Efficacy Of Breath Stacking Technique On Pulmonary Function On Patients With Upper Abdominal Surgeries

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ABSTRACT

Background: *Pulmonary complications are the second most common complications after upper abdominal surgery and contribute significantly to morbidity, mortality, hospitalization and costs. Breath stacking is a method of breathing that induces increased alveolar ventilation by pulmonary expansion and enhance pulmonary function* ***Purpose:*** *To determine the therapeutic effect of breath stacking technique on pulmonary ventilation after upper abdominal surgeries.* ***Subjects and Methods:*** *Forty-two subjects (16 males, 26 females) recruited from El Hussein University Hospital who received upper abdominal operations as (exploratory laparotomy, hepatectomy, open cholecystectomy, splenectomy, stomach cancer removal), participated in this randomized controlled trial the evaluation took place on the second postoperative day. The subjects were randomly allocated in two groups equal in numbers: Study group (A) (n=21) who received traditional chest physiotherapy in addition to breath stacking, while control group (B) (n=21) received only traditional chest physiotherapy-two times a day for the first two days following surgery, then once daily from day three until day ten. In this trial, forced vital capacity, forced expiratory volume and peak expiratory flow rate were measured using computerized spirometry (Medisoft Micro 5000 Hand-held, attached to PC via USB) measured before and after ten days.* ***Results:*** *There was a statistically significant effect ($p < 0.01$) in treatment in both groups.* ***Conclusion****: Breath stacking has a positive effect on pulmonary function in subjects with upper abdominal surgery.*

Keywords: *Abdominal surgeries; breath stacking; computerized spirometry; pulmonary function.*

INTRODUCTION

The term "Upper Abdominal Surgery" (UAS) was used to describe any operation that required an incision that extended above the umbilicus. The path to recovery following UAS is frequently complex and involves many different types of healthcare providers. For physicians and patients equally, recovery is still an enigmatic term with no universally accepted definition. Fatigue and restricted breathing movements are common in the first few days after surgery [1].

After UAS, Postoperative Pulmonary Complications (PPCs) occur more frequently than any other type of problem. Increased morbidity, mortality, hospital stays, and costs are directly attributed to them [2]. The rate of PPC development is greater after open abdominal surgery compared to laparoscopic surgery [3]. Pneumothorax, dyspnea, collapse, hypoxemia, effusion of the pleura, hypercapnia, bronchospasm, respiratory infections, respiratory failure, as well as ventilatory failure are all components of PPCs [4].

Atelectasis incidences documented in the literature range from 20% to 90% while postoperative pneumonia ranges from 9% to 40% following laparotomy [5].

On the 1st post-operative day of UAS, pulmonary function tests such as Forced Vital Capacity (FVC) as well as Forced Expiratory Volume in One Second (FEV1) show a significant decline. Atelectasis, decreased diaphragmatic movement, as well as respiratory insufficiency are symptoms of restrictive lung disease, which can develop as a result of this deterioration in vital as well as inspiratory capacity [6].

There may be substantial clinical and economic consequences of PPCs following thoracic and UAS. These complications are linked to increased hospital stays and costs, more frequent admissions to the Intensive Care Unit (ICU), along with a higher incidence of mortality in hospitals [7].

Certain components of UAS, including anesthesia, the incision, factors involved in the surgical procedure, and the patient's unique characteristics, may result in problems include diaphragm reflex inhibition, discomfort, hypoventilation, a decrease in respiratory muscle strength, and cough inhibition [8].

Both general anesthesia and UAS have adverse impacts on the lungs. Smaller lung volumes due to impaired diaphragmatic activity and ventilatory reaction increase the risk of alveolar collapse, atelectasis, premature airway closure, impaired mucus clearance, and bacterial colonization, among other complications. these characteristics aggravate PPC, which is the main cause of mortality as well as morbidity in the postoperative period following UAS [9]. Breath stacking, which involves periodic expansion of the lungs, reduces basal atelectasis and keeps the chest wall along with lungs in compliance [10]. It was shown that patients with various diseases could generate and maintain higher inspiratory volumes with the method to evaluate VC than they could with incentive spirometry. The Breath Stacking (BS) approach involves taking many breaths via a unidirectional valve using an expiratory branch block [11]. One easy method that (BS) helps with both breathing in oxygen and releasing trapped secretions. It involves encouraging the patient to take deep, intervalled breaths, stacking them on top of each other [12].

The BS approach involves utilizing a one-way valve onto a manual resuscitation bag to administer high quantities of breaths to the patient through an appropriate interface [13]. Peak Cough Flow (PCF), as well as cough efficacy, are both improved with periodic lung expansion through BS, which also reduces basal atelectasis and keeps the lungs and chest wall compliant [14]. We aimed to evaluate therapeutic effect of breath–stacking on pulmonary ventilation after upper abdominal surgeries.

MATERIALS AND METHODS

Study design

The study design was a pre- and post-test, single-blind randomized, the randomization method is closed envelope. Randomized controlled experiment conducted between September 2022 to March 2023. Before the beginning of the study, ethical approval was given from Cairo University Faculty of Physical Therapy's ethical committee (NO: P.T.REC/012/004068).

