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Comparative Study of Breathing Techniques After Coronary Artery By Pass Grafting

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ABSTRACT

Study Objective: Comparative Study of Breathing Techniques after Coronary Artery by Pass Grafting
Design: A randomized trial**.**

Method and Measurements: The effectiveness of three deep breathing techniques was evaluated in 30 male patientsafter coronary artery bypass graft in a randomized trial. Patient were randomly and equally assigned to Blow bottle(group A), IR-PEP (group B), and deep breathing (group C). The techniques were deep breathing with a blow bottle-device, Inspiratory resistance-positive expiratory pressure mask (IR-PEP) and performed with no mechanical device.Pulmonary function and roentgenological changes were evaluated.

Results: No significant differences found between all three groups except for a longer duration of anesthesia in thegroup B than the group C. Pain from the sternotomy measured by VAS while the patient take a deep breath showingno significant difference between the group A (2.6± 1.8), Group B (2.8 ± 2.1) and Group (2.4 ± 2.2).

Conclusion: There were no major differences between the three treatment groups on the fourth post-operative day. The relative decrease in pulmonary function tended to be less marked by chest physiotherapy using the Blowbottle technique than by Deep breathing without any mechanical device and the technique was at least as good as theIR-PEP technique. The Blow bottle is furthermore an inexpensive method that will be well accepted and easilylearned by patients, and works as well as more complex techniques. However, a technique that offers even bettersupervision and the assistance of a deep inspiration with optimal continuance may prevent further lung functiondeterioration.

KEY WORDS: Physical therapy, breathing exercises, thoracic surgery, coronary artery bypass, respiratory function tests, postoperative care

INTRODUCTION:

In order to prevent or diminish postoperative complications Physiotherapy treatment is often prescribed to patients undergoing cardiac surgery, the physiotherapy treatment generally consists of early mobilization, range of motion exercises during the hospital stay [1]. Chest physiotherapy and breathing exercises are also prescribed to patients undergoing cardiac surgery in order to prevent or reduce post-operative pulmonary complications. There is an agreement on the value of pre- and post-operative breathing exercises and physiotherapy treatment[2]. The value of postoperative chest physiotherapy has recently been established and accepted, but it is still unclear which treatment techniques are the most effective[3-5]. In the literature a wide variety of treatments have been suggested. Many strategies and diverse therapies are applied postoperatively and these differ within and between countries. Early mobilization and physical activity is often the first choice of treatment, but evidence as to the optimal intensity, timing and choice of exercises is scarce. There are only limited published data on how the cardiac surgery patient should be mobilized and exercised during the first postoperative period in hospital[6-8]. After coronary artery bypass grafting physiotherapy-consisting of breathing exercises emphasising inspiration, incentive spirometry, techniques to clear bronchial secretions, and early mobilisation-is given with the aim of increasing lung ventilation and preventing chest infections[9]. Recently, changes to the post-operative care of cardiac surgery patients have been advocated. Patients could be managed using “rapid recovery guidelines” without compromising patient outcomes or levels of satisfaction[10]. Early extubation (7-11 hours post-operatively) following cardiac surgery resulted in a decrease in length of intensive care unit (ICU) stay and no increase in clinically important post-operative complications[11]. Introduction of a “fast-track regime” (using shorter acting anesthesia, less reduction in intra-operative body core temperature and defined clinical milestones) for patients following coronary artery surgery did not increase the incidence of post-operative pulmonary complications[12]. Respiratory physiotherapy is routinely used in the prevention and treatment of post-operative pulmonary complications after cardiac surgery. The goals of physiotherapy are to improve ventilation–perfusion matching, increase lung volume, enhance mucociliary clearance, and decrease pain[13].

