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ORIGINAL ARTICLE

COMPARISON OF EFFECTS OF INCENTIVE SPIROMETRY AND DEEP BREATHING EXERCISES ON PULMONARY FUNCTIONS AFTER CORONARY ARTERY BYPASS GRAFTING

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ABSTRACT

OBJECTIVE: To compare the effects of incentive spirometry (IS) and deep breathing exercises (DBE) on pulmonary functions after coronary artery bypass grafting (CABG).

METHODS: This quasi-experimental study consisted of 40 patients from both genders aged 35-60 years, undergoing CABG. Two equal groups were selected through convenient sampling. Group-A patients performed IS while group-B performed DBE. The outcome measures were values of oxygen saturation (SaO_2)by pulse oximetry, and partial pressures of oxygen (pO_2) and carbon dioxide (pCO_2) measured by arterial blood gases (ABGs).

RESULTS: Mean pO_2 (mmHg) at day 1 & day 4 was 136±23.04 & 74.42±16.22 respectively in group-A ($p<0.001$) as compared to 127.96 ±16.99 & 70.80±10.89 respectively in group-B ($p<0.001$). Mean value of SaO_2 at day 1 & day 4 was 98.52±1.68 & 94.07±2.36 in group-A ($p<0.001$) as compared to 97.90±1.99 and 95.40±2.04 in group-B ($p<0.001$) respectively. Mean pCO_2 (mmHg) was 42.32±4.57 & 40.07±3.49 at day 1 & day 4 in group-A ($p<0.05$) and 40.85±4.03 & 39.61±3.40 in group-B ($p>0.05$) respectively. Common complications observed were atelectasis (n=29/40; 72.5%), pleural effusion (n=6/40; 15%) and pulmonary edema (n=5/40; 12.5%). Majority (n=19; 47.5%) of patients were discharged till 5th postoperative day. Median stay at hospital was 3 days in group-A & 4 days in group-B.

CONCLUSION: There was an improvement in ABGs and SaO_2 after CABG surgery in patients receiving chest physiotherapy interventions. Both techniques are equally effective in preventing and treating chest complications in patients having CABG.

Clinical Trial Registry Number: IRCT20200204046373N2

KEYWORDS: Coronary Artery Bypass (MeSH); Pulmonary Function Tests (MeSH); Respiratory Function (MeSH); Spirometry (MeSH); Arterial Blood Gases (MeSH); Blood Gas Analysis (MeSH).

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INTRODUCTION

Coronary artery bypass surgery (CABG) is one of the long-establishedproceduresaround the world as more than one million CABG procedures are being done every year. The patients who underwent bypass surgery are predisposed to post-operative pulmonary complications and oxygenation disorders which lead to high mortality and morbidity.[1] The prevalence of chest complications after CABG surgery are remarkably high and the incidence is around 30% -60%.[2]

Currently, literature does not support use of incentive spirometry (IS) for decreasing the incidence of pulmonary complications following cardiac or upper abdominal surgery.[3] Post CABG pulmonary complications are more life threatening and amultidisciplinary team of primary care physician, anesthetist, cardiopulmonary surgeon, heart and lung physician and physical therapist is necessary to decrease post-CABG problems.[4]

These complications play a major role in high mortality, morbidity rates and are main factors of longer hospital stay with increased expenses.[5] These pulmonary complications are produced due to abnormal oxygenation and differences in gaseous exchange.[6] Evidence suggest that arterial hypoxemia after coronary artery bypass graft surgery is 100%.[7] As cardiac & pulmonary systems are closely associated, any difference in normal values of pulmonary system may directly affect cardiac functions.[8]

Chest physiotherapy techniques play a vital role in preventing and treating post-operative complications in such patients.[3] Deep breathing exercises (DBE) are used in post-CABG patients to improve pulmonary ventilation and restore lung volume by opening the collapsed alveoli and preventing lung collapse.[9] Few of these early interventions are incentive spirometry, deep breathing exercises, continuous positive airway pressure, and early mobilization to prevent pulmonary complications after CABG.[10,11] Any of these methods can be used to improve pulmonary function but no single interventions can be preferred over the other.[5, 7] Incentive spirometry can be used post-surgery to improve the gaseous exchange and oxygenation, provided the patient cooperation and smooth completion of the maneuver.[11] IS has been extensively used during post-operative management of cardiac patients, but still evidence is lacking to support spirometer use for minimizing

