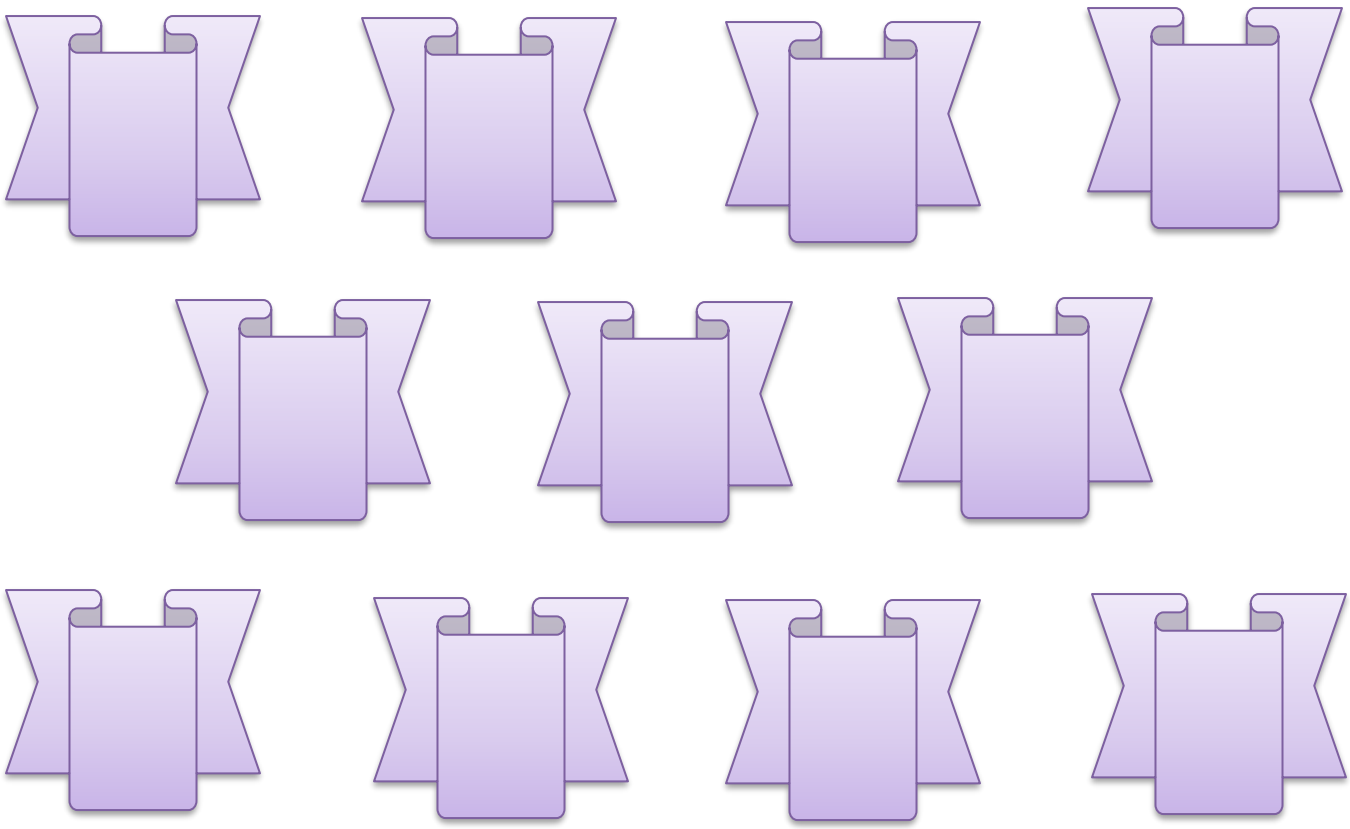
International Journal of Medical Arts

Volume 5, Issue 11, November 2023

https://ijma.journals.ekb.eg/



Print ISSN: 2636-4174

Online ISSN: 2682-3780

Available online at Journal Website
https://ijma.journals.ekb.eg/
Main Subject [Physical Therapy]

Original Article

Effect of Intra-Thoracic Oscillations on Blood Gases after Coronary Artery Bypass Graft Surgery

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Article information

Received: 08-09-2023

Accepted: 18-11-2023

DOI: 10.21608/IJMA.2023.235023.1804.

