IOSR Journal of Nursing and Health Science (IOSR-JNHS)
e-ISSN: 2320–1959.p- ISSN: 2320–1940 Volume 5, Issue 4 Ver. V (Jul. - Aug. 2016), PP 92-106
www.iosrjournals.org

Effect of Inspiratory Muscle Training on Clinical Outcomes of Patients Undergoing Cardiothoracic Surgeries

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Abstract: *Inspiratory muscle training is a therapeutic strategy that aimed at preventing post-operative pulmonary complications.*
Aim: *this study aimed to study the effect of inspiratory muscle training on clinical outcomes of patients underwent cardiothoracic surgeries.*
Materials and Method: *A quasi-experimental study was conducted in Cardiothoracic Surgery Department at Student Hospital affiliated to Tanta University. A sample of 40 adult patients of both sexes underwent cardiothoracic surgeries based on statistical power analysis were selected and divided into 2 equal groups:*
Group 1 (Control Group): *was received routine hospital care.*
Group 2 (Study Group): *was received pre and postoperative inspiratory muscle training which was implemented by the researcher.* ***Three tools*** *were used to collect data:* ***Tool (I) Cardiothoracic Patient Assessment Tool***. ***Tool II Cardiovascular and Respiratory System Assessment Tool***,***Tool III Clinical Outcome Assessment Tool***. ***Results:*** *The incidence of post-operative pulmonary complications was higher in the control group (70% and 60%) while it was (30% and 25%) of the study group during the 5th and 7th post-operative day respectively. Duration of stay in ICU was longer in thecontrol group4-17 days while it was 2-9 days in the study group. None of the study group compared to fifth (20%) and fourth (25%) of the control group needed re-intubation and ICU readmission respectively. A high proportion of the study group (55% and 70%) had dyspnea relieved by practicing of inspiratory muscle training compared to none of the study group.*
Conclusions and Recommendations: *Inspiratory muscle training is an effective strategy in improving patient's outcomes after cardiothoracic surgery. It was recommended that all cardiothoracic surgical patients should receive pre and post-operative inspiratory muscle training as a daily routine care.*
Keywords: *Inspiratory muscle training, clinical outcomes*

I. Introduction

Cardiothoracic surgery is associated with a significant risk of serious complications. So, cardiothoracic surgical patients require intensive care management postoperatively. Many of these complications are likely caused in some part by the exaggerated systemic inflammatory response to cardiopulmonary bypass (CPB).Postoperative pulmonary complications (PPCs) are the most frequently observed complications after cardiothoracic surgery, of which pneumonia and atelectasis are the most common.PPCs have significant clinical and economic impact associated with increasing morbidity, length of stay and associated cost [(1-3)].

In Egypt **Al-Qubati 2013[(4)]**stated that postoperative pulmonary complications occurred in 7.82% of patients with coronary artery revascularization, 2.23% in patients with valvular replacement and 5.05% in patients with congenital heart diseases.Acute Respiratory Distress Syndrome (ARDS) occurred in 3.35% of patients with a mortality rate of about 66.6%, pneumonia in 2.79%, atelectasis in 3.35%, pleural effusion in 2.22% and pneumothorax in 0.55%.

In Cardiothoracic Surgery Department at Tanta University Hospital (2014), about 200 patients underwent cardiothoracic surgeries [(5)]. A study conducted in Cardiothoracic Surgery Department, Faculty of Medicine Tanta university Hospital revealed that; the overall incidence of postoperative pulmonary complications was 64.4% and the mortality rate was 45.8% [(6)].

Postoperative pulmonary complications (PPCs) were defined as pulmonary abnormalities that produce identifiable disease or dysfunction that is clinically significant and adversely affects the clinical outcomes. PPCs may be due to preoperative, intraoperative or postoperative factors. Among the most common postoperative pulmonary complications are atelectasis, pneumonia, pneumothorax, hemothorax, pleural effusion, acute respiratory distress syndrome, pulmonary oedema, respiratory failure with prolonged mechanical ventilation and /or exacerbation of underlying chronic lungdisease [(7-9)].

Dysfunction of the respiratory muscles due to surgery may lead to decrease in vital capacity, tidal volume and total lung capacity. This causes atelectasis in basal lung segments and decreased functional residual capacity affecting gas exchange by increasing ventilation /perfusion (V/Q) mismatch. Patients with median sternotomy tend to take a shallow breath, thus retaining carbon dioxide and cause a wide range of postoperative pulmonary Complications [(10-13)].

During the immediate postoperative period, the patient is admitted to the critical care unit. He is intubated and receives mechanical ventilation often up to 24 hours or more. After extubation the patient is provided supplemental oxygen via nasal cannula or face mask during the first 24 to 48 hours. Immediately after extubation the patient requires aggressive inspiratory muscle training [(14, 15)].

Critical care nurse plays a major role in preparing patients and families for operations. Preoperative instructions and psychological support are an integral component of nursing care. The nurse assesses the patient before surgery and plane for postoperative care. The critical care nurse has a vital role in detecting, preventing and managing the post-operative pulmonary complications throughout the perioperative period. The use of preoperative inspiratory muscle training strongly reduces the number of patients who developed postoperative pulmonary complications [(16, 17).]

Inspiratory Muscle Training (IMT) is a course of therapy consists of series of breathing and coughing exercises that aims at increasing ventilation, increasing total lung capacity, increasing inspiratory muscle strength, keeping air way clearance, preventing post-operative pulmonary complications, eliminating the useless uncoordinated pattern and decreases the work of breathing [(18-22)].

Inspiratory muscle training (IMT) includes the following: incentive spirometry (IS), diaphragmatic breathing exercises, segmental breathing exercises (lateral costal expansion exercises, posterior costal expansion exercises, apical costal expansion exercises) and huff coughing exercises [(23-25)].

