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The Effect of Breathing Exercise by Using Incentive Spirometry on Dyspnea Severity after Sternotomy

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Abstract

Dyspnea is a common adverse effect after sternotomy. It can linger for weeks or months, although the symptoms usually lessen with time. Open heart surgery can improve health, vitality, and quality of life. However, the operation can cause a variety of adverse effects including shortness of breath (dyspnea). ***Aim:*** The aim of this study was to evaluate the effect of breathing exercise by using incentive spirometry on dyspnea severity after sternotomy. ***Design:*** A quasi-experimental research design was used to achieve the aim of this study. ***Subject:*** A purposive sample of 60 adult patients who fulfilled the inclusion criteria from both genders after sternotomy were involved in this study and divided into two equal groups (30 patients in each group). ***Setting:*** The research was carried out in the surgical intensive care unit (ICU) at the Cardiothoracic Academy within Ain Shams University. ***Tools:*** three tools were used for data collection Tool **I:** Patient's personal characteristics and health status assessment questionnaire. Tool **II:** Postoperative hemodynamic status, Blood Gases and chest auscultation sound assessment questionnaire. Tool **III:** Dyspnea severity score tool. ***The results:*** This study found that there was a statistically significant difference regarding severity of dyspnea between the control and study group, in which the study group showed lower severity of dyspnea in comparison to control group. ***Conclusion:*** Incentive spirometry has demonstrated a positive effect on reducing dyspnea severity following sternotomy by promoting lung expansion, improving pulmonary function, and preventing postoperative complications. ***Recommendations:*** Preparing an educational program for patients and their families to use incentive spirometry regularly after sternotomy.

Keywords: Breathing exercise**,** Dyspnea, Incentive spirometry, Sternotomy

Introduction

Median sternotomy which used for Open-heart surgery remains a common procedure with more than a million cases performed worldwide annually. The procedure involves a vertical incision in the sternum, allowing full access to the thoracic cavity for heart-related surgeries. Since the 1960s, median sternotomy has been the preferred approach for performing coronary artery bypass graft (CABG) surgeries aimed at treating coronary heart disease, in addition to various valve repair or replacement procedures and operations designed to correct congenital heart defects ***(Wiens et al., 2024).***

Sternotomy is regarded as the standard incision in cardiac surgery, leading to low rates of failure and proven excellent long-term results. It is also applicable in thoracic surgery for procedures involving the mediastinum, bilateral lungs, or the lower trachea and main stem bronchus. Proper execution of sternotomy is essential to reduce both short- and long-term morbidity and mortality. The surgical method is well defined, and specific principles are acknowledged as critical for minimizing complications. Identifying the correct landmarks, properly preparing midline tissue, performing osteotomy while avoiding injury to nearby

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structures such as the pleura, pericardium, innominate vein, brachiocephalic artery, and dilated ascending aorta, along with effective bleeding control, are key steps in the procedure ***(Kirmani et al., 2023).***

Postoperative dyspnea frequently occurs in the early stages after sternotomy and pulmonary complications following surgery remain a major contributor to morbidity, mortality, increased healthcare costs, and prolonged hospital admissions after heart surgery ***(Srimookda, et al., 2021)***. Patients undergoing cardiac surgery often experience pulmonary issues and gas exchange abnormalities in the initial hours following the procedure. The prompt implementation of relaxation methods, including appropriate positioning, mobilization, shoulder girdle exercises, and breathing techniques, is advised as part of the recovery plan for numerous postoperative patients ***(Akram &Hegazy, 2020***).

Incentive spirometry is frequently utilized after surgical procedures, particularly thoracic and abdominal surgeries. Its primary purpose is to foster the expansion of the alveoli and to prevent or address dyspnea. An incentive spirometry facilitates deep inhalation by offering visual feedback that motivates the patient to breathe in slowly and deeply, thereby optimizing lung inflation and helping to avert or lessen atelectasis. Ideally, patients are positioned sitting or in a semi-Fowler's position to promote diaphragmatic movement. Nonetheless, this technique can be carried out with the patient in any position ***(Abdelhafez & Fouad, 2023).***

An incentive spirometry (IS), also known as Sustained Maximal Inspiration Devices, measures the airflow inhaled through the mouthpiece and is utilized to enhance lung ventilation, mitigate the effects of anesthesia or shallow breathing, help clear respiratory secretions, support respiratory gas exchange, and reinflate collapsed alveoli. The purpose of an incentive spirometry is to enhance the process of inhaling. When utilizing an IS, patients should be positioned appropriately, ideally in an upright setting in a bed or chair, as this position promotes optimal ventilation ***(El-Koa et al., 2023).***