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Citation: Amin AGF, Abd Alhady AA, Ali HF, El-Moatasem AM. Effect of Intra-Thoracic Oscillations on Blood Gases after Coronary Artery Bypass Graft Surgery. IJMA 2023 November; 5 [11]: 3848-3854. doi: 10.21608/IJMA.2023.235023.1804.

ABSTRACT

Background: Coronary artery disease] CAD [causes significant respiratory, medical, and physical problems affecting the quality of life [QoL [. Quake device, one of the oscillatory positive expiratory pressure [OPEP] family, may improve the health of patients with CAD, but more research is needed.

The Aim of the work: The main aim of this study was to examine the effects of intra-thoracic oscillations on blood gases after coronary artery bypass graft surgery [CABG].

Patients and Methods: The research included a cohort of 60 male individuals who had the surgical procedure known as Coronary Artery Bypass Grafting [CABG] aged 55–65; they were recruited from the 6 October hospital. The patients were divided equally into groups A and B; group A included patients who underwent therapy with OPEP using the Quake device in conjunction with conventional and medically recommended therapies; group B included patients treated by traditional treatment and their prescribed medical treatment. Both treatments were performed once daily from the first day till the seventh day after operation. They were evaluated using Arterial Blood Gases [ABG], the sit-to-stand test, and the [SF-36] QoL questionnaire.

Results: The previous and post-study comparison revealed a significant enhancement in both groups of ABG values [PH, PaO_2, $PaCO_2$, and HCO_3] and, the sit-to-stand test and SF-36 questionnaire. The study group had a statistically significant advantage over the control group when comparing all assessed post-treatment parameters to those of the control group.

Conclusion: Early rehabilitation after CABG surgery via Quake device could improve ABG, patient's functional capacity,reflecting a better QoL.

Keywords: Intra-thoracic oscillations; OPEP; Quake device; ABG; CABG.

INTRODUCTION

Coronary artery disease [CAD] is a cardiovascular disorder characterized by the development of atherosclerosis in the blood arteries responsible for supplying blood to the heart. This pathological process leads to the narrowing and hardening of these vessels. The condition is often called ischemic heart disease [IHD] [1].

Coronary artery bypass grafting [CABG] is a cardiac surgical intervention whereby healthy blood arteries are sourced from the leg, arm, or chest to establish connections both proximal and distal to the constricted or obstructed segments of the coronary arteries. The newly formed blood vessels, also known as grafts, provide a novel conduit, reinstating blood circulation to the cardiac region [2]. CABG is associated with significant postoperative morbidities, including pulmonary complications such as atelectasis, pleural effusion, and pneumonia. The prevalence of atelectasis and pleural effusion in individuals after CABG surgery is 63%. Pulmonary dysfunction and the resulting hypoxemia are seen in 30%–60% of patients, contributing to postoperative morbidity and mortality [3].

It is common practice for patients with open heart surgery to get recommendations for engaging in chest physiotherapy and respiratory exercises, either with or without mechanical equipment. Several techniques may be used to promote respiratory health and function. These include positioning, incentive spirometry [IS], early mobilization, expiratory positive airway pressure, respiratory muscle training, cough support, deep breathing exercises, and the active cycle of breathing technique [ACBT] [4]. The IS is widely regarded as the primary therapy method for patients who have had surgery or are hospitalized. Extensive research has been conducted on using IS in the inpatient environment. The patient is encouraged to engage in deliberate and profound inhalation, facilitated by visual feedback, which promotes the expansion and re-opening of constricted air passages [5].

Physiotherapy encompasses a range of modalities to address secretion problems that may arise in patients following CABG surgery. Among these modalities is using deep breathing exercises, representing a non-invasive therapeutic approach with potential benefits for cardiac autonomic function, depression, anxiety, hypertension, and pulmonary disorders. These techniques promote mucus mobilization and airway lubrication, which improves lung ventilation [6]. Over the years, various physical therapy equipment has been produced for treating respiratory problems, providing choices to conventional chest physiotherapy. These advancements are characterized by reduced time and effort requirements and increased patient freedom, particularly for those with infectious lung diseases. These techniques facilitate the mobilization and clearance of mucus from the airways, leading to improved lung ventilation, enhanced pulmonary function, and increased independence [7].