Incentive spirometry (IS) involves using a hand held device to help the patient achieve maximal ventilation. IS provides the patients with a visual clue about inspiratory volume as to how well they are performing their deep breathing exercises and therefore may serve as a motivator or provides an incentive to their performance. Incentive spirometry is designed to replace the natural mechanism of sighing or yawning thus preventing and reversing the alveolar collapse that causes atelectasis and pneumonia [(26, 27)].

Diaphragmatic breathing is the breathing that promotes the use of the diaphragm. It is used to increase the volume of air exchanged during inspiration and expiration. Diaphragmatic breathing improves gas distribution at higher lung volumes, strengthen the diaphragm during breathing and decrease the energy cost of ventilation. Also, this technique includes pursed lip breathing technique during exhalation maneuver. It is usually practiced for at least 20 minutes two or three times daily [(28, 29)]

Segmental breathing exercises are performed on a segment of the lung that needs increased ventilation or movement due to hypoventilation that occurs as a result of pain, muscle guarding after surgery, atelectasis and pneumonia. Segmental breathing exercises are used to prevent accumulation of fluid and to increase chest mobility by directing inspired air to predetermined areas. Segmental breathing exercises include lateral costal expansion, apical costal expansion and posterior costal expansion exercises [(30, 31)].

II. Aim of the study

The Aim of the study was to Study the effect of inspiratory muscle training on clinical outcomes of patients undergoing cardiothoracic surgeries.

III. Materials and Method

Study design: The present study was a quasi- experimental research design.
Setting: The study was conducted in Cardiothoracic Surgery Department at Student Hospital affiliated to Tanta University. It was consisted of two units, Open Heart Surgery and Chest Surgery Unit.

Sample: The sample of the study composed of 40 adult patients undergoing cardiothoracic surgeries in previously mentioned setting. They enrolled in this study according to the following inclusion criteria; Adult conscious patients with age ranging from 21-60 years old who were undergoing any elective open cardiothoracic surgery, both sex**,** Patients falling in first and second category of risk factors (good and fair outcome category) for postoperative pulmonary complications.

Patients who were undergoing emergent cardiothoracic surgery, falling in the 3rd and 4th category of risk factors for postoperative pulmonary complications and have history of a neuromuscular disorder were excluded from thesample.

Tools of Data Collection
Three tools were used by the researcher**;**

Tool (I) Cardiothoracic Patient Assessment Tool: This tool was developed by the researcher after reviewing the related literature [32, 33] except part B which was developed by Parsonnet et al (1989) [34] and it was consisted of 3 parts as follow:

Part A: Patient's Biosocio-Demographic Data:included;age, sex, marital status, educational level, occupation, body mass index, smoking history, diagnosis, previous hospitalization, type of cardiothoracic surgery, date of admission, date of operation, date of discharge, past medical history, past surgical history and post-operative medication.

Part B: Preoperative Risk Scores for Postoperative Pulmonary Complications:
This part was conducted through the use of **Parsonnet Scale (1989) [34]** and used in the preoperative period to assess postoperative morbidity and mortality. The scale was consisted of 13 items included; gender, morbid obesity, diabetes, hypertension, ejection fraction, age, reoperation, preoperative intraaorticballoon pump, dialysis dependent, pacemaker dependent, left ventricular aneurysm, emergency surgery and catastrophic state.

Part C: Laboratory Investigations and Diagnostic studies: which included: Arterial blood gases(ABG), White blood cell count per mm^3 , Sputum culture for isolation of different microorganisms and Chest x-ray to diagnose postoperative pulmonary complications.

Tool (II) Cardiovascular and Respiratory System Assessment Tool: was developed by the researcher based on relevant literature [35,36]to assess the effect of inspiratory muscle training on cardiovascular and respiratory system, it was consisted of 2 parts as follow:
Part A: Cardiovascular System Assessment: was consisted of pulse rate, blood pressure, postoperative pain which included site, radiation, quality, severity and duration, dyspnea which included type and relieving factors and cyanosis.
Part B: Respiratory System Assessment: was consisted of respiratory rate, depth, rhythm and symmetry of chest wall expansion, use of accessory muscles, presence of cough, sputum**,** hemoptysis and respiratory sounds.

Tool (III) Clinical Outcome Assessment Tool: This tool was used to assess the incidence of postoperative pulmonary complications and it was consisted of 2 parts as follow:
Part A:Melbourne Group Scale (MGS): This part was developed by **Melbourne** and modified by **Bradley (2012) [37]**to assess the incidence of postoperative pulmonary complications and it was consisted of 8 categories (temperature more than 38°C, physician diagnosis of pneumonia or chest infection, chest x-ray report of atelectasis or consolidation, production of purulent (green /yellow) sputum differing from preoperative, positive signs of sputum microbiology, oxygen saturation (Sao_2)less than 90% on room air, white blood cell count greater than 11000/mm^3,readmission to or prolonged stay over (36 hours) on the intensive care unit for respiratory problems) where clinically significant postoperative pulmonary complications were determined by the presence of 4 or more positive categories.

Part B: Clinical Outcome: This part was developed by the researcher after reviewing the related literature [38-40] to assess the clinical outcomes of the inspiratory muscle training and consisted of the following items: duration of post-operative mechanical ventilation, duration of O_2 therapy, need for re- intubation, need for chest tube re-insertion, length of postoperative ICU stay, need for ICU readmission and total period of hospitalization.

A Pilot Study

A pilot study was carried out on 4 patients undergoing cardiothoracic surgeries in order to test the clarity, feasibility and applicability of the different items of the determinant tools and accordingly;some modification was done and those patients were excluded from the study.

