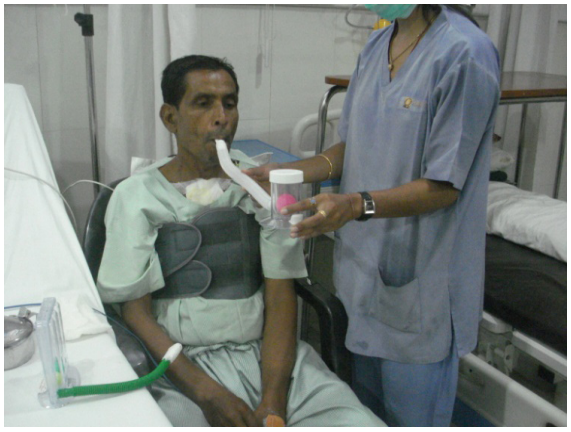


**Figure 2:** Subject Performing Volumetric Spirometry

**Figure 3:** Using Peak Expiratory Flow Meter for assessing the PEFR

## DATA ANALYSIS AND RESULT

Data analysis was done using SPSS windows Version 20.0. An alpha-level of 0.05 was used to determine statistical significance. Microsoft word and excel has been used to generate graphs and tables. Descriptive statistical analysis was performed to find out mean and standard deviation of SpO2 and PEFR. Analysis of variance was performed to see the variation of SpO2 and PEFR for both groups. Independent sample t-test was carried out to compare mean SpO2 and PEFR of deep breathing exercise with PEP device and incentive spirometer with EPAP.

**Group analysis for $SPO_2$ within groups of Group A and Group B**

| | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Group A | Between Groups | 305.067 | 3 | 101.689 | 114.196 | .000 |
| | Within Groups | 49.867 | 56 | .890 | | |
| | Total | 354.933 | 59 | | | |
| Group B | Between Groups | 119298.333 | 3 | 39766.111 | 52.770 | .000 |
| | Within Groups | 42200.000 | 56 | 753.571 | | |
| | Total | 161498.333 | 59 | | | |

**Table 1:** ANOVA for $SPO_2$

From ANOVA of Group A, there is significant difference in $SPO_2$ between points of time of observation (p=0.00). It has been found that $SPO_2$ increase significantly from day 0 to 4th day after treating with deep breathing exercise with PEP device.

The value of F to find the difference in $SPO_2$in Group B is significant (p=0.00). It has been found that $SPO_2$ increased significantly after application of incentive spirometer with EPAP to the patients.

In other words, deep breathing exercises with PEP device and incentive spirometer with EPAP are effective in increasing $SPO_2$.

| | Treatment | N | Mean ± SD | T | Df | P |
|---|---|---|---|---|---|---|
| Day1 | Deep breathing exercise with PEP device | 15 | 94.40 ± 1.29 | 1.897 | 28 | .068 |
| | Incentive spirometer with EPAP | 15 | 93.20 ± 2.07 | | | |
| Day2 | Deep breathing exercise with PEP device | 15 | 97.33 ± 1.29 | 3.139 | 28 | .004 |
| | Incentive spirometer with EPAP | 15 | 95.53 ± 1.80 | | | |
| Day3 | Deep breathing exercise with PEP device | 15 | 99.73 ± 3.45 | 3.466 | 28 | 0.002 |
| | Incentive spirometer with EPAP | 15 | 98.33 ± 1.49 | | | |
| Day4 | Deep breathing exercise with PEP device | 15 | 100.0 ± 0.00 | 1.740 | 28 | .093 |
| | Incentive spirometer with EPAP | 15 | 99.73 ± .59 | | | |

**Table 2:** To compare effectiveness of deep breathing exercise with PEP device and ncentive spirometer with EPAP to increase $SPO_2$.

Independent t-test was performed to compare the effectiveness between deep breathing exercise with PEP device and incentive spirometer with EPAP to increase $SPO_2$. The tests were carried out separately for different points of time.

