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Effect of Pulmonary Strategies on Pulmonary Function, Dyspnea and Pain among High Risk Patients Post Open Heart Surgery

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Abstract: Background: Open heart surgery is one of the recommended treatments for cardiovascular disease. Post open heart surgery, patients experience moderate to severe dyspnea, pain and hypoxemia. **Purpose**: To evaluate the effect of pulmonary strategies on pulmonary function, dyspnea and pain among high risk patients post open heart surgery. **Setting**: Current research was conducted at the Cardiothoracic Surgical Intensive Care Unit (ICU) and Cardiothoracic Surgical Department in Menoufia University Hospital. **Sample**: A purposive sample of sixty patients was obtained. **Design:** A Quasi-experimental design was used. **Instruments:** 1) Demographic and Medical Data Questionnaire; 2) Visual Analogue Pain Scale (VAS); 3) Dyspnea Severity Score Scale; 4) Bio physiological Measurements. **Results**: There was a highly statistically significant improvement in the total mean score of pulmonary function (FVC, FEV1, and FEV1/FVC) in the study group compared to the control group ($P < 0.000$) post-intervention. After the intervention, the study group experienced significantly lower severity of dyspnea than the control group ($P = 0.001$). Additionally, the study group exhibited significantly reduced mean pain intensity scores compared to the control group ($P = 0.001$) post-intervention. **Conclusion:** Pulmonary strategies are effective in improving pulmonary function, reducing dyspnea episodes and pain intensity post open heart surgery. **Recommendation:** Using pulmonary strategies as a routine hospital care to improve pulmonary function, dyspnea and pain post open heart surgery.

***Keywords**: Dyspnea, pain, post open heart surgery, pulmonary strategies and pulmonary function.*

Introduction

Globally, Cardiovascular Disease (CVD) is the primary cause of death. Approximately 620 million of the 8 billion impacted in 2023 have heart and circulatory disorders. Universally 1 in 13 individuals worldwide suffer from cardiac or circulatory disease. About 20.5 million deaths occurred in 2021 that's around 56,000 deaths a day, or one death every 1.5 seconds (British Heart Foundation, 2023).

One of the recommended treatments for Coronary Artery Disease (CAD) is open heart surgery. CABG surgery is one of the most common methods of open heart surgery (Shah et al., 2020). Every year, nearly 230 million open heart operations are performed worldwide. After open heart surgery patients face risks of Post-operative Pulmonary Complications (PPCs). These complications encompass respiratory issues like infections, pneumonia, and respiratory failure. Post-operative pulmonary complications are the primary cause of mortality and morbidity post open heart surgery (Chaudhary et al., 2020).

Risk factors for PPCs following heart surgery have been repeatedly found to include advanced age, obesity (body mass index), smoking, high pulmonary artery pressure (PAP), diabetes mellitus, abnormal pulmonary function test results, chronic obstructive pulmonary disease (COPD), and emergency surgery. COPD has been the most commonly found respiratory risk factor for PPCs, with an incidence of postoperative complications ranging from 26% to 78% in various studies (Sadeghi etal., 2023).

Reductions in lung volumes and oxygenation decrease in the first days following open heart surgery. Lung function is adversely affected by the consequences of the median sternotomy, cardiopulmonary bypass, dissection of the internal mammary artery, and hypothermia for myocardial protection. Following surgery, the effects of general anesthesia, intubation, and analgesia negatively impact mucociliary clearance (Gilani et al., 2021). . Coughing will be less effective when lung volumes are diminished, as they are during the postoperative period, because expiratory flow rate and lung volume are closely correlated. Pulmonary function may be impacted by poor breathing, immobility, inadequate patient cooperation, and the lack of a typical coughing motion and sigh mechanism (Chaudhary et al., 2020).

Anesthesia administered during open heart surgery can significantly impact the pulmonary function and increasing the risk of post-operative pulmonary complications. A noteworthy consequence is the substantial decline in Functional Residual Capacity (FRC) resulting from elevated abdomen pressure in supine position and altered respiratory muscle function (Alaparthi et al., 2021). Post-operative pain also causes shallow breathing, which lowers FRC and inspiratory volumes and increases the risk of pneumonia and atelectasis. Inspiratory volumes are further constrained during anaesthesia by decreased pulmonary compliance and compromised diaphragm and chest wall movement. Deep inspiration and efficient coughing may be difficult to accomplish as a result of the anxiety and postoperative pain from the heart surgery. This eventually leads to the accumulation of secretions and alters gas exchange (Kotta & Ali, 2021; Hennawi et al., 2023).