The Quake device is a cylindrical apparatus that functions using manual rotation, namely via the use of the hand. This rotational motion generates vibrations inside the bowl. Low-frequency oscillations and excessive expiratory pressure may be attributed to a slow-spinning handle. Nevertheless, the generation of high-frequency oscillations and the production of low expiratory pressure are achieved by rapid handle rotation. Using oscillatory positive expiratory pressure [OPEP] has enhanced airway clearance by about twofold, indicating a significant advantage [7].

The main aim of this study was to examine the effects of intra-thoracic oscillations on ABG after coronary artery bypass graft surgery [CABG].

PATIENTS AND METHODS

The present investigation included 60 male patients who had CABG surgery between August 2022 and January 2023. The version 3.1.9.7 of G*power program was utilized to identify the sample size. A prior type of power analysis was conducted with α error probability of 0.05 and power [1-β error probability] equal to 0.95. A total of 36 participants was the minimum sample size for the study.

The individuals in question were enlisted from the 6 October Hospital. The research ethics committee of the Faculty of Physical Therapy at Cairo University approved the inquiry [No: P.T.REC/012/003830]. Before enrolling patients into the trial, the investigators ensured that informed written permission was acquired from each participant. This process included providing detailed information about the study's objectives and the significance of the study procedures. The inclusion criteria were as follows: All patients were conscious, clinically and medically stable, had body mass index [BMI] of 25–29.9 kg/m^2, underwent CABG, and

were aged 55–65 years. All patients received treatment according to their recommended medical therapy. The exclusion criteria were as follows: Hemodynamic instability, patients on high inotropic supports, patients with existing pulmonary disease or associated pulmonary complications, patients who need mechanical ventilation for an extended period beyond 24 h or necessitate re-intubation, neuromuscular disorders, active hemorrhage and hemoptysis, and poor cognition and mentality.

Evaluation procedures: Prior to and after the seventh day of therapy, all patients underwent evaluation using the subsequent measures: primary outcome assessed by Arterial Blood Gases [ABG] Analyzer [PH, PaO_2, $PaCO_2$, HCO_3] while secondary outcomes assessed by sit-to-stand test, and the [SF-36] QoL questionnaire.

Treatment protocols

The sixty men [according to prevalence of coronary artery disease] participants were randomized to two groups of equal size. Group A included 30 patients who underwent OPEP [Quake device] therapy with conventional and medically recommended therapies. The participant's lips were securely sealed around the mouthpiece and instructed to perform full inhalation and exhalation. During Quake breathing, individuals were instructed to inhale deeply and retain the breath for 3–5 s. The handle was turned consistently and comfortably at a pace of half to one rotation per second. It was advised to repeat this technique six times, constituting one set; ten sets were performed, each set followed by a ten-min rest period. Each patient received a daily session for 7 days for 120 min each. Subsequently, they were guided to exhalation to facilitate the airway-clearing process [7].

Group B included 30 patients treated by traditional treatment and their prescribed medical treatment. The traditional treatment was as follows: 1] Deep breathing exercise: patients get treatment via deep breathing exercises, whereby they are instructed to assume a posture conducive to their comfort. Participants were instructed to do a breathing exercise consisting of inhaling through the nose for 2 s, followed by a breath hold for 3 s. Subsequently, they were instructed to exhale slowly through pursed lips for 4 s and conclude the exercise by holding their breath for an additional 3 seconds. Engaging in a series of one-minute repeats, with a two-second intermission between each repetition, performed two sessions daily [8]; 2] Percussion and vibration: Chest wall vibrations and hand percussion maneuvers were performed. A vibrating apparatus operating at a consistent frequency of 50 Hz per second was used for 1.5 min to achieve the desired outcome. The application of the device included positioning it on the patient's posterior chest wall. Subsequently, the posterior chest wall of the patient was treated with manual percussion. This included using a cupped hand palm and striking the area from the wrist region at a standardized height of 10 cm. The manual percussion was executed at a frequency of 25 occurrences over 10 s and throughout 2 min. Subsequently, the patient was advised to do efficacious coughing maneuvers [9]; 3] IS:The patients were given an incentive spirometer, accompanied by practical guidance on its use and the precise documentation of readings. Participants were encouraged to assume a supine position and were provided with guidance to do a controlled inhalation via the oral cavity, taking about 10 s to complete the inhalation phase. They were then instructed to exhale fully and repeat this sequence for 10 consecutive cycles. The participants were instructed to manipulate the plastic marker on the equipment to indicate the maximum inspired volume observed throughout the participants' ten breaths. Patients were instructed to do this exercise three times daily for 7 days after the surgical procedure [8].