METHODS AND MATERIAL:

30 male patients scheduled for CABG at RNH hospital were the study conducted. Patients who had unstable angina, previous open heart surgery or renal dysfunction requiring dialysis were not included. The study was approved by the Ethics

Committee of RNH hospital and informed consent was obtained from each patient. The surgical approach was through a median sternotomy and CABG was performed with saphenous vein grafts and/or the left and/or right internal mammary artery. Cold blood cardioplegia and pericardial cooling with ice were used. An insulation pad was used to protect the phrenic nerve. The patient's lungs were kept deflated during the aortic occlusion. The pericardium, the mediastinum and one or both pleura were drained, usually less than 24 hours after surgery. Post-operatively the patients were artificially ventilated and a positive end-expiratory pressure of 5 cm H2O was used. Following surgery, inspired oxygen fraction in nitrogen was 0.5–0.8. The patients were tracheally extubated, when hemodynamically stable and able to normoventilate without distress. All patients received basic post-operative chest physiotherapy as conventionally used at the clinic by two physiotherapists once or twice

daily. The therapy consisted of mobilization and active exercises of the upper limbs and thorax, breathing exercises and instructions in coughing techniques. Patients were mobilized as early as possible by the nursing staff and physiotherapists according to the ordinary routines. The patients were instructed to sit out of bed and stand up on the first postoperative day, walk in the room or a short distance in the corridor on the second day, and walk freely in the corridor on the third post-operative day. Before surgery the patients were randomly assigned in three treatment groups. The patients in the group A were instructed to do deep breathing exercises with a blow bottle device. A bottle with 10 cm of water and a 40 cm plastic tube (1 cm diameter) were used. The manoeuvre gives a resisted exhalation with an expiratory peak pressure of +10 (±1) cm H2O. In the group B the deep breathing was performed through an PEP/RMT. The system consisted of a face mask/ventil connected to a T-tube where inspiratory and expiratory airflows are separated by a valve. Various resistance nipples were applied to receive wanted pressure, measured by a manometer. The expiratory pressure used was +10 cm H2O and the inspiratory pressure -5 cm H2O. The nipples used for expiratory pressure were 2.5 mm, 3.0 mm or 3.5 mm and for inspiratory pressure; 4.0 mm, 4.5 mm or 5.0 mm. In the group C the patients were instructed to inspire deeply through the nose and expire through the mouth without any mechanical device. In all three groups the patients were instructed to perform a maximal inspiration, while expiration was ended at approximately functional residual capacity (FRC) to avoid airway closure. Pre-operatively the patients practiced the different breathing techniques and received general information about post-operative routines, early mobilization and efficient coughing. All groups were instructed to perform 30 deep breaths with or without the mechanical device once an hour at daytime. The breathing exercises were, if possible, done in a sitting position and three sessions of 10 deep breaths each were performed, interrupted by a pause and coughing or huffing, if needed. Exercises were started 1 hour after extubation and continued until the fourth post-operative day. The patients were actively encouraged to use the suggested treatments by the staff during the 4 days of the investigation.

Measurements:
Pulmonary function measurements were performed pre-operatively and on the fourth post-operative day with a Medical Graphics Pulmonary Function System with proprietary software. The equipment was calibrated every morning prior to measurements. Four medical laboratory technicians who were unaware of the patient's randomization performed the tests. The patients were in a sitting position and a nose-clip was used. Predicted values for pulmonary function were related to age, sex, length and weight according to the values reported[14] .The results of the postoperative pulmonary function were expressed in percentage of the individual pre-operative values, and the relative decrease in pulmonary function was compared between the treatment groups. Three slow inspiratory vital capacities were obtained and the largest used for measurement of vital capacity (VC) and inspiratory capacity (IC). For the measurement of forced expiratory volume in 1 second (FEV1), the highest value of two or three technically satisfactory manoeuvres was retained. FRC and residual volume (RV) were measured with the single breath nitrogen washout technique. Total lung capacity (TLC) was calculated as VC + RV. The pulmonary diffusing capacity for carbon monoxide (DLCO) was measured. The gas mixture used for the measurement was 0.5% neon, 0.3% carbon monoxide, 21% oxygen, balance nitrogen. The gas sample was aspirated automatically into the chromatograph for analysis. The patients were instructed to exhale slowly and maximally to RV, and then rapidly inhale the gas mixture to TLC. The DLCO measurement was considered acceptable if the inspired volume was greater than 90% of the patients' VC. Two or three repeated tests were performed and the highest accepted value was retained. Repeated tests were separated by a washout period of at least 5 minutes DLCO was expressed both in absolute values and per liter of alveolar volume (DLCO/VA), measured by neon dilution during the breath holding manoeuvre. The DLCO values were corrected for the patient's current haemoglobin concentration using the equation of Cotes . At the time of the pulmonary function test the patients were asked to quantify the pain from the median sternotomy incision while taking a deep breath. A continuous visual analogue scale (VAS) from 0 (no pain) to 10 (the worst imaginable pain) was used.

