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Research methods

A Pilot Quasi-Experimental Study to Evaluate the Effectiveness of the ELTGOL Technique with Conventional Chest Physiotherapy on Respiratory Function and Postoperative Pulmonary Complications in CABG Patients

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Abstract

Background

Patients undergoing coronary artery bypass grafting are at risk of pulmonary complications due to anesthesia, reduced lung function, and altered respiratory mechanics that leads to mucus retention. In physical therapy, Airway Clearance Techniques are used postoperatively to clear mucus from the lungs, aiming to improve lung function and reduce pulmonary complications in the early recovery period.

Objective

This study aimed to determine the effect of the ELTGOL technique combined with conventional chest physiotherapy on respiratory function and the prevention of postoperative pulmonary complications in patients following CABG surgery.

Methods

Fifty-seven patients (ages 45-80) of both sexes who underwent CABG and were in phase 1 of cardiac rehabilitation participated in this pilot randomized control trial (32 in the control group, 32 in the experimental group). Interventions started on POD 2 and continued until discharge (POD 5). The control group received conventional physiotherapy, including breathing exercises, incentive spirometry, and early mobilization, while the experimental group received the ELTGOL technique in addition to these treatments. Outcome measures included chest X-ray improvements, spirometric values, PF ratio, oxygen saturation, chest expansion, and RPE scale.

Results

The data collected on post-extubation day & the POD 5 revealed statistically significant improvement in the scores of inspiratory spirometery reading ($p<0.01$), chest x-ray ($p<0.01$), chest expansion ($p<0.01$) and Borg scale scores ($p<0.01$) for both the groups. However, on POD 5 statistically significant difference was observed in the scores of chest x-ray ($p=0.022$) and Borg scale scores ($p=0.043$) in experimental group.

Conclusion

The addition of the ELTGOL technique to conventional physiotherapy improved respiratory function and reduced postoperative pulmonary complications in the early recovery period in CABG patients.

INTRODUCTION

Cardiovascular diseases (CVD) are the leading cause of death globally,[1] affecting the cardiac muscle and the vascular systems supplying the heart, brain, and other vital organs.[2,3] In India, the age-standardized CVD death rate is 272 per 100,000 population, surpassing the global average of 235 per 100,000, according to the Global Burden of Disease study.[4,5]

Coronary Artery Bypass Grafting (CABG) is the gold standard for Triple Vessel Diseases (TVD), with approximately 1 million procedures performed annually world-

wide.[5] It significantly improves life expectancy for patients with left main coronary artery disease when compared to Percutaneous Coronary Intervention (PCI).[6,7] Various arterial and venous conduits are employed to restore vascularization and enhance long-term outcomes after CABG.[8]

Post-operative pulmonary complications (PPCs) are common in patients undergoing open thoracic surgeries like CABG and the prevalence is between 30% and 60%.[5, 9] Anesthesia, intubation, and surgical trauma can reduce Functional Residual Capacity (FRC) and alter surfactant production.[10] PPCs can lead to ineffective airway clearance (IAC), if left unrecognized and untreated, may lead to significant pulmonary sequestration such as atelectasis, disrupting ventilation-perfusion, affecting blood oxygenation, or may even lead to death in serious complications.[5,11]

This complication can lead to ineffective airway clearance (IAC), a common nursing diagnosis observed in patients' post-CABG. Unrecognized and untreated, IAC may progress to significant pulmonary sequestration or even death.

Chest physiotherapy is crucial in postoperative CABG cases to prevent atelectasis and limit lung volume reduction.[12] Physiotherapists guide patients in breathing exercises, Active Cycle of Breathing Techniques (ACBT), early mobilization, and inspiratory muscle training to enhance oxygenation after open-heart surgery.[13] These techniques are typically combined, especially for patients with impaired cough, muscle weakness, or reduced mucociliary clearance.[14]

ELTGOL (L'Expiration Lente Totale Glotte Ouverte en décubitus Latéral), which was first described by POSTIAUX et al. in 1987 is a less well-known airway clearing technique but increasingly getting popular.[15,16] It is performed in the lateral decubitus position and involves slow expiration with an open glottis, moving air from Functional Residual Volume (FRC) to Residual Capacity (RC).[15,16] This mucus-clearing technique increases airflow resistance and narrows the diameter of the peripheral airways in the inferolateral lung, enhancing the airflow-mucus interface.[17-19]

This technique is indicated for patients with pulmonary secretions such as Chronic Bronchitis[15] and Bronchiectasis.[19] However, evidence of its efficacy in postoperative CABG patients and its impact on open thoracic surgeries is lacking. This study aims to evaluate the effectiveness of the ELTGOL technique combined with conventional chest physiotherapy on respiratory function and the prevention of postoperative pulmonary complications in postoperative CABG patients.