Statistical analysis: An unpaired t-test was used to compare the characteristics of the individuals a cross different groups. The Shapiro-Wilk test was used to assess the normality of the data distribution. The Levene's test was used to assess the equality of variances a cross the groups. A Mixed Multivariate of variance [MANOVA] was used to examine the impact of therapy on several physiological and functional measures, including pH, PaO_2, $PaCO_2$, HCO_3, sit-to-stand test performance, and SF-36 scores. The statistical study was performed using IBM SPSS version 25 for the Windows operating system, a software package produced by IBM SPSS in Chicago, IL, USA.

RESULTS

Subject characteristics: Table [1] displays the demographic characteristics of both the study and control groups. The groups exhibited

no statistically significant differences in age, weight, height, and BMI [p > 0.05].

Effect of treatment on pH, PaO_2, $PaCO_2$, HCO_3, sit-to-stand test, and SF-36

The results of the mixed MANOVA analysis indicated a statistically significant interaction effect between the therapeutic intervention and the passage of time [F = 10.45, p = 0.001]. There was a statistically significant main effect of the treatment condition [F = 13.61, p = 0.01]. The statistical analysis identified a significant main effect of time [F = 258.22, p < 0.001].

Within group comparison: There was a significant elevation in pH, PaO_2, and HCO_3 levels, as well as a considerable reduction in $PaCO_2$ levels, seen in both groups after the therapy compared with the pre-treatment measurements [p > 0.001]. The percent of change in pH, PaO_2, $PaCO_2$, and HCO_3 of the study group was 0.95, 15.08, 17.69 and 15.48%, respectively, and that in the control group was 0.68, 8.86, 10.58 and 6.96%, respectively [**Table 2**]. There was a significant reduction in the sit-to-stand test scores and a significant improvement in SF-36 scores for both groups after the therapy compared with their scores before the treatment [p > 0.001]. The study group exhibited a percent change of 46.93% in the sit-to-stand test and 17.65% in the SF-36. In comparison, the control group showed a percent change of 40.01% in the sit-to-stand test and 8.63% in the SF-36 [**Table 3**].

Between-group comparison: Following the therapy, the study group exhibited a significant rise in pH, PaO_2, and HCO_3 levels while experiencing a significant drop in $PaCO_2$ levels compared with the control group [p < 0.01]. Meanwhile, the study group exhibited a significant reduction in the sit-to-stand test scores while displaying a significant enhancement in SF-36 scores compared with the control group [p < 0.001; **Tables 2–3**].

Table [1]: A comparative analysis of the characteristics of the subjects in both the study group and the control group

	Study group	Control group			
	Mean ± SD	Mean ± SD	MD	t- value	p-value
Age [years]	59.97 ± 2.94	60.23 ± 2.82	–0.26	–0.35	0.72
Weight [kg]	74.40 ± 5.82	75.07 ± 6.95	–0.67	–0.40	0.68
Height [cm]	164.70 ± 5.19	166.73 ± 4.95	–2.03	–1.55	0.12
BMI [kg/m²]	27.45 ± 2.16	27.05 ± 2.77	0.4	0.62	0.53

SD, Standard deviation; MD, mean difference; p-value, Probability value

Table [2]: Mean pH, PaO_2, $PaCO_2$, and HCO_3 pre and post-treatment of study and control groups