Critical care nurse's role is to advise the patient to take slow, deliberate inhales via the mouthpiece while sitting, semi fowler or standing in a comfortable position with perfect posture and holding the incentive spirometry in the correct, upright position. The patient is encouraged to accomplish a specific volume, which can vary depending on their height and age. The patient receives visible feedback as the piston rises to the clinician's predefined marker. The patient is encouraged to hold his breath for at least 2 or 3 seconds during full inhalation. Expiration occurs slowly and gently, with the lips no longer sealed around the mouthpiece. After a series of ten inhalations, coughing should be encouraged to rid the lungs of mucus. It is recommended to utilize an incentive spirometer for at least ten deep breaths every hour while awake ***(Ernstmeyer & Christman, 2023).***

Significance of the study

Broncho-pulmonary complications present a major difficulty for critical care nurses after cardiac surgery. Patients who are intubated undergo variations in lung volumes, capacities, oxygen saturation, and arterial blood gases. Lung capacities can diminish by 30-60%, remaining at a lowered level of 12% for as long as one year, resulting in dyspnea ***(Ali et al., 2020).***

Patients undergoing cardiothoracic surgery often face complications in the lungs after the operation, such as reduced oxyhemoglobin saturation and dyspnea. These issues can arise in as many as 20% of cases and are attributed to factors like general anesthesia, ischemia related to extracorporeal circulation, sternotomy, and prolonged hypothermia ***(Tanner & Colvin, 2020).***

Based on data from the open-heart surgery department at Tanta University, there are approximately 20 patients treated for open heart surgery each month. Additionally, it was noted that around 53% of these patients underwent CABG with the use of cardiopulmonary bypass ***(Atia et al., 2023)***.

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Aim of the study

The study was conducted to evaluate the effect of breathing exercise by using incentive spirometry on dyspnea severity after sternotomy through the following objectives: Assess dyspnea severity for the studied patients, apply breathing exercise by using incentive spirometry for the study group and evaluate the effect of using incentive spirometry on dyspnea severity after sternotomy for the study group.

Research question

What is the effect of breathing exercise by using incentive spirometry on dyspnea severity after sternotomy?

Research Hypothesis

H_1: Using incentive spirometry has no effect on dyspnea severity after sternotomy.

H_2: Using incentive spirometry will decrease dyspnea severity after sternotomy.

Subject and Methods

The subject and methods for this study was portrayed under the four main items as follows:

I- Technical Item

The technical item included research design, setting, subject and tools for data collection.

Research design

A Quasi-experimental research design was used to achieve the aim of this study as a framework for caring out research activities. Quasi-experimental research offers the main benefits of being cost-effective and requiring minimal resources. Additionally, it is easy to show the effectiveness of interventions as they are carried out in real-life settings with limited controls ***(Siedlecki, 2020)***.

Setting

The research was carried out in the surgical intensive care unit (ICU) at the Cardiothoracic Academy within Ain Shams University. Positioned on the 4th floor of the hospital, the ICU at the Cardiovascular and Thoracic Academy hospital is comprised of 10 sections, separated by curtains, stainless and glass dividers, and an isolation room at the end of the ICU. Every section and isolated room are equipped with 1 bed, 1 ventilator, 1 monitor, and portable suction. Additionally, the ICU houses 2 crash carts, 2 direct current cardioversion (DC), and 1 Hemodialysis machine. The number of nurses in each shift was 10 nurses, distributed among the patients at a ratio of one nurse to one patient.

Subjects

A purposive sample of 60 adult patients who fulfilled the inclusion criteria from both genders after sternotomy were involved in this study from the above-mentioned setting who accepted to participate in the study. The sample was divided into two equal groups (30 patients in each group):

The study group: which consisted of 30 patients who received a standardized using of incentive spirometry that were implemented by the investigator

The control group: which consisted of 30 patients after sternotomy and who received the routine nursing care.

Inclusion criteria: Recently extubated patients from mechanical ventilator and patients who don't have a history of chronic respiratory diseases.

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Tools for data collection:

Tools of data collection that used to achieve the purpose of the current study were three tools:

Tool I : Patient's personal characteristics questionnaire.

This tool was adopted from ***(El Reabai et al. 2023)*** and included two parts:

Part 1: **Personal characteristics** which included the patient's age, gender, marital status, educational level and smoking status.

Part 2: **Health status** included type of surgery, patient's height, patient's weight, body mass index (BMI), length of stay (LOS) in hospital, previous cardiothoracic surgery, duration of mechanical ventilation.

Tool II: Postoperative hemodynamic status, Blood Gases and chest auscultation sound assessment questionnaire.

This tool included 3 parts:

Part 1: **Postoperative hemodynamic status** was developed by the investigator and included patient's temperature (T), blood pressure (BP), heart rate (HR), central venous pressure (CVP), oxygen saturation (SPO2), respiratory rate (RR), pain severity and tidal volume inhaled by spirometry.