METHODOLOGY

Sample: A total 64 subjects were selected for the study on the basis of inclusion and exclusion criteria. The sample size of 64 was based on feasibility, availability of eligible post-operative CABG patients during the study period, and consistency with similar studies. Although formal power analysis was limited by preliminary data, the number was adequate to observe meaningful trends in clinical outcomes.

Source of subjects: Fortis Hospital, Shalimar Bagh, Delhi and Institute of Heart Lungs Diseases Research Centre, PSRI Hospital, Delhi.

Method of sampling: All the subjects were selected using sample of convenience.

Research design: Quasi-Experimental Pilot Study

Method of selecting subjects: Selection of the subjects was done on the basis of inclusion and exclusion criteria.

INCLUSION CRITERIA

- Both male and female
- Age 45-80 (The most common age group undergoing CABG is between 50–80 years, as supported by epidemiological studies and cardiac surgery registries).
- Recent CABG patients
- Patient with CAD without any comorbidity (COPD, Cystic fibrosis)

EXCLUSION CRITERIA

- Patients on Intra-Aortic Balloon Pump (IABP) support
- Patients on Extracorporeal Membrane Oxygenation (ECMO) support
- Patients on either Temporary Pace maker (TPI) or Permanent Pace maker (PPI)
- Hemodynamically unstable
- Patients with delayed postoperative discharge beyond POD-5
- Patients previously underwent Valvular Heart surgeries
- Uncooperative patients
- Psychiatric disorders affecting participation

ASSIGNMENTS OF SUBJECTS TO GROUPS

Although randomization was initially planned, logistical challenges and clinical considerations during the study period led to a non-randomized assignment of participants to groups based on availability and clinical criteria Subjects selected based on inclusion and exclusion criteria were randomly assigned to two groups: the control group (Group A) and the experimental group (Group B).

INSTRUMENTATION

- Spirometer
- Mechanical Chest Vibrator
- Measuring tape
- Chest binder
- RPE scale (Rate of Perceived Exertion for dyspnea)

VARIABLES

Independent variables: Conventional Chest Physiotherapy and ELTGOL Technique

Dependent variables: Post-operative CABG patients

OUTCOME MEASURES

- Improvement in Chest X-ray
- Spirometric values
- PF Ratio
- Oxygen saturation level
- Chest Expansion
- RPE scale

Although sputum volume is the gold standard for directly assessing airway clearance, it is not always a feasible or reliable measure in post-operative CABG patients, particularly within the early recovery period. The selected outcome measures, including spirometry, chest X-ray, chest expansion, and ABG analysis, are well-established clinically relevant indicators of respiratory function and indirect markers of airway clearance. These measures have been widely used in studies assessing pulmonary rehabilitation and post-operative care in cardiac patients.

Intervention Delivery and Blinding: The ELTGOL technique and conventional chest physiotherapy were delivered by a heart-lung transplant physical therapist with specialized expertise in post-operative pulmonary rehabilitation. Blinding was not possible due to the distinct nature of the interventions. Both participants and clinicians were aware of the assigned treatment. To minimize bias, objective measures (spirometry, chest X-ray, and ABG analysis) were used, following standardized procedures for reliable outcome assessment.

PROCEDURE

Based on the inclusion and exclusion criteria, 64 subjects were selected and divided into two groups: Group A (Control) and Group B (Experimental). Seven out of the 64 patients opted out of participating in the study and 7 patients who had complications after the surgery and could not get discharge on POD 5 (Post-operative day 5) were also eliminated.

The study received Ethical Committee approval. Patients were informed about the objectives through video explanations and provided written consent. The control group received conventional therapy, while the intervention group received ELTGOL. A subgroup was monitored until discharge (POD 5) to assess mucus clearance effects.

After extubation, postoperative CABG patients were assessed on POD 1 (Post-operative day 1) before physiotherapy, with key data collected in semi-Fowler's position. Conventional chest physiotherapy continued until mediastinal or pleural drains were removed, followed by thoracic expansion exercises with a chest binder. Once inotropes were tapered, patients sat in a chair in the CTVS ICU and ambulated around the bed. From POD 3 (Post-operative day 3), they moved to the ward, maintaining treatment and ambulating within the room. The next day, hallway walks began with monitoring. On POD 5 (Post-operative day 5), isometric lower limb exercises, dynamic quads, stair training, and discharge instructions for home exercises were provided.