Patients undergoing open heart surgery are more susceptible to physiological and psychological responses of pain. Open heart surgery is an incredibly unpleasant process because of the median sternotomy, tissue injury, and inflammation in the area of the incision, sternal protracted retraction, and mediastinal tube inseration, following open heart surgery, so the most common symptom that patients report is pain. Even with increased attention from around the world, managing pain remains one of the biggest problems in intensive care units. The experienced pain degree is higher than estimated and painkillers are not prescribed enough (Elsayed et al., 2024).

Post-operative pulmonary complications continue to be a significant contributor to morbidity, mortality, higher hospital stays, and greater costs following heart surgery (El-Reabai et al., 2023). Dyspnea post open heart surgery is the seventh most frequent and a significant complaint in the early postoperative period. Predicting high-risk patients for dyspnea caused by PPCs and developing strategies to reduce these risks are valuable pursuits. The most common cause of dyspnea is atelectasis with pleural effusion and pneumonia being subsequent common cause among patients needing early postoperative consultation with a pulmonologist. Patient with dyspnea had a prolong ICU length of stay and hospitalization (Zerang et al., 2022).

Pulmonary strategies are a preventative measure for respiratory protection for patients undergoing cardiac surgery. Pulmonary strategies can be utilized post cardiac surgery to improve ventilation-perfusion inequalities, increase pulmonary compliance, and help reinflate collapsed alveoli. Pulmonary strategies have been increasingly utilized as a multimodal program for the respiratory protection which includes coughing and deep breathing exercises, incenitive spirometry, energy conservation techniques and airway clearance training. Studies have shown that pulmonary strategies not only improve the management of patients' symptom but also prevent postoperative complication and saves healthcare costs (Zhou, et al., 2023).

Coughing and deep breathing exercises with incentive spirometry is one of the beneficial pulmonary strategies that suitable and economical non-pharmacological methods for both pain relief and PPCs prevention. It promotes better gas exchange, tissue perfusion, and lung expansion. Another device that encourages deep breathing and aids in inflating collapsed alveoli is incentive spirometry, which helps to improve lung function following open heart surgery (Alwekhyan et al., 2022).

Coughing and deep breathing exercises alternative with incentive spirometry raises oxygen saturation, expands breathing volume, and strengthens respiratory muscles. Incentives spirometry is also inexpensive and simple to use. Due to these numerous benefits, incentive spirometry is applied in clinical settings all over the world for patients scheduled for open heart surgery (Rodrigues et al., 2021).

Coughing and deep breathing exercises and incentive spirometry are used to treat or prevent atelectasis; deep breaths promote removal of secretions and opening up the collapsed lung areas. Also, it softening respiratory discharge, prevent the accumulation of mucus and fluid in the lungs, protect against pneumonia and other dangerous lung infections, keep lungs healthy if patient's bedridden by managing the symptoms of lung diseases, particularly thoracic and abdominal surgery. Through encouraging the patient to breathe deeply and slowly, incentive spirometry simulates the natural sighing movement (Rodrigues et al., 2021).

Critical care nurses should help patients undergoing open heart surgery especially in the first 72 hours' post-operative when complications are most likely to arise. Utilizing alternative pulmonary strategies, including coughing and deep breathing exercises with incentive spirometry, presents a viable option for critical care nurses to improve pulmonary function, expands breathing volume facilitate patients' recovery and increase anticipated favorable outcomes. Critical care nurses can apply the coughing, breathing exercises, chest physiotherapy and incentive spirometry are the most beneficial strategy for avoiding postoperative complications especially for patient at high risk and preventing patients pain and maintaining comfort. These methods are easy to use and may be acceptable to the patients and nurses, also are capable of implementing them independently (Alaparthi et al., 2021).

Significance of the study

Although open heart surgery has been shown to increase survival and enhance ventricular function, there is a chance that the procedure will result in pulmonary complications afterward especially among high risk patient, including pneumonia, atelectasis, respiratory failure, pneumothorax, or bronchospasm. Despite a recent decline in the worldwide death rate from these problems, patient morbidity remains a major factor, leading to extended hospital stays that have an adverse effect on patients and raise medical costs. A lot of pulmonary strategies are suitable and inexpensive method for PPCs prevention. Pulmonary strategies are including the use of both Deep breathing exercises and coughing exercise and Incentive spirometry (Chaudhary et al., 2020).