Part 2: **Blood Gases** it was adopted from ***(Yazdannik et al., 2016)*** and included PH, PC02, Pao2, and HCO3.

Part 3: **Chest auscultation sound** it was adopted from ***(El-Reabai et al., 2023)***

Tool III : Dyspnea severity score tool. "***Standardized scale"***

Numerical rating scale (NRS) was used to assess dyspnea severity. This tool was adopted from ***(El-Reabai et al., 2023).*** NRS is a valid measure frequently used to assess patient reported dyspnea. The point scale consists of 0–10, corresponding with increasing shortness of breath, where 0 score represented no dyspnea, 1–4 represented mild, 5–6 represented moderate, and 7–10 represented severe dyspnea. The patient was asked to verbalize the most appropriate number of his/her shortness of breath, as guided by the scale. A pilot study reported that NRS showed good agreement when assessing dyspnea severity in the emergency department.

Validity

The tools were formulated and submitted to five experts in critical care and medical surgical nursing academic staff (3 assistant professors and 2 lecturer) to assess the content validity then needed modifications were done.

Reliability

Cronbach alpha coefficient was calculated to assess the reliability of the scales used by examining their internal consistency (Tool I part II: 0.788, Tool II: 0.837 and Tool III: 0.849). Cronbach's alpha reliability coefficient normally ranges between 0 and 1. Higher values of Cronbach's alpha (More than 0.7) denote acceptable reliability. Spearman's correlation coefficient was used to determine correlations between different variables.

II- Operational Item

Pilot study

The pilot study was done on 10% (6 patients) of the sample to examine the clarity of questions and time needed to complete the study tools. According to the results no modifications were performed.

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Field work

The study was approved by the director of cardiothoracic surgery department and the Nursing directors of the critical care unit, in the previously mentioned study setting after getting permission and collaboration to conduct the study from the Faculty of Nursing Helwan University which sent them a letter describing the purpose of the study.

The study was carried out through three major phases: preparatory phase, implementation, and evaluation phase:

1-First phase (preparatory phase)

This phase included reviewing of past, current, national and international related literature and theoretical knowledge of various aspects of the study using books, articles, internet, periodicals and magazines to develop tools for data collection.

To obtain their participation, the study's objective was conveyed to the director of the cardiothoracic surgery department in Ain Shams University before gaining their formal consent and administrative authority to collect the necessary data.

After describing the study's objectives and the confidentiality of the patient's data for research purposes, each patient submitted informed consent.

The investigator was available at the study setting 3 days per week (Saturday, Sunday, and Monday) or (Tuesday, Wednesday, and Thursday) by rotation through the morning and afternoon shifts. In this phase the investigator introduced himself for available patients to explain the aim of the study and take their oral consent to participate in the study prior to any data collection. The investigator completed the initial assessment and filled out additional assessment questionnaires for all research subjects in both the study and control groups in order to gather data.

Data collection took six months started from the beginning of April 2024 until the end of September 2024 and accomplished throughout the following phases:

2-Second phase (Implementation phase)

For The Study group: Immediately after extubation and for three consecutive days the patient received an incentive spirometry to be used 5 to 10 times every 2 hours, THE investigator educated all patients in this phase the standardized technique of using the incentive spirometry, patient was positioned in semi fowler position. Patient was asked to take a slow, deep breath into the incentive spirometry while holding their breath for two to three seconds, watch the balls rise to keep track of the patient's progress, then, exhale into the mouthpiece while continuing to breathe normally for several breaths, following this procedure, the patient performed a deep coughing exercise to remove secretions, repeat this approach with the patient throughout the day, the investigator was observing how many balls raised which determined the tidal volume inhaled on each trial and the patient was requested to verbally express the seriousness of dyspnea using the Dyspnea severity score tool at the conclusion of each day. The investigator then recorded this information over the course of three days.

For The Control group:

The patients were under the care of the physiotherapist and nurse did not consistently use incentive spirometry, possibly due to experiencing pain. Some patients in this group only used incentive spirometry four or five times within period while the investigator was in the ICU (approximately 9 hours). Others used incentive spirometry only when prompted by the nurse or physiotherapist. At the end of each day, the investigator asked the patients to verbally express the severity of dyspnea using the Dyspnea severity score tool over the three days, and then documented their responses.

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For both groups: Every two hours, check vital indicators, check blood gas parameters (PH, HCO3, PCO2, Pao2), according to ICU policy (every 3 hours) and Measure postoperative pain on a numerical scale and assess it: (Pain at rest, Pain while taking deep breath, Pain while coughing)

3-Third phase (Evaluation phase)

The investigator Evaluate the effect of breathing exercise by using incentive spirometry on dyspnea severity after sternotomy for all the research participants. Evaluation was done for participants of both the study and control groups three times during: 1st, 2nd and 3rd day, using tool II to assess patient's hemodynamic stability, blood gases parameters and chest auscultation sound and tool III to assess severity of dyspnea.