Administrative Design and Ethical Considerations

Official Permission to carry out the study was obtained from the responsible authoritiesSpecial training was demonstrated to the researcher by chest physiotherapist to gain perfection in inspiratory muscle training techniques and auscultation of respiratory sounds before starting the actual research study

Data were collected over a period of 7 months, started from December 2014 to June 2015.Verbal and written consent was obtained from the patients to participate in the study after explaining the purpose of the study and their right to refuse participation or withdrawn from the study at any time.Confidentiality and privacy were assured.

Content Validity: All tools were tested for content validity by nine jury of experts in the field of medical-surgical nursing, critical care nursing at the faculty of Nursing, cardiothoracic surgery, chest physiotherapists anesthesiologist at the faculty of medicine and accordingly some modifications were done.
The validity of the Parsonnet Scale was found to be 60%.
The validity of Melbourne Group Scale was found to be 85%**Reliability of the tool**
Alpha Cronbach's test was used to test tool reliability and the estimated reliability of the entire test =0.854.
The reliability of the Parsonnet riskscale was found to be greater than 80.The reliability of Melbourne Group Scale was found to be about 90%.

Phases of the Actual Study: The present study was conducted on four phases.

1. Assessment phase:-

Immediately upon admission initial assessment was carried out by the researcher for all study subjects in both control and study groups to assess the patients who met the inclusive and exclusive criteria of the study. Assessment was done by using tool (I) part (A, B) to collect baseline data.

2. ***Planning Phase:***

This phase was formulated based on assessment phase and literature review [(277- 285).] Priorities and expected outcome criteria were put when planning patient care which included: reduction in the incidence of post-operative pulmonary complications, reduction of dyspnea, no need for re-intubation or chest tube re-insertion, reduced duration of post-operative mechanical ventilation, reduced duration of oxygentherapy and decreased the length of ICU stay and total days of hospitalization. In this phase, a colored booklet was developed by the researcher to be distributed to each patient in the study group to be considered as a reference value for the study group patients and their families.

3. ***Implementation phase:***

In this phase, **study group** was encouraged to early mobilization and was received inspiratory muscle training (implemented by the researcher) as agreed by the treating physicians in the Open Heart and Chest Surgery Critical Care Units. Inspiratory Muscle Training was taught to all patients in the study group preoperatively in four sessions on every other day, each session has been taken a duration of 40 minutes and was given individually to each patient in the presence of one of the family members.

Inspiratory muscle training (incentive spirometry, diaphragmatic breathing, lateral costal expansion, posterior costal expansion, apical costal expansion and huff coughing exercises) was demonstrated by the researcher and then redemonstrated by the patient until the patient was performing the technique efficiently and correctly. The study group redemonstrated the inspiratory muscle training postoperatively immediately after extubation 30 minutes after taking the pain relieving medication.

Inspiratory muscle training was re-demonstrated postoperatively by patients in the study group in 5 sessions daily for one week, each session lasted for 40 minutes. In each session each type of exercises was re-demonstrated 5 times and the patient is instructed to gradually increase the duration and frequency of exercises. Additionally, other positions such as sitting or standing may be used as the patient progress during treatment.

Group (I): Control group

Control group was exposed to routine hospital care as prescribed by cardiothoracic surgery team. The hospital routine of care was consisted of allowing the patient to move but not immediately when the patient became stable and pharmacological treatment of post-operative pulmonary complications only when they developed.

4. Evaluation phase:

Evaluation was done for both study and control groups using tool I part C (laboratory investigations and diagnostic studies) to evaluate the development of post-operative pulmonary complication, tool II (cardiovascular and respiratory system assessment tool) to evaluate the effect of inspiratory muscle training on cardiovascular and respiratory system post operatively and Tool III to evaluate the clinical outcomes of inspiratory muscle training after cardiothoracic surgeries five times in the 1st day post-operatively and then three times daily for one week.

Statistical analysis

The collected data were organized, tabulated and statistically analyzed using SPSS software (Statistical Package for the Social Sciences, version 16. For quantitative data, the range, mean and standard deviation were calculated. For qualitative data, comparison between two groups and more was done using Chi-square test (χ^2).Significance was adopted at $p<0.05$ for interpretation of results of tests of significance [(41)].

IV. Results

The results of the present study revealed thatthe mean age of the control group was 39.00±9.14, while it was 42.40±10.66 in the study group. As for patient's sex, more than half (55%) of the control group were males, where in the study group, half of them were males .In relation to marital status, an equal proportion 60% of the control and the study group were married. With regard to educational level, it was observed that less than half 40% of the control and near to half 45% of the study group had secondary school education level. Regarding occupation, half (50%) of the control group and 40 % of the study group were manual workers and 15% and 40% of the control and study group respectively were house wives.

Table 1: It was noticed that one fifth (20%) of both the study and the control group had a diagnosis of coronary artery disease and lung cancer. About one third (30%) of the control group and (35%) of the study group had valve diseases.No statistical significant difference was observed between the studied groups regarding diagnosis where p=0.950. Regarding the type of cardiothoracic surgery, it was found that one fifth (20%) of control and study group had CABG and pneumectomy surgery. About one third (30%) of control group and (35%) of study group had valvularsurgery. It was observed that minority of the control and the study group (5%) had resection of mediastinal mass and chest wall cancer. No statistical significant difference was observed between the studied groups regarding the type of cardiothoracic surgery where p=0.950.

Figure 1: It was noticed that the mean values of pre-operative risk scale for post-operative pulmonary complications (Parsonnet risk scale) was 7.20±1.06 and 8.75±0.44 for control and the study group respectively andthe difference between the two groups was statically significant where p= 0.0001 denoting that the study group subjects were at higher risk than those in the control group.

