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EFFECT OF PREOPERATIVE INCENTIVE SPIROMETRY IN PREVENTION OF POST-OPERATIVE PULMONARY COMPLICATIONS IN CARDIAC SURGICAL PATIENTS

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ABSTRACT

Objective: To evaluate the efficacy of pre-operative incentive spirometry versus no incentive spirometry before open heart surgery for the prevention of postoperative pulmonary complications (PPCs).

Study Design: Comparative analytical study.

Material and Methods: Consecutive adult patients who underwent elective open heart surgery during study time period were enrolled. The study participants were divided into two groups depending on their use of spirometry technique. Incentive Spirometer (IS) group consisted of patients who were educated about the Incentive Spirometry technique 3 days before surgery. While No IS group (NIS) consisted of participants who were given IS after the open heart surgery.

Results: A total of 122 patients were enrolled in the study. IS group consisted of 61 patients while NIS group consisted of 60 patients. Mean age of the patients was 53 ± 11 years for IS and for NIS was 53 ± 13 years. IS group patients had better PaO2/FiO2 ratio of 395 ± 95, 359 ± 93 and 334 ± 59 at extubation, 6 hours after extubation and 24 hours after surgery respectively than that of 317± 73, 307 ± 89 and 301 ± 34 in the NIS group. IS group patients had better inspiratory effort of 250 ± 100 ml vs 150 ± 75 ml than NIS group patients 6 hours after extubation (p value 0.03). IS group had 600 ± 125 ml of inspiratory effort while NIS group patients had 350 ± 150 ml effort 24 hours after surgery (*p* value 0.04). There were less cases of pleural effusion, atelectasis and need of non-invasive ventilation in IS group as compared to NIS group but this difference was not statistically significant.

Conclusion: IS group patients had better post-operative recovery in immediate post-operative period. Therefore, we recommend pre-operative use of IS at least three days before surgery.

Keywords: Incentive spirometry; surgery; postoperative care; postoperative complication; physical therapy.

INTRODUCTION

Postoperative pulmonary complications (PPC) present elevated rates of morbidity, mortality, increased hospital costs and extended length of hospital stay predominantly in abdominal, cardiac and thoracic surgery[1-3]. Atelectasis, pneumonia, tracheobronchitis, bronchospasm, exacerbation of chronic obstructive pulmonary disease, acute respiratory failure and prolonged mechanical ventilation (> 48 hours) can be categorized as PPCs[1,4,5]. Consequently, physical therapy techniques of lung re-expansion have been suggested as methods to prevent and/or to treat the PPCs, in addition to improve the ventilatory function in the postoperative period[1,6,7]. Techniques such as deep inspiration (DI), incentive spirometry (IS) and positive airway pressure exercises result in the generation of a persistent increase in the transpulmonary pressure, with consequent expansion of collapsed alveolar units to prevent and/or to treat the post-operative complications[8]. The Incentive spirometry has been widely used in clinical practice, especially in the management of patients in the pre and post-operative stay of major surgeries, because of its low cost, easy availability and good compliance of patients to the method[9,10]. Despite the modernization of the procedures used in cardiac surgery, pulmonary function is still impaired[11]. After surgery, patients are more susceptible to developing respiratory complications. About 65% of patients develop atelectasis and 3% catch pneumonia[12]. For this reason, the different respiratory therapy techniques have an important role to prevent or

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reduce such complications[13].

Although literature review on the subject could not provide any tangible evidence that supports use of any specific physiotherapy technique in preventing or minimising the PPCs. We have evaluated whether patient education in IS 3 days before the surgery plays any role in decreasing the PPCs or not. The objective of the study was to evaluate the efficacy of pre-operative incentive spirometry (IS) vs No IS before open heart surgery for the prevention of postoperative pulmonary complications (PPCs). The results of this will help in improving our institutional best practices to optimise of the cardiac surgical patients pre-operatively.

MATERIAL AND METHODS

Ethical approval for this study was taken from Institutional Review Board (IERB) AFIC/NIHD, Rawalpindi. The study was designed as a comparative analytical study. Eligible patients were consecutive elective adult patients who underwent open heart surgery from November 2015 to January 2016. Written informed consent was obtained from all patients after satisfying their concerns. The study participants were divided into two groups depending on their use of spirometry technique. Incentive Spirometer (IS) group consisted of the patients who were educated in the use IS 3 days before surgery; they were able to generate an inspiratory effort of around 900 ml one day before surgery. No IS (NIS) group consisted of participants who were provided with IS in cardiac Intensive Care Unit (CICU) after the surgery. All elective CABG surgery patients were included in the study except any patient who was American society of anesthesiologists (ASA) class > III, age >70 years, undergoing emergency surgery, poor left ventricular function (left ventricular ejection fraction <40%), valvular heart disease (any disease process involving one or more of the valves of the heart), any patient requiring a reoperation, renal impairment (elevated serum creatinine >2.4 mg/dl), and significant pulmonary disease as defined by preoperative FEV1 or forced vital capacity (FVC) values < 50% of the predicted value, re-ventilated, required IABP, having BMI >35, COPD or the patient who developed delirium/ confusion and who were unable to perform effective IS.