III- Administrative Item

Approval to carry out this study was obtained from the dean of the Faculty of Nursing Helwan university and director of Cardiothoracic surgeries department, Ain Shams University.

Ethical considerations

An official permission to conduct the proposed study was obtained from the Scientific Research Ethics Committee at Faculty of Nursing in Helwan University in the session Number (39) on 13/ 2 / 2024. Participation in the study was voluntary and subjects were given complete information about the study and their role before signing the informed consent. The ethical considerations included explaining the purpose and nature of the study, stating the possibility to withdraw at any time, confidentiality of the information where it will not be accessed by any other persons without taking permission of the participants. Ethics, values, culture and beliefs will be respected.

IV-Statistical Item

The collected data results of the impact of breathing exercise by using incentive spirometry on patient's dyspnea severity were scored, tabulated and analyzed by personal computer using statistical package for the social science (SPSS) program version 26 for windows and it was used for data entry and statistical analysis. Descriptive as well as inferential statistics were done such as means± and standard deviation (SD), frequencies (n) and percentage (%) and analysis of variance (ANOVA). The significance level was set at $P \leq 0.05$.

Results

Table (1): Frequency and percentage distribution for both control and study group regarding personal characteristics (N=60).

Items	Control (n = 30)		Study (n = 30)		Test statistic	*P*-value
	N	%	N	%		
Age category:						
20>30 years	1	3.3	0	0		
30>40 years	3	10	5	16.7	x^2 =2.474	0.480
40>50 years	8	26.7	11	36.7		
50≥60 years	18	60	14	46.6		
Gender:						
Male	18	60	20	66.7	x^2 =0.287	0.592
Female	12	40	10	33.3		
Marital status:						
Single	0	0	2	6.7		
Married	28	93.3	27	90	x^2 =5.018	0.074
Divorced	0	0	1	3.3		
Widowed	2	6.7	0	0		

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Education:						
Basic education	7	23.3	8	26.7	x^2=1.525	0.677
Secondary education	7	23.3	5	16.7		
University education	15	50	17	56.6		
Postgraduate education	1	3.3	0	0		
Smoking status:						
Non smoker	22	73.3	19	63.3	x^2=0.810	0.667
Smoker	5	16.7	6	20		
Quit smoking	3	10	5	16.7		
Years of smoking:	15.4±5.50		21±6.69		*t test= 2.23*	0.17
Since smoking:	2.0±1.00		7.4±12.72		*t test= 0.505*	0.504
Duration of smoking:	24.66±16.04		14.4±11.74		*t test= 1.108*	0.333

*: *Significant at P ≤ 0.05*

Table 1: showed that, there was no statistically significant difference between socio-demographic characteristics of the two groups regarding age category (*P*-value = 0.480), gender (*P*-value = 0.592), marital status (*P*-value = 0.074), education (*P*-value = 0.677) as well as smoking status (*P*-value = 0.677).

Table (2): Frequency and percentage distribution for both control and study group regarding health status (n=60).

Items	Control (n = 30)		Study (n = 30)		Test statistic	*P*-value
	N	%	N	%		
Type of surgery						
Coronary artery bypass graft	13	43.3	12	40	x^2=6.088	0.298
Mitral valve replacement	8	26.7	4	13.3		
Double valve replacement	4	13.3	3	10		
Aortic valve replacement	4	13.3	10	33.3		
Tricuspid valve replacement	0	0	1	3.3		
Atrial septal defect	1	3.3	0	0		
Height:	168±5.46		171±6.87		*t test=3.73*	0.058
Weight:	75.4±11.5		76.66±9.7		*t test=0.212*	0.647
Body Mass Index:						
Normal	14	46.7	21	70	x^2=3.40	0.183
Overweight	10	33.3	6	20		
Obese	6	20	3	10		
Length of stay in hospital:						
<1 week	25	83.3	28	93.3	x^2=1.456	**0.02***
>1 week	5	16.7	2	6.7		
Previous cardiothoracic surgery:						
No	30	100	28	93.3	x^2=2.069	0.150
Yes	0	0	2	6.7		
Duration of mechanical ventilation						
1-4 hours	0	0	1	3.3	x^2=5.324	**0.01***
5-8 hours	12	40	17	56.7		
9-12 hours	17	56.7	9	30		
More than 12 hours	1	3.3	3	10		

*: *Significant at P ≤ 0.05*

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Table 2: illustrate that, there was a statistically significant between two groups regarding length of stay in hospital and duration of mechanical ventilation (*P*-value = 0.02*, 0.01* respectively). And there was no statistically significant difference between health status of the two groups regarding type of surgery (*P*-value = 0.298), body mass index (*P*-value = 0.183), previous cardiothoracic surgery (*P*-value = 0.150).

