Efficacy of Localized Cryotherapy on Incisional Pain associated with Incentive Spirometry Post Coronary Artery Bypass Graft Surgery

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Abstract

Background: After coronary artery bypass graft surgery, considerable postoperative incisional pain is observed when incentive spirometry is used. As a result, the major postoperative treatment strategy for cardiac surgery is pain management. Localized cryotherapy is regarded as a quick, inexpensive, and non-pharmacological pain management technique. **Aim:** Determine the efficacy of localized cryotherapy on incisional pain associated with the use of incentive spirometry post coronary artery bypass graft surgery. **Setting:** Crossover study design was utilized at Cardiothoracic Surgical Intensive Care Unit (ICU) and Cardiothoracic Surgery Department at Shebin El-Kom, Menoufia University Hospital, Menoufia Governorate, Egypt. **Sample:** A Purposive sample of 60 adult patients were included in the study. **Tools of data collection:** Three tools were used for data collection; Tool I Structured interview questionnaire, Tool II Subjective pain assessment sheet, Tool III Objective pain assessment sheet. **Results:** There were statistically significant effects on pain intensity, pain distress, visual analog pain score, patients' perception and most of physiological indicators related to incisional pain associated with the use of incentive spirometry after localized cryotherapy application. **Conclusions:** Application of localized cryotherapy in form of cold gel pack application was effective for reducing incisional pain and its physiological indicators associated with incentive spirometry in patients post coronary artery bypass graft. **Recommendations:** For post-operative CABG patients, localized cryotherapy should be promoted as a non-pharmacological treatment option before incentive spirometry.

Keywords: Coronary artery bypass graft, Incentive spirometry, Incisional pain, Localized cryotherapy

Introduction

Cardiovascular diseases (CVDs) have the highest incidence of deaths in the world. The recent World Health Organization (WHO) statistics show that more than 16 million people die each year as a result of CVDs. In 2018, there were 163,171 fatalities in Egypt from coronary artery disease (29.38%) of all deaths. Egypt death rate is ranked 15th in the world according to WHO statistics. The treatment with coronary artery bypass graft (CABG) is widely used around the world for cardiovascular diseases patients and over 800,000 CABG surgeries are carried out globally **(Mansor, Abo-El-Ata & Sobeh, 2021).**

CABG is a type of heart surgery that bypass a blocked artery to improve blood flow to the heart. To gain access to the heart, the sternum is split open medially. The surgical procedure involves grafting a segment of the saphenous vein or internal mammary artery between the aorta and the blocked coronary artery distal to the obstructive lesion **(American Heart Association, 2020).**

The sternum is wired securely together at the end of the procedure, and the skin is sutured, leaving an incision line on the sternum. The most frequent and substantial causes of morbidity, mortality, and hospitalizations costs following CABG surgery are postoperative pulmonary complications (PPCs) **(Masoumeh et al., 2018).**

Along with lowering PPCs, routine postoperative CABG care is recommended to enhance patients' pulmonary functioning. The majority of these interventions concentrate on managing the airways, which may involve a number of procedures such mechanical ventilation, endotracheal suctioning, extubating

and chest physiotherapy using incentive spirometry. Many patients experience incisional, chest, and sternal pain after CABG surgery. If this pain is not adequately controlled, patients may be unable to use incentive spirometry, which is crucial for preventing PPCs **(Yan et al., 2019).**

Consequently, incentive spirometry use might make patients feel worse and make it harder for them to do crucial tasks after CABG surgery. This might be because incentive spirometry takes a long time to complete, which could change muscle tension and alter skeletal position and cause incisional, chest, and sternal pain **(Seweid et al., 2021).**

Incision into the highly innervated parietal pleura, opening of the rib cage, greater intercostal muscle straining, and pressure and pressure on the sternal wound all contribute to increased discomfort. Therefore, pain management following CABG surgery is regarded as the most important postoperative care strategy, which is essential to preserve the patient's comfort and avoid issues with the respiratory system **(El-Nagar et al., 2020).**

The use of both pharmacological and non-pharmacological methods could be used to treat incisional pain. Pharmacological analgesics for pain treatment are linked to a number of side effects, including the potential for drug dependence, hypotension, impaired vital functions, drowsiness, nausea, and vomiting, as well as the possibility of anaphylactic shock in specific circumstances. Additionally, it can come at a high cost to the healthcare system. Because of this, it is not advisable to utilize this treatment when simpler, less expensive options exist to successfully lessen or control pain **(Urden et al., 2016).**