	Pre-treatment	Post-treatment			
	Mean ± SD	**Mean ± SD**	**MD**	**% of change**	**p-value**
PH					
Study group	7.37 ± 0.07	7.44 ± 0.02	–0.07	0.95	0.001
Control group	7.36 ± 0.05	7.41 ± 0.03	–0.05	0.68	0.001
MD	0.01	0.03			
	p = 0.56	**p = 0.01**			
PaO_2 [mmHg]					
Study group	83.27 ± 2.93	95.83 ± 2.35	–12.56	15.08	0.001
Control group	82.37 ± 3.48	89.67 ± 3.71	–7.3	8.86	0.001
MD	0.9	6.16			
	p = 0.31	**p = 0.001**			
$PaCO_2$ [mmHg]					
Study group	47.10 ± 5.12	38.77 ± 3.22	8.33	17.69	0.001
Control group	46.33 ± 5.28	41.43 ± 4.25	4.9	10.58	0.001
MD	0.77	–2.66			
	p = 0.57	**p = 0.008**			
HCO_3 [mEq/L]					
Study group	26.17 ± 5.94	30.22 ± 3.53	–4.05	15.48	0.001
Control group	25.72 ± 5.14	27.51 ± 4.09	–1.79	6.96	0.001
MD	0.45	2.71			
	p = 0.75	**p = 0.008**			

SD, Standard deviation; MD, Mean difference; p-value, Probability value

Table [3]: Mean sit-to-stand test and SF-36 pre and post-treatment of study and control groups

	Pre-treatment	Post-treatment			
	Mean ± SD	**Mean ± SD**	**MD**	**% of change**	**p-value**
Sit to stand test [s]					
Study group	23.80 ± 2.73	12.63 ± 1.47	11.17	46.93	0.001
Control group	24.67 ± 2.88	14.80 ± 1.82	9.87	40.01	0.001
MD	–0.87	–2.17			
	p = 0.23	**p = 0.001**			
SF-36					
Study group	77.97 ± 4.61	91.73 ± 3.25	–13.76	17.65	0.001
Control group	79.10 ± 4.52	85.93 ± 3.32	–6.83	8.63	0.001
MD	–1.13	5.8			
	p = 0.34	**p = 0.001**			

SD, Standard deviation; MD, Mean difference; p-value, Probability value

DISCUSSION

The elimination of respiratory secretions is a significant consideration during the rehabilitation period after heart surgery since postoperative discomfort can impede the clearance of secretions from the respiratory tract. Despite the significant progress made in the field of anesthetics, cardio-pulmonary bypass operations, and pre- and post-operative care, CABG remains linked to a notable incidence of pulmonary complications [PPC] [10]. In the preoperative and postoperative care of patients after heart surgery, the use of pulmonary physiotherapy has considerable significance in addressing pulmonary complications, enhancing patient prognosis, and contributing to overall treatment efficacy [11].

The technique of hand stroke with chest wall vibration is a well-recognized modality in physio-therapy used to facilitate the clearance of the respiratory system. Nevertheless, this process needs a significant workforce, depends on the operator, and entails a significant expenditure of time. Furthermore, patients may have discomfort in the initial postoperative period [12].

OPEP devices are portable devices used to help in airway clearing. These devices function by generating high-frequency oscillations during exhalation, which in turn produce shear pressures. These shear forces decrease the viscoelastic properties of secretions and enhance the movement of mucus. In addition, PEP decreases the likelihood of airway collapse during exhalation while promoting collateral ventilation to ensure the openness of the airway. Additionally, PEP aids in the central movement of secretions, enabling their expulsion during expectoration [13].

The primary objective of this investigation was to evaluate the effectiveness of intra-thoracic oscillations using the OPEP Quake device in improving ABG after CABG.

Upon comparing the overall characteristics of the participants from both groups, age, weight, height, and BMI showed insignificant differences between the groups; **Mohamed *et al.*** [14] postulated that mucociliary clearance is influenced by physiological factors as age, gender, body weight, and height.

The assessment of ABG analysis pertains to evaluating the sufficiency of ventilation, oxygenation, and the acid-base equilibrium inside the body. This is accomplished by quantifying arterial blood pH, PaO_2, $PaCO_2$, and HCO_3 concentrations. The analysis of ABG data has considerable significance in identifying and managing individuals suffering from pulmonary and other severe medical conditions. However, this process might sometimes present challenges [15].