Incentive spirometry devices are being offered as alternative therapy method in recent research to help facilitate and improve the mobilization of mucus from airways, which can lead to greater lung ventilation and improved pulmonary function. These devices provide adequate airway clearance, effective breathing capacity, and safety. Also, deep breathing exercises enhance postoperative lung expansion and decrease pulmonary problems (Chaudhary et al., 2020; Amin et al., 2021).

Coughing and deep breathing exercises and incentive spirometry, offers significant advantages for respiratory system, particularly after surgery or during recovery from illness. This combination promotes lung expansion, enhances oxygenation, and aids in clearing mucus, reducing the risk of pulmonary complications such as pneumonia. Additionally, it helps improve overall lung function and encourages patients to engage actively in their recovery, fostering a sense of empowerment and responsibility for their health. By integrating these techniques, patients can achieve better outcomes and a quicker return to normal activities (Zerang et al., 2022; Gugnani, 2020). Thus, the current study aimed to evaluate the effect of pulmonary strategies on pulmonary function, dyspnea and pain among high risk patients post open heart surgery.

Purpose of Study

The purpose of the current study was to examine the effect of pulmonary strategies on pulmonary function, dyspnea and pain among high risk patients post open heart surgery.

Definitions of Variables

- **High-risk patients**: are theoretically defined as individuals who have a higher likelihood of experiencing serious health complications or adverse outcomes due to their medical condition or other contributing factors, such as chronic diseases (e.g., diabetes, hypertension, cardiovascular diseases, and respiratory diseases), and smoking (Chaudhary et al., 2020). In the present study, high-risk patients are operationally defined as individuals with diabetes mellitus, chronic respiratory diseases as (Asthma and COPD), obesity and a history of smoking. It was assessed by using Medical Data Questionnaire.
- **Pulmonary function**: is theoretically defined as 'noninvasive tests that show how well the lungs are working and are often considered the basis for diagnosis in many categories of pulmonary diseases. These tests measure lung volume, capacity, rates of flow, and gas exchange' (Ponce, 2023). In the present study, pulmonary function is operationally defined as an individual obtaining a forced vital capacity (FVC) score less than 80% of the predicted value, forced expiratory volume in the first second (FEV1) less than 80% of the predicted value, and an FEV1/FVC ratio less than 0.70, which are used to detect improvements in pulmonary function and was assessed by using spirometry machine.
- **Severity of dyspnea**: is theoretically defined as 'the subjective experience of breathing discomfort that consists of qualitatively distinct sensations that vary in intensity' (Gondos et al., 2016). In the present study, the severity of dyspnea is operationally defined as the score obtained by the individual on the dyspnea severity score scale. The scoring system is interpreted as follows: 0 represents no dyspnea, 1-4 represents mild dyspnea, 5-6 represents moderate

dyspnea, and 7-10 represents severe dyspnea. It was assessed by using the dyspnea severity score scale.

- **Pain Intensity**: is theoretically defined as 'an unpleasant sensory or emotional experience associated with actual or potential tissue damage' (Markfelder and Pauli, 2020). In the present study, pain was operationally defined as the score obtained by the individual on the Visual Analog Scale (VAS). The scoring system is interpreted as follows: 0 represents no pain, 1-3 represents mild pain, 4-6 represents moderate pain, 7-9 represents severe pain and 10 represents excruciating pain and was assessed by the Visual Analog Scale.
- **Pulmonary Strategies Intervention:** is theoretically defined as 'preoperative measures with inspiratory or expiratory muscle training that can be used as a preventative measure for lung protection in patients undergoing cardiac surgery. Different techniques can be utilized during this period to improve ventilation-perfusion inequalities, increase pulmonary compliance, and help reinflate collapsed alveoli' (Zhou et al., 2023). In the present study, the pulmonary strategies intervention included deep breathing and coughing exercises alternated with the use of an incentive spirometer for 10 minutes, every two hours, for three consecutive days post-open heart surgery. In this study, the effectiveness of the pulmonary strategies intervention was assessed by measuring changes in pulmonary function (e.g., FVC, FEV1, FEV1/FVC ratio) and the severity of dyspnea (using a dyspnea severity scale) pre- and post-intervention.

Research Hypotheses

1) Patients who receive the pulmonary strategies are expected to have higher capacity of pulmonary function than patients who didn't receive the intervention.

2) Patients who receive the pulmonary strategies are more likely to have fewer severity of dyspnea score compared to the control group.

3) Patients who receive the pulmonary strategies are more likely to exhibit less pain intensity than the control group who didn't receive the intervention.

4) There is a negative relationship between the improvement of the pulmonary function and severity of dyspnea.