The use of relaxation techniques, guided imagery, music therapy, touch therapy, and administering heat and cold therapy are among the non-pharmacological pain reduction techniques that are currently highly valued. These procedures can be carried out independently and are simple to utilize, which may be acceptable to both patients and nurses. Localized cryotherapy (the application of cold gel packs) is an easy, non-pharmacological, and economical method for pain relief. It has few negative effects but numerous positive impacts on treating pain in sports and orthopedic injuries. Pain from procedures and post-operative care can be relieved by the cold. Because it lowers skin temperature and acts as analgesia while skin temperature is at 13.6°C, the analgesic effects decrease after treatment when skin temperature rises to 15.6°C **(Chailler et al., 2020).**

Studies have shown that cold application causes a lowering in tissue temperature and a consequent decrease in the conduction rates of sensory and motor nerves, which has the inhibitory or direct analgesic impact. It is thought that the stimulation of cold receptors on the skin is what produces the indirect analgesic action of cold application **(Aktas & Karabulut, 2019)**.

There are few researches on the use of cold therapy to reduce pain in post-operative cardiac patients, and there is also minimal data regarding the impact of cold therapy on incisional pain linked to the use of incentive spirometry in patients after CABG surgery. In that study, researchers tried to add an evidence-based nursing intervention to the care of patients undergoing CABG surgery by determining the impact of cold gel pack application (CGP) on reducing sternal incisional pain brought on by incentive spirometry **(Rigi et al., 2016).**

Significance of the study

In order to use incentive spirometry appropriately and efficiently and assist prevent PPCs, patients may have postoperative incisional pain. The result could be respiratory failure, hypoxemia, atelectasis, or pneumonia. It could also make it difficult to breathe normally, do deep breathing exercises, cough effectively, and clear phlegm. Despite increased awareness of pain management on a global scale, cardiothoracic surgery units still face significant pain management issues. In patients who have undergone CABG, procedural pain has received limited attention. It is well known that procedural pain may have a detrimental effect on the results of CABG surgery **(AlOtaibi & El-Sobkey, 2015)**

The pain could not be reduced or relieved by pharmacological treatment alone. Application of superficial cold gel packs is an efficient technique for pain relief because it slows down the speed of nerve conduction,

which in turn lessens pain. However, there are currently no national statistics on CABG accessible in Egypt, and there is little research on the impact of using a cold gel pack on incisional pain in post-operative CABG patients who are using incentive spirometry. Therefore, the purpose of the current study was to explicitly assess the effectiveness of cryotherapy on incisional discomfort related to incentive spirometry following CABG surgery **(Seweid et al., 2021).**

Aim of the study

This study aimed to determine the efficacy of localized cryotherapy on incisional pain associated with the use of incentive spirometry post coronary artery bypass graft surgery.

Research hypotheses:

1. Post coronary artery bypass graft surgery patients who receive localized cryotherapy would have reduced incisional pain when incentive spirometry is being used.
2. Post coronary artery bypass graft surgery patients who are subjected to cryotherapy would have stable physiological indicators after localized cryotherapy application.
3. That patients with coronary artery bypass graft surgery would prefer the application of localized cryotherapy before the use of incentive spirometry.

Definitions of variables

A. Independent Variable

Localized Cryotherapy: is theoretically defined " the local use of cold application for the purpose of lowering temperature to achieve therapeutic benefits" **(Selfe, et al., 2020).** In the present study, localized cryotherapy is operationally defined as the use of a cold gel pack locally or over a particular body part for 20 minutes after bringing it from the freezer and wrapping it in a washcloth or towel**.**

B. Dependent Variable

Incisional pain: is theoretically defined as" Acute pain results from tissue damage caused by surgery and typically lasts up to three months after which it is deemed chronic or persistent " **(Small1 & Laycock, 2020).** Incisional pain in this study is operationally evaluated by Pain Intensity Scale, Pain Distress Scale and Visual Analog Pain Scale.

Method

Research design:

In a crossover research design, patients get two or more treatments or procedures at different periods of time and the sequence of treatments being randomly assigned to each subject **(Lim, 2021).**

Setting:

This study was conducted at Cardiothoracic Surgical Intensive Care Unit (ICU) and Cardiothoracic Surgery Department at Shebin El-Kom, Menoufia University Hospital, Menoufia Governorate, Egypt.