TABLE I: EFFECTS OF INCENTIVE SPIROMETRY AND DEEP BREATHING EXERCISES ON PULMONARY FUNCTIONS AFTER CORONARY ARTERY BYPASS GRAFTING

		Group-A Incentive spirometry (N=20)			Group-B Deep breathing exercises (N=20)		
		Mean±SD	t	p-value	Mean±SD	t	p-value#
pO_2 (mmHg)	Day 1	136±23.04	16.013	0.000*	127.96±16.99	12.897	0.000*
	Day 4	74.42±16.22			70.80±10.89		
SaO_2 percent	Day 1	98.52±1.68	9.214	0.000*	97.90±1.99	4.291	0.000*
	Day 4	94.07±2.36			95.40±2.04		
pCO_2 (mmHg)	Day 1	42.32±4.57	2.905	0.006*	40.85±4.03	1.202	0.224*
	Day 4	40.07±3.49			39.61±3.40		

pO2: partial pressure of oxygen; SaO2: arterial oxygen saturation; pCO2: partial pressure of carbon dioxide;#Paired sample t test;*p-value <0.05 is considered significant

chest problems. This lack of evidence has led to controversies in the reduction of pulmonary complications in terms of gaseous exchange and oxygenation after CABG, so there is need of further exploration about the significance of the IS technique.[12,13]

Afrasiabi et al. conducted a study which concluded that there was no significance difference on arterial blood gases values after the use of IS.[14] Carvalho CR et al.[15] and Tyson AF et al.[16] also concluded in their studies that evidence supporting the positive outcomes after use of incentive spirometry are still lacking and more studies to explore the positive association of IS and reduction in post-operative pulmonary complications are needed. Brooks-Brunn JA, with a conflicting opinion, advocated the use of incentive spirometry to improve chest functions.[17]

Post-operative complications after CABG play a major contributing role in increased morbidity and mortality rates, prolonged hospital stay and increased expenses, so to reduce these factors, breathing exercises should be done post-operatively.[15] The arterial blood gases being the most reliable method to measure oxygenation and gas exchange can be determined.[18] After cardiac surgery, to monitor and maintain stability in the values of hemodynamic measurements, the inserted arterial lines are controlled; therefore, sampling of arterial blood gas analysis is very much contingent.[19]

According to a study which compared both techniques proved that both are equally effective, and no technique is superior than other.[20] The combined use of incentive spirometry and DBE are frequently used in CABG patients.[21] Similarly incentive spirometry alone does not reduce pulmonary complications in post-CABG patients.[22]

Lack of evidence is still there, and there are very few studies available on these techniques. Rare study showed any difference or additive effects of any technique over other. Physiotherapy plays dynamic role in post-CABG rehabilitation so current study was designed to compare the effects of incentive spirometry and deep breathing exercises on pulmonary functions after coronary artery bypass grafting.

METHODS

This quasi-experimental study conducted at Doctor's Hospital & Medical Centre, Lahore Pakistan from July 2019 - Jan, 2020. Approval was taken from Institutional review board committee of Doctor's Hospital & Medical Centre, Lahore Pakistan.

A sample of 40 was analyzed using Epitool. CABG patients of either gender, aged between 35-60 years were selected by convenient sampling. Patients with previous history of lung disorder, bone tuberculosis, osteoarthritis, neurological diseases and osteoporosis patients, chest operative, unstable hemodynamics and patients unwilling to participate were excluded from the study.

Patients were equally assigned to two groups on non-random basis (Figure 1). Group-A with 20 patients received incentive spirometry only and group-B comprised of 20 patients was treated with deep breathing exercises.

Participants received treatment twice daily in cardiac ICU in each session for 45 minutes. Group-A patients inspire slowly until top level marked in spirometer is gained. In Group-B, three sets of 10 deep breaths through slow and uniform nasal have been done with IS. Supplemental oxygen was administered by facemask at 6.0 L/min on first post-operative day. In coming days, in case of need for supplemental oxygen, the evaluation was performed after removing the source of oxygen for ten minutes. The outcome measures are values $SaO_2$by pulse oximetry, and pO_2 and pCO_2 measured by ABGs, periodically half an hour after giving physiotherapy interventions by taking blood sample.