Concerning the impact of intra-thoracic oscillations, the present study showed the efficacy of a seven-day therapy regimen using the Quake device in addition to traditional treatment, which has caused a significant improvement in ABG as PaO_2 showed a significant rise, with a percentage change of 15.08%, and $PaCO_2$ showed a significant decrease with the percentage of change 15.48%. At the same time, the patients in the control group who received traditional treatment [deep breathing, percussion, and IS] only showed less improvement in both PaO_2 and $PaCO_2$, with the percentage of change at 8.86 % and 10.58%, respectively. This is consistent with **Singh and Ganesh** [16], who found that there was a statistically significant improvement in PaO_2 and $PaCO_2$ after using the OPEP device [Flutter] in the first, third, and fifth day post-CABG more than the control group who was given only conventional therapy. The Flutter is used during expiration while the Quake is used during inspiration and expiration.

However, the current results contradicted those of **Alam *et al.*** [12], who found that both OPEP device [Acapella] and traditional

treatment [IS] improved oxygenation [PaO_2 and PCO_2] after coronary artery bypass graft with no statistically significant difference was seen between the two techniques. The Acapella is used during expiration while the Quake is used during inspiration and expiration.

The observed enhancement in ABG values in the present research might be attributed to using the Quake device, which falls under the oscillating positive expiratory pressure devices. This device generates robust vibratory pulses during exhale and inhalation, inducing powerful percussive pulses. In addition to its role in lowering mucus viscoelasticity, it also aids in maintaining airway patency to avoid collapse, thus improving airflow and ultimately enhancing alveolar ventilation [17].

The sit-to-stand test is a reliable and appropriate assessment tool that may be administered to older persons with any level of functioning upon their departure from the critical care unit. The discriminative quality of the factor above has the potential to effectively differentiate individuals at high risk of cardiovascular events from those at low risk. Consequently, this factor may provide valuable insights for tailoring tailored clinical management strategies, targeted exercise programs, and rehabilitation approaches for this patient cohort [18].

The present study showed the impact of intra-thoracic oscillations, revealing that a treatment period of seven days via the Quake device, in addition to traditional treatment, has caused a significant improvement in the sit-to-stand test results which showed a significant decrease with a percentage of change 46.93% while the control group showed improvement with percentage of change 40.01%. The probable reason for such improvement could be for more effective secretion clearance using the Quake device, resulting in better lung ventilation, which eventually affects the functional capacity of the patients [19]. This aligns with findings of **Winkelmann *et al.*** [20], who concluded that the sit-to-stand test administered before cardiac surgery and four to five days after the procedure is safe and effective. This is evidenced by the lack of adverse cardiorespiratory effects that could worsen the patient's clinical condition.

Girgin *et al.* [11] applied pulmonary rehabilitation to patients undergoing CABG for four days post-operative, helping them recover their functional capacity faster.

The concept of quality of life [QoL] has gained significant prominence in the fields of medicine, social sciences, and healthcare. This is due to its ability to include the objective clinical or physiological aspects of a patient's condition and their subjective view of how it affects their overall well-being. After undergoing CABG surgery, patients may experience symptoms such as depression, less patience, diminished overall well-being, and a decline in functional capacity compared to their preoperative state. These emotions, whether experienced individually or in combination, can significantly diminish the overall well-being and satisfaction of a patient's life [21].

Compared with conventional treatment and physical activity, PEP [Quake] therapy shows advantages in terms of short-term and long-term results that are relevant to patients and healthcare professionals. According to **Osadnik *et al.*** [22], those in the PEP group had faster enhancements in dyspnea, as measured by mMRC scores, after their discharge compared with those in the control group.

Concerning the impact of intra-thoracic oscillations, the present study has shown that a treatment period of seven days via the Quake device, in addition to traditional treatment, has caused a significant improvement in the SF-36 questionnaire results, which showed a significant increase with a percentage of change 17.65% while the control group showed improvement with a percentage of change 8.63%. This finding is consistent with **Zolfaghari *et al.*** [23], who reported that the post-intervention QoL [measured using the SF-36 questionnaire] showed a significant improvement in patients who received 16 sessions of chest physical therapy following elective CABG surgery.