Table 2: Regarding PH during the 3rd post-operative day, the mean ±SD was reported as 7.40±0.05 for the control group and 7.37±0.04 for the study group. Regarding the partial pressure of arterial oxygen (Pao_2) during the 5th and 7th postoperative days, it was found that the mean ±SD was 82.15±8.83and 83.50±10.97 of the control group and 87.30±4.00 and 90.85±3.22 of the study group respectively. Statistical significant differences were found regarding PH during the 3rd post-operative day and Pao_2 during the5th and7th day postoperatively where p=0.031, 0.023 and 0.007 respectively.

Table 3: Regarding mean ± SD of respiratory rate, it was noticed to be (26.45±2.66 and 25.60±3.07) of the control group, while it was (23.25±2.65 and 21.80±3.91) of the study group on the 5th and 7thpost operative day respectively and statistical significant difference was found in relation to respiratory rate where p=0.001 and 0.002 during the 5th and 7th day post-operatively respectively.

Table 4: This table showed that 40% and 60% of the control group had dyspnea at rest compared to fifth (20%) and tenth (10%) of the study group during the 1st and3rd post-operative day respectively. Less than two thirds (60%) and less than half 45% of the control group compared to only tenth (10%) and none of the study group had dyspnea on exertion during the 5th and 7th post-operative day respectively. Statistical significant difference was found between the two groups related to dyspnea at rest and on exertion where p=0.0001 and 0.003 respectively. Moreover, three quarters (75%) and all (100%) of the control group had dyspnea relieved by O_2 therapy compared to an equal proportion (25%) of the study group during the 1st and 3rd post-operative day respectively. In addition, about third (35%) and more than half (55%) of the study group had dyspnea relieved by practice of inspiratory muscle training compared to none of the control group during the 1st and3rd post-operative day respectively. The differences between the two groups regarding relieving factors of dyspnea were statistically significant where p=0.0001 and 0.010 respectively

Table 5: Regarding occurrence of post-operative pulmonary complications, a high proportion of the control group (60%. 65%, 70% and 60%) developed significant postoperative pulmonary complications compared to less proportion (40%, 35%, 30% and 25%) of the study group during the 1st, 3rd,5th and 7th post-operative day respectively. A statistical significant difference was found between the two groups regarding occurrence of post-operative pulmonary complications during the 5th and7th post-operative days where p=0.011 and 0.025 respectively.

Table 6: This table emphasized that themean ± SD of control group for post-operative duration of mechanical ventilation was (5.25±4.49) which was higher than that of the study group (2.60±2.37). Regarding mean ± SD of post-operative duration of O_2 therapyof the control group was (5.15±2.16), which was longer than that of the study group (2.36±1.99). Statistical significant differences were found between the two groups regarding mean

values of post-operative duration of mechanical ventilation and duration of O2 therapy where p= 0.025 and 0.0001 respectively.

Figure 2: In relation to the need for post-operative re-intubation, this figure emphasized that none of the study group compared to one fifth of the control group needed re-intubation. The difference between the two groups related to need for re-intubation was statistically significant where p=0.035. About one third (30%) of the control group compared to tenth (10%) of the study group needed chest tube re-insertion. The difference between the two groups regarding chest tube re-insertion was not statically significant where p= 0.114.

Table 7: Regarding mean values of duration of post-operative ICU admission, the mean± SD was 8.70±3.96 of control group and 4.55±2.26 of study group. A very high statistical significant difference was noted between the two groups regarding mean values of duration of post-operative ICU admission where p=0.0001. In relation to mean values of total period of hospitalization, the mean± SD was 20.40±8.83 of the control group while it was 15.20±8.11 of the study group. Although there was no statistical significant difference between the control and the study groups regarding the mean values of total period of hospitalization where p=0.060.

Figure 3: This figure emphasized that none of the study group compared to one fourth 25%of the control group needed postoperative I.C.U readmission. The difference between the two groups regarding the need for post-operative ICU re-admission was statistically significant where p=0.017.

Variables	The studied adult patients undergoing cardiothoracic						χ^2	P
	Control group(n=20)		Study group(n=20)		Total(n=40)			
	N	%	n	%	N	%		
Diagnosis:								
valvular diseases	6	30.0	7	35.0	13	32.5	1.140	0.950
Coronary artery diseases	4	20.0	4	20.0	8	20.0		
Chronic empyema	2	10.0	1	5.0	3	7.5		
Lung cancer	4	20.0	4	20.0	8	20.0		
Chest wall cancer	1	5.0	1	5.0	1	2.5		
Mediastinal mass	1	5.0	1	5.0	3	7.5		
Congential heart diseases	2	10.0	2	10.0	4	10.0		
Type of cardiothoracic surgery:								
Valve surgery	6	30.0	7	35.0	13	32.5	1.140	0.950
Coronary artery bypass graft	4	20.0	4	20.0	8	20.0		
Decortication of the lung	2	10.0	1	5.0	3	7.5		
Pneumectomy	4	20.0	4	20.0	8	20.0		
Chest wall cancer resection	1	5.0	1	5.0	2	5.0		
Mediastinal mass resection	1	5.0	1	5.0	2	5.0		
Repair of congenital heart diseases	2	10.0	2	10.0	4	10.0		

Table 1: Clinical data of the studied adult patients undergoing cardiothoracic surgeries

Figure 1: Mean values of pre-operative risk scale for post-operative pulmonary complications (Parsonnet risk scale) of the studied adult patients undergoing cardiothoracic surgeries.