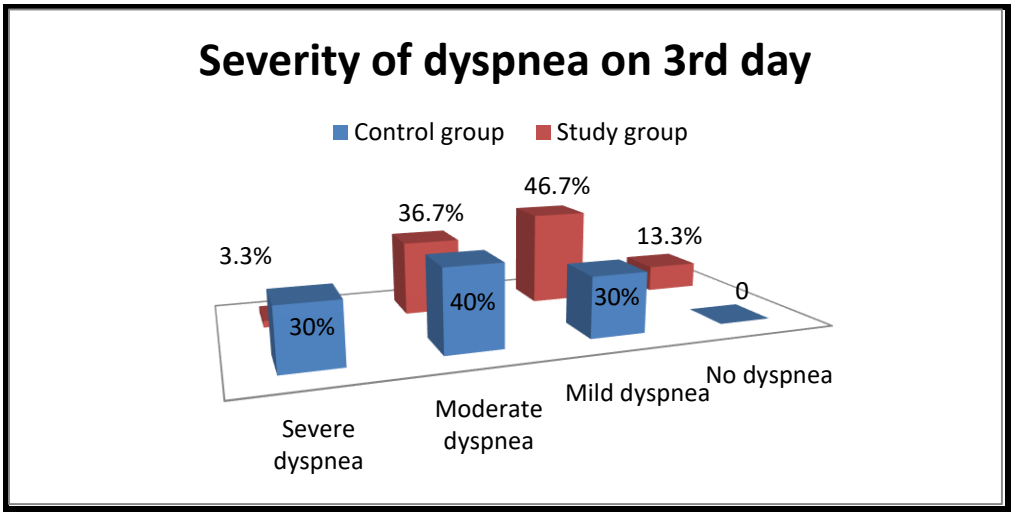

Figure (1): Bar graph representing severity of dyspnea of both the study and control group:

Fig 1: reveals that 46.7% of the study group has mild dyspnea, while 40% of the control group has moderate dyspnea.

Table (3): Frequency and percentage distribution for both control and study group regarding post-operative hemodynamic status (n=60).

Items	1st Day				2nd Day				3rd Day				ANOVA F (p)
	Control (n = 30)		Study (n = 30)		Control (n = 30)		Study (n = 30)		Control (n = 30)		Study (n = 30)		
	N	%	N	%	N	%	N	%	N	%	N	%	
Temperature:													
Normal	27	90	29	96.7	29	96.7	30	100	30	100	30	100	3.76 (0.06)
Hyperthermia	1	3.3	1	3.3	0	0	0	0	0	0	0	0	
hypothermia	2	6.7	0	0	1	3.3	0	0	0	0	0	0	
Test & (P-Value)	x^2=2.07 (0.355)				x^2=1.017 (0.313)				*Not Computed*				
Blood Pressure:													
Normal	16	53.3	14	46.7	19	63.3	27	90	24	80	30	100	**21.55 (0.00*)**
Hypertension	7	23.3	9	30	5	16.7	3	10	2	6.7	0	0	
Hypotension	7	23.3	7	23.3	6	20	0	0	4	13.3	0	0	
Test & (P-Value)	x^2=0.383 (0.826)				**x^2=7.89 (0.019*)**				**x^2=6.667 (0.036*)**				
Heart Rate:													
Normal	18	60	19	63.3	21	70	24	80	25	83.3	29	96.7	**20.03 (0.00*)**
Tachycardia	12	40	11	36.7	9	30	6	20	5	16.7	1	3.3	
Test & (P-Value)	x^2=0.071 (0.791)				x^2=0.800 (0.371)				x^2=2.96 (0.085)				
Central Venous Pressure:													
Normal	22	73.3	25	83.3	25	83.3	26	86.7	26	86.7	29	96.7	**6.65 (0.012*)**
Hypervolemia	2	6.7	0	0	2	6.7	0	0	1	3.3	0	0	
Hypovolemia	6	20	5	16.7	3	10	4	13.3	3	10	1	3.3	
Test & (P-Value)	x^2=2.282 (0.319)				x^2=2.162 (0.339)				x^2=2.16 (0.339)				