An anteroposterior chest roentgenogram was taken in the standing position before the operation and on the fourth post-operative day. Presence or absence of atelectasis and/or pleural effusion was recorded.

Evaluation was performed by a radiologist who was unaware of the patient's randomization. The size of atelectasis seen on the chest radiograph was scored in the right and left lung separately. An arbitrary

scale was used for scoring of atelectasis: 0, no abnormality; 1, minimal abnormality (plate atelectasis); 2, moderate abnormality (segmental atelectasis); 3, major abnormality (lobar atelectasis). The left hemidiaphragm was described as raised if the highest point was at the same horizontal level or higher than that on the right.

Statistical analysis

The pre-operative, demographic and operative variables for the groups were compared by one-way analysis of variance or chi-square test. The pre- and post-operative pulmonary function values were compared by a paired *t*-test for each variable. The relative decrease of the pulmonary function variables after the operation was calculated for each patient and the mean value for the three groups were analysed with one-way analysis of variance. If a difference was found between the groups, the means were compared by Scheffe's test. Chest roentgenological scores were examined and analysed separately in the left and the right lung, and differences between the treatment groups were analysed with a chi-square test. All results refer to two-sided tests and a probability value less than 0.05 was considered significant.

RESULTS:

No significant differences between all three groups were found except for a longer duration of anesthesia in the IR-PEP group than the deep breathing group. Pain from the sternotomy measured by VAS while the patient took a deep breath showed no significant difference between the Blow bottle (2.6± 1.8),

IR-PEP (2.8 ± 2.1) and Deep breathing (2.4 ± 2.2) groups.

Pulmonary function:

The preoperative lung function did not differ between treatment groups in any of the measured variables. The measured variables were normal as related to predicted values with VC 86 ± 14% of predicted and FEV1 94 ± 19% of predicted. Pulmonary function values before surgery and on the fourth post-operative day are given in Table II[14]. Four days post-operatively all pulmonary function variables were significantly decreased in the three groups ($p < 0.0001$) compared to pre-operative values. The post-operative mean VC for all patients was 61 % of the pre-operative value, and FEV1 was reduced to 64%.

The relative decrease in pulmonary function variables, on the fourth post-operative day, displayed a small difference between the three treatment groups, when analysed with one-way analysis of variance. Post hoc analysis showed that the Blow bottle group had significantly less reduction in TLC ($p = 0.01$)

and a tendency to less reduction in FRC ($p = 0.05$) and FEV1 ($p = 0.05$), than the Deep breathing group. The IR-PEP group fell in between and did not significantly differ from the other two groups. DLCO on the fourth post-operative day was decreased to 57% ($p < 0.0001$) of pre-operative values. No significant

difference between treatment groups was found.

Chest roentgenological changes:

No patient showed signs of atelectasis before the operation. On the fourth post-operative day atelectasis was found 25 in of the patients. The incidence and severity of chest roentgenological signs of atelectasis in the left and right lung are presented in Table III. Atelectasis was present only in the left lung in 8 patients, only in the right lung in 5 patients and in both lungs in 12 patients on the fourth post-operative day. There were no significant differences among the three groups in the occurrence of atelectasis in the left lung (p = 0.46) or in the right lung (p = 0.71). 5 patient had signs of elevated left hemidiaphragm; they were 7 in the Blow bottle group, 9 in the IR-PEP group and 10 in the Deep breathing group. Two patients had signs of elevated right hemidiapragm and they were both in the IR-PEP group. Pleural effusions were found in 20 patients In 13 patients the effusion was left side and in the remaining 7 patients it was bilateral. Of the patients with left sided pleural effusion 6 were in the Blow bottle group, 5 in the IR-PEP group and 9 in the Deep breathing group. The incidence of left pleural effusions did not significantly differ between treatment groups. The incidence of right side pleural effusion was 3, 2 and 2.