Üzmezoğlu *et al.* [24] conducted a study that revealed that the use of oscillating physio-therapy equipment, known as the flutter, over 4 weeks resulted in a significant enhancement in the physical sub-scale scores of the SF-36 questionnaire among patients diagnosed with bronchiectasis.

Conclusion: It was concluded that early rehabilitation after CABG surgery via Quake device could improve ABG, functional capacity, reflecting better QoL. Quake devices should be viewed as a safe, non-invasive therapeutic option that could be implemented as a routine practice along with traditional chest physio-therapy in CABG patients.

Financial and non-financial relations and activities of interest: None

REFERENCES

1. Ullah M, Wahab A, Khan SU, Zaman U, Rehman KU, Hamayun S, *et al.* Stent as a Novel Technology for Coronary Artery Disease and Their Clinical Manifestation. Curr Probl Cardiol. 2023 Jan;48[1]:101415. doi: 10.1016/j.cpcardiol.2022.101415.

2. Cho H. CABG vs. PCI: Greater Outcomes for Severe Coronary Artery Disease. San José State University. 2023; Master's Projects. 1286. doi: 10.31979/etd.m4an-mtfp.

3. Esmealy L, Allahbakhshian A, Gholizadeh L, Khalili AF, Sarbakhsh P. Effects of early mobilization on pulmonary parameters and complications post coronary artery bypass graft surgery. Appl Nurs Res. 2023 Feb;69:151653. doi: 10.1016/j.apnr.2022.151653.

4. Fazal AIA, Fatema K, Islam MW, Salek S, Kibria MG. Effectiveness of Incentive Spirometry to Reduce Pulmonary Complications and Improve Respiratory Parameter after Coronary Artery Bypass Graft Surgery: A Narrative Review. J Clin Respir Dis Care. 2023;09[02]:244.

5. El-Reabai NM, Khalil NS, MageedGado AS. The effect of postoperative incentive spirometry on dyspnea severity among patients undergoing coronary artery bypass graft. Egypt Nurs J. 2023 Jan 1;20[1]:22-9. doi: 10.4103/enj.enj_45_22.

6. Nabilah A, Wijianto W, Purbasasana P. Physiotherapy Management in Post Operation CABG [Coronary Artery Bypass Graft]: A Case Study. Acad Physiother Confer Proceed. 2021; Available from: https://proceedings.ums.ac.id/index.php/ apc/article/view/127.

7. El Nahas NG, Hamed A. Reinforcement of airway clearance by quake device training in patients with chronic Bronchitis. Pharmacophore. 2019;10[3]:21-7.

8. Toor H, Kashyap S, Yau A, Simoni M, Farr S, Savla P, Kounang R, Miulli DE. Efficacy of Incentive Spirometer in Increasing Maximum Inspiratory Volume in an Out-Patient Setting. Cureus. 2021 Oct 4;13[10]:e18483. doi: 10.7759/cureus.18483.

9. Salehi Derakhtanjani A, Ansari Jaberi A, Haydari S, Negahban Bonabi T. Comparison the Effect of Active Cyclic Breathing Technique and Routine Chest Physiotherapy on Pain and Respiratory Parameters After Coronary Artery Graft Surgery: A Randomized Clinical Trial. Anesth Pain Med. 2019 Oct 16;9[5]:e94654. doi: 10.5812/aapm.94654.

10. Tanner TG, Colvin MO. Pulmonary Complications of Cardiac Surgery. Lung. 2020 Dec;198[6]:889-896. doi: 10.1007/s00408-020-00405-7.

11. Girgin Z, Ciğerci Y, Yaman F. The Effect of Pulmonary Rehabilitation on Respiratory Functions, and the Quality of Life, following Coronary Artery Bypass Grafting: A Randomised Controlled Study. Biomed Res Int. 2021;2021:6811373. doi: 10.1155/2021/6811373.

12. Alam M, Hussain S, Shehzad MI, Mushtaq A, Rauf A, Ishaq S. Comparing the Effect of Incentive Spirometry with Acapella on Blood Gases in Physiotherapy After Coronary Artery Bypass Graft. Cureus. 2020 Feb 3;12[2]:e6851. doi: 10.7759/cureus.6851.

