Effect of Deep Breathing Exercises on Pulmonary Functions after Cardiac Surgery

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ABSTRACT

Background: Postoperative pulmonary complications (PPCs) are common after cardiac Surgery. They are a major contributor to morbidity, compromise oxygenation, extend hospitalization, and raise death. **Aim:** The present study aimed to evaluate the effect of deep breathing exercises on pulmonary functions after cardiac surgery. **Subjects and Method: Design:** A Quasi experimental design was used. **Setting:** The study conducted in intensive care units of cardiac surgery and surgical wards settings at Al-Nasr specialized hospital in Port Said Governorate and Damietta cardiac and gastrointestinal center in Damietta Governorate. **Subjects:** It included a purposive sample of 74 patients post-operative cardiac surgery. **Tools:** Four tools were used for data collection consisted of; medical and surgical history assessment in addition to patient sociodemographic characteristics, Pulmonary functions assessment, Melbourne Group Scale Version II, and Observational checklist for deep breathing exercises. **The Results**: There were statistically significant differences between pre and post applying deep breathing exercises regarding all pulmonary functions after cardiac surgery with P-Value of (<0.001). **Conclusion**: There was statistically significant relation between the studied patients' BMI, education, and health habits and post patients` education regarding applying deep breathing exercises. Furthermore, there was statistically significant relation between deep breathing exercises and pulmonary functions after cardiac surgery. **Recommendations**: Further research is necessary to design and implement educational programs for critical units' nurses regarding importance of applying deep breathing exercises for patients after cardiac surgery to enhance pulmonary functions and prevent pulmonary complications.

***Keywords*:** Cardiac surgery, Deep breathing exercise, Patient, Pulmonary function.

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INTRODUTION

Cardiac disease and coronary artery disease (CAD) are a very dangerous. The World Health Organization (WHO) states that coronary heart disease CHD is the cause of death with a rapidly increasing number of 6.7 million cases (WHO, 2019). Based on data from the 2019 Basic Health Research results, shows a prevalence of 1.5% (Arrafi, et al., 2022).

Cardiac surgical procedures are performed if treatment through a healthy lifestyle and pharmacology is no longer feasible (Cleveland Clinic, 2022). In the cardiac surgery population, measurable derangements in pulmonary function occur in almost all patients, and approximately 10–25% develop postoperative pulmonary complications (PPCs) requiring substantial healthcare resource utilization (Girgin, Ciğerci, & Yaman, 2021). These complications prolong postoperative hospitalization and impose increased financial and psychological burdens on patients and society. Breathing disorders can result in irreversible cardiac complications and increase postoperative mortality (Jafari, et al., 2023).

Reasons for this impairment include general anesthesia, opening of the thorax, surgical trauma, cardiopulmonary bypass, loss of thoracic mechanics, increased interstitial lung water, pleural effusions and diaphragmatic dysfunction. In addition, immobilization and fear may also affect pulmonary function (Bulut, & Karabulut, 2023).

Postoperative pulmonary complications include atelectasis, arterial hypoxemia, pneumonia ,respiratory failure, prolonged use of a ventilator, pleural effusion, and pulmonary edema (Chaudhary, Chaudhary, Ghewade, & Mahajan, 2020). For the prevention and treatment of postoperative pulmonary complications, breathing exercises is routinely used, after cardiac surgery. The main aim of breathing exercises is to improve ventilation–perfusion matching, increase lung volume, enhance mucociliary clearance and decrease pain (Kinas, & Bilgic, 2024).

Breathing exercises are cost-effective techniques with minor complications, aiming to improve the respiratory condition. The most common breathing exercises are deep breathing, effective coughing, pursed-lip breathing (PLB), diaphragmatic

breathing, respiratory muscle training (RMT), and incentive spirometry (Vitomskyi, Al-Hawamdeh, Lazarieva, & Vitomska, 2020).

While Amin et al. (2021) asserted that postoperative breathing techniques include many techniques such as early mobilization, positioning, breathing exercises, splinted coughing or huffing, percussion, vibration, active cycle of breathing techniques (ACBT) and also the use of different mechanical devices such as the incentive spirometer (IS), positive expiratory pressure mask therapy and continuous positive airway pressure.

These exercises enhance the respiratory tract function, strengthen respiratory muscles, improve thoracoabdominal movements ,increase lung volume, clear the lungs from secretions ,and manipulate breathing patterns, e.g., by reducing the breathing rate and abdominal breathing and breathing through the nose instead of the mouth (Oshvandi, et al., 2020).

The positive effect of breathing exercises on postoperative atelectasis, arterial oxygen saturation (SpO2), and pulmonary function (Wu, et al., 2020). Deep breathing exercises (DBE) are performed to initiate diaphragmatic descent during inhalation and diaphragmatic ascent during exhalation. When performing diaphragmatic breathing the patient inhales, the air reaches the alveoli, it reverses the post-operative hypoxemia which is the result of the anesthesia, improves the ventilation and oxygenation, reduces the work of breathing as the muscles of the neck and the shoulders relax, and also increases the excursion of the diaphragm. It performed for 3 sets of 10 breaths to bring about an effect in the diaphragmatic breathing exercise group in his study (Azizi, et al., 2020).

Compared to other health care professionals in the multidisciplinary team, nurses have the opportunity to observe the patients continuously. Therefore, they have better chances to notice the changes in patients at the early stages. They monitor vital signs, changes in airway obstruction, and identify the complications that develop and provide the necessary equipment and patient care (Girgin, et al., 2021).

Nurses hold a very unique position on the management of the symptoms and providing optimal care for the patient. Planning, implementing, and evaluating

appropriate nursing activities to solve patients' respiratory problems and basic interventional practices such as aspiration, oxygen therapy, body positions, and postural drainage defined the duties, authorities, and responsibilities of nurses, and nurses are expected to implement these applications. Furthermore, it is a known fact that there is a direct correlation between the quality of care provided by nurses and patient outcomes (Moneruzzaman, Sun, Changwe, & Wang, 2023).