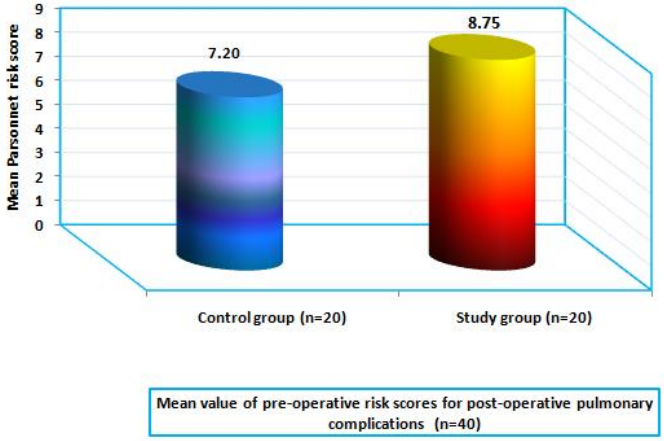


Table 2: Mean values of arterial blood gases (ABGs) of the studied patientsundergoing cardiothoracic surgeries

Laboratory investigation of ABGs of the studied patientsat post-operative days	The studied patients undergoing cardiothoracic surgeries		t-test	P
	Control group (n=20)	Study group (n=20)		
	Mean ±SD	Mean ±SD		
PH at post-operative days:				
1st day	7.30-7.50 7.39±0.05	7.30-7.47 7.37±0.04	1.566	0.126
3rd day	7.33-7.51 7.40±0.05	7.30-7.46 7.37±0.04	2.247	0.031*
5th day	7.30-7.51 7.39±0.06	7.33-7.46 7.39±0.04	0.062	0.951
7th day	7.25-7.51 7.40±0.07	7.35-7.51 7.38±0.03	0.962	0.342
F value **P**	0.242 0.867	0.927 0.432		
Pao_2 at post-operative days:				
1st day	77-91 84.45±4.90	75-95 83.50±5.21	0.594	0.556
3rd day	69-90 83.15±5.30	76-90 83.15±4.16	0.000	1.000
5th day	53-91 82.15±8.83	79-93 87.30±4.00	2.376	0.023*
7th day	54-95 83.50±10.97	82-95 90.85±3.22	2.876	0.007*
F value **P** **Scheffe test** **P**	0.288 0.834	14.859 0.0001* 1st vs 7th, P=0.0001* 3rd vs 5th, P=0.026* 3rd vs 7th, P=0.0001*		
$Paco_2$ at post-operative days:				
1st day	34-49 39.35±4.80	29-50 39.85±5.31	0.312	0.757
3rd day	30-50 38.00±5.20	33-50 40.05±5.44	1.218	0.231
5th day	32-55 40.10±5.94	32-46 37.10±3.29	1.976	0.055
7th day	28-67 40.25±8.64	34-47 37.25±2.93	1.470	0.150
F value **P**	0.528 0.664	2.667 0.054		
Sao_2 at post-operative days:				
1st day	90-99 95.80±2.52	92-99 96.60±2.11	1.087	0.284
3rd day	91-100 95.95±2.46	93-99 96.35±1.50	0.621	0.538
5th day	80-99 94.95±4.99	93-100 97.65±1.81	2.274	0.029*
7th day	82-99 95.00±4.82	95-99 98.30±1.26	2.960	0.005*
F value **P**	0.362 0.781	5.738 0.001*		
Scheffe test **P**		1st vs 7th, P=0.024* 3rd vs 7th, P=0.007*		

***Significant(P<0.05)**

Table 3: Mean values of respiratory rate (RR) of the studied adult patients undergoing cardiothoracic surgeries.

Respiratory rate (RR) at post-operative days of follow up	The studied adult patients undergoing cardiothoracic surgeries (n=40)		t-test	P
	Control group (n=20)	Study group (n=20)		
	Range Mean±SD	Range Mean±SD		
RR (c/m) at post-operative days:				
1st day	20-30 26.50±2.54	20-30 26.50±2.46	0.000	1.000
3rd day	22-30 25.55±2.30	20-29 24.90±2.53	0.849	0.401
5th day	20-33 26.45±2.66	18-28 23.25±2.65	3.805	0.001*
7th day	22-35 25.60±3.07	16-29 21.80±3.91	3.417	0.002*
F value **P**	0.766 0.517	9.503 0.0001*		
Scheffe test **P**		1st vs 5th & 7th, P=0.010* & 0.0001* 3rd vs 7th, P=0.016*		

***Significant(P<0.05)**

Table 4: Dyspnea and its relieving factors among the studied adult patients undergoing cardiothoracic surgeries.

Dyspnea and its relieving factors at post-operative days of follow up	The studied adult patients undergoing cardiothoracic surgeries at postoperative days of follow up (n=40)																		χ^2	P
	Control group (n=20)								χ^2	P	Study group (n=20								χ^2	P		
	1st		3rd		5th		7th				1st		3rd		5th		7th					
	n	%	n	%	n	%	n	%			n	%	n	%	n	%	n	%				
n#•Dyspnea:																						
At rest	8	40.0	12	60.0	7	35.0	5	25.0	38.17	0.0001*	4	20.0	2	10.0	0	0	0	0	15.20	0.002*	14.20	0.0001*
On exertion	0	0	4	20.0	12	60.0	9	45.0	23.74	0.0001*	0	0	7	35.0	2	10.0	0	0	19.60	0.0001*	8.533	0.003*
Orthopnea	2	10.0	3	15.0	0	0	1	5.0	2.105	0.551	1	5.0	1	5.0	0	0	0	0	3.403	0.356	1.858	0.173
Paroxysmal nocturnal	5	25.0	1	5.0	0	0	0	0	3.403	0.356	2	10.0	1	5.0	0	0	0	0	2.05	0.562	0.206	0.650
#•Relieving factors of dyspnea:																						
Rest	0	0	5	25.0	5	25.0	7	35.0	30.28	0.0001*	0	0	9	45.0	2	10.0	0	0	6.150	0.104	13.635	0.0001*
O^2 therapy	15	75.0	20	100	14	70.0	8	40.0	75.09	0.0001*	5	25.0	5	25.0	0	0	0	0	11.80	0.008*	40.025	0.0001*
Practice of IMT	0	0	0	0	0	0	0	0	64.76	0.0001*	7	35.0	11	55.0	2	10.0	0	0	22.92	0.0001*	6.619	0.010*
Upright positioning	15	75.0	20	100	19	95.0	15	75.0	9.573	0.144	7	35.0	11	55.0	2	10.0	0	0	17.50	0.001*	35.511	0.0001*
•Cyanosis:																						
No cyanosis	16	80.0	19	95.0	16	80.0	16	80.0	2.832	0.830	18	90.0	19	95.0	18	90.0	19	95.0	3.654	0.723	4.252	0.119
Central	2	10.0	0	0	2	10.0	2	10.0			0	0	0	0	1	5.0	0	0				
Peripheral	2	10.0	1	5.0	2	10.0	2	10.0			2	10.0	1	5.0	1	5.0	1	5.0				