Methods

Research Design:

A Quasi-experimental (study and control) design was used.

Setting:

The current study was conducted at the cardiothoracic surgical intensive care unit and cardiothoracic department at Menoufia University Hospital in Menoufia Governorate, Egypt.

Sample:

A purposive sample of 60 participants undergoing open heart surgery. These patients fulfilled the following criteria: (a) adult, aged from 18 to 65 years old, (b) alert, able to communicate; c) extubated within 4-6 hours after open heart surgery; d) hemodynamically stabile patients. Patients were excluded if they had infectious disease, chronic debilitating or terminal diseases and psychiatric disease or mental disabilities because might interfere with the clinical outcomes. Patients who matched the criteria for inclusion in the study were randomly spilt into two equal groups of 30 patients each, with random assignment to each group. In addition to standard hospital treatment, coughing and breathing exercises alternatively with incentive spirometry was used to the experimental group and the control group received standard usual hospital care, which included the use of coughing and breathing exercises only.

Sample Size Calculation:

Steven (2012) equation was used to statistically compute the sample size, which came out to be 63 patients at 95% confidence power for the study. Thirty-two patients were enrolled in the intervention group and 31 patients were served as the control group. The final analysis included 30 patients who were assigned in the study group and 30 patients were allocated to the control group. The remaining 3 patients, two patients refused to take part in the research and one patient died before completing the intervention. So, the final number was 60 patients.

$$\mathbf{n} = \frac{N * p(1-p)}{[(N-1)*(d\hat{}2 \div z\hat{}2)] + p*(1-p)]}$$

Where:

N= population size through past six months (75 cases)

n= sample size (63)

Z = confidence level at 95% (1.96)

p = Probability 50% (0.5 used sample size needed)

d= Error Proportion (0.05)

Instruments

Instrument one: Demographic and Medical Data Questionnaire:

It included data, such as age, sex, type of surgery, past history, and risk factors of postoperative complication (smoking, diabetes mellitus, chronic respiratory disease and obesity). Data was obtained from the patient's medical records by the researchers at the initial data collection point.

Instrument two: Visual Analogue Pain Scale (VAS):

It is a subjective measure for intensity of pain. It was developed by McCormack et al., (1988) and revised by Couper et al., (2006). The pain scores are represented in a continuum between (0) indicated no pain and (10) indicated worst pain. The interpretation provided was as follows: (0) indicates no pain, 1-3 mild pain, 4-6 moderate pain, 7-9 severe pain and 10 indicates the worst pain. The scale's internal consistency is (Cronbach's α = 0.92). The scale's test-retest reliability is 0.97 (Alghadir et al., 2018).

Instrument three: Dyspnea Severity Score Scale:

It was developed by Johnson et al., (2016). It was used to assess the severity of dyspnea. Use a Numeric Rating Scale (NRS) to assess the severity of dyspnea. The NRS is a commonly used and effective measure to assess patient-reported dyspnea. The score range is 0-10, which corresponds to the worsening of dyspnea, with 0 being no dyspnea, 1-4 being mild, 5-6 being moderate, and 7-10 being severe dyspnea. Ask the patient to use a scale to indicate the most appropriate number of shortness of breath. A pilot study found that the NRS demonstrated good agreement in assessing the severity of dyspnea in the emergency department. A test retest method was used to test reliability of tool. The comparison is expressed through correlation coefficient alpha for it was 0.93 (Johnson et al., 2016).

Instrument four: Bio physiological Measurements:

Pulmonary Function:

the pulmonary function test which assessed [Forced vital capacity (FVC), forced expiratory volume in the first second (FEV1)] using Easy One Plus Portable Diagnostic Spirometer Machine. The American Thoracic Society/European Respiratory Society guidelines were followed during the procedure (Miller et al., 2005). Out of the three trials, the best and reproducible value was considered. The pulmonary functions were measured before intervention and post intervention for all the groups. For the concurrent validity comparison of The Spirokit, the intra-class correlation (ICC 2, 1), coefficients of variation 95% limits of agreement (95% LOA), and Cohen's Kappa Index were analyzed (Kim et al., 2024).

Validity of Instruments

In this study a panel of expertise in critical care and emergency nursing and medicine, evaluated the clarity and content validity of each instrument prior to study.

Reliability of Instruments

Reliability was assessed for instrument (1 and 2) using Cronbach's alpha (α = 0.92). Also, the reliability for instrument (3) was 0.93 and 0.95 for instrument (4).