Significance of the study

Cardiac surgery patients often develop a restrictive pulmonary impairment and gas exchange abnormalities in the early postoperative period (Lagier, Zeng, Fernandez-Bustamante, & Vidal-Melo, 2022). In Egypt, a mean 1,533 cardiac surgery cases per year were performed during the last 3 years with mean of 170.3 per center among 9 major cardiac surgery centers (Elkhayat, et al., 2022).

Cardiac surgery may lead to several complications, mainly induced by sternotomy and extracorporeal circulation, such as respiratory muscle weakness, reduction in pulmonary function, and pulmonary infections, especially in the immediate postoperative period, which comprises the first hours after surgery until hospital discharge (Mera, Wilches & Benavides-Cordoba, 2024). Pulmonary complications after cardiac surgery are a significant cause of postoperative morbidity. Patients develop restrictive respiratory abnormalities with reduced lung volumes and impaired gas exchange in the early postoperative period (Overbeek, et al., 2024).

Postoperative pulmonary complications (PPC) remain a main issue following cardiac surgery. PPC defined as the occurrence of at least one pulmonary complication among following: atelectasis, pleural effusion, respiratory failure, respiratory infection, pneumothorax, bronchospasm, aspiration pneumonitis. Among 676 analyzed patients, 373 patients presented a PPC 55% (Fischer et al., 2022).

Postoperative pulmonary complications (PPCs) are more common than postoperative cardiac events, but universal guidelines about prevention and patient optimization are lacking in this field. A systematic review found that PPCs occur in roughly one in eight patients undergoing surgery, which leads to over two-thirds of inpatient postoperative deaths. Extrapolation of data from more than 400 hospitals

shows that over 1 million PPCs and nearly 50,000 deaths occur annually across the United States (US) due to development of respiratory complications after surgery (Sigona, & Richman, 2023).

As stated, pulmonary complications are an unavoidable complication following CABG surgery. Various studies have shown a different outbreak in patients ranging from 3 to more than 50%. However, the occurrence of pulmonary complication following cardiopulmonary bypass surgery is a multivariate outcome that should be studied according to the preoperative, perioperative and postoperative (Mali, & Haghaninejad, 2019). Therefore, this study aims to evaluate the effect of deep breathing exercises on pulmonary functions after cardiac surgery.

AIM OF THE STUDY

Evaluate the effect of deep breathing exercises on pulmonary functions after cardiac surgery.

Objectives

1. Assess postoperative pulmonary functions after cardiac surgery.
2. Apply deep breathing exercises for patients after cardiac surgery.
3. Find out effect of deep breathing exercises on pulmonary functions after cardiac surgery.

Research question

What is the effect of deep breathing exercises on pulmonary functions after cardiac surgery?

SUBJECTS AND METHOD

A. Technical design

This design includes a description of the research design, setting, subjects, and tools of data collection.

Study design

A Quasi experimental research design (one group pre- and post- applying deep breathing exercises) was utilized to meet the aim of this study.

Study setting

The study was conducted at Al-Nasr specialized hospital in Port Said Governorate and Damietta Cardiac and Gastroenterology Center in the Damietta Governorate at intensive care units' and surgical ward settings. Al-Nasr specialized hospital in Port Said Governorate which has one intensive care unit after cardiac surgery that is consists of five beds and one surgical ward that is consists of fourteen beds. Damietta cardiac and gastrointestinal center in Damietta Governorate which has one intensive care unit after cardiac surgery that is consists of ten beds and one surgical ward that is consists of fourteen beds.

Subjects

A purposive sample of 74 adult postoperative cardiac surgery patients in previous mentioned settings excluding patients with altered level of consciousness, mental health disorders, postoperative hemodynamic instability, patients with disabilities and patients with past and present history with respiratory disorders.

Sample size

The sample size was calculated using g power software with power 0.80 and significant level 0.05 and effect size 0.33 (Fatima and Kazmi, 2021) given 74 participants (Faul, Erdfelder, Lang & Buchner, 2007).

Tools for data collection

Four tools were used for data collection:

Tool 1: **Medical and surgical history questionnaire**

This tool was developed by the researcher based on reviewing recent, relevant and related literature by Abdelbaky, Mohammed, and Mobarak, (2020); Abd-

Elmalek, Abdel-Aziz, Khalaf, and Taha, (2019) to asses present medical history as diagnosis and actual complaints and past medical history as cardiovascular, respiratory, renal, neurological, hematological, cancer and other medical diseases and past surgical history e.g., Abdominal surgery and previous cardiac surgery. In addition, patient socio-demographic characteristics as age, gender, BMI, education, marital status, income, working status and smoking history.

Tool II: Pulmonary functions assessment

This tool was developed by Oshvandi et al., (2020) in an English language to assess pulmonary functions and it include four parts. **Part one** is arterial blood gases test to assess PH, PaO2, PaCO2, HCO3, SaO2, **part two** is respiratory pattern_as eupnea, tachypnea, bradypnea, apnea, hyperpnea, Cheyne-stokes, Biot`s, Kussmaul`s, Apneustic). **Part three** chest sound (as normal chest sound, wheezes and crackles) and **part four** is reported chest X-ray results as hemothorax, pneumothorax and atelectasis that referred to patients record.

Tool III: Melbourne Group Scale Version II

This scale was adopted from Lugg et al., (2016); Li et al., (2018) in an English language to assess criteria for diagnosis of a post-operative pulmonary complications which consists of eight items, diagnosis that confirmed when four or more of the following items are present. These items are chest radiograph report of consolidation/collapse, raised temperature >38 ◦C on two or more consecutive days, SpO2 less than 90% on room air on two consecutive days, Production of yellow or green sputum which is different to pre-operative assessment, An otherwise unexplained white cell count $>11 \times 10^9\ L^{-1}$ or prescription of an antibiotic specific for respiratory infection, Physician diagnosis of chest infection, Presence of infection on sputum culture report and Abnormal breath sounds on auscultation which differ from pre-operative assessment.

Tool IV: Observational checklist for deep breathing exercises

This tool was adopted from Urell, Emtner, Hedenstrom, and Westerdahl, (2016) and it includes five items which are assisting patient to assume fowler's or

semi-fowler's position, providing and demonstrating splinting with blanket or pillow, placing hands anteriorly along lower rib cage, third fingers touching at midline, taking deep breath slowly through the nose, feeling the chest expand and hold breath for 2 to 5 seconds, then exhale slowly and completely through the mouth.