Subjects:

A Purposive sample of 60 adult patients**,** one group only involved in this research. Patients were included in the study if they have the following criteria; fully conscious, first planned coronary artery bypass graft surgery and being able to assess one's own degree and quality of pain and describe it. Patients were excluded from the study if they have the following criteria; oversensitivity to cryotherapy, received opioids analgesics for at least 4 hours before intervention, patient with diabetes, and patients with postoperative complications such as infection, bleeding or wound complications.

Sample size calculation:

The sample size for the current study was determined using a power analysis. a one-tailed test with a 5% level of significance, an alpha level of 0.05, and a greater size effect of 0.65 gave 80% power to detect a change in the percentage of CABG surgery patients. As a larger sample size affords more power, and based on the results of a previous study, the researchers anticipated a greater effect of local cryotherapy application, a large effect size was considered in this research to estimate the sample size **(Seweid et al., 2021).**

Tools of data collection: -

Data was collected using the following three tools. They were developed and written in the Arabic language on a review of the relevant literature by the researchers.

Tool I: Structured interview questionnaire: It aimed to assess demographic characteristics of the patients, medical related data and patients' perception (sensation and preference) for cryotherapy. It compromised three parts;

Part one; It was concerned with the demographic characteristics of patients which included patient's age, sex, marital status, educational level, occupation and the place of residence (6 items).

Part two; It was adopted from **(Chailler, 2009)** and was concerned with medical related data of patients which included previous surgery, presence of other disease, tobacoo smoking, preoperative percentage of ejection fraction, duration of chest tube, mechanical ventilation and its duration, length of ICU stay, previous use of cryotherapy and allergy to any types of medications (10 items).

Part three; It was developed by **(Chailler, 2009)** and was used to assess patients' perception (sensation and preference) for cryotherapy which included patients' experience following incentive spirometry with the application of cold gel pack for incisional pain, fear from side effects with the application of cold gel pack, decreasing of pain sensation with cold gel pack application compared to analgesics, changing levels of pain stimulating analgesics using, cryotherapy can make breathing easier and expectorate more freely cryotherapy is the easiest method for incisional pain relieving, prefer using of cryotherapy to decrease pain after CABG and patients' preference for cryotherapy using another time with incentive spirometry (8 items).

Tool II: Subjective pain assessment sheet.

It compromised two parts;

Part one; McCaffery pain assessment tool's **"Pain Intensity Scale" (McCaffery et al., 1994).** In adults who had undergone postoperative coronary artery bypass graft surgery and were completely aware and oriented, it was utilized to measure pain intensity. This scale consists of a 10-point numeric scale, where "0" denotes no pain, "1-3" mild pain, "4-6" moderate pain, "7-9" severe pain, and "10" intolerable pain.

Part two; Johnson **"Pain Distress Scale" (Johnson, 1973).** It was employed to evaluate the unfavorable emotional reactions linked to pain. This section contains a 10-point numeric scale, where "0" denotes no discomfort, "1-3" indicates minor distress, "4-6" indicates moderate distress, "7-9" indicates severe distress, and "10" denotes the greatest conceivable distress.

Tool III: Objective pain assessment sheet.

It included two parts;

Part one; "Physiological indicators of pain assessment". The researcher developed it after considering the relevant articles **(Zaccagnino & Nedeljkovic, 2017).** It contained oxygen saturation, respiratory rate, mean arterial pressure, and pulse rate (SpO2).

Part two; Visual Analog Pain Scale "VAS". It was adopted from **Chesworth (1989)**, it is a reliable method for evaluating acute postoperative pain. The minimum and greatest extremes of experienced pain are shown by the ends of a 10 cm horizontal or vertical line that makes up the VAS. Based on the patient's facial expression, a mark is drawn on the line to represent the degree of pain, which is then translated into a numerical value.

Validity and Reliability: Content validity was tested by a jury of 5 experts in the fields of Medical-Surgical Nursing, Critical Care Nursing and Cardiothoracic Surgery. The tools were revised by the experts for clarity, application, completeness, simplicity, and relevancy; minor adjustments were made, and the final form was established. To ensure the validity of tool I translation, the back-translation technique was used.