Ethical Considerations

The Research Ethics Committee of the Faculty of Nursing give formal permission to perform the study with an assigned approval number (approval number: 877) and after explaining the purpose of the study to the hospital director, the researcher was given official permission to proceed. After being informed of the goal, technique, and benefits of the experimental procedure, a written agreement was obtained from the patient. The researcher clarified that participation in the study was completely voluntary and that they could withdraw from the study at any time without any negative impact on how they were treated. To protect the privacy and security of the patient data, it was stored in a locked cabinet.

Pilot Study

The pilot study was conducted on 10% of the study sample (6 patients) to test the practicality and applicability of the data collection instruments and estimate the amount of time needed to fulfill data collection instruments. The pilot study's subjects weren't included in the final analysis.

Procedure

- An official letter was submitted from the Dean of the Faculty of Nursing to the director of Menoufia University hospital including the purpose of the study and methods of data collection. Data were gathered over a period of 9 months, from the beginning of November 2022 to the end of July 2023.

- A total of two equal groups of 30 patients each (study and control) were randomly selected from a sample of 60 patients undergoing open heart surgery. To prevent data contamination, the researcher initially worked with the control group. For the control group; the patients received routine hospital care. The study group received pulmonary strategies intervention (incentive spirometry combined with coughing and breathing exercises) for 10 min every two hour for the first three consecutive days post open heart surgery.
- Demographic and medical data questionnaire of the participants were retrieved from the patient's medical record by the researchers. All participants were assessed by using instrument (two, three and four) pre intervention to obtain base line data and on the third day post intervention for both study and control group.
- The control group received the usual care which includes the use of coughing and breathing exercise only for five-minute every shift and changing the position every 2 hours by the bedside nurse.
- Meanwhile, for the study group pulmonary strategies intervention was implemented in combination with routine hospital care. At pre-operative (The day before surgery), the researcher interviewed the study group at cardiothoracic department and taught them how to use pulmonary strategies which include deep breathing and coughing exercise alternatively with incentive spirometry to achieve the purpose of study through demonstration and re-demonstration and using videos for more explanations. One teaching session was provided for each patient regarding the importance of deep breathing and coughing exercise alternatively with incentive spirometry pre and post-operative. Each patient was asked to show how to use an incentive spirometry and demonstrate breathing and coughing exercise. Each patient received a teaching session for 30–40 min according to patient's understanding and interactions.
- Patients in the study group received pulmonary intervention strategies intervention such as deep breathing and coughing exercise alternatively with incentive spirometry. Patients were positioned in sitting or semi-sitting and instructed to take deep, slow breaths through their nose, with hands on their chest to ease breathing and manage pain. Each inhalation was followed by a three-second breath hold before exhaling through the mouth. This cycle was repeated ten times every two hours for five minutes while awake, under researcher supervision. Patients learned specific techniques for deep inspiration, focusing on slow inhalation, breath -holding, and controlled exhalation. Relaxation was emphasized throughout the

exercises to minimize discomfort and fatigue.

- Then, the patient was instructed to rest 10 minutes and then sit up as straight as possible, not to bend the head forward or backward, and hold the incentive spirometry (IS) in an upright position. After that, the patient was asked to put the mouthpiece in the mouth and close the lips tightly around it. The patient was instructed not to block the mouthpiece with the tongue. Then, the patient was instructed to inhale slowly and deeply through the mouthpiece to raise the indicator. If the patient could not inhale any longer, the mouthpiece was removed and the patient's breath was held for at least 3 second. Finally, the patient was asked to exhale normally. These exercises consisted of 10 deep breaths, repeated every two hours for 5 minutes every session while the patient was awake, under the supervision of the researcher.
- Afterwards, patients in the study group (post-surgery) after extubation from a mechanical ventilator and once stability of patient's condition were asked to perform the pulmonary care intervention. The researcher asked each patient to perform the exercises for 10 minutes every two hours for three days, as allowed by their physician. This duration was reported to have a significant impact on improving pulmonary function, reduce dyspnea and pain in high risk patients post open heart surgery (Zerang et al., 2022).
- For both groups, pulmonary function parameters, severity of dyspnea, and pain were assessed before the intervention (as baseline) and after third day from the intervention.

Statistical Analysis

A statistical analysis was conducted on the data using SPSS version 22 on an IBM-compatible computer. Descriptive statistics, including frequencies and percentages, were used to present the data. Quantitative variables were expressed as means (x) and standard deviations (SD), and comparisons between two groups were made using an independent samples t-test. Qualitative variables were compared with a Chi-square test ($\chi 2$) to examine the association between them. The relationship between variables was assessed using Pearson’s correlation coefficient (r). A P-value of less than 0.05 was considered statistically significant.