Table 1 Demographic and operative variables (mean ± SD)

	Group A	**Group B**	**Group C**	***p*-value**
Age (years)	64.3 ± 8.4	63.8±8.6	61.5±8.9	0.40
Body mass index (kg/m^2)	26.9±3.3	27.2±3.4	27.1±3.0	0.93
Smokers/non-smokers (*n*)	6/4	3/7	4/6	0.80
Operation time (hours)	4.0±0.6	3.7±0.6	3.7±0.6	0.14
AoO (minutes)	59±15	55±20	53±15	0.17
IMA grafts (*n*)	5	7	8	0.55
Pleural space entered (*n*)	5	8	9	0.34
Duration of anesthesia	11.5±2.1	12.9±2.7	11.2±1.9	0.01

AoO = aortic occlusion time; IMA = intern mammary artery.

Table 2. Pulmonary function data before and on the fourth post-operative day following coronary artery bypass surgery (mean ± SD)

Pre-operative					Post-operative			
	Group A	**Group B**	**Group C**	***p*-value ***	**Group A**	**Group B**	**Group C**	***p*-value †**
VC (l)	4.1±0.5	4.0±0.7	3.9±0.5	0.40	2.4±0.5	2.4±0.5	2.2±0.4	0.8
IC(1)	3.0±0.6	3.1±0.6	3.1±0.6	0.39	2.1±0.4	2.1±0.4	1.7±0.5	0.59
FEV1(1)	2.6±0.5	3.1±0.6	2.6±0.5	0.25	1.7±0.4	1.7±0.5	1.9±0.4	0.05
FRC(1)	3.2±0.5	3.0±0.7	3.1±0.5	0.35	2.1±0.5	2.4±0.6	2.1±0.5	0.05
TLC(1)	5.9±1.0	6.5±1.1	6.1±0.6	0.10	4.1±0.6	4.3±1.1	3.9±0.5	0.01
DLCO (ml/min/mmHg)	20.6±5.1	24.9±7.2	25.0±5.1	0.05	14.3±3.0	16.9±5.4	16.1±4.2	0.35
DLCO/VA (ml/min/mmHg/l)	3.5±1.0	3.5±0.7	3.9±0.8	0.40	3.3±0.7	3.7±1.0	4.1±0.8	0.41

* The difference between the means of the treatment groups.
† The difference between the means of the relative decrease in pulmonary function from before the operation.
VC = vital capacity; IC = inspiratory capacity; FEV1 = forced expiratory volume in 1second; FRC = functional residual capacity; TLC = total lung capacity; DLCO = single breath diffusing capacity for carbon monoxide; DLCO/ VA = DLCO per unit alveolar volume.

Table 3. The incidence of chest roentgenological signs of atelectasis in the left/right lung on the fourth Post-operative day after coronary artery bypass graft surgery.

	Group A (n=10)	**Group B (n=10)**	**Group C (n=10)**
No abnormality	4	3	4
Plate atelectasis	2	2	3
Segmental atelectasis	3	3	2
Lobar atelectasis	1	2	1

DISCUSSION:

The pulmonary function after CABG were severely reduced in all treatment groups on the fourth post-operative day. The reduction is similar to what have been shown in several previous studies on the fourth post-operative day after open heart surgery [15,16]. The reasons for the restrictive impairment and atelectasis are multiple and include, besides the effects of anaesthesia[17], The reduction in lung volumes and expiratory flow rates impairs cough and clearance of secretions, and pain may reduce the ability to cough even more. In the present study the scoring of post-operative pain by VAS on the fourth post-operative day was similar in the three treatment groups. The best technique for lung expansion is claimed to be a maximal inspiration.