B- Operational design

The study field of work was carried out through the following phases:

Preparatory Phase

It includes reviewing of relative and recent literature related to the research topic, different studies and theoretical knowledge of various aspects of the problems using all official websites as PUBMED, GOOGLE SCHOLAR, MEDLINE database, EBESCO Cochrane Database and Scopus, Scientific books, Articles, and Periodicals as well as Nursing Centre so as to assist the researcher to be more familiar with the matter and develop the tools for data collections.

Tools' validity

The study tools that include medical and surgical history assessment, pulmonary functions assessment, Melbourne group scale version II, and observational checklist for deep breathing exercises were tested by a panel of eleven experts in the nursing field who were review the study tools clarity, feasibility, relevance, comprehensiveness, understanding and applicability.

Tools' reliability

The Cronbach alpha coefficient was calculated to assess the reliability of the developed tools to assess its internal consistency. The Cronbach's alpha value of the Pulmonary functions assessment was 0.902, and of the Melbourne Group Scale was 0.895, and of the Observational checklist for deep breathing exercises was 0.899.

Pilot Study

A pilot study was conducted before starting the actual data collection. The pilot study was carried out on 8 patients (10%) of study sample of the cardiac surgery

patients. These were not excluded from the main study sample. The purpose of the pilot study was to test the clarity, feasibility and applicability of the study tools and estimate the time needed to complete the tools. It also helped to find out any obstacles and problems that might interfere with the data collection process. Needed modifications were done based on the findings of the pilot study.

Field work

Field study Field study was conducted for eight months from the beginning of August (2022) to the end of March (2023). Data was collected four days a week (the first day after cardiac surgery for pre application of deep breathing exercises and three days after application of deep breathing exercises and observation of patients' outcomes). The study was carried out through the following four phases (assessment, planning, implementation and evaluation).

Phase I: Assessment (Pre-application phase)

First, the researcher visited the study settings and arranged with the nursing director for the actual implementation of the study, then evaluated the intensive care units' and surgical ward in the two study settings after obtaining permission from the directors of study settings. The open-heart surgery was done three times per a week, the weekly operation list included 3 cases of cardiac surgery with mean of 25 cases per month at Damietta cardiac and gastrointestinal center and was done once a day per a week, the weekly operation list included one case of cardiac surgery with mean of 20 cases per month at Port Said Al Nasr specialized hospital. Then the researcher interviewed the nurses who work in intensive care units' and surgical ward and introduced herself and explained the aim of the study for the purpose of obtaining their cooperation.

The researcher invited every patient individually to participate in the study and explained for him/her the purpose of the study. After their agreements to participate, consent was obtained to gain their cooperation. Preoperative education for patient undergoing cardiac surgery about deep breathing exercises done in surgical unites. The exercises included 10 deep breaths per hour and the instruction were to take as deep inhalations as possible, hold for seconds and then breath out.

Post-operative, the patients received in the critical care unit connected to the ventilator until the patient return to complete conscious. After extubation, the pre-test (pre applying deep breathing exercises of pulmonary functions assessment using Melbourne Group scale version II.

Phase II: Planning

In this step the researcher designed a plan for deep breathing exercises implementation and follow-up plan for laboratory examinations throughout the three days post patient weaning from mechanical ventilation. The deep breathing exercises teaching strategy was determined by selecting the appropriate teaching method which was in the form of (role play by the researcher) and selecting the appropriate teaching media which was in the form of booklet material.

Phase (III): Deep breathing exercises implementation

At the beginning, the deep breathing exercises were started approximately one hour after extubation and continued for the first three postoperative days (24 hr., 48 hr., 72 hr.). The patients were encouraged to perform the deep breathing exercises while awake (daytime). The exercises done in the fowler or semi-fowler position. The session was taken at day-time during the working shift in morning and afternoon shifts. The deep breathing exercise was done in three sessions per day, every session was included 30 deep breaths (three sets of ten deep breaths repeated every one hour).

The researcher demonstrated all the deep breathing exercises steps in front of the patients while discussing with them the rationale and the precaution for each step. Tool IV (observational checklist for deep breathing exercises) was used to assess patients' performance for steps of deep breathing exercises in every session. Patients' pulmonary functions measured every day to assess arterial blood gases test which include values of PH, PaO2, PaCO2, HCO3, SaO2 and respiratory patterns was assessed and Chest X-ray was done two times. The first time at the beginning of the first day for pre application of deep breathing exercises and the second time at the third day from applying deep breathing exercises to assess patients' outcomes after application of deep breathing exercises and it was reported by researcher from patients` records.

Phase IV: Evaluation

The deep breathing exercises outcome was evaluated using the second and the third tools:

The tool II (Patients' pulmonary functions assessment) measured every day from starting day until third day from applying deep breathing exercises to assess arterial blood gases test values of PH, PaO2, PaCO2, HCO3, SaO2 except respiratory patterns and chest x-ray was done two times. The first time at the beginning of the first day for pre application of deep breathing exercises and the second time at the last day after application.

The tool III (Melbourne Group Scale Version II) was used pre implementation of deep breathing exercises at the first day postoperative after extubation. Then, it was done at the last day to assess post-operative pulmonary complications.

Ethical considerations

An approval was taken from the Research Ethics Committee of the Faculty of Nursing, Port Said University code no. (NUR 12/12/2021) (8). The purpose of the study was explained to the participants before obtaining the written consent to share in the study. A brief explanation of the aim of the study was given to assure participants that the information obtained is confidential and used only the purpose of the study, stressing on confidentiality of the collected information. The researcher emphasized that the participations were absolutely voluntary and that each patient had the right to withdraw from the study at any time without explaining any reasons, as well as confidentiality was assured.

C. Administrative design

Official letters were directed from the Dean of the faculty of Nursing to the managers of the previous mentioned hospital requesting their cooperation and permission to conduct the study, after explaining the aim of the study. Also, patients' consent was obtained before starting data collection.