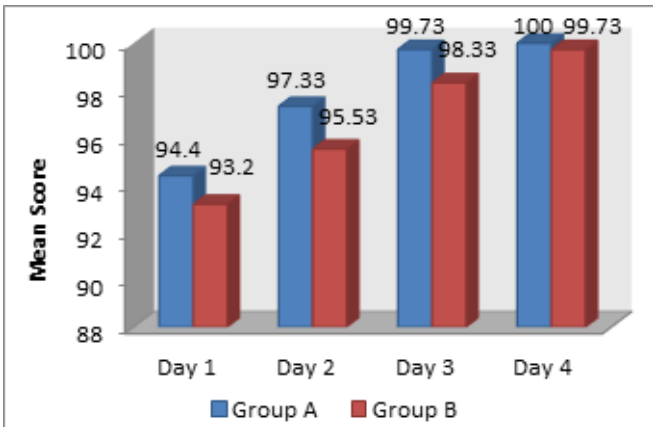
On Day 1, t = 1.897 which is not significant (p = 0.068). It has been inferred that on first day there was no difference in effectiveness between deep breathing exercise with PEP device and incentive spirometer with EPAP.

On Day 2, t = 3.139 which is significant (p = 0.004) implying that $SPO_2$ increases more when deep breathing exercise with PEP device was applied as compared to incentive spirometer with EPAP.

On Day 3, t = 3.466 which is significant (p = 0.002) implying that $SPO_2$ increases more when deep breathing exercise with PEP device was applied as compared to incentive spirometer with EPAP.

On Day 4, t = 1.740, which is not significant (p = 0.093) implying that deep breathing exercise with PEP device and incentive spirometer with EPAP were equally effective to increase $SPO_2$.

It can be inferred from the above findings that deep breathing exercise with PEP device is more effective than incentive spirometer with EPAP in improving $SPO_2$.




**Graph 1:** Comparison of mean scores of $SPO_2$ between group A and group B on different points of time.

Group analysis for PEFR within groups of Group A and Group B

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Group A | Between Groups | 382.200 | 3 | 127.400 | 50.101 | .000 |
| | Within Groups | 142.400 | 56 | 2.543 | | |
| | Total | 524.600 | 59 | | | |
| Group B | Between Groups | 77740.000 | 3 | 25913.333 | 45.729 | .000 |
| | Within Groups | 31733.333 | 56 | 566.667 | | |
| | Total | 109473.333 | 59 | | | |

**Table 3:** ANOVA for PEFR

From ANOVA of Group A, there is significant difference in PEFR between points of time of observation (F = 50.101, p=0.00). It has been found that PEFR increased significantly with deep breathing exercise and PEP device.

The value of F = 45.729 to find the difference in PEFR in Group B is significant (p=0.00). It has been found that PEFR increased significantly after application of incentive spirometer with EPAP to the patients.

In other words, deep breathing exercises with PEP device

and incentive spirometer with EPAP are effective in increasing PEFR.

| | Treatment | N | Mean ± SD | t | df | p |
|---|---|---|---|---|---|---|
| Day1 | Deep breathing exercise with PEP device | 15 | 164.00 ± 24.72 | 1.969 | 28 | .059 |
| | Incentive spirometer with EPAP | 15 | 148.66 ± 17.26 | | | |
| Day2 | Deep breathing exercise with PEP device | 15 | 201.33 ± 26.95 | 3.721 | 28 | .001 |
| | Incentive spirometer with EPAP | 15 | 170.66 ± 17.09 | | | |
| Day3 | Deep breathing exercise with PEP device | 15 | 237.33 ± 8.14 | 3.036 | 28 | .005 |
| | Incentive spirometer with EPAP | 15 | 206.67 ± 27.16 | | | |
| Day4 | Deep breathing exercise with PEP device | 15 | 284.66 ± 29.72 | 3.750 | 28 | .001 |
| | Incentive spirometer with EPAP | 15 | 243.33 ± 30.62 | | | |

**Table 4:** To compare effectiveness of deep breathing exercise with PEP device and Incentive spirometer with EPAP to increase PEFR

Independent t-test was performed to compare the effectiveness between deep breathing exercise with PEP device and incentive spirometer with EPAP to increase PEFR. The tests were carried out separately for different points of time.