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Oxygen saturation:													
<90%	16	53.3	8	26.7	10	33.3	4	13.3	7	23.3	1	3.3	**21.45 (0.00*)**
>90%	14	46.7	22	73.3	20	66.7	26	86.7	23	76.7	29	96.7	
Test & (P-Value)	x^2 =**4.44 (0.035*)**				x^2=3.354 (0.067)				x^2=**5.19 (0.023*)**				
Respiratory Rate:													
Normal	7	23.3	10	33.3	10	33.3	13	43.3	15	50	28	93.3	**39.72 (0.00*)**
Tachypnea	23	76.7	20	66.7	20	66.7	17	56.7	15	50	2	6.7	
Test & (P-Value)	x^2 =0.739 (0.390)				x^2 =0.635 (0.426)				x^2 =**13.87 (0.00*)**				
Pain Severity:													
No Pain	0	0	0	0	0	0	2	6.7	1	3.3	8	26.7	**6.05 (0.017*)**
Mild Pain	1	3.3	11	36.7	5	16.7	12	40	10	33.3	15	50	
Moderate Pain	11	36.7	11	36.7	10	33.3	11	36.7	11	36.7	7	23.3	
Severe Pain	11	36.7	6	20	11	36.7	5	16.7	8	26.7	0	0	
Very Severe Pain	7	23.3	2	6.7	4	13.3	0	0	0	0	0	0	
Test & (P-Value)	x^2 =**12.58 (0.006*)**				x^2 =**11.18 (0.025*)**				x^2 =**15.33 (0.002*)**				
Tidal Volume in Spirometry:													
Mean±SD	**110±200**		**480±231**		**340±269**		**640±232**		**550±262**		**880±272**		**3.02 (0.001*)**

**: Significant at P ≤ 0.05*

Table 3: revealed that, there was a statistically significant difference between the three measures of blood pressure, heart rate, CVP, oxygen saturation, respiratory rate, pain severity within the first, second, and third day (P-value = 0.00*, 0.00*, 0.012*, 0.00*, 0.00*, and 0.017* respectively), while there was no statistically significant difference between the three measures of temperature within the first, second, and third day (P-value = 0.06). There was a statistically significant difference between the two groups regarding oxygen saturation within first and third day (p-value = 0.035*, and 0.023* respectively). As well there was a statistically significant difference between two groups regarding tidal volume in spirometry (p-value = (0.001*)

Table (4): Frequency and percentage distribution for both control and study group regarding chest auscultation sound (N=60).

Items	1st Day				2nd Day				3rd Day				ANOVA F (p)
	Control (n = 30)		Study (n = 30)		Control (n = 30)		Study (n = 30)		Control (n = 30)		Study (n = 30)		
	N	%	N	%	N	%	N	%	N	%	N	%	
Chest auscultation sound:													
Normal	14	46.7	17	56.7	15	50	18	60	18	60	19	63.3	**4.73 (0.03*)**
Wheezes	8	26.7	6	20	7	23.3	5	16.7	5	16.7	4	13.3	
Crackles	6	20	5	16.7	6	20	5	16.7	5	16.7	5	16.7	
Rhonchi	1	3.3	1	3.3	1	3.3	1	3.3	1	3.3	1	3.3	
Stridor	1	3.3	1	3.3	1	3.3	1	3.3	1	3.3	1	3.3	
Test & (P-Value)	x^2 =0.667 (0.955)				x^2 =0.697 (0.952)				x^2 =0.138 (0.998)				

**: Significant at P ≤ 0.05*

Table 4: reported that, there was a statistically significant difference between the three measures of chest auscultation sound within the first, second, and third day (P-value = 0.03*).

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Table (5): Relation between pain severity and severity of dyspnea in the third day (N=60).

Items	Severity of dyspnea in 3rd day								Test statistic	*P*- value
	No (n=4)		Mild (n=23)		Moderate (n=23)		Severe (n=10)			
	N	%	N	%	N	%	N	%		
Pain Severity:										
No Pain	4	100	3	13	2	8.7	0	0		
Mild Pain	0	0	16	69.6	9	39.1	0	0	$x^2 = 49.67$	**0.00***
Moderate Pain	0	0	4	17.4	9	39.1	5	50		
Severe Pain	0	0	0	0	3	13	5	50		

**: Significant at P ≤ 0.05*

Table 5: shows that, there was a statistically significant association between pain severity and dyspnea severity (*P*-value= 0.00*) in which moderate and severe pain accompanied with severe dyspnea.

Table (6): Relation between blood gases and severity of dyspnea in the third day (n=60).

Items	Severity of dyspnea in 3rd day								Test statistic	*P*- value
	No (n=4)		Mild (n=23)		Moderate (n=23)		Severe (n=10)			
	N	%	N	%	N	%	N	%		
PH:										
Normal (7.35-7.45)	2	50	16	69.6	18	78.3	5	50	x^2 =4.833	0.565
More than 7.45	1	25	4	17.4	4	17.4	4	40		
Less than 7.35	1	25	3	13	1	4.3	1	10		
PCO2:										
Normal (35-45)	2	50	18	78.3	15	65.2	6	60	x^2 =5.733	**0.004***
More than 45	1	25	2	8.7	7	30.4	2	20		
Less than 35	1	25	3	13	1	4.3	2	20		
HCO3:										
Normal (22-28)	4	100	20	87	14	60.9	5	50	*Fisher's Exact test* = 8.866	**0.003***
More than 28	0	0	3	13	8	34.8	3	30		
Less than 22	0	0	0	0	1	4.3	2	20		
Pao2:										
Normal (75-100)	2	50	9	39.1	8	34.8	3	30	x^2 =1.933	0.926
More than 100	2	50	12	52.2	13	65.5	5	50		
Less than 75	0	0	2	8.7	2	8.7	2	20		