Testing reliability of the proposed tools was estimated using Chronbach's Alpha test to measure the internal consistency of the tools. It was found that Chronbach's Alpha test for the tool I was 0.9, 0.8 for Tool II, and 0.7 for tool III which reflects reliable tools.

Pilot Study: A pilot study was carried out on 10% (6 patients) before data collection to test the applicability and feasibility of the tools and to make necessary modifications before conducting the main study. Patients who were included in the pilot study were excluded from the study sample.

Ethical Considerations:

Ethical approval was granted from the responsible authorities of the Faculty of Nursing at Menoufia University after an explanation of the purpose of the study (**Research N. 875**, Code of

Ethics). Official permission was obtained from Menoufia University Hospital administrative authority after providing the details about the nature of the study. Informed consent was obtained from the patients before starting the data collection procedure to explain the purpose of the study. Patients were given the guarantee that their participation was elective and that they had the freedom to leave the study at any time without facing any repercussions. They received assurances on the protection of their anonymity and information confidentiality. Respect was shown for morals, values, culture, and beliefs.

Data collection (Procedure):

Data were collected from the beginning of October 2021 to the end of January 2022. All postoperative coronary artery bypass graft surgery patients admitted to the Cardiothoracic Surgical ICU and Cardiothoracic Surgery Department at Menoufia University Hospital who met the inclusion criteria were enrolled in this study.

To reduce o errors caused by patient variation, a crossover research design was used in which each patient provided as his or her own control. With this design psychological and physical bias is reduced, variability is decreased, subject-to-subject variance is minimized, and the relative effects of treatment are also minimized. The researchers used tools II and III to thoroughly analyze the pain of postoperative coronary artery bypass graft surgery patients before incentive spirometry was used for two consecutive days. There were two different periods in each day. The same group underwent two phases of testing: a control phase without localized cryotherapy (cold gel pack) application and a study phase with localized cryotherapy (cold gel pack) application. Between these two phases, there was a two-hours washout period.

a. **Control Phase**: Phase without localized cryotherapy (application of a cold gel pack)

The researchers assessed the patients' baseline levels of pain. By providing them with a thorough description of the incentive spirometry, patients were prepared to use it. The patient was instructed to exhale normally, secure their lips over the mouthpiece, and then take a slow, deep breath without using their nose. To support the area, a folded blanket or pillow was placed over the chest incision. Patients were asked to hold their breath and count to three once they were no longer able to inhale. Patients were told to conduct three cycles with the gadget while taking their lips out of the mouthpiece and exhaling properly. The researchers did a pain assessment immediately upon completion.

Study Phase: Phase with localized cryotherapy (application of a cold gel pack)

Baseline pain assessment was performed by the researchers after washout time elapsed. According to the manufacturer's recommendations, the cold gel pack that would be used for localized cryotherapy was placed in the freezer for 30 to 40 minutes. According to advice from other studies, the researchers immediately put the cold gel pack over the median sternotomy incision of the patients for 20 minutes after bringing it from the freezer to their bedside and wrapping it in a washcloth or towel **(Alfuth et al., 2016)**. The cold gel pack was left on place until it was time to remove it, and the researchers remained beside each patient bed to confirm this. Patients were prepared for the use of incentive spirometry (three cycle). Patients got instruction on how to utilize incentive spirometry (three cycle).

The researcher then used data collection tools II and III to evaluate pain. As soon as the pain evaluation was over, the cold gel pack was cleaned in accordance with hospital infection control procedures and put back into the freezer for future usage. In this study there were no reported side effects to the studied patients as the researchers applied localized cryotherapy for maximum 20 minutes to attain therapeutic effects and avoid side effects at the same time. The most severe side effects of localized cryotherapy according to previous studies include injuries to the skin and tissues that may occur if localized cryotherapy applied longer than 30 minutes. Therefore, in this study, the dressing layer over the chest incision was separated from the cold gel pack by a piece of cloth or a towel.

Results

Table (1) illustrates distribution of patients regarding to their demographic data. It was found that (66.7%) of the studied patients were males and older than 50 years old. 58.3% of the study sample were married. Concerning educational level, this table show that (46.7%) of the patients had intermediate educational level, while only (6.7%) of them were illiterate. 56.7% of studied patients were employee and (63.3%) of them live in urban areas.