***Significant(P<0.05)**

Table 5: Occurrence of post-operative pulmonary complications (Melbourne Group Scale) (MGS) among the studied adult patients undergoing cardiothoracic surgeries.

Post-operative pulmonary complications at post-operative days of follow up	The studied adult patients undergoing cardiothoracic surgeries (n=40)				χ^2	P
	Control group (n=20)		Study group (n=20)			
	n	%	N	%		
•1st post-operative day:						
No complications	8	40.0	12	60.0	1.600	0.206
Significant pulmonary complications	12	60.0	8	40.0		
•3rd post-operative day:						
No complications	7	35.0	13	65.0	3.600	0.058
Significant pulmonary complications	13	65.0	7	35.0		
•5th post-operative day:						
No complications	6	30.0	14	70.0	6.400	0.011*
Significant pulmonary complications	14	70.0	6	30.0		
•7th post-operative day:						
No complications	8	40.0	15	75.0	5.013	0.025*
Significant pulmonary complications	12	60.0	5	25.0		

***Significant (P<0.05)**

Table 6: Mean values of post-operative duration of mechanical ventilation andO2 therapy among the studied patients

Post-operative duration of mechanical ventilation and O2 duration therapy	The studied adult patients undergoing cardiothoracic surgeries (n=40)		t-test	P
	Control group (n=20)	Study group (n=20)		
•Duration of post-operative mechanical ventilation (hours):				
Range	0-15	2-8	2.332	0.025*
Mean±SD	5.25±4.49	2.60±2.37		
•Duration of O2 therapy (hours):				
Range	1-9	0.62-7	4.251	0.0001*
Mean±SD	5.15±2.16	2.36±1.99		

***Significant (P<0.05)**

Figure 2: Need for post-operative re-intubation and chest tube re-insertion among the studied adult patients undergoing cardiothoracic surgeries

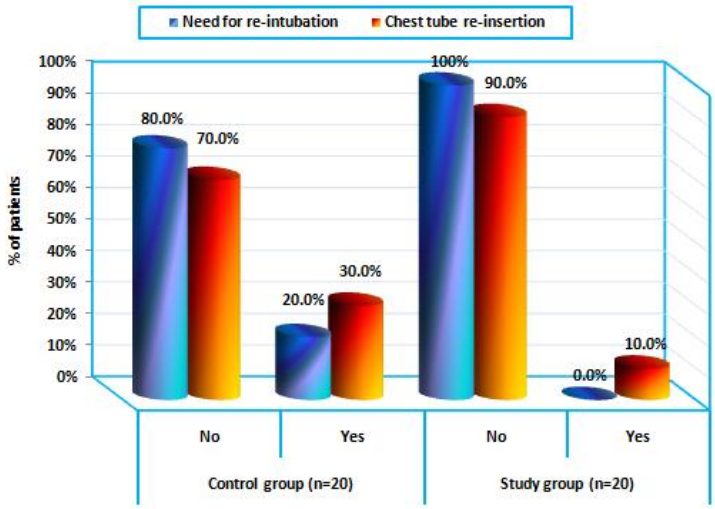
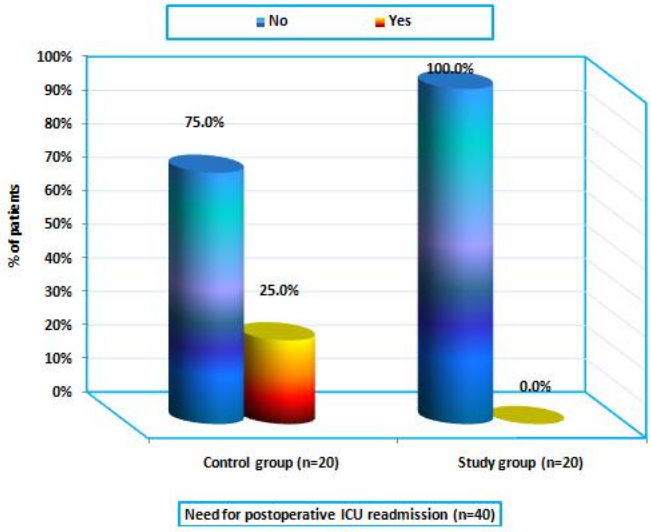


Table 7: Mean values of duration of post-operative ICU admission and total period of hospitalizationamong the studied adult patients

Post-operative ICU admission and Total period of hospitalization.	The studied adult patients undergoing cardiothoracic surgeries (n=40)		t-test	P
	Control group (n=20)	Study group (n=20)		
• Duration of post-operative ICU admission (days): Range Mean± SD	 4-17 8.70±3.96	 2-9 4.55±2.26	4.070	0.0001*
• Total period of hospitalization (days): Range Mean± SD	 9-35 20.40±8.83	 9-30 15.20±8.11	1.939	0.060

*Significant (P<0.05)

Figure 3: Need for postoperative ICU readmission among the studied adult patients undergoing cardiothoracic surgeries



V. Discussion

Characteristics of the study Sample;the findings of the present study revealed that the mean age of the studied groups was 40.70 years. This finding was in line with ***Alaparthi et.al, (2013) (***[42] who found that the mean age of the studied sample was 40.4 years. On the other hand, this result was disagreed by ***Spruit et.al, 2006*** [43]***, Jones et.al, 2007*** [44] and ***Granger et. al, 2013*** [45]***who*** concluded that the mean age of their studied groups was 65 years. ***Leroy et.al, (2010)*** [46] found that the mean age of the studied groups was 32 years.Similarly,this result was contradicted by***Arbane et.al, (2010)*** [47] and ***Hoffman et.al, (2013)*** [48] whostated that the mean age of their studied sample was 64 years. ***Also, Coats et.al, (2013)*** [49] mentioned that the mean age of the studied sample was 59 years. ***Bissett et.al, (2014)*** [50] found that themean age of the studied sample was 61.6 years.