D. Statistical design

All statistical analyses were performed using SPSS for windows version 20.0 (SPSS, Chicago, IL). Continuous data were normally distributed and were expressed in mean ±standard deviation (SD). Categorical data were expressed in number and percentage. One-way analysis of variance (ANOVA) test was used for comparison among more than two for variables with continuous data. Chi-square test (or fisher's exact test when applicable) was used for comparison of variables with categorical data. The reliability (internal consistency) test for the questionnaires used in the study was calculate. Statistical significance was set at $p<0.05$.

RESULTS

Table (1) shows the distribution of the studied patients according to their sociodemographic characteristics which revealed that 41.9% of the studied patients their age ranged from 50 to 60 years old. While 63.5% of them were males. Moreover, 71.6% of studied patients` BMI was ideal. Concerning education, 47.3% of the studied patients had university degree, and 85.1% of them were married. Otherwise, 31.1% of them were an employee, and 58.1% of them had enough income.

Table (2) reported that 58.1% of the studied patients had diagnoses of valve replacement. However, 91.9% complained of shortness of breathing, especially with activity (dyspnea), 90.5% had a rapid, fluttering heartbeat (palpitation), and 73% complained of chest pain / tightness with activity. Regarding their past medical history, 83.3% of the studied patients had cardiovascular diseases. Meanwhile, 55.4% of them didn't have a major surgical history, and 17.6% of them had minor surgery.

Table (3) elaborates differences between arterial blood gases values pre and post applying deep breathing exercises among studied patients with cardiac surgery, which shows statistically significant differences between values of Pao2 and Sao2 pre and post applying deep breathing exercises.

Table (4) displays differences between respiratory patterns Pre and Post applying deep breathing exercises among studied patients with cardiac surgery, the study results found a statistically significant differences in all respiratory patterns

except Kussmaul`s, and Apneustic pattern. Regarding chest sounds, there were statistically significant differences in normal and crackle sounds (p= <0.001). Moreover, chest x-ray shows a statistically significant differences related to clear and pneumothorax (p= <0.001, 0.007).

Table (5) illustrates differences between pulmonary functions pre and post applying deep breathing exercises using the Melbourne group scale **.**That revealed a statistically significant differences between pre and post deep breathing exercises regarding chest radiograph report of consolidation/collapse, an otherwise unexplained white cell count >11 × 10^9 L^ (-1) or prescription of an antibiotic specific for respiratory infection, and abnormal breath sounds on auscultation which differ from pre-operative assessment with a p-value of <0.001 **.**Moreover, no significant differences were found regarding raised temperature >38 ◦C on two or more consecutive days, SpO2 less than 90 on room air on two consecutive days, and production of yellow or green sputum which is different from pre-operative assessment.

Table 6 portrays the differences between applying deep breathing exercises pre and post patient education how to applying deep breathing exercises. This found statistically significant differences between pre- and post- education regarding all items of deep breathing exercises with a p-value of <0.001 for each.

Table (1): Sociodemographic characteristics of the studied patients (n=74).

	n	%
Age (Years)		
< 40	10	13.5
40 – 50	24	32.4
50 – 60	31	41.9
> 60	9	12.2
Mean ±SD	50.4 ±9.4	
Body mass index (BMI)		
Ideal weight (18.5 – 24.9)	53	71.6
Overweight (equal 25 and more)	21	28.4
Mean ±SD	22.8 ±2.0	
Gender		
Male	47	63.5
Female	27	36.5
Education		
Read & write	3	4.1
Preparatory	2	2.7
Secondary	34	45.9
University	35	47.3
Marital status		
Single	3	4.1
Married	63	85.1
Widow	8	10.8
Occupation		
Employee	23	31.1
Worker	20	27.0
Retired	10	13.5
Housewife	21	28.4
Income		
Enough	43	58.1
Not enough	31	41.9

Table (2): Medical and surgical history of studied patients (n=74)

	N	%
Diagnosis		
Valve replacement	43	58.1
Coronary artery bypass grafting (CABG)	28	37.8
Both (Valve replacement and Coronary artery bypass grafting (CABG))	3	4.1
Actual complain		
Irregular heartbeats	13	17.6
Chest pain / tightness with activity	54	73.0
Feeling of faint or dizziness	38	51.4
Shortness of breathing, especially with activity (dyspnea)	68	91.9
Fatigue, especially with activity	12	16.2
Rapid, fluttering heartbeat (palpitation)	67	90.5
Swollen feet or legs	10	13.5
Past medical history		
Cardiovascular	62	83.8
Respiratory	3	4.1
Renal	3	4.1
Neurological	1	1.4
Others	23	31.1
Past surgical history (Major)		
Yes	33	44.6
No	41	55.4
Yes (n= 33)		
Abdominal surgery	31	93.9
Previous cardiac surgery	2	9.1
Past surgical history (Minor)		
Yes	13	17.6
No	61	82.4
Yes (n=13)		
Appendectomy	7	61.5
Laparoscopic cholecystectomy	1	7.7
Diagnostic laparoscopy	5	46.2

Table (3): Comparison between arterial blood gases values pre and post applying deep breathing exercises among patients with cardiac surgery (n=74)

	Pre – test (pre applying deep breathing exercises)	**Post – test (post applying deep breathing exercises)**			**One-way ANOVA**	
		24 hours post	**48 hours post**	**72 hours post**		
	Mean ±SD	**Mean ±SD**	**Mean ±SD**	**Mean ±SD**	F	P
Ph	7.39 ±0.08	7.39 ±0.08	7.39 ±0.05	7.40 ±0.03	0.691	0.558
Pao2	86.73 ±5.44	90.98 ±3.86	93.94 ±3.32	95.71 ±2.30	75.056	<0.001**
Paco2	42.65 ±10.71	42.48 ±8.56	41.67 ±7.02	40.33 ±3.45	1.334	0.263
HCO3	24.53 ±1.86	25.13 ±4.67	24.73 ±4.34	24.34 ±1.44	0.727	0.536
Sao2	96.20 ±2.10	97.19 ±1.90	97.98 ±1.30	98.44 ±1.04	26.292	<0.001**

X2: Chi-Square test **significant at P< 0.05* ***highly significant at P< 0.001*

Table (4): Comparison between Respiratory patterns, Chest sounds and Chest X-ray Pre and Post applying deep breathing exercises among patients with cardiac surgery (n=74)