INTERVENTION

PROTOCOL FOR GROUP "A" (CONTROL GROUP)

Each exercise session lasted 15-20 minutes, starting with 10 deep breaths in three sets, with 30-60 second pauses in between.[20] Spirometry exercises involved 10 repetitions in 2 sets for both inspiration and expiration, sometimes tilted for inadequate effort.[21] ACBT was routinely included,[22] along with gentle range of motion exercises,[23] where patients relaxed and performed 10 repetitions per joint in two sets. A final assessment measured PF ratio in ABG readings, peripheral oxygen saturation, chest X-ray improvement (Grade 0: No improvement in Chest X-ray on POD 5; Grade 0.5: Partial Improvement in Chest X-ray on POD 5 and Grade 1: Complete improvement in Chest X-ray on POD 5), Chest Expansion and Borg scale scores, comparing these with previous readings taken on POD 1 after extubation.

PROTOCOL FOR GROUP "B" (EXPERIMENTAL GROUP)

Starting on **postoperative day 2 (POD-2)**, the ELTGOL technique was performed three times daily for 10 minutes per session, alongside conventional chest physiotherapy, until patient discharge. Sessions were spaced at six-hour intervals to balance effective airway clearance with patient comfort and tolerance. The first treatment session could not be performed on POD-0 (Day of surgery) or POD-1 (Post-operative day 1), as many patients remained intubated and mechanically ventilated. The treatment dose and frequency were based on clinical guidelines and prior research recommending early and frequent respiratory interventions to prevent postoperative pulmonary complications, particularly in cardiac surgery patients.

ELTGOL is an active-passive airway clearance technique performed with the patient in a **lateral decubitus position (left side up)**. The physiotherapist stands behind the patient, instructing them to inhale and exhale slowly through an **open glottis**, while applying infra-lateral abdominal and thoracic compression. Pillows are positioned behind the right knee and on the abdomen for support. A spirometer mouthpiece may be used to help maintain the glottis in the open position during the maneuver.

This approach combines physiological principles of ELTGOL — slow expiratory airflow from Functional Residual Capacity to Residual Capacity, increased peripheral airway resistance, and enhanced airflow–mucus interface — with practical clinical application, allowing effective and safe implementation in postoperative CABG patients.

STATISTICAL ANALYSIS

Data were collected on the post-extubation day and the 5th postoperative day, processed with IBM SPSS Statistics 23, and analyzed descriptively. Independent sample t-tests compared scores between groups, while paired sample t-tests assessed scores within groups. A master chart analyzed 50 subjects, including demographic characteristics (age, weight, height, BMI), with statistical significance set at $p < 0.05$ and a 95% confidence level.

Table 1. Comparison of Baseline and Post-operative Parameters Between Groups

Outcome Measure	Group 1 – Control (Mean ± SD)	Group 2 – Experimental (Mean ± SD)
Age (years)	7 ± 7.66	61.84 ± 7.49
Height (cm)	164.12 ± 8.36	164.05 ± 10.55
Weight (kg)	66.35 ± 8.86	68.2 ± 11.77
BMI	24.66 ± 3.19	25.43 ± 4.06
Post-Extubation – Inspiratory Spirometer (ml)	0.32 ± 0.48	0.36 ± 0.57
Post-Extubation – Expiratory Spirometer (ml)	1.24 ± 0.44	1.08 ± 0.28
Post-Extubation – CXR	0	0
Post-Extubation – Oxygen Saturation (%)	98.64 ± 1.75	98.56 ± 1.83
Post-Extubation – PF Ratio	333.92 ± 64.39	317.56 ± 90.98
Post-Extubation – Chest Expansion (cm)	1.40 ± 0.50	1.62 ± 0.61
Post-Extubation – Borg Score	6.56 ± 1.89	6.56 ± 1.58
POD 5 – Inspiratory Spirometer (ml)	1.48 ± 0.50	1.40 ± 0.65
POD 5 – Expiratory Spirometer (ml)	1.24 ± 0.44	1.16 ± 0.37
POD 5 – CXR	0.7 ± 0.25	0.86 ± 0.23
POD 5 – Oxygen Saturation (%)	97.08 ± 1.75	97.24 ± 2.07
POD 5 – PF Ratio	372.24 ± 126.17	406.6 ± 104.17
POD 5 – Chest Expansion (cm)	3.12 ± 1.07	3.66 ± 1.09
POD 5 – Borg Score	4.20 ± 2.65	2.84 ± 1.93

RESULTS

Descriptive analysis showed that the average age of participants was 57 ± 7.66 years in the control group and 61.84 ± 7.49 years in the experimental group. Details of each outcome measure are presented in Table 1.

WITHIN GROUP COMPARISON

A comparison between the data collected post-extubation and on the 5th postoperative day showed significant improvements in inspiratory spirometry ($p<0.01$), chest X-ray ($p<0.01$), oxygen saturation ($p<0.01$), chest expansion ($p<0.01$), and Borg scale scores ($p<0.01$) for the control group. These within-group findings are summarised in Table 2. However, there was no significant change in the PF ratio, and the expiratory spirometry t-value for the control group was not calculated due to a standard error of 0.