In relation to sex, the current study showed that nearly half of the studied groups were females. This finding was similar to the findings of***Hulzebos et.al, (2006)*** [51], ***Benzo et.al, (2011)*** [52] ***and Granger et.al, (2013)***[45] who reported that nearlyhalf of the studied sample were males. Similarly***Coats et.al, (2013)*** [49] and***Condessa et.al, (2013)*** [53] concluded that half of the studied patients were females and the other half was males. On the other hand, this result was contradicted by ***Jones et.al, (2007)*** [44] who found that the majority of the studied sample was females. ***Cader et.al,*** (**2010)** [54] observed that more than half of the studied groups in their study were females. ***Martin et.al,(2011)*** [55]***, Kodric et.al, (2013)*** [56] and***Shakouri et.al, (2015)*** [57], who concluded that majorityof the studied groups were males.

As regard to marital status, the findings of the current study revealed that half of the studied groups were married. This finding was in accordance with ***Ellis et.al, (2012)*** [58] whofound that more than half of the studiedgroups were married.

In relation to educational level, the finding of the current study revealed that less than half of the studied sample had secondary education. The finding of the present study was disagreed by ***Ellis et.al, (2012)*** [58] and***Molassiotis et.al, (2015)*** [59] whoobserved that majority of the studied groups had secondary education. **Concerning occupation,** the findings of the present study revealed that less than half of the studied sample was manual workers. This may be due to low educational level of the studied patients in the current study. This finding was contradicted by ***Ellis et.al, (2012)*** [58] and***Molassiotis et.al, (2015)*** [59] who reported that majority of the studied sample were retired.

Regarding the type of cardiothoracic surgery, the findings of the present study revealed that the majority of studied groups had coronary artery bypass graft (CABG) surgery, valve surgery and pneumectomy. This finding was in agreement with by ***Crisafulli et.al, (2013)*** [60] and ***Valkenet et.al, (2013)*** [61] who found that the majority of studied groups had coronary artery bypass graft surgery and valve surgery. Also, ***Kodric et.al, (2013)*** [56] reported that the majority of the studied groups underwent coronary artery bypass graft surgery. **Concering arterial blood gases (ABGs) results,**the present study showed a statistical significant difference of PH in the study group was towards the normal range during the 3rd post-operative day. The findings of the current study also revealed that pao_2 and sao2 were higher in the study group than in the control group. No statistical significant difference was found between control and study group in relation to Paco2. These improvements in arterial blood gases may be explained by improvement in the patient's breathing patterns (as slow deep breathing that resulted from redemonstration of inspiratory muscle training in study group versus shallow rapid breathing in control group). Also, diaphragmatic breathing pulls oxygen into the deepest lobes of the lungs where a better gas exchange occur thus enhancing delivery of oxygen and nutrients to the tissues and removing carbon dioxide. These findings were agreed by ***El Badawy et.al, (2007)*** [62]who found statistical significant improvements in arterial blood gases (PH and Pao_2) after using inspiratory muscle training and***Aly et.al,(2007)*** [63] who stated that there were significant improvements of the arterial blood gases after the application of inspiratory muscle training. Additionally, the findings of the current study were incongruent with ***Restrepo et.al, (2011)*** [64] who concluded that pre and post-operative use of incentive spirometry improved arterial oxygenation (Pao_2, Sao_2). ***Chawla et.al, (2013)*** [65] showed that the level of arterial oxygen saturation significantly increased after inspiratory muscle training. Also, ***Brocki et.al, (2015)*** [66]reported that Spo_2 was improved in the study group on the third and fourth postoperative days.
In contrast, the result of the current study was in disagreement with by ***Ferreira*** **et.al, 2009** [67] who found that arterial Pao_2 was increased in the control and the study group immediately after extubation, but this increase was not statistically significant due to routine oxygen supplementation to all patients within the first 12 hours after surgery. Additionally, ***Bavarsad*** **et.al,** ***(2015)*** [68] observed a slight but non-significant increase in oxygen saturation in the inspiratory muscle training group, where as it remained unchanged in the control group.

I In relation to the rate of respiration, the result of the current study presented that respiratory rate was lowered toward the normal limit in the study group than in the control group. Deep, regular and symmetrical breathing was higher in the study group than in the control group. With regard to respiratory sounds, the present study revealed that clear right and left lung sounds were higher in the study group than in control group during post-operative days. In addition diminished breath sound and crackles were lower in study group than control group. The findings of the present study were agreed by***Restrepo et.al, (2011)*** [64] who reported that pre and post-operative use of incentive spirometry decreased respiratory rate and improved previously absent or diminished breath sounds. ***Elbouhy et.al, (2011)*** [69] found decrease in respiratory rate toward the normal limit in the inspiratory muscle training group than in the control group and this reduction was statistically significant which may be due to more accommodation of the patient to training. Moreover, the finding of the present study was supported by ***Elkins et.al, (2105)*** [70] who found that inspiratory muscle training significantly improved rapid shallow breathing in the study than in the control group. On the other hand, the findings of the present study were contradicted by ***Condessa et.al, (2013)*** [53] who proved that shallow rapid breathing was decreased in the control and inspiratory muscle training group during weaning off mechanical ventilation.