Results

Table 1: illustrates that the Mean ± SD of age in the study and the control group are 35.60 ±7.43, 36.20 ±7.06 respectively. Regarding gender, around 60% of the experimental group as compared to 53.3% of the control group are males. About two thirds (63.3 %) of the experimental group as compared to 70% of the control group had Rheumatic Heart Disease, 66.7% of the study group and 73.3% of the control group have mitral valve replacement surgery. There is no statistical significant difference between both study and control groups regarding demographic and medical data.

Table 2: shows that 60% and 53.3% of the patients in the experimental group

and the control group suffer from diabetes millets respectively. More than half (66.6%) of the study group and 56.7% of the control group were obese. More than two thirds of (73.3 %) of the study as compared to 66.7% of control group has COPD. About 63.4% of the study group and 66.7% of the control group have heavy smoking. There was no statistical significant difference between both studied groups in relation to risk factors of PPC.

Table 3: shows that there were statistically significant differences found in the total mean score of all pulmonary function (FVC, FEV1 and FEV1/FVC) in the study group than the control group after using pulmonary strategies intervention (P=0.001). The mean FVC scores increased in the study group (64.57 ± 6.75) compared to 57.31 ± 5.22 the control group after intervention (P=0.001). Also, total mean score of EFV1significantly increased in the study group (49.05 ± 7.04) compared to 41.31 ± 6.44 the control group following intervention (P=0.001). Also, total mean score of FEV1/FVC significantly increased in the study group (87.33 ± 11.87) compared to 63.56 ± 8.77 the control group post intervention (P=0.001).

Table 4: shows that, there were statistically significant reduction in the total mean score of severity of dyspnea in the experimental group (1.10 ± .84) than the control group (3.96± .80) post intervention (P=0.001).

Table 5: demonstrates that there was a highly statistically significant decrease in the total mean pain intensity score in the study group (1.83± 1.82) than the control group (4.23 ± 1.99) post intervention (P=0.001).

Table 6: shows that there was a statistically significant negative correlation between severity of dyspnea and the pulmonary function (FVC, FEV1 and FEV1/ FVC) in the study group with (r = -0. 873, -0.826 and -0.775) and the control group with (r = -0. 965, -0.906 and -0.756) post intervention, (P< 0.01, P< 0.01 and P< 0.000) respectively, which indicated that there was improvement in pulmonary function when the severity of dyspnea was low.

Table (1): Demographic and Medical Data of Studied Groups (N=60)

Demographic and Medical Data	Study group (n=30)		Control group (n=30)		X	P Value
	N	%	N	%		
Age (years):						
▪ Range	22-49		20-50		T=0.414	0.680
▪ Mean ±SD	35.60 ±7.43		36.20 ±7.06			
Sex:						
▪ Male	18	60	16	53.3	0.685	0.420
▪ Female	12	40	14	46.7		
Past history:						
▪ Ischemic heart disease	5	16.7	2	6.7	0.638	0.424
▪ Rheumatic heart disease	19	63.3	21	70		
▪ No past history of disease	6	20	7	23.3		
Type of surgery:						
▪ Aortic valve replacement	3	10	2	6.7	0.456	0.796
▪ Coronary artery bypass	7	23.3	6	20		
▪ Mitral valve replacement	20	66.7	22	73.3		

Note: p value>0.05: not significant

Table (2): Risk Factors for Postoperative Pulmonary Complications among the Studied Groups (N=60)

Risk Factors of PPC	Study group (n=30)		Control group (n=30)		X	P Value
	N	%	N	%		
Diabetes Mellitus						
▪ Yes	18	60	16	53.3		
▪ No	12	40	14	46.7	0.435	0.412
Obesity						
▪ Yes	20	66.7	17	56.7	0.553	0.454
▪ No	10	33.3	13	43.3		
Chronic respiratory Disease						
▪ COPD	22	73.3	20	66.7	0.638	0.796
▪ Asthma	8	26.7	10	33.3		
Smoking status:						
▪ No smoking	12	40	14	46.7	0.554	0.534
▪ Mild smoker(1-10 cigarettes per day)	2	6.7	2	6.7		
▪ Moderate Smoker(11-19 cigarettes per day)	6	20	4	13.3		
▪ Heavy Smoker (20 cigarettes per day)	10	33.3	10	33.3		