In the experimental group, significant improvements were noted in inspiratory spirometry ($p<0.01$), chest X-ray ($p<0.01$), oxygen saturation ($p=0.015$), PF ratio ($p<0.01$), chest expansion ($p<0.01$), and Borg scale scores ($p<0.01$) on the 5th postoperative day. No significant change was observed in expiratory spirometry.

BETWEEN GROUPS COMPARISON

The comparison between the control and experimental groups revealed no significant differences on the post-extubation day. These between-group results are summarised in Table 3. However, by the 5th postoperative day, significant differences were found in chest X-ray scores ($p=0.022$) and Borg scale scores ($p=0.043$). Improvements in spirometer readings, oxygen saturation, PF ratio, and chest expansion were observed in both groups, but these were statistically comparable with no significant difference.

DISCUSSION

This study found that conventional physiotherapy (Group A) significantly improved spirometry, chest X-ray scores, oxygen saturation, chest expansion, and Borg scale scores in CABG patients from post-extubation to day 5 postoperatively. Similarly, the ELTGOL technique (Group B) led to significant improvements in spirometry, chest X-ray scores, oxygen saturation, PF ratio, chest expansion, and Borg scale scores by day 5. However, expiratory spirometry readings showed no significant change in either group.

While both interventions showed benefits, the lack of a statistically significant difference in airway clearance measures (e.g., expiratory spirometry and PF ratio) between the two groups suggests that the ELTGOL technique may offer similar advantages to routine physiotherapy in improving respiratory function after CABG. This aligns with previous studies such as Savci et al., who found comparable effects of ACBT and incentive spirometry on respiratory outcomes in CABG patients.[24]

Furthermore, the clinical significance of these improvements, particularly in terms of lung volumes and ventilation-perfusion ratio, supports the use of the ELTGOL technique in improving quality of life through airway clearance, although further research is needed to assess its specific advantages over conventional physiotherapy. ELTGOL enhances lung volumes from Functional Residual Capacity (FRC) to Residual Volume (RV) through slow expiration with an open glottis, improving the ventilation-perfusion ratio and preventing lung damage.[15] Conducted in the lateral de-

Table 2. Comparison of Outcome Measures Within the Groups (Paired Sample t-test)

Group	Outcome Measure	t-value	Significance
Control Group	Inspiratory Spirometer (ml)	-12.27	<0.01*
	Expiratory Spirometer (ml)	-	-
	CXR	-14	<0.01*
	Oxygen Saturation	4.07	<0.01*
	PF Ratio	-1.809	0.083
	Chest Expansion (cm)	-9.49	<0.01*
	Borg Score	7.13	<0.01*
Experimental Group	Inspiratory Spirometer (ml)	-9.66	<0.01*
	Expiratory Spirometer (ml)	-1.45	0.161
	CXR	-18.77	<0.01*
	Oxygen Saturation	2.61	0.015*
	PF Ratio	-4.72	<0.01*
	Chest Expansion (cm)	-8.21	<0.01*
	Borg Score	12.07	<0.01*

Table 3. Comparison of the Scores Between the Groups (Independent Sample t-test)

Outcome Measure	Post-Extubation t-value	Post-Extubation Significance	POD 5 t-value	POD 5 Significance
Inspiratory Spirometer (ml)	-0.27	0.79	0.49	0.62
Expiratory Spirometer (ml)	1.55	0.13	0.70	0.49
CXR	-	-	-2.36	0.022*
Oxygen Saturation	0.16	0.88	-0.29	0.77
PF Ratio	0.73	0.47	-1.05	0.29
Chest Expansion (cm)	-1.32	0.19	-1.73	0.09
Borg Score	0.005	1	2.08	0.043*

cubitus position, it effectively clears secretions from the inferolateral lung, while Forced Expiratory Technique (FET) helps move secretions proximally.[25,26] Coughing then clears these secretions from the mouth, improving overall respiratory function. Given the limitations of this study (e.g., lack of a primary outcome measure focused specifically on airway clearance), future studies with more robust designs and larger sample sizes are needed to confirm these findings.[27,28]

CONCLUSION

This quasi-experimental study suggests that the ELTGOL technique, when combined with conventional chest physiotherapy, may contribute to improved chest X-ray scores and reduced Borg scale ratings in postoperative CABG patients, indicating potential benefits in mucus clearance during the early recovery period.

LIMITATIONS AND FUTURE SCOPES

The study's limitations include a small sample size and no long-term effect evaluation. As this pilot study focused on short-term effects of ELTGOL in postoperative CABG patients, we recommend its routine use for airway clearance. However, further research is needed to assess long-term outcomes, including quality of life and functional capacity.

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SUPPLEMENTARY MATERIALS

Treatment Protocol for Group A and Group B

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Graphs

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