	Pre applying deep breathing exercises		Post applying deep breathing exercises		Chi – Square / Fisher's exact test	
	n	%	n	%	X^2	P
Respiratory patterns						
Eupnea	11	14.9	62	83.8	70.310	<0.001**
Tachypnea	21	28.4	4	5.4	13.910	<0.001**
Bradypnea	17	23.0	3	4.1	11.331	<0.001**
Apnea	11	14.9	2	2.7	6.831	0.009*
Hyperpnea	7	9.5	1	1.4	4.757	0.029*
Kussmaul`s	3	4.1	1	1.4	1.028	0.311
Apneustic	4	5.4	1	1.4	1.863	0.172
Chest sounds						
Normal	12	16.2	64	86.5	73.135	<0.001**
Wheezing	14	18.9	8	10.8	1.922	0.166
Crackles	62	83.8	3	4.1	95.494	<0.001**
Chest X-ray						
Clear	29	39.2	54	73.0	17.146	<0.001**
Pleural effusion	11	14.9	6	8.1	1.661	0.197
Hemothorax	4	5.4	1	1.4	1.863	0.172
Pneumothorax	15	20.3	4	5.4	7.306	0.007*
Hemopneumothorax	2	2.7	1	1.4	0.340	0.560
Atelectasis	13	17.6	8	10.8	1.387	0.239

Table (5): Comparison between pulmonary functions Pre and Post applying deep breathing exercises using Melbourne group scale (n=74)

	Pre applying deep breathing exercises		Post applying deep breathing exercises		Chi – Square / Fisher's exact test	
	n	%	n	%	X^2	P
Chest radiograph report of consolidation/collapse	45	60.8	20	27.0	17.146	<0.001**
Raised temperature >38 ◦C on two or more consecutive days	29	39.2	18	24.3	3.772	0.052
SpO2 less than 90 on room air on two consecutive days	6	8.1	4	5.4	0.429	0.512
Production of yellow or green sputum which is different to pre-operative assessment	11	14.9	6	8.1	1.661	0.197
An otherwise unexplained white cell count >11 × 10^9 L^ (-1) or prescription of an antibiotic specific for respiratory infection	31	41.9	7	9.5	20.394	<0.001**
Abnormal breath sounds on auscultation which differ from pre-operative assessment	56	75.7	11	14.9	55.224	<0.001**

Table (6): Comparison between applying deep breathing exercises Pre and Post patient education how to applying deep breathing exercises (n=74).

	Pre applying deep breathing exercises		Post applying deep breathing exercises						Chi – Square / Fisher's exact test	
			1st day		**2nd day**		**3rd day**			
	N	%	n	%	N	%	n	%	X^2	P
Assist patient to assume fowler's or semi-fowler's position.	27	36.5	74	100.0	74	100.0	74	100.0	167.614	<0.001**
Provide and demonstrate splinting with blanket or pillow.	35	47.3	68	91.9	71	95.9	72	97.3	90.965	<0.001**
Place hands anteriorly along lower rib cage, third fingers touching at midline.	39	52.7	57	77.0	67	90.5	70	94.6	47.326	<0.001**
Take deep breath slowly through the nose, feeling the chest expand.	20	27.0	45	60.8	63	85.1	71	95.9	94.137	<0.001**
Hold breath for 2 to5 seconds, then exhale slowly and completely through the mouth.	19	25.7	41	55.4	58	78.4	69	93.2	82.760	<0.001**
Mean ±SD	**3.11 ±1.11**		**3.85 ±1.43**		**4.50 ±1.09**		**4.81 ±0.77**		**33.210**	**<0.001****

DISCUSSION

In patients undergoing open coronary surgery, respiratory dysfunction, including as atelectasis, restrictive ventilator malfunction, and hypoxemia, are common (Yazdannik, et al., 2019). Cardiac surgery may lead to several complications, mainly induced by sternotomy and extracorporeal circulation, such as respiratory muscle weakness, reduction in pulmonary function, and pulmonary infections, especially in the immediate postoperative period, which comprises the first hours after surgery until hospital discharge. Deep breathing exercise may significantly reduce complications induced by cardiac surgery (Aquino, Prado, Crisafulli, Clini, & Galdino, 2024). Chest physiotherapy is widely used in postoperative care to prevent pulmonary complications such as decreased lung volume, atelectasis, decreased oxygenation and pneumonia (Mera, Wilches & Benavides-Cordoba, 2024).

The main goal of postoperative breathing techniques is to mitigate potential postoperative pulmonary complications (PPCs) after heart surgery. In addition, these techniques could reduce the mortality among those patients (Shahood, et al., 2022).

Concerning the demographic characteristics of the studied patients, the present study revealed that more than two fifth of the studied patients their age group falls between 50 and 60 years old. A possible explanation is that developing and elevation in the prevalence rate of cardiac diseases is increased with advanced age. These results consist with the study by Ghorbani, Hajizadeh, Sheykhi, & Asl (2019) which entitled the effects of deep-breathing exercises on postoperative sleep duration and quality in patients undergoing coronary artery bypass graft and reported that the mean age of the patients were 56.87 years; and 54.75 years respectively. Also, the present results were corroborated by Abdelhafez, and Fouad, (2023) who studied effect of incentive spirometry on postoperative pulmonary complications and oxygenation following open heart surgery reported that that the age of the study participants was above 50 years old and the majority of them were men, married, and had graduated from high school.

Regarding body mass index (BMI), the present results clarified that more than two thirds of the studied patients' BMI was ideal. These findings may be due to pre-operative preparations such as weight loss to reduce post-operative heart surgery complications. Similarly, study done by Kinas, and Bilgic, (2024) who studied impact of breathing exercises in patients who had open heart operation on respiratory function and exercise tolerance and reported that the most of patient had normal weight. While, the present result inconsistent with Amin et al. (2021) who studied effects of three pulmonary ventilation regimes in patients undergoing coronary artery bypass graft surgery who reported that the highest mean among the studied patients had overweight scores.

Concerning education, about half of the studied patients had university degree, and the most of them were married. Otherwise, about a third of them were employee, and more than half of them had enough income. The present results similar to a study conducted by Manapunsopee, et al. (2020) entitled effectiveness of incentive spirometry on inspiratory muscle strength after coronary artery bypass graft surgery and showed that the most of the patients had university educational level and married.