The quantitative data has been presented in the form of frequency tables and

TABLE-II: POST-OPERATIVE PULMONARY COMPLICATIONS IN PATIENTS UNDERGOING CORONARY ARTERY BYPASS GRAFTING

Complications	Group-A Incentive spirometry (N=20)		Group-B Deep breathing exercises (N=20)		Total (n=40)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Atelectasis	16	80	13	65	29	72.5
Pleural effusion	3	15	3	15	6	15
Pulmonary edema	2	10	3	15	5	12.5

mean±SD. The qualitative data has been presented in form of frequencies and percentage. Paired t-test was used to observe effects of these interventions. Repeated measure ANOVA test has been used to compare the interventions between two groups at different follow-ups.

RESULTS

Out of 40 patients, 28 (70%) were males and 12 (30%) were females. Twenty five (62.5%) were smokers and 15 (37.5%) were non-smokers.

Overall, 77.5% (n=31) of the patients usually necessitate both lungs sides and triple grafts are put in 60% patients (n=24). Upper lobes were spared in all the subjects, 60% (n=24) had lung secretions gathered in their lower lobes, and 40% (n=16) had changed the middle lobe of right lung.

Majority (n=19; 47.5%) of patients were discharged till 5th post-op day and remaining were discharged till 7th postoperative day. Median stay at hospital was 3 days in group-A & 4 days in group-B.

Mean pO_2 (mmHg) at day 1 & day 4 was 136±23.04 & 74.42±16.22 respectively in group-A ($p<0.001$) as compared to 127.96 ±16.99 & 70.80±10.89 respectively in group-B ($p<0.001$). Mean value of SaO_2 at day 1 & day 4 was 98.52±1.68 & 94.07±2.36 in group-A ($p<0.001$) as compared to 97.90±1.99 and 95.40±2.04 in group-B ($p<0.001$) respectively (Table 1).

Thirty nine (97.5%) subjects undergoing CABG surgery developed respiratory complications after surgery. Common complications observed were atelectasis (n=29/40; 72.5%), pleural effusion (n=6/40; 15%) and pulmonary edema (n=5/40; 12.5%). Atelectasis was more common in group A (n=16/20, 80%) as compared to group B (n=13/20; 65%) [Table II]. Pneumothorax was not reported in any patient.

DISCUSSION

The pulmonary functions after CABG surgery can be improved by aid of deep breathing exercises, incentive spirometry and early mobilization.[11] The main objective of study was to figure out the efficacy of incentive spirometry versus deep breathing exercises in prevention of the chest complications in post-CABG patients. For this procedure incentive spirometry was predominantly used against deep breathing exercises in post-operative patients to avoid serious chest complications. This study disclosed that both groups manifested improvement in restoring the normal oxygen saturation and ABGs, but there is no prominent difference in ABGs and oxygen saturation between the groups.