All the patients underwent standard intra-operative anaesthesia management as per the institutions guidelines and shifted to CICU still intubated for post-operative management. They were extubated after they fulfilled a set protocol

Table-1: Demographic as well as clinical date for comparing the IS vs NIS group, LVEF= Left ventricular ejection fraction, CPB= cardiopulmonary bypass.

Variables	IS GROUP (n=61)	NIS Group (n=60)	*p*-value
Age (mean + SD) years	55 ± 9	56 ± 11	0.91
Height (mean + SD) cm	164 ± 9	158± 11	0.41
Weight (mean + SD) kg	71 ± 14	71 ± 11	0.82
LVEF (mean + SD) %	51 ± 8	52 ± 9	0.53
CPB Time (mean + SD) mins	107 ± 59	103 ± 30	0.70
Cross Clamp Time (mean + SD) mins	61 ± 31	62 ± 23	0.92

Table 2: Comparison of Important clinical findings between IS group Vs NIS group.

Variable	IS Group	NIS Group	*p*-value
Inspiratory volume at first attempt with IS (mls) [mean ± SD]	300 ± 150	200 ± 45	0.03
Inspiratory volume at first 24 hours (mls) [mean ± SD]	600 ± 125	350 ± 150	0.04
Pleural Effusion (n)	3 (4.1%)	4 (6.6%)	0.29
Atelectasis (n)	4 (6.5%)	7 (11.6%)	0.38
Requirement of NIV (n)	8 (13.1%)	11 (18.3%)	0.44
CICU Stay (hours) [mean ± SD]	34 ± 23	44± 27	0.42
Ventilation Time (hours) [mean ± SD]	8 ± 6	9 ± 7	0.47
Mortality (n)	1(1.6%)	1 (1.6%)	0.50

for extubation which included adequate gas exchange (PaO2 > 70 mmHg, FIO2 < 0.4, PaCO2 = 35–40 mmHg, and spontaneous RR < 25), hemodynamic stability (i.e. adequate cardiac output, controlled arrhythmias, and no pulmonary edema), correction of any acid-base abnormality and absence of bleeding.

Data was collected in CICU 24 hours after the surgery. A research Officer of CICU /primary investigator was responsible for collection of data by filling a data collection tool. Data collection tool was developed to measure the demographics, clinical findings and patient outcomes including complications. Data variables of clinical findings included were EF%, cardiopulmonary bypass time, cross clamp time, CICU stay, extubation time, PaO2/ FiO2 at extubation, 6 and 24 hours after extubation. Development of any PPCs during CICU stay were also recorded. Inspiratory effort was recorded by observing patients doing incentive spirometry. We used a three ball incentive spirometer, of which first ball would rise with 400 ml inspiratory effort, 2nd ball rose on more than 400 ml inspiratory effort and 3rd ball rising on more than 800 ml inspiratory volume. The average of inspiratory volume was calculated from each patient's best three attempts in both the groups. Final data was transferred into an IBM SPSS version 21.0 for further analysis. The values were expressed as mean and standard deviation and *p* values < 0.05 were considered statistically significant.

RESULTS

A total of 122 patients were enrolled in the study. IS group consisted of 61 patients while NIS group consisted of 60 patients (one patient in NIS group had to be excluded as he was found to have MR II on post-operative transthoracic Echo). Mean age of the patients was 55 ± 9 years for IS and for NIS was 56 ± 11 years. Table-1 show demographic as well as some clinical characteristics of both the groups. Is group patients had better PaO2/FiO2 ratio of 395 ± 95, 359 ± 93 and 334 ± 59 at extubation, 6 hours after extubation and 24 hours after surgery respectively than that of 317± 73, 307 ±