In relation to dyspnea,the findings of the current study presented that dyspnea at rest and on exertion were higher in the control group than in study group. O_2 therapy was the essential relieving factor of the patients, while inspiratory muscle training was the essential relieving factor of dyspnea in the study group. This result may be due to improved lung expansion and pulmonary volumes associated with inspiratory muscle training.

The findings of the present study came in accordance withthe findings of ***Mancini et.al, 2010*** [71]who stated that the study group who received inspiratory muscle training reported a subjective improvement in dyspnea during the activities of daily living***Bosnak-Guclu et.al, (2011)*** [72] and ***Huang et.al, (2011)*** [73] who reported that inspiratory muscle training significantly alleviated dyspnea in the study group compared with control group. Also, ***Mohamed (2012)*** [74] found that inspiratory muscle training significantly increased inspiratory muscle strength and endurance and resulted in decrease in dyspnea sensation at rest and during exercises. Moreover, the findings of the current study were supported by ***Kodric et.al, (2013)*** [56]whoconcluded that training of inspiratory muscles has a positive effect on dyspnea and activities of daily living. ***Crisafulli et.al, (2013)*** [60] observed that dyspnea improved faster and more significantly in the study when compared with control group. In contrast, ***Jeong et.al, (2015)*** [75] found that dyspnea was reduced in the study group but this reduction was not statistically significant.

As regard mean duration of post-operative mechanical ventilation, the findings of the current study concluded that mean duration of mechanical ventilation was significantly more in the control group than in study group. The finding of the present study was in line with ***Elkins et.al,(2015)***[70] who revealed that total duration of mechanical ventilation was shorter in the inspiratory muscle training group. On the other hand, the finding of the current study was in contrast with **Condessa *et.al, (2013)*** [53] whostated that inspiratory muscle training didn't accelerate weaning from mechanical ventilation. ***Lunardi et.al, (2011)*** [13] reported that inspiratory muscle training in routine care wasn't resulted in decreased ventilation time.

Regarding the need for re-intubation, the finding of the current study revealed that none of the study group needed re-intubation compared to small percent of the control group and this may be attributed to the reduction in the incidence of post-operative pulmonary complications in the study group, beside that none of the study group developed neither acute respiratory distress syndrome nor acute respiratory failure in the postoperative days. The finding of the current study was in handwith***Lunardi et.al, (2010)*** [76] who stated that re-intubation for respiratory failure was lower in the study group than in control group. In contrast, the findings of the current study were contradicted by ***Elkins et.al, (2105)*** [70] who found that no statistical significant difference found between the two groups in relation to the need for re-intubation.

As regard chest tube re-insertion, the findings of the current study revealed that the need for chest tube re-insertion was lower in the study group than in control group and this may be attributed to the protective effect of inspiratory muscle training in the study group which resulted in reduction in the incidence of post-operative pulmonary complications such as pneumothorax and pleural effusion which needed chest tube re-insertion. This finding was agreed by***Lunardi et.al, (2010)*** [76] who concluded that postoperative inspiratory muscle training reduced the rate of respiratory complications, thoracic drainage time, the need to return to mechanical ventilation and the need for chest tube re-insertion.

In relation to the duration of intensive care unit stay, the findings of the current study revealed a significant reduction of post-operative stay in intensive care unit in the study than in control group. This result may be due to reduction of the incidence or the severity of post-operative pulmonary complications in the patients of the study group. The finding of the present study was in accordance with***Matheus et.al, (2012)*** [77]who showed a significant reduction in length of stay in the coronary care unit in the study group. Also, ***Elkins et.al, (2105)*** [70] found that inspiratory muscle training significantly shortened the length of stay in the ICU.

As regard total days of hospitalization, the finding of the current study revealed that there was no statistical significant difference between the two groups regarding the duration of hospitalization. This result may be due to complications other than post-operative pulmonary complications such as post-operative cardiac, neurological or renal complications. The finding of the present study was in line with ***Lunardi et.al, (2011)*** [13] who stated that inspiratory muscle training in routine care wasn't resulted in decreased length of hospital stay.
On the other hand, the finding of the present study was in disagreement with ***Arbane et.al, (2011)*** [47] who stated that period of hospitalization was longer in the control than in the study group. Additionally, ***Mohamed (2012)*** [74] concluded that inspiratory muscle training significantly shortened the duration of postoperative hospitalization in patients underwent thoracic surgery.

VI. Conclusion and Recommendations

Based on the findings of the present study, it can be concluded that: Inspiratory muscle training is an effective nursing strategy in improving patient's outcomes after cardiothoracic surgery. Inspiratory muscle training is easy, cost effective and non-invasive procedure which helped in reducing the incidence of postoperative pulmonary complications, prevents re-intubation, chest tube re-insertion, decrease duration of ICU

stay and prevents the need for IUC re-admission. Inspiratory muscle training is effective when it was taught to the patient in the pre-operative period. Inspiratory muscle training had a positive effect on dyspnea at rest and during exertion and even if the patient experienced dyspnea, practice of inspiratory muscle training exercises helped in relieving it.

In the light of the current study findings, the following recommendations are suggested:
For patients: those who scheduled for cardiothoracic surgery should be provided with both written and verbal information about techniques of inspiratory muscle training. Inspiratory Muscle Training should be taught to patients preoperatively in several sessions until the patient performs the technique efficiently, correctly and independently. Patients should redemonstrate postoperative inspiratory muscle training immediately after extubation.

For nurses: In-service training programs should be conducted periodically for the nurses in the critical care unit to improve and update their knowledge about inspiratory muscle training. Inspiratory muscle training techniques should be used as a routine nursing intervention for all post-operative patients.

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