Table (2) displays 26.7 % of the patients were hypertensive and only (6.7 %, 11.7% and 8.3%) of the studied patients had kidney, liver and rheumatoid diseases respectively. It was clear that (66.7%) of them were smokers. About 65% of patients had preoperative ejection fraction over 50% but (11.7%) of them had previous cardiothoracic surgery compared with (66.7%) didn't have any previous surgery. Chest tube was removed less than 24 hours postoperatively in (61.7%) of patients and (46.6%) of them spent more than 24 hours being mechanically ventilated. Finally, (93.3%) of patients spent longer than 48 hours in the ICU, while (20%) of them previously used cryotherapy.

Table (3) reveals that (86.7%) of patients in the study phase experienced less pain in the second day compared to (66.7%) in the first day, while (3.3 %) of them experienced cold sensation in the second day. In addition, (91.7%) of them were fear from side effects of cryotherapy application in the first day comparing to (25%) in the second day. In the second day (83.3%) of studied patients would prefer using cryotherapy during incentive spirometry compared to (26.7%) in the first day. In this table, there were statistically significant differences in all items of patients' perception (sensation and preference) about cryotherapy application between first and second day at study phase *(P <0.05).*

Table (4) represents comparison of incisional pain mean scores of the studied sample in both the control and the study phases. It was noticed that mean scores of pain intensity scale, pain distress scale and visual analog scale were decreased with localized cryotherapy application (2.07±1.1, 2.05±1.1, 2.40±1.30) respectively in the study phase compared to the control phase (3.07±1.7, 3.15±1.7, 3.43±2.03) which indicates that application of localized cryotherapy has a significant effect on pain reduction relative to incentive spirometry use *(P3 = 00.0).*

Table (5) demonstrates mean physiological indicators during incentive spirometry in both the control and study phases. In this table there was no significant effect of localized cryotherapy on oxygen saturation *(P3 = 0.413)*. On the other hand, the mean scores of pulse rate, respiratory rate and mean arterial blood pressure were decreased with localized cryotherapy application (77.23±6.82, 15.93±1.86, 87.45±10.51) respectively in the study phase compared to the control phase (79.85±7.39, 18.23±3.15, 91.78±8.72) which indicates that application of localized cryotherapy has a significant effect on visual pain score and most of physiological indicators of incisional pain induced on incentive spirometry use *(P3 = 00.0).*

Table (1) Frequency and Percentage Distribution of the Studied Patients Regarding Their Demographic Characteristics (n=60).

Demographic Characteristics	N	%
Age		
25 < 40 years	5	8.3
40< 50 years	15	25
≥ 50 years	40	66.7
Sex		
Male	40	66.7
Female	20	33.3
Marital Status		
Single	5	8.3
Married	35	58.3
Widow	7	11.7
Divorced	13	21.7
Educational level		
Illiterate	4	6.7
Primary Education	11	18.3
Intermediate Education	28	46.7
University Education	17	28.3
Occupation		
Employee	34	56.7
Worker	9	15
Unemployed	17	28.3
Residence		
Urban	38	63.3
Rural	22	36.7

Table (2): Frequency and Percentage Distribution of the Studied Patient Regarding Their Medical Data (n=60).

Medical Data	N	%
Presence of chronic diseases	29	48.3
If yes, Type of Disease		
Hypertension	16	26.6
Kidney diseases	4	6.7
Liver diseases	7	11.7
Rheumatoid	2	3.3
Previous Surgery		
None	40	66.7
Cardiothoracic	7	11.7
Non- cardiothoracic	13	21.6
Smoking		
Yes	40	66.7
No	20	33.3
Ejection Fraction		
<50%	21	35
≥50%	39	65
Duration of Chest Tube		
<48 hours	37	61.7
≥48 hours	23	38.3
Mechanical Ventilation		
Yes	53	88.3
No	7	11.7
Duration of Mechanical Ventilation		
<24 hours	25	41.7
≥24 hours	28	46.6
None	7	11.7
Length of ICU Stay		
<48 hours	4	6.7
≥48 hours	56	93.3
Allergy to medication	6	10
Previous use of cryotherapy	12	20

Table (3): Comparing Patients' Perception (sensation and preferences) of Cryotherapy between the First and the Second day in the Study phase (n=60).