13. Alghamdi SM, Barker RE, Alsulayyim ASS, Alasmari AM, Banya WAS, Polkey MI, Birring SS, Hopkinson NS. Use of oscillatory positive expiratory pressure [OPEP] devices to augment sputum clearance in COPD: a systematic review and meta-analysis. Thorax. 2020; 75[10]:855-863. doi: 10.1136/thoraxjnl-2019-214360.

14. Mohamed AM, Badr NM, Hagag AA, Mohamed YM. Intra versus extra-thoracic oscillations in chronic obstructive pulmonary disease [a randomized clinical trial]. J Adv Pharm Educ Res. 2019;9[3]:85-90.

15. Pompey J, Abraham-Settles B. Clarifying the Confusion of Arterial Blood Gas Analysis: Is it Compensation or Combination? Am J Nurs. 2019;119 [3]:52-56. doi: 10.1097/01.NAJ.0000554035.74335.59.

16. Singh N, Ganesh BR. Effect of flutter device on airway mucus clearance, physiological parameters, and arterial blood gas analysis in patients with coronary artery bypass grafting during Phase 1 cardiac rehabilitation - A randomized control trial. Int J Med Sci Public Health. 2020;9[1]:16-20. doi: 10.5455/ijmsph.2020.0721723102019.

17. Khalil NS, Ismaeel MS, Askar AH, Sayed MS. Effects of manual hyperinflation with rib cage compression and endotracheal suctioning on arterial blood gas parameters in mechanically ventilated patients at a university hospital, Egypt. Egypt J Bronchol. 2021 Dec;15:47[1-7]. doi: 10.1186/s43168-021-00096-5.

18. Wang Z, Yan J, Meng S, Li J, Yu Y, Zhang T, *et al.* Reliability and validity of sit-to-stand test protocols in patients with coronary artery disease. Front Cardiovasc Med. 2022;9:841453. doi: 10.3389/fcvm.2022.841453.

19. Hichkad S, Ganesh BR. Effect of Blow Bottle Device and Flutter on Functional Capacity, Dyspnea, Fatigue, and Peak Expiratory Flow Rate in Mild-to-Moderate COPD Patients: A Comparative Study. Ind J Resp Care. 2021 Sep;10[3]:294-8. doi: 10.4103/ijrc.ijrc_70_21.

20. Winkelmann ER, da Silva LG, da Silva MM, Windmoller P, Silva AB. Cardiopulmonary responses of the sit-to-stand test in individuals pre and post-heart surgery: cross section. J Physiother Res. 2021;11[4]: 730-7. doi: 10.17267/2238-2704rpf.v11i4.4127.

21. Perrotti A, Ecarnot F, Monaco F, Dorigo E, Monteleone P, Besch G, Chocron S. Quality of life 10 years after cardiac surgery in adults: a long-term follow-up study. Health Qual Life Outcomes. 2019 May 22;17[1]:88. doi: 10.1186/s12955-019-1160-7.

22. Osadnik CR, McDonald CF, Miller BR, Hill CJ, Tarrant B, Steward R, *et al.* The effect of positive expiratory pressure [PEP] therapy on symptoms, quality of life and incidence of re-exacerbation in patients with acute exacerbations of chronic obstructive pulmonary disease: a multicentre, randomised controlled trial. Thorax. 2014 Feb;69[2]:137-43. doi: 10.1136/thoraxjnl-2013-203425.

23. Zolfaghari M, Mirhosseini SJ, Baghbeheshti M, Afshani A, Moazzam S, Golabchi A. Effect of physiotherapy on quality of life after coronary artery bypass graft surgery: A randomized study. J Res Med Sci. 2018 Jun 6;23:56. doi: 10.4103/jrms.JRMS_96_17.

24. Üzmezoğlu B, Altıay G, Özdemir L, Tuna H, Süt N. The Efficacy of Flutter® and Active Cycle of Breathing Techniques in Patients with Bronchiectasis: A Prospective, Randomized, Comparative Study. Turk Thorac J. 2018 Jul;19[3]:103-109. doi: 10.5152/TurkThoracJ.2018.17050.

International Journal of Medical Arts

https://ijma.journals.ekb.eg/
Print ISSN: 2636-4174
Online ISSN: 2682-3780