Note: p value>0.05: not significant

Table (3): Effect of Intervention on Pulmonary Functions among the Studied Groups Post Intervention (N=60)

Pulmonary Function Test	Study Group (n=30) Mean ± SD	Control Group (n=30) Mean ± SD	t- test	P Value
1-FVC				
▪ **Pre intervention**	54.22 ± 6.93	55.24 ± 6.62	-0.164	0.966
▪ **Post intervention**	64.57 ± 6.75*	57.31 ± 5.22	2.618	0.001
2-FEV1				
▪ **Pre intervention**	37.80 ± 7.33	38.19 ± 6.58	-2.618	0.839
▪ **Post intervention**	49.05 ± 7.04*	41.31 ± 6.44	2.547	0.001
3-FEV1/FVC				
▪ **Pre intervention**	55.35 ± 4.72	55.28 ± 4.95	-0.766	0.446
▪ **Post intervention**	87.33 ± 11.87	63.56 ± 8.77	2.907	0.001

Note: p value<0.05: significant
Note: p<0.001: High significant

Table (4): Effect of Intervention on Severity of Dyspnea among the Studied Groups Post Intervention (N=60)

Severity of Dyspnea	Study group (n=30)	Control group (n=30)	t- test	P value
▪ **Pre intervention**	5.80 ± 1.09	5.73 ± 1.14	0.231	0.818
▪ **Post intervention**	1.10 ± .84	3.96± .80	13.42	0.001

Table (5): Effect of Intervention on Pain Intensity among the Studied Groups Post Intervention (N=60)

Pain intensity	Study group (n=30)	Control group (n=30)	t- test	P Value
▪ **Pre intervention**	6.46 ± 1.08	6.10 ± 1.21	1.273	0.208
▪ **Post intervention**	1.83± 1.82	4.23 ± 1.99	4.86	0.001

Table (6) Relationship between the Total Scores of Severity of Dyspnea and Pulmonary Function Post Intervention

Pulmonary Function	Severity of Dyspnea			
	Study Group (n=30)		Control Group (n=30)	
	r	P value	r	P value
▪ FVC	-0. 873	0.01	-0.965	0.01
▪ FEV1	-0. 826	0.01	-0.906	0.01
▪ FEV1/ FVC	- 0.775	0.000	- 0.756	0.000

Discussion

After cardiac surgery, dyspnea is the most common complain owing to respiratory disorders had a longer ICU stay than those in whom dyspnea was related to other hypoxemia, poor oxygenation pulmonary complications. Developing treatment strategies with consideration of these causes may help reduce the length of stay, morbidity, and mortality in patients with postoperative dyspnea after cardiac surgery (Shahood et al., 2022).

According to current study's hypothesis, patients who receive pulmonary strategies interventions are expected to have improvement in their pulmonary function than the control group who don't receive the intervention. The study's results supported this hypothesis, showing a highly statistical significant improvement in the mean scores of pulmonary function (FVC, FEV1, and FEV1/FVC) post-intervention in the study group, compared to the control group who received standard hospital care. These findings are consistent with those of Zerang et al., (2022) who found that incentive spirometry combined with deep breathing exercises and coughing significantly improved the mean score of pulmonary function (FVC, FEV1 and FEV1/ FVC) than the control group post intervention.

Also, these findings are in the same line with those of Shahood et al., (2022) who examined the impact of incentive spirometry and chest physiotherapy on lung function in patients undergoing heart surgery and found that the study group had significant improvement in lung function than control group. Similar finding with Murata et al., (2021) who found that postoperative FVC, FEV1 in the study group enhanced post intervention compared to control group. This finding is corroborated by Toor et al., (2021) who evaluated the effect of preoperative is with coughing and deep breathing exercises for inhibiting post-operative pulmonary complications in patients undergoing open heart surgery: a prospective randomized controlled trial and found that there was a highly statistically significant improvement in pulmonary functions post-intervention in the intervention group than the control group.

Furthermore, the present research's findings are consistent with those of Gilani et al., (2021) and Oshvandi et al., (2020) who reported that breathing exercise protocols including directed maneuvers, coughing, deep breathing exercises and incentive spirometry significantly improved FVC and FEV1 post- open heart surgery.

However, Monisha and Muthukumar (2018) found no statistically significant difference regarding pulmonary function between IS group and control group in patients post open heart surgery. The explanation for this finding may be due to the nature of the illness and the fact that the majority of the sample had chronic respiratory diseases such as asthma, chronic bronchitis and respiratory infections. These conditions can impair airflow to and from the lungs, causing the lungs to retain too much air and take longer to empty.