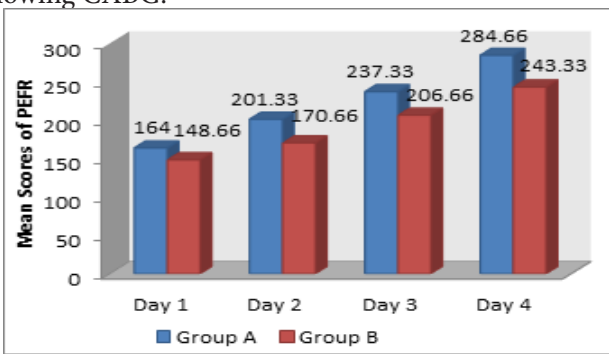
On Day 1, t = 1.969 which is not significant (p = 0.059). It has been inferred that on first day there was no difference in effectiveness between deep breathing exercise with PEP device and incentive spirometer with EPAP.

On Day 2, t = 3.721 which is significant (p = 0.001) implying that PEFR increases more when deep breathing exercise with PEP device was applied as compared to incentive spirometer with EPAP.

On Day 3, t = 3.036 which is significant (p = 0.005) implying that PEFR increases more when deep breathing exercise with PEP device was applied as compared to incentive spirometer with EPAP.

On Day 4, t = 3.750, which is significant (p = 0.001) implying that deep breathing exercise with PEP device is more effective to increase PEFR as compared to incentive spirometer with EPAP.

It can be inferred from above that deep breathing exercise with PEP device is more effective than incentive spirometer with EPAP on preventing pulmonary complications following CABG.




**Graph 2:** Comparison of mean scores of PEFR between group A and group B on different points of time

## DISCUSSION

The purpose of this study is to compare the immediate effects of Deep Breathing Exercises with PEP device and Incentive Spirometry (IS) with EPAP and preventing pulmonary complications following Coronary Artery Bypass Surgery.

The main objectives of the study were:

a) To find out the effects of Deep Breathing Exercises with PEP device following CABG.
b) To find out the effects of Incentive Spirometry with EPAP following CABG.
c) To compare the effects of Deep Breathing Exercises with PEP device and Incentive Spirometry with EPAP following CABG.

A Comparative study with 30 subjects fulfilling the inclusion criteria were allowed to participate in the study. Measures like $SpO_2$ and PEFR were assessed.

Pre treatment assessments of subjects of Group A were taken in the morning prior starting the treatment protocol. Post treatment assessment were done after completion of the treatment session in the evening prior to supper.

Pre treatment and post treatment assessment of subjects of Group B were taken twice daily prior starting the treatment protocol and after completion of the sessions.

Result shows statistically significant increase in $SpO_2$ from Day 0 to Day 3 after treating with deep breathing exercise with PEP device and incentive spirometer with EPAP at p=0.00 level. In other words, deep breathing exercises with PEP device and incentive spirometer with EPAP are effective in increasing $SPO_2$.

There is a significant increase in PEFR from day 0 to Day 3 after treating with deep breathing exercise with PEP device and incentive spirometer with EPAP at p=0.00 level. In other words, deep breathing exercises with PEP device [25, 26, 27] and incentive spirometer with EPAP in early mobilization [28, 29] are effective in increasing PEFR.

Independent t-test was performed to compare the effectiveness between deep breathing exercise with PEP device and incentive spirometer with EPAP to increase $SpO_2$ and PEFR. Implying that deep breathing exercise with PEP device is more effective to increase $SpO_2$ and PEFR as compared to incentive spirometer with EPAP.

It also proved that deep breathing exercise with PEP device is more effective than incentive spirometer with EPAP in improving $SPO_2$ and PEFR in both groups.

## CONCLUSION

Based on the statistical analysis, it is concluded that Deep Breathing Exercises with PEP device is more effective than Incentive Spirometry with EPAP in preventing postoperative complications following CABG surgery.

It can be inferred that deep breathing exercise with PEP device is more effective than incentive spirometer with EPAP in improving $SPO_2$ and PEFR in both the groups.

"There is significant difference between the effectiveness of

Deep Breathing Exercises with PEP device and Incentive Spirometry with EPAP in preventing postoperative complications following CABG surgery".

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Begum Affrin Zaman, V. Kiran, Barnali Bhattacharjee, & Abhijit Dutta. (2016). COMPARATIVE STUDY ON THE IMMEDIATE EFFECTS OF DEEP BREATHING EXERCISES WITH PEP DEVICE VERSES INCENTIVE SPIROMETRY WITH EPAP ON PREVENTING PULMONARY COMPLICATIONS FOLLOWING CABG. *International Journal of Physiotherapy,* 3(1), 140-146.