**: Significant at P ≤ 0.05*

Table 6: specified that, there was a statistically significant association between HCO3, pco2 and dyspnea severity (*P*-value= 003*, and 0.004* respectively), while there was no statistically significant association between PH & Pao2, and dyspnea severity (*P*-value= 0.565, and 0.926 respectively).

Discussion

As regards to age, the recent investigation found that more than half of the patients were between the ages of 50 ≥60 years. These finding are congruent with ***(Sweity et al. 2021))*** who conducted a study entitled "preoperative IS for preventing PPCs in patients undergoing CABG", which showed that the mean age was 54.4±3.8 years. In addition, this finding opposes ***(Fayyaz et al., 2016)*** who published master thesis about "Preoperative IS, Effectiveness to Improve Postoperative Oxygenation in Patients having CABG Surgery" found that mean age was 39.44±12.06 years.

Regarding patients' gender and level of education, current study findings explained that about two third of the study participants in both the study and control groups were men and more than half of them had university education. These findings were supported by ***(Patra et al. 2017),*** who conducted "Assessment of Coronary Artery Bypass Grafts Status in Symptomatic Patients: An Observational Study"

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in India and discovered that more than half of the patients investigated were male. On the other hand, ***(Ahmed et al., 2015)*** from Egypt "Coronary artery bypass grafting, Effect of defining and implementing nursing care standards on patient's outcomes" discovered that more than half of the patients were illiterate. According to the study's findings, there were no appreciable differences in the socio-demographic characteristics of the study group compared to the control group.

As regards to type of surgery, more than half of participants in the study and control were undergone valves replacement surgeries and more than third were undergone CABG. This is consistent with ***(Abdelhafez & Fouad., 2023)***" who carried out a study about "Effect of incentive spirometry on postoperative pulmonary complications and oxygenation following open heart surgery" and mentioned that valve replacement surgery is the most common open-heart procedure in cardiac centers, and it was more common in both the study and control groups.

By assessing length of stay in hospital, in the study group; the most of the patients were discharged within a week and the majority of the control group were discharged within a week while minority in both groups stayed in hospital more than week. Contrawise, ***(El-Reabai et al., 2023)*** in their study entitled "The effect of postoperative incentive spirometry on dyspnea severity among patients undergoing coronary artery bypass graft" reported that more than two third of study sample stayed in hospital more than week.

The current study demonstrated that there was statistically significant difference between two groups regarding length of stay in hospital and duration of mechanical ventilation. The same result is supported by ***(Abdelhafez & Fouad., 2023)*** who showed that There was statistically significant variation between the two groups in terms of length of ICU stay and duration of mechanical ventilation.

Regarding temperature, there was no statistically significant difference between the three measures of temperature within the first, second, and third day and current result was similar to ***(Allam et al., 2023)*** who studied "Effect of Active Cycle Breathing Technique on Airway Clearance among Patients Underwent Cardiac Surgery" which clarified that there was no statistically significant difference between the control and study group within the first and third day of temperature measures.

While, the current study revealed that there was a statistically significant difference between the study and control group on the three measures of blood pressure. This finding inconsistent with ***(Allam et al., 2023)*** who mentioned that there were no significant changes observed between the study and control groups.

Additionally, this research results regarding heart rate found that there was no statistically significant difference between the study and control group on the second- and third-day measures. These findings were not harmonized with ***(Abdelhafez & Fouad., 2023)*** who revealed that there was a statistically significant difference between the study and control group regarding heart rate in the second- and third-day measurements. While, this study agrees with the current research that there is no statistically significant difference between the two research groups in central venous pressure measurements on the first and second days after the operation.

In relation to oxygen saturation, the findings of this study specified that there was a statistically significant difference between the three measures of oxygen saturation between two groups. This result was in accordance with ***(Jain & Mistry., 2018)*** who conducted a study about "Comparative study on effects of active cycle of breathing technique and manual chest physical therapy after uncomplicated coronary artery bypass grafting surgery" which stated that there were statistically significant difference regarding oxygen saturation among the study and control and group on the 3rd day post active cycle of breathing technique had a positive effect on the improvement of Spo2 and oxygenation. Additionally, ***(Zhao et al., 2023)*** in their recent study titled" Volume Incentive Spirometry Reduces Pulmonary Complications in Patients After Open Abdominal Surgery: A Randomized Clinical Trial" mentioned

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that at third day after operation, patients in the volume incentive spirometry (VIS) group had a significantly higher SpO2 than that in the control group.