Furthermore, Chaudhary et al. (2020) who studied the immediate effects of breathing exercises with acapella and incentive spirometer on preventing early pulmonary complications following CABG and revealed that the highest percentage of the patients were employee and had enough income. This funding may be due to about more than half of the studied patients are employees and workers and most of them have a health insurance so their income is enough.

Regarding health habits of the studied patients, the current findings elaborated that the most of the patients did not smoke. These results may be due to patients' understanding of the danger of smoking on pulmonary condition and the increase prevalence of post-operative complications. This result in the same line with the study by Alaparthi et al. (2021) which entitled contrasting effects of three breathing techniques on pulmonary function, functional capacity and daily life functional tasks in patients following valve replacement surgery and reported that the highest mean of patients was not smoke. Whereas, the current result disagreed with the study by Franklin, and Anjum, (2023) which entitled Incentive spirometer and inspiratory muscle training and revealed that the highest percentage of patients were ranged between quit and active smokers.

Regarding medical and surgical history of studied patients, the current results demonstrated that more than half of the studied patients had diagnoses of valve replacement. However, the majority of them complained of shortness of breathing, especially with activity (dyspnea), and had a rapid, fluttering heartbeat (palpitation), and about three quarters of them complained of chest pain / tightness with activity. These findings could be because the predominant diagnosis at the time was valve irritation. These results were consistent a with research conducted in Egypt by Ahmed et al. (2019) on "Comparison the efficacy of conservative therapy and blow bottle among open heart surgery patients for the avoidance of postoperative pulmonary problems, and revealed that the majority of individuals had rheumatic fever according to their medical histories and had surgery to replace their mitral valves.

Regarding their past medical history**,** the most of the studied patients had cardiovascular diseases. Meanwhile, more than half of them didn’t have a major surgical history of abdominal surgery. The present results consistent with Abdelhafez, and Fouad, (2023) who studied effect of incentive spirometry on postoperative

pulmonary complications and oxygenation following open heart surgery and reported that more than two thirds of patients had past history of cardiovascular diseases and the most of them had history of Mitral valve replacement surgery.

Concerning comparison between arterial blood gases values pre and post applying deep breathing exercises among patients with cardiac surgery**,** the present results demonstrated significant differences between arterial blood gases values pre and post applying deep breathing exercises among studied patients with cardiac surgery, which shows statistically significant differences between values of arterial oxygen pressure (PaO2) and oxygen saturation (SaO2) pre and post applying deep breathing exercises. These findings indicated that patients who performed scheduled breathing exercises had a better oxygen delivery status compared to the those received routine hospital treatment, and enjoyed faster improvement in oxygen delivery and returning to the preoperative state as mentioned in the study by Zerang, Amouzeshi, and Barkhordari-Sharifabad, (2022) who studied comparison of the effect of incentive spirometry and deep breathing exercises on hemodynamic parameters of patients undergoing coronary artery bypass graft surgery and found significantly higher arterial blood SaO_2 and PaO_2 in the experimental group compared to the control group on the third day after surgery.

The current results in the same line with Shahid et al. (2024) who studied effects of deep breathing exercises on old versus young patients undergoing valve replacement surgery and reported that there was a significant difference between oxygen saturation values of participants with valve replacement surgery without non-invasive ventilation after deep breathing exercises. Also, Joshi, and Singh (2023) who conducted a comparative study related effect of segmental breathing exercise and deep breathing exercise in CABG patients which indicated that patients who receive scheduled breathing exercises following coronary artery bypass surgery have higher oxygenation. These treatments include deep breathing exercises, incentive spirometry, and directed cough manoeuvres, and inferred that there are temporary changes in the oxygen delivery process after breathing exercises and that the blood oxygen level may return to normal after a short time

Related to comparison between respiratory patterns, chest sounds and chest x-ray pre and post applying deep breathing exercises among patients with cardiac

surgery, the present results displayed that there were differences between respiratory patterns pre and post applying deep breathing exercises among studied patients with cardiac surgery, the study results found a statistically significant differences in all respiratory patterns except Kussmaul`s, and Apneustic pattern. These results may be related to the effectiveness of the implemented deep breathing exercises. The current findings supported by Saliba, Blackstock, McCarren, and Tang (2022) who studied effect of positive expiratory pressure therapy on lung volumes and health outcomes in adults with chest trauma and revealed that there was a significant reduction of in the atelectatic area in the lung and improvement in chest x-ray after a series of three sets of 10 deep breaths on the second postoperative day. Also, Abdelhafez, and Fouad, (2023) reported that the impact of deep breathing techniques on the pulmonary function test (PFT) were demonstrated a mean decline in respiratory patterns on the fourth postoperative day when compared to the preoperative day with statistically significant differences between the study and control groups.

Regarding chest sounds**,** the present results clarified that there were statistically significant differences in normal and crackle sounds. Moreover, chest x-ray showed a statistically significant differences related to clear and pneumothorax. These results may be due to deep breathing exercises may aid in the removal of pulmonary secretions which lead to chest sound improvement. The current findings concur with the findings of the study by Westerdahl, Lindmark, Eriksson, Hedenstierna, & Tenling, (2019) which entitled the immediate effects of deep breathing exercises on atelectasis and oxygenation after cardiac surgery and found that after a series of three sets of 10 deep breaths a significant decrease in atelectatic area in both lungs.

Concerning comparison between pulmonary functions pre and post applying deep breathing exercises using Melbourne group scale (MGS-2), the current findings illustrated that there were a statistically significant differences between pre and post deep breathing exercises regarding chest radiograph report of consolidation/collapse, an otherwise unexplained white cell count >11 × 10^9 L^ (-1) or prescription of an antibiotic specific for respiratory infection, and abnormal breath sounds on auscultation which differ from pre-operative assessment. The Melbourne group scale

(MGS-2) was designed to help in perform routine respiratory assessments and diagnosis for postoperative pulmonary complications (Li, et al., 2018).