Item	Study Phase				χ^2	P-value
	(Day 1) cryotherapy application		(Day 2) cryotherapy application			
	N	%	N	%		
Sensation during cryotherapy						
-Experience cold	15	25	2	3.3	11.597	0.003*
- feeling slight numbness	5	8.3	6	10		
- comfort and less pain	40	66.7	52	86.7		
Fear from side effect						
-Yes	55	91.7	15	25	54.857	0.000*
-No	5	8.3	45	75		
Decrease pain level comparing to analgesic						
-Yes	17	28.3	41	68.3	19.221	0.000*
-No	43	71.7	19	31.7		
Changing pain level makes you use analgesic						
-Yes	51	85	22	36.7	29.414	0.000*
-No	9	15	38	63.3		
Cryotherapy can make breathing easier and expectorate more freely						
-Yes	6	10	35	58.3	50.758	0.000*
-No	54	90	25	41.7		
Cryotherapy is the easiest method						
-Yes	18	30	49	81.7	32.457	0.000*
-No	42	70	11	18.3		
Prefer using cryotherapy to decrease pain after CABG						
-Yes	13	21.7	44	73.3	32.114	0.000*
-No	47	78.3	16	26.7		
Prefer using cryotherapy during incentive spirometry						
-Yes	16	26.7	50	83.3	38.923	0.000*
-No	44	73.3	10	16.7		
P. value: highly significant if <0.001	**P. value:** significant if <0.05					

Table (4): Differences in the Studied Patients' Mean Incisional Pain Scores between the Control and Study Phases (*n*=60).

Pain Assessment														
Control Phase (without cold gel pack application)							**Study Phase (with cold gel pack application)**							
1st day			**2nd day**				**1st day**			**2nd day**				
B	**A**	***t*-test (P_1)**	**B**	**A**	***t*-test (P_1)**	***t*-test (P_2)**	**B**	**A**	***t*-test (P_1)**	**B**	**A**	***t*-test (P_1)**	***t*-test (P_2)**	***t*-test (P_3)**
Mean ± SD	**Mean ± SD**		**Mean ± SD**	**Mean ± SD**			**Mean ± SD**	**Mean ± SD**		**Mean ± SD**	**Mean ± SD**			
A-Pain Intensity														
1.91 ± 1.16	4.96 ± 1.07	-14.975 (0.000*)	1.48 ± 0.87	3.93 ± 1.07	-13.260 (0.000*)	6.992 (0.000*) **3.07±1.7**	2.03 ± 1.11	2.93 ± 1.11	-4.352 (0.000*)	1.33 ± 0.70	2.00 ± 1.04	-5.149 (0.000*)	8.335 (0.000*) **2.07±1.1**	14.538 (0.000*)
B- Pain Distress														
2.26 ± 1.27	4.98 ± 1.12	-12.692 (0.000*)	1.45 ± 0.85	3.90 ± 1.08	-13.371 (0.000*)	8.046 (0.000*) **3.15±1.7**	1.98 ± 1.15	2.85 ± 1.21	-4.065 (0.000*)	1.40 ± 0.82	2.00 ± 1.04	-4.753 (0.000*)	6.769 (0.000*) **2.05±1.1**	15.154 (0.000*)
C. Visual Analog Pain Scale														
1.86 ± 1.12	5.63 ± 0.75	-20.396 (0.000*)	1.41 ± 0.82	4.81 ± 0.85	-23.144 (0.000*)	7.742 (0.000*) **3.43±2.03**	2.00 ± 1.22	3.68 ± 0.67	-9.775 (0.000*)	1.48 ± 0.85	2.46 ± 1.21	-5.319 (0.000*)	12.010 (0.000*) **2.40±1.3**	14.918 (0.00*)

P_1: p value for comparing mean pain scores between before and after localized cryotherapy application
P_2: p-value for comparing the mean scores between the first and second day
P_3: p-value for comparing the mean score differences between the study phase and the control phase
p significant if <0.05.
B: pain assessment before localized cryotherapy
A: pain assessment after localized cryotherapy

Table (5): Mean Scores of the Physiological Indicators of the Studied Patients between the Control and Study Phases (*n*=60).