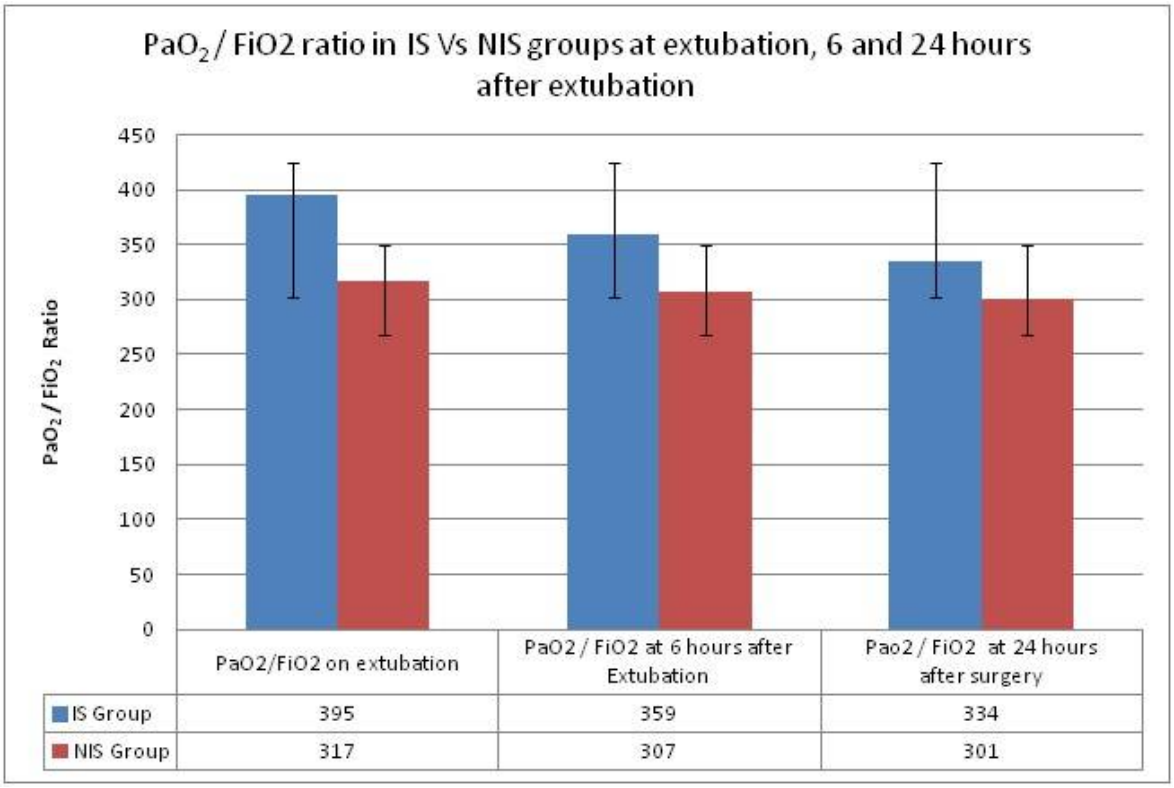

Figure-1: PaO2 / FiO2 ratio in IS Vs NIS groups at extubation, 6 hours and 24 hours after extubation. Patients in IS group had better PaO2 / FiO2 ratio than NIS group patients.

89 and 301 ± 34 in the NIS group (Graph 1).

Table-2: Comparison of Important clinical findings between IS group Vs NIS group. Only Inspiratory volume at first attempt and at[24] hours in IS group had statistically significant difference from that of the NIS group. Other clinical parameters showed some difference but it was not statistically significant.

IS group patients had better average inspiratory effort of 250 ± 100 ml vs 150 ± 75 ml of NIS group patients 6 hours after extubation (*p* value 0.03). IS group had 600 ± 125 ml of inspiratory effort while NIS group patients had 350 ± 150 ml effort 24 hours after surgery (*p* value 0.04). There were less cases of pleural effusion, atelectasis or need of non-invasive ventilation in IS group as compared to NIS group (table-2), but the difference was not found to be statistically significant (p value was > 0.05). Average length of stay in ICU was 34± 23hours (median two days) in IS and in non-IS group it was 44 ± 27 (median three days) [*p*-value 0.42]. There was no significant difference in the mortality between both the groups.

DISCUSSION

After Coronary artery bypass graft (CABG), the main causes of postoperative morbidity and mortality include PPCs, respiratory dysfunction and arterial hypoxemia[7]. Therefore, there is a lot of emphasis on avoiding these complications in immediate post-operative period. Incentive spirometry (IS) is a respiratory therapy technique that uses a mechanical device (an incentive spirometer) to reduce such PPCs during immediate postoperative period. However, IS alone is not as effective as in conjunction with other physiotherapy techniques like chest physiotherapy, deep breathing manoeuvres, blow bottle exercises and early mobilization and sometimes non Invasive ventilation (NIV)[8,9]. All these techniques when combined are proven to be helpful in preventing PPCs.