The current findings consist with Kochupurackal, et al. (2024) who studied Postoperative pulmonary complications with high versus standard FiO2 in adult patients undergoing major abdominal surgery and reported that the Melbourne group scale identified all cases of respiratory infection and 95.5% of cases with more than 2 types of Postoperative pulmonary complications. Whereas, the present results in the same line with Lockstone, et al. (2019) who conducted study entitled non-invasive positive airway pressure therapy to reduce postoperative lung complications following upper abdominal surgery and illustrated that there were significant improvements in patients' scores regarding the Melbourne group scale postintervention.

Also, the current results showed that no significant differences were found regarding raised temperature >38 ◦C on two or more consecutive days, SpO2 less than 90 on room air on two consecutive days, and production of yellow or green sputum which is different from pre-operative assessment. This result in the same line with Chaudhary, et al. (2020) who elaborated that the recording of body temperature, breath sounds and subjective symptoms, as is commonly done in postoperative studies, may not be sensitive enough to detect small or moderate pulmonary changes. Even with a chest x-ray small pulmonary changes may pass unnoticed. While, the present results disagreed with Wang, et al. (2022) who studied comparison of tools for postoperative pulmonary complication following cardiac surgery and illustrated that Fever is common in the days following surgical procedures and 38°C is usually used as a threshold.

Regarding comparison between applying deep breathing exercises pre and post patient education how to applying deep breathing exercises, the current results portrayed that there were statistically significant differences between pre- and post-education regarding all items of deep breathing exercises. This could happen as a result of the studied patients' high level of education, which led to improve patients' awareness regarding importance of deep breathing exercises and the proper technique of deep breathing exercises practice.

The present results agreed with Moradian, Heydari, and Mahmoudi, (2019) who studied the role of preoperative breathing exercises in reducing postoperative atelectasis after CABG and illustrated that after one treatment session of 30 voluntary deep breaths a significant reduction of atelectatic lung area and a small improvement in oxygenation was found, and asserted that deep breathing without any mechanical device was as effective as deep breathing with a mechanical PEP device. Also, Zerang et al. (2022) who conducted breathing exercises were repeated ten times every two hours and continued until three days after surgery and revealed that the breathing exercises significantly reduce postoperative complications, and the included patients provides visual positive feedback and leads to increased adherence to treatment; therefore, it can be performed to improve oxygen delivery based on the patient's tolerance, motivation and willpower and cooperation.

Concerning relationship between socio-demographic characteristics of studied patients and pulmonary function assessment, the present findings showed that there was a statistically significant relation between the studied patients` age and their BMI, and Pao2 post applying deep breathing exercises. The present results agreed with results of the study by Lockstone, et al. (2019) which titled non-invasive positive airway pressure therapy to reduce postoperative lung complications following upper abdominal surgery and concluded that there was significant relation between patients' age and their body mass index and their proportion of Pao2.

Moreover, the present results revealed a statistically significant relation between the studied patients' education and arterial blood gases values post applying deep breathing exercises regarding all items. This result agreed with Abdelhafez, and Fouad (2023), and Lockstone, et al. (2019) who found a statistically significant relationship between the socio-demographic features of the studied patients and postoperative blood gases and education.

Furthermore, the present results revealed a statistically significant relation between the studied patients' health habits as smoking and proportions of Ph and Paco2 post applying deep breathing exercises. This result may be due to the influence of healthy habits on the condition. This result may be due to the influence of patients' healthy habits on their health status. The present results in the same line with the study by Odor, et al. (2020) which entitled perioperative interventions for prevention

of postoperative pulmonary complications and asserted the significant relation between patients' health habits as healthy dietary habits, smoking, and exercises on their health condition.

Regarding relationship between socio-demographic characteristics of studied patients and respiratory pattern Eupnea (Eupnea= normal breathing pattern), the present results revealed a statistically significant relation between the studied patients' education level and health habits as smoking and respiratory pattern eupnea (normal respiration) post applying deep breathing exercises. These results may due to the relation between patients' educational level and their work type which can lead to more stressful life and poor health habits can effect on patients' respiratory patterns. The present results agreed with Batchelor, et al. (2019) who studied guidelines for enhanced recovery after lung surgery and reported a significant relation between patients' health habits as smoking and their life style with patients' respiratory patterns.

Concerning relationship between socio-demographic characteristics of studied patients and normal chest sounds, the current findings illustrated a statistically significant relation between the studied patients' age and marital status and normal chest sounds pre applying deep breathing exercises. Moreover, there was a statistically significant relation between the studied patients' BMI, gender, education, occupation, and health habits and normal chest sounds post applying deep breathing exercises. These findings conflict with those of Abdelhafez, and Fouad (2023), and Batchelor, et al. (2019) who reported there were no significant relation between patients' characteristics as age, sex, and marital status with pulmonary functions.

Regarding relationship between socio-demographic characteristics of studied patients and clear chest X-ray, the present results clarified that there was a statistically significant relation between the studied patients' age and clear chest X-ray pre applying deep breathing exercises. Furthermore, there was a statistically significant relation between the studied patients' marital status, income, and health habits and clear chest X-ray post applying deep breathing exercises. These results may be related to relation between stress caused by social and financial warriors and incidence of cardiovascular diseases. The present findings in the same line with Zanini, et al. (2019) who studied effects of different rehabilitation protocols in inpatient cardiac

rehabilitation after coronary artery bypass graft surgery and illustrated that there was relation between clear chest radiography and patients' characteristics as work condition, marital status, and health habits as smoking.

Regarding relationship between socio-demographic characteristics of studied patients pre and post patients' education regarding applying deep breathing exercises, the present results showed that there was a statistically significant relation between the studied patients' BMI, education, and health habits and post patients` education regarding applying deep breathing exercises. These findings consistent with Kamarajah, Bundred, Weblin, and Tan (2020) who studied critical appraisal on the impact of preoperative rehabilitation and outcomes after major abdominal and cardiothoracic surgery which reported a significant relation between rehabilitation interventions as deep breathing exercises and patients' characteristics as body mass index, and health habits.