There is some evidence that regular chest physiotherapy significantly decreases the incidence of pulmonary complications after major abdominal and thoracic surgery[13]. The blow bottle is a cheap and simple method of producing a positive expiratory pressure. The use of the blow bottle in post-operative care is aimed at increasing the pulmonary volume and facilitating the release of pulmonary secretions, but documentation of efficacy in patients after heart surgery has been scarce[20]. cardiac surgery patients treated with blow bottles, intermittent positive pressure breathing (IPPB) and incentive spirometry. The incidence of pulmonary complications was 31% in the IPPB group, 16% in the spirometry group but only 7% in the Blow bottle group. The result was not statistically significant and the equipment and technique of the blow bottle was not in full detail described. It is therefore difficult to know if our results support these findings. The IR-PEP system is used to create an active inspiration in addition to PEP. The inspiratory resistance is believed to increase demands on the diaphragm and improve recovery of its function, but this has not been clearly established. In this study the blow bottle was found to be at least as effective as the IR-PEP mask in preventing pulmonary function decrease on the fourth post-operative day. Airway closure is a normal physiological phenomenon during deep expiration, which may occur already at normal FRC in the elderly. Thus, the reduction in FRC post-operatively will promote airway closure[21] which may eventually lead to resorbtion atelectasis, when breathing exercises are made. It is therefore important to start from a high lung volume and to finish expiration before closing volume is reached. Improper performance of deep breathing exercise may decrease, rather than increase end-expiratory lung volume if a patient exhales forcefully toward residual volume[22] . It is important to halt the expiration at or near FRC so that airway closure is prevented or limited as much as possible.The optimal frequency and duration of the treatment are important factors to consider. In the present study the patients were encouraged to perform 30 deep breaths once per hour except during the night, and the frequency and duration of the exercises were chosen according to the ordinary routines at the clinic. Deep breathing therapy is suggested to be provided at least every 1–2 hours, but the optimal frequency is not yet

known[9]. Compared three physiotherapy regimes in 110 men undergoing CABG and concluded that the addition of breathing exercises or incentive spirometry to a regimen of early mobilization and coughing confers no extra benefit after uncomplicated CABG. The patients in the two treatment groups were instructed to take at least 10 deep breaths or use the incentive spirometer at least 10 times in each waking hour. Perhaps are 10 deep breaths per hour, or even 30, not enough to give a clinical important improvement. Atelectasis were found in some patients on the fourth post-operative day, which is equal to what have been found in earlier studies after CABG[23,24]. The occurrence of atelectasis showed no statistical difference between the groups in the

present study. Right-sided abnormalities were equally rare, as was found in a previous study.[24]
Few data are available concerning post-operative diffusion capacity abnormalities in patients after CABG. A decrease in DLCO by 25%, and a decrease in DLCO/VA by 17%, has been reported 2 hours post-operatively in 10 patients undergoing cardiac surgery requiring cardiopulmonary bypass[25]. The
single-breath test, used in the present study, is the most common method to measure pulmonary diffusing capacity. The transfer of carbon monoxide is a complex phenomenon and there is a large inter-laboratory variability in the results for the measurement of DLCO[26], which necessitates the use of the same
equipment pre- and post-operatively. Our results showed a reduction in DLCO to 57% of the pre-operative value on the fourth post-operative day, while corrected for lung volume, DLCO/VA remained almost unchanged. It is therefore possible that the reduction in DLCO could be due solely to the reduction
in lung volume.
Deep breathing exercises was the first choice of breathing technique and this in agreement with the results[27]. The use of breathing exercises with positive pressure devices is used extensively in clinical
practice post-operatively in Brazil[28] and after thoracic surgery in Australia and New Zealand[29].
Post-operative complications are relatively frequent after cardiac surgery. It has earlier been suggested
that breathing exercises after uncomplicated cardiac surgery confers no extra benefit[30,31].
Deep breathing exercises are advocated to improve tidal volume and facilitate secretion removal[32,33].
In the present study, 93% of the physical therapists instructed the patients to perform breathing exercises on a regular basis postoperatively. Deep breathing was the first choice of breathing technique, and this is in agreement with previous studies[34,35].

CONCLUSION

There were no major differences between the three treatment groups on the fourth post-operative day. The relative decrease in pulmonary function tended to be less marked by chest physiotherapy using the Blow bottle technique than by Deep breathing without any mechanical device and the technique was at least as good as the IR-PEP technique. The Blow bottle is furthermore an inexpensive method that will be well accepted and easily learned by patients, and works as well as more complex techniques. However, a technique that offers even better supervision and the assistance of a deep inspiration with optimal continuance may prevent further lung function deterioration.

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