For the effect of pulmonary strategies on severity of dyspnea, the current study demonstrated a statistically significant decrease in the mean severity of dyspnea scores in the experimental group than the control group post-intervention. The findings supported the hypothesis of the present study that patients who receive pulmonary strategies are more likely to have a decrease in severity of dyspnea scores compared to patients who don't receive the intervention. El-Reabai et al., (2023) who examined the impact of postoperative incentive spirometry on dyspnea severity among patients undergoing CABG and found a significant reduction in the severity of dyspnea in the experimental group than the control group post-intervention. In addition, this result is comparable to that of Hennawi et al., (2023) and Alwekhyan et al., (2022) who compared the effects of coughing and deep breathing exercises in addition to incentive spirometry on severity of dyspnea and found that the research group's total mean score of dyspnea was significantly lower on the second and third days than control group post intervention.

Additionally, Murata et al., (2021) and Zarbock et al., (2020) showed that after using incentive spirometry with deep breathing exercise, the total mean score of severity of dyspnea was statistically significant decreased in the research group compared to the control group. The study's results also correspond to those of Feizi et al., (2020) who reported that after using incentive spirometry and deep breathing exercise, the mean score of severity of dyspnea significantly changed from moderate to mild to nonexistent in the study group than the control group post intervention, which indicates that early intervention, increased IS practice, chest physiotherapy, deep breathing and cough exercises all contributed to decrease in the severity of dyspnea.

However, the current study finding different with those of Sorour et al., (2019) who evaluated efficiency of IS on severity of dyspnea among patients undergoing open heart surgery and found that IS had limited effect on severity of dyspnea in both groups post intervention. A potential reasoning of Sorour’s research findings can be related to the small sample size and the heterogeneity of the critically ill patients who participated in his study.

In relation to the effect of pulmonary strategies on pain intensity, there was a statistically significant decrease in the pain intensity in the intervention group compared to the control group, who received standard hospital care. This result is similar to Barkhordari-Sharifabad and Zerang, (2022) who investigated the impact of incentive spirometry and breathing exercise on pain intensity after open heart surgery and found that pain intensity significantly reduced in the experimental group compared to the control group after intervention.

This finding is in the same line with Sweity et al., (2021) who investigated the impact of breathing exercise and incentive spirometry on pain intensity among ICU patients post open-heart surgery lasting more than 72 hours and found that the pain intensity was significantly lower in the research group than in the control group. Additionally, Toor et al., (2021) observed that after the intervention, the pain intensity was statistically significant lower in the experimental group than the control group post intervention. The study's findings also correspond to those of Manapunsopee et al., (2020) who reported statistically significant decrease pain intensity in the experimental than the control group, which indicates that early encouragement to do coughing and breathing exercise with incentive spirometry also reduces pain and improves pain control post intervention. The researcher explained that decreased pain intensity allow patient to breath normally and therefore decreased severity of dyspnea.

However, the results of this study different from those reported by Monisha and Muthukumar (2018) who found that active cycle of breathing technique did not significantly reduce pain intensity Post CABG. A possible explanation of Monisha and Muthukumar's results may be due to the intervention exclusive focus on deep breathing exercises only 3-5 breaths every shift.

Considering the correlation between severity of dyspnea and pulmonary function, there was a statistically significant correlation between the severity of dyspnea and pulmonary function and a statistically significant correlation was found between the mean score of dyspnea and the mean score of FVC, FEV1 and FEV1/ FVC (Murata et al., 2021; Franco et al., 2021).

Limitation of the study: -

- Participants were selected from a single hospital; thus, findings should be interpreted carefully.

Conclusion

Based on the result of the present study, it can be concluded that postoperative pulmonary strategies can be recognized as a simple, effective, noninvasive, non-pharmacological intervention that significantly improve pulmonary function, decrease the severity of dyspnea, and pain intensity post open heart surgery.

Recommendations

Based on the findings of the current study, the following is recommended:

- It is suggested that postoperative incentive spirometry combined with coughing and deep breathing exercises could be one of the main nursing interventions for open heart surgery patients. Continuing training for critical care nurses to practice proper technique of incentive spirometry and coughing and deep breathing exercises to improve pulmonary function, oxygenation and dyspnea.
- Replication of this study using a larger probability from various Egyptian geographic locations to enhance the generalizability of the findings.
- Investigate the long-term impacts of deep breathing and both flow and volume-oriented spirometers, assessing diaphragmatic muscle strength and enhance breath with less effort.

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