Concerning relationship between socio-demographic characteristics of studied patients and chest radiograph report of consolidation/collapse pre and post applying deep breathing exercises, the present results revealed that showed a statistically significant relation between the studied patients' age and health habits as smoking and chest radiograph report of consolidation/collapse pre applying deep breathing exercises. Moreover, there was a statistically significant relation between the studied patients' income and health habits and chest radiograph report of consolidation/collapse post applying deep breathing exercises. The present results consistent with the study by Hamasaki (2020) which entitled effects of diaphragmatic breathing on health and concluded that patients' age and health habits had significant relation with incidence of pulmonary complications as atelectasis.

Regarding relationship between Socio-demographic characteristics of studied patients and raised temperature >38 ◦C on two or more consecutive days pre and post applying deep breathing exercises. The present results elaborated a statistically significant relation between the studied patients' age and health habits and raised temperature >38 ◦C on two or more consecutive days pre applying deep breathing exercises. Moreover, there was a statistically significant relation between the studied patients' income and raised temperature >38 ◦C on two or more consecutive days post applying deep breathing exercises.

The present results disagreed with the results of the study by Park, et al. (2023) which entitled driving pressure-guided ventilation and postoperative pulmonary complications in thoracic surgery and illustrated that there was no significant relation between patients' characteristics and their raised temperature.

Concerning relationship between socio-demographic characteristics of studied patients and SpO2 less than 90 on room air on two consecutive days pre and post applying deep breathing exercises. The current findings showed that shows that there was a statistically significant relation between the studied patients' education and SpO2 less than 90 on room air on two consecutive pre applying deep breathing exercises. The current findings in inconsistent with the study by Zheng, et al. (2020) which entitled does a pulmonary rehabilitation-based ERAS program (PREP) affect pulmonary complication incidence, pulmonary function and quality of life after lung cancer surgery? and concluded a significant relation between patients' proportions of SpO2 with BMI, and smoking. Also, the present results disagreed with Shahid et al. (2024) who revealed a significant relation between patients' age and showed that deep breathing exercises are a more effective way for improving the oxygen saturation of young patients after valve replacement surgery as compared to older patients.

Concerning relationship between socio-demographic characteristics of studied patients and an otherwise unexplained white cell count >11 × 10^9 l^ (-1) or prescription of an antibiotic specific for respiratory infection pre and post applying deep breathing exercises, the current findings reported that showed no statistically significant relation between the studied patients' sociodemographic characteristics and otherwise unexplained white cell count >11 × 10^9 L^ (-1) or prescription of an antibiotic specific for respiratory infection pre and post applying deep breathing exercises.

The present results in the same line with Saing, and Satria, (2021) who studied effectiveness of preoperative incentive spirometry in patients following elective thoracotomy for prevention of postoperative pulmonary complications and revealed no relation between patients' characteristics and white cell count.

Regarding relationship between socio-demographic characteristics of studied patients and abnormal breath sounds on auscultation pre and post applying deep

breathing exercises, the current findings portrayed a statistically significant relation between the studied patients' health habits as smoking and abnormal breath sounds on auscultation pre and post applying deep breathing exercises. The present results agreed with the study by Shaw, et al. (2021) which entitled postoperative pulmonary complications following major head and neck cancer surgery and clarified that abnormal breath sounds and patients' health habits as smoking, and healthy life style.

CONCLUSION

Based on the findings of the present study, it can be concluded that:

There was statistically significant relation between deep breathing exercises and pulmonary functions after cardiac surgery. Through the assessment of the pulmonary functions among the studied patients after cardiac surgery, it was found that there was significant improvement after implementation of deep breathing exercise in pulmonary functions after cardiac surgery. Additionally, there was statistically significant differences between applying deep breathing exercises pre and post patient education how to applying deep breathing exercises.

RECOMMENDATIONS

Based on the results of the present study, the following recommendations were suggested:

1. Applying deep breathing exercise for patients undergoing cardiac surgery as a routine care.
2. Assessment of nurses' knowledge regarding deep breathing exercises and developing educational program about it.
3. Design educational materials such as booklet, pamphlets and videos should be developed for cardiac patients according to benefits of deep breathing exercises on reducing surgery pain and improving pulmonary functions.
4. Further research is necessary to design and implement training program for critical care nurses regarding applying deep breathing exercises for patients after cardiac surgery to enhance pulmonary functions and prevent pulmonary complication.

5. Conduct another research to detect difference between cardiac patient's outcomes post the use of deep breathing alone and using of mechanical techniques as incentive spirometry (IS), and positive expiratory pressure (PEP).

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أثر تمارين التنفس العميقة على الوظائف الرئوية بعد جراحة القلب

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الخلاصة

تُعد المضاعفات الرئوية من الأسباب الأكثر شيوعاً للوفيات بين المرضى بعد جراحة القلب المفتوح وترتبط المضاعفات الرئوية بعد الجراحة بزيادة طول فترة الاقامة في المستشفى ولها تاثير كبير على تكلفة الرعاية الصحية لمرضى جراحة القلب. ولذلك، تهدف هذه الدراسه إلى تقييم أثر تمارين التنفس العميق على الوظائف الرئوية بعد جراحة القلب. تم استخدام دراسة بحثية تجريبية لإجراء الدراسة في وحدات العناية المركزة لجراحة القلب وأقسام الجراحة الداخلية في مستشفي النصر التخصصى بمحافظة بورسعيد و المركز التخصصى للقلب و الجهاز الهضمى بمحافظة دمياط؛ شملت الدراسة 74 مريض بعد جراحة القلب. وقد أظهرت نتائج الدراسة أن وجود فروق ذات دلالة احصائية في الوظائف الرئوية لدى المرضى الخاضعين للدراسة بعد تنفيذ تمارين التنفس العميقة بعد جراحة القلب ب24 ساعة وبعد 48 ساعة وبعد 72 ساعة ($p<0.001$). وقد تلخصت الدراسة بوجود تأثير ايجابي لتمارين التنفس العميقة على تحسن الوظائف الرئوية بعد جراحة القلب. وأوصت الدراسة بتنفيذ برنامج تعليمي لممرضات الرعاية الحرجة حول أهمية تنفيذ تمارين التنفس العميق بعد جراحة القلب وتأثيرها الإيجابي على الوظائف الرئوية لمنع المضاعفات التنفسية للمرضى بعد إجراء جراحة القلب.

الكلمات المرشدة: الوظائف الرئوية، تمارين التنفس العميق، المريض، جراحة القلب.