We have investigated that whether educating and getting the patients well versed with the incentive spirometer renders any benefit in their post-operative recovery or not. Many international studies and two Cochrane reviews were found during review of literature which analysed the effectiveness of IS in preventing PPCs but they have come out with equivocal results. Our study is a little different in the sense that we were comparing two groups of patients one of which who were pre operatively educated / trained in doing IS for at least three days while others were given IS for the first time post-operatively. We found that the IS group patients who were trained to do the incentive spirometry preoperatively were more receptive towards this therapy and were found to have better Pao2 / FiO2 ratios in first 24 hours as compared to No IS group patients (graph-1). The patients who started IS after the surgery without any pro-operative education, struggled to generate good inspiratory effort; whereas IS group patients were a lot better than NIS group (table-2). This better inspiratory effort not only resulted in their early recovery, minimal PPCs and decrease in ICU Length of Stay (LOS). A recent Cochrane update regarding the effectiveness of IS in CABG patients suggests that there is no evidence of benefit from IS in reducing pulmonary complications and in decreasing the negative effects on pulmonary function in patients undergoing CABG. But as indicated by the reviewers the modest number of patients studied, methodological shortcomings and poor reporting of the included trials, these results should still be interpreted cautiously.

The results in our study also suggest that pre-operative training significantly improves the patient's compliance with the treatment. IS group patient tried to achieve their pre-operative level of inspiratory effort and hence resulted in good expansion of lungs, decreased cases of atelectatic respiratory complications and pulmonary oedema. This in turn decreased their ICU LOS and hospital stay. There was also reduced need of administering NIV to IS group patients as compared to Non IS group (table-2).

Our results corroborate with Weiner P et al[11] study which has concluded that lung functions can be increased significantly when incentive spirometry and specific inspiratory

muscle training are used before and after operation. Hulzebos EH[12] et al published the Cochrane database of systematic reviews in 2012 that concludes that evidence derived from small trials suggests that preoperative physical therapy reduces PPC's (atelectasis and pneumonia) and length of hospital stay in patients undergoing elective cardiac surgery which is in conformity with our findings as well.

Another Cochrane systematic review conducted by Freitas ER[13] have however found no evidence of benefit from IS in reducing PPC's and in decreasing the negative effects on pulmonary function in patients undergoing CABG whereas KatsuraM[14] et al while highlighting the limitations of the reviewed studies, have concluded in their very recent Cochrane Systematic review that preoperative respiratory therapies were associated with a reduction of postoperative atelectasis, pneumonia, and duration of hospital stay in adults undergoing cardiac and major abdominal surgery. Guimarães MM[15] have found no evidence regarding the effectiveness of the use of incentive spirometry for prevention of PPC's in upper abdominal surgery. The above mentioned studies show that available evidence of this subject right now is at best very divergent.

Agostini P and Singh S[16] in their study conclude that physiological evidence suggests that incentive spirometry may be appropriate for lung re-expansion following major thoracic surgery[17]. Despite this conflicting evidence regarding the effectiveness of incentive spirometry in CABG patients; in our clinical practice we have found that patients who try to achieve their pre-operative inspiratory effort do well in immediate post-operative period and require less respiratory and physiotherapy effort and they also face less PPCs.

CONCLUSION

IS was found to be very effective in decreasing immediate post-operative PPCs if it was started at least 3 days before the surgery. IS helps in better oxygenation in first 24 hours after open heart surgery, and ensures good inspiratory effort by the patients, which in turn results in decreased incidence of atelectatic pulmonary complications. There was less need of NIV in patients who were put on IS; hence decreasing their CICU LOS. Although many international studies have come up with conflicting evidence but we recommend educating patient in doing IS at least 3 days before the surgery and introducing IS therapy as soon as possible in the post-operative period to minimise risk of PPCs in immediate post-operative period.

Limitation of Study

Our study was limited in respect that sample size was only 122 patients. Our study did not evaluate the long term benefits of IS or its effects on in-hospital morbidity / mortality. A large sample multicentre study with appropriate design is recommended to conclusively establish its benefits.

CONFLICT OF INTEREST

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; or other equity interest), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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AUTHORS CONTRIBUTION

Rehan Masroor, study design, result interpretation and manuscript writing, Muhammad Bakhsh, study design and manuscript writing, Umair Younus, data interpretation, Safdar Ali Khan, result interpretation and literature review, Iftikhar Ahmed, Kaleem Ahmad, Interpretation of results, Rehana Javaid, data analysis.

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