Control Phase (without cold gel pack application)							Study Phase (with cold gel pack application)							
1st day			2nd day				1st day			2nd day				
B	A		B	A			B	A		B	A			
Mean ± SD	Mean ± SD	*t*-test (P_1)	Mean ± SD	Mean ± SD	*t*-test (P_1)	*t*-test (P_2)	Mean ± SD	Mean ± SD	*t*-test (P_1)	Mean ± SD	Mean ± SD	*t*-test (P_1)	*t*-test (P_2)	*t*-test (P_3)
A. Pulse														
76.65 ± 6.47	83.31 ± 6.02	-6.929 (0.000*)	75.51 ± 7.28	83.95 ± 5.60	-7.567 (0.000*)	0.861 (0.393) **79.85±7.39**	75.51 ± 7.28	76.11 ± 6.80	-1.976 (0.053)	78.50 ± 6.43	78.80 ± 6.29	-1.464 (0.148)	-3.375 (0.000*) **77.23±6.82**	4.927 (0.000*)
B. Mean arterial pressure (mmHg)														
90.95 ± 9.21	91.61 ± 9.28	0.768 (0.145)	93.23 ± 7.66	91.35 ± 8.70	0.098 (0.453)	-0.065 (0.219) **91.78±8.72**	97.83 ± 13.86	91.68 ± 7.85	-2.073 (0.043*)	80.15 ± 6.82	90.13 ± 8.20	-11.362 (0.000*)	5.236 (0.000*) **87.45±10.51**	6.184 (0.000*)
C. Respiratory rate														
16.50 ± 2.02	20.21 ± 3.07	-9.165 (0.000*)	16.33 ± 1.80	19.90 ± 3.13	-9.026 (0.000*)	-0.985 (0.498) **18.23±3.15**	17.31 ± 2.98	16.53 ± 1.78	5.876 (0.000*)	16.91 ± 1.98	15.13 ± 1.33	5.331 (0.000*)	-0.883 (0.379) **15.93±1.86**	5.786 (0.000*)
D. Oxygen saturation (So_2)														
98.10 ± 0.83	98.21 ± 0.76	-1.308 (0.196)	98.30 ± 0.74	98.55 ± 0.56	-0.786 (0.465)	-0.698 (0.395) **98.29±0.74**	96.51 ± 1.44	98.66 ± 0.54	-10.527 (0.000*)	98.01 ± 0.85	98.45 ± 0.56	-0.246 (0.000*)	-0.453 (0.621) **98.41±1.24**	-0.607 (0.413)

P_1: p value for comparing physiological indicators mean scores between before and after localized cryotherapy application
P_2: p-value for comparing the mean scores between the first and second day
P_3: p-value for comparing the mean score differences between the study phase and the control phase
p significant if <0.05.
B: mean score before localized cryotherapy
A: mean score after localized cryotherapy

Discussion

For all patients, using an incentive spirometer after CABG surgery is a painful experience. Following heart surgery, pain management is essential to maintaining the patient's comfort and avoiding issues with the respiratory system. There aren't any established protocols or recommendations for handling this linked pain, though. It is proposed that pain management using non-pharmacological techniques, including cold therapy, can reduce the discomfort brought on by unpleasant procedures. Localized cold application decelerates tissue metabolism and nerve transfer speed locally and also having vasoconstrictive, anti-inflammatory, antispasmodic, and analgesic effects **(Çevik et al., 2020).**

Despite the empowering findings of numerous studies on the effects of cold application on reducing pain carried on by the use of incentive spirometers, there is little research on the impact of application of a cold gel pack on incisional pain in post CABG patients using incentive spirometers **(Mohammadi et al., 2018).** So, the present study aimed to specifically determine the efficacy of localized Cryotherapy application on incisional pain associated with incentive spirometer post CABG surgery.

This study reveals that about two thirds of the studied patients were males lived in urban areas and their age were more than fifty years old, and more than half of them were married and employed. Meanwhile, the minority of the studied patients were illiterate and more half of them were married, this is congruent with **Khalkhali et al., (2019)** and **Çevik et al., (2020**) who examined effect of applying cold gel pack on the pain associated with deep breathing and coughing after open heart surgery. While **Pishkarmofrad et al., (2016)** contradicted this result and stated that more than half of the studied patients were females.

Regarding patients' medical data, about one third of the studied patients had hypertension but minority of them had kidney, liver and rheumatoid diseases. Meanwhile; about two thirds of the studied patient were smokers, didn't have any previous surgery and with postoperative chest tube removed in less than 24 hours. Also, about half of them were mechanically ventilated for more than 24 hours. Meanwhile; the majority of the studied patients spent more than 48 hours in the ICU. One fifth of patients had previous experience in using cryotherapy.