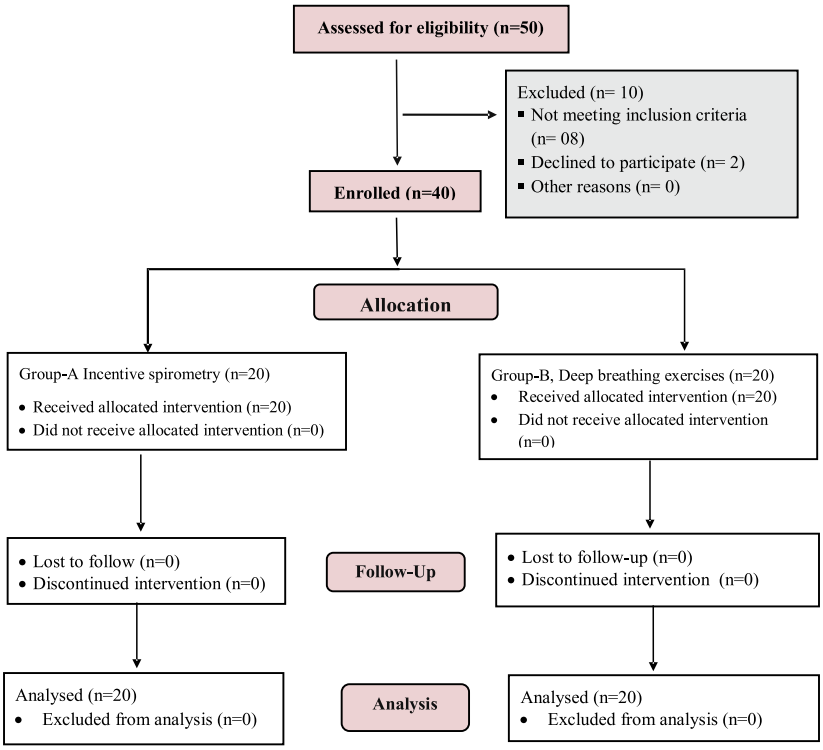

Figure 1: Study Flow Chart

A systematic review of seven trials was done by Agostini *et al.* to evaluate the effectiveness of IS after thoracic surgery. Out of 7 studies, three advocated the use of IS to improve gaseous exchange while other studies considered IS not effective post thoracic surgery. As a conclusion, they determined IS effective to improve oxygenation and gaseous exchange after thoracic surgery.[23] The current study showed that deep breathing exercises and incentive spirometry are equally effective in bypass patients.

Mordianet al. conducted a study to evaluate combined use of incentive spirometry and planned DBE and concluded the significant improvement in PaO_2 and SaO_2 post-CABG but did not explain which method is more effective than the other.[24] On the other hand, there are some conflicting results by some studies. Yánez-Brage I *et al*. concluded that incentive spirometry is not significant to improve mean arterial blood gases as compared to the group that did not use IS on second post-operative day, but significant improvement was noticed on third post-operative day.[25] Similarly, in another study temporary increase in blood oxygenation with breathing exercise was observed and this increase is reversible after short period of time, so for prolong improvement in oxygenation, repeated exercises are required.[26]

Carvalho CR et al. conducted a systematic review of 30 studies about incentive spirometry and described little evidence available on use of incentive spirometry after CABG and further studies are required to identify and establish the use of this technique.[15] Yazdannik A *et al*. stated that arterial blood gas parameters (PaO_2, SaO_2, and $PaCO_2$) can be significantly improved with incentive spirometry use after CABG surgery.[1] However, current study assesses the effects of chest physiotherapy techniques on ABGs, pO_2, pCO_2 and SaO_2.

Another study described that spirometry is not superior to routine physical therapy interventions.[27] In a review, it is concluded that there is lack of evidence supporting the benefits of chest physiotherapy after bypass.[19] My study compared the incentive spirometry with deep breathing exercises after CABG surgery.

Further investigation is required to check the extent to which our findings can be generalized. There could be multiple variables that should have been measured at the baseline while in this study only few variables have been quantified due to lack of time and resources. Therefore changes in score may be attributed to these variables.

There is a limited data available regarding chest physiotherapy techniques used for the treatment of respiratory complications after bypass surgery. There is not even a single study that suggests the supremacy of one therapy technique over another. None of the above mentioned studies suggested use of both deep breathing exercises and incentive spirometry as important treatment options.

CONCLUSION

Deep breathing exercises and IS both are evenly efficacious in prevention and treatment of the lung complications in patients undertaking CABG surgery, as they improve ABGs and SaO_2. But as far as improvement in chest complications are concerned there is no statistically significant and prominent difference. There is improvement in ABGs and SaO_2 after CABG surgery and in patients receiving chest physiotherapy interventions. However, no technique is superior to other in preventing and treating chest complications in patients having bypass surgery.

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AUTHOR'S CONTRIBUTION

Following authors have made substantial contributions to the manuscript as under:

AF: Conception and study design, acquisition of data, drafting the manuscript, critical review, approval of final version to be published

SK: Analysis and interpretation of data, drafting the manuscript, approval of final version to be published

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICT OF INTEREST

Authors declared no conflict of interest

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DATA SHARING STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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