As well, the present study findings according to respiration rate approved that there was a statistically significant difference between the study and control group on three measures. This finding goes in line with ***(Abeer et al., 2019)*** who examined "Effect of deep breathing on heart rate variability following coronary artery bypass graft" and demonstrated that there was a statistically significant difference in postoperative respiration rate between the study and control groups.

Concerning pain severity, the present study showed that there was a significant difference between the study and control group within first, second- and third-day measures. This outcome corresponded with ***(Sweity et al., 2021)*** who reported that there were significant differences between the incentive spirometry group in the numerical rating scale (NRS) pain scale, with obvious less pain in the incentive spirometry group than the control group.

In addition to tidal volume that inhaled by incentive spirometry, the results of the present investigation signified that there was a statistically significant difference between two groups. This finding aligned with ***(Hussain et al., 2022)*** who examined "Active cycle of breathing techniques (ABCT) improves post-operative pulmonary complications in coronary artery bypass graft surgery patients" and clarified that ACBT had a positive effect on improving chest expansion and lung tidal volume in the interventional group.

From the investigator point of view, regular use of Incentive spirometry enhances lung tidal volume among the study group participant by promoting deep inhalation and lung expansion. Also, it strengthens respiratory muscles, reduces airway collapse, improves ventilation, and aids secretion clearance, leading to better pulmonary function and oxygenation.

With respect to severity of dyspnea, the study found that utilizing incentive spirometry led to a significant decrease in dyspnea severity, from moderate to mild to no dyspnea by the third day and between the three measures of dyspnea severity within the first, second, and third day. This result agreed with a published thesis by ***(El-Reabai et al., 2023)*** This study concluded that individuals with dyspnea reported improvement after utilizing incentive spirometry, deep breathing, and practicing coughing.

As regards to chest auscultation sound, the current study illustrated that there was a statistically significant difference between the three measures of chest auscultation sound within the first, second, and third day and about two third of the study group had improvement in chest sound. This result was congruent with ***(El-Reabai et al., 2023)*** who found that chest auscultation showed significant improvement and increased normality of breath sounds in over half of the participants after three days of incentive spirometry use compared to before.

By assessing the relation between pain severity and dyspnea severity. The current study specified that there was a significant association between pain severity and dyspnea severity. The same result was supported by ***(Clark et al., 2014***) in their study entitled "Dyspnea and pain frequently co-occur among Medicare managed care recipients" stated that patients who claim shortness of breath most likely express numerous sorts of pain.

From the investigator point of view, pain severity and dyspnea severity are closely related because severe pain especially after cardiothoracic surgery restricts deep breathing and lung expansion, leading to shallow breathing, decreased tidal volume, and ventilation-perfusion mismatch. Pain also triggers sympathetic activation, increasing heart rate and oxygen demand, which can worsen breathlessness.

Considering relation between blood gases and severity of dyspnea. The results of this study revealed that there was a statistically significant association between Pco2, Hco3 and severity of dyspnea. this finding is harmonized with ***(Santus et al., 2023)*** who conducted a study about " Acute

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dyspnea in the emergency department: a clinical review " and mentioned that an increase in arterial carbon dioxide pressure (PaCO2) can cause shortness of breath. Also, severe increase in PaCO2, possibly contributing to dyspnea, is a frequent event.

Additionally, ***(Neto et al., 2025)*** who examined " Impact of mild hypercapnia in critically ill patients with metabolic acidosis" demonstrated that in acid accumulation or loss, can lead to decreased blood pH and bicarbonate levels, potentially causing increased respiratory drive and dyspnea.

Conclusion

Based on the results of this study, it can be concluded that Incentive spirometry has demonstrated a positive effect on reducing dyspnea severity following sternotomy by promoting lung expansion, improving pulmonary function, and preventing postoperative complications such as atelectasis. By encouraging deep breathing and sustained inspiratory efforts, it enhances oxygenation and ventilation, leading to greater respiratory efficiency and comfort. Patients who incorporate incentive spirometry into their recovery regimen often experience improved lung capacity, reduced discomfort, and faster overall recovery, highlighting its value as an essential tool in postoperative care for individuals undergoing sternotomy.

Recommendations

- Preparing an educational program for patients and their families to use incentive spirometry regularly after sternotomy.
- Replication of this study using a larger probability sample drawn from various geographical locations in Egypt to acquire data that can be more widely generalized.
- Future studies could be conducted with sufficient research funding, utilizing postoperative incentive spirometry following major surgery and for various respiratory conditions, in order to alleviate the severity of dyspnea without the use of medication.

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