The findings of the current study are consistent with **Wang et al., (2017)** who demonstrated that having a chest tube in for a long time and being older are risk factors for developing chronic pain after thoracotomy. Further, the findings of the current study are congruent with **Attia & Hassan (2017)** who stated that about half of the studied patients had no previous cardiothoracic surgery and had no surgical history& had preoperative ejection fraction over 50 percent. Majority of the patients spent more than 48 hours in the intensive care unit (ICU) and half of them were mechanically ventilated for longer than 24 hours. But this study finding is contradicted with the study by **Mazloum et al., (2018)** who stated that two chest tubes were consecutively removed in less than 30 minutes.

Furthermore, minority of patients had pre-operative ejection fraction less than 50 percent**, Pieri et al., (2016)** reported relatively the same result. In the current study, two thirds of patients were smokers, **Tang et al., (2021)** agreed that and found more than half of patients had smoking history.

Concerning patients' perception (sensation and preferences) of localized cryotherapy application**,** the current results show that the majority of the studied patients experienced comfort and less pain at both the first and the second day of localized cryotherapy application, while minority of them felt slight numbness at both the first and the second day. Moreover, one quarter of them felt cold at the first day and minority of them felt cold at the second day. Moreover, the vast majority of studied patients in the second day stated that they preferred using cryotherapy during incentive spirometry compared to the first day.

This is in accordance with **Khalkhali et al., (2019)** who concluded that minority of patients felt slight numbness at the first time of applying cold gel pack, and at the second time minority of them felt cold and minority

experienced slight numbness. Most of patients stated they would use the gel pack for pain management in the future. This may be attributed to that applying cold gel packs to the sternum seems to be an appealing way for managing pain and is thought to be effective for pain reduction.

The findings of the present study clarify that the mean scores of pain associated with the use of incentive spirometry including pain intensity, pain distress and visual analog pain scale decreased with localized cryotherapy application. This result proved that the localized cryotherapy application is an effective method for management of incisional pain associated with incentive spirometry post coronary artery bypass graft surgery. This might be due to the direct analgesic action of cold application, which is known to slow down the conduction velocities of sensory and motor nerves. Additionally, the inhibition and blockage of pain signals leads to the stimulation of cold receptors on the skin, which has an indirect analgesic effect. The current study's findings are consistent with those of **Keawnantawat et al., (2018),** that conducted to investigate the efficiency of cold treatment in lowering immediate pain following cardiac surgery, yet there are contradictory findings in the study by **Aktas & Karabulut (2019).**

Regarding total physiological indicator mean scores before and after localized cryotherapy application, it was noticed that there were statistically significant difference regarding mean arterial pressure, pulse rate and respiratory rate between control and study phases and their values have been reduced to normal after localized cryotherapy application, while there was no change in oxygen saturation. It might be related to the vasoconstriction caused by using a cold pack gel, which affects heart rate, blood pressure, and respiration rate. This method might increase the rate at which muscles re-oxygenate, which would increase respiratory rate.

These results are matched with **Seweid et al, (2021)** who concluded that administering a cold treatment improved mean arterial blood pressure and respiratory rate but did not definitively enhance oxygen saturation. These results are controverted by **El-Nagar et al., (2020)** that there was no significant difference in respiratory rate before and after cold application.

Finally, the current study affirmed the hypotheses that post coronary artery bypass graft surgery patients who received localized cryotherapy (application of a cold gel pack) would experience reduced incisional pain and have stable levels of the majority of physiological indicators related to the use of incentive spirometry.

Conclusion

The current study results confirmed the hypotheses and concluded that application of localized cryotherapy in form of cold gel pack application was effective for reducing incisional pain and most of its physiological indicators associated with incentive spirometry in patients post coronary artery bypass graft. In addition, the majority of studied patients in the second day preferred using cryotherapy during incentive spirometry compared to the first day.

Recommendations

Based on the results of the present study the following recommendations are suggested:

- For post-operative patients who have CABG surgery, localized cryotherapy should be promoted as a non-pharmacological treatment option before incentive spirometry.
- More research is necessary to examine the effectiveness of different types of localized cryotherapy, such as (chip, pack, massage, and ice towel), on the incisional discomfort linked to incentive spirometry following CABG surgery.
- The study should be performed on a sizable, non-probability sample and in a different hospital setting from diverse geographical regions in order to generalize the study's findings.

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