Participants

A total of 42 patients (16 males and 26 females) who had UAS as (exploratory laparotomy, hepatectomy, open cholecystectomy, splenectomy, stomach cancer removal), the evaluation took place on the second post operative day. There were 21 participants in each of the two groups. They were recruited from EL Hussein University Hospital based on the eligibility criteria. Their ages varied from 25 to 45. We ruled out patients who were allergic to BS masks, who had Chronic obstructive pulmonary disease, asthma, Crohn's disease, serious liver trauma with hemodynamic consequences, those with cognitive disorders, patients having sepsis and complications following surgery, or who needed mechanical ventilation after leaving the recovery room.

Measurement procedure

In our randomized clinical trial, all patients in both groups had evaluated twice, the first on the 2nd post-operative day (between 24 and 48 h following surgery), the second on the 10th post-operative day, by computerized spirometry (Medisoft Micro 5000 Hand-held, attached to PC via USB) measuring the primary outcome variables (FVC, FEV1, Peak Expiratory Flow Rate PEFR). These measurements were taken following the American Thoracic Society Guidelines [15].

-Treatment procedure:

BS was administered using a silicone mask connected to a one-way valve that permitted only inspiration (the expiratory branch was blocked) [16]. The patients were requested to inhale while wearing a mask which was set to allow only inspiration and block the expiratory stem. They were placed in a supine position having the head of the bed raised 30°. The subjects were instructed to inhale deeply and repeatedly for 20 seconds before the expiratory stem was opened to permit exhalation; the procedure was performed twice a day for three days (postoperative days 3-5), 3 sets of 5 maneuvers/set, with a rest of at least two minutes between sets. The technique was performed on three consecutive sets of 5 repetitions, with a 30-second rest in between them. Two-minute break in between each set. The method required the subject to maintain an inclination of 30 degrees to the horizontal plane while performing the procedure. As much as twenty minutes could be spent on therapy in total. In addition to chest physical therapy program which includes exercises for breathing, vibration, splinted coughing/huffing, and positioning, in addition to early mobilization. Each patient would take four sets of five breaths, with a total of three seconds of prolonged breathing, intervals of relaxed breathing, and then two or three coughs or huffs, supported by a pillow or their hands, during each session. Both groups' patients participated in the traditional chest physiotherapy program two times a day for the first two days following surgery, then once daily from day three until day ten.

Data analysis:

To compare the ages of the groups, an independent t-test was used. The distribution of genders between the groups was compared using a chi-squared test. The Shapiro-Wilk test was used to ensure that the data followed a normal distribution. To ensure that the groups were homogenous, we used Levene's test for homogeneity of variances. The mean values of FVC, FEV1, and PEFR were compared between the study and control groups using an independent t-test. Before and after treatment, we compared each group using a dependent t-test. All statistical tests were set to have a significance level of $p < 0.05$. We used SPSS 25 for Windows (IBM SPSS, Chicago, IL, USA) to run all of our statistical analyses.

RESULTS

- Subject characteristics:

The subjects in the study and the control groups were shown in Table (1). The distribution of ages and genders didn't differ significantly among the groups ($p > 0.05$).

Table 1. Comparison of participants characteristics among study and control groups:

	Study group	Control group	p-value
	Mean ± SD	Mean ± SD	
Age (years)	37.43 ± 7.11	37.85 ± 8.08	0.85
Sex			
Females	12 (57%)	14 (67%)	0.52
Males	9 (43%)	7 (33%)	

SD, standard deviation; p value, probability value

<u>Effect of treatment on FVC, FEV1 and PEFR:</u>

- Within group comparison:

Compared to pre-treatment values, after treatment values for FVC, FEV1, and PEFR in both the study and control groups were significantly higher ($p > 0.001$). In the study group, the percentage changes for FVC, FEV1, and PEFR were 51.84%, 86.63%, and 57.19%, respectively, compared to 33.60%, 50.55%, and 36.62% in the control group (table 2).

- Between groups comparison:

Before treatment, there was no statistically significant difference among the groups ($p > 0.05$). After treatment, the study group's FVC, FEV1, and PEFR were significantly higher than the control group's ($p > 0.01$) (table 2).

Table 2. Mean FVC, FEV1 and PEFR before and after treatment of study and control groups:

	Study group	Control group			
	Mean ± SD	Mean ± SD	MD	t-value	p value
FVC (L)					
Pre treatment	2.72 ± 0.61	2.53 ± 0.66	0.2	1.01	0.32
Post treatment	4.13 ± 0.74	3.38 ± 0.62	0.75	3.54	0.001
MD	-1.41	-0.85			
% of change	51.84	33.60			
t- value	-8.35	-6.79			
	p = 0.001	p = 0.001			
FEV1 (L)					
Pre treatment	1.72 ± 0.62	1.82 ± 0.53	-0.1	-0.55	0.58
Post treatment	3.21 ± 0.68	2.74 ± 0.44	0.47	2.65	0.01
MD	-1.49	-0.92			
% of change	86.63	50.55			
t- value	-13.65	-12.84			
	p = 0.001	p = 0.001			
PEFR (L/sec)					
Pre treatment	2.66 ± 0.97	2.58 ± 0.78	0.08	0.26	0.79
Post treatment	4.20 ± 0.94	3.53 ± 0.65	0.67	2.67	0.01

MD	**-1.54**	**-0.95**
% of change	**57.89**	**36.82**
t- value	**-6.43**	**-5.72**
	p = 0.001	**p = 0.001**

SD, standard deviation; MD, mean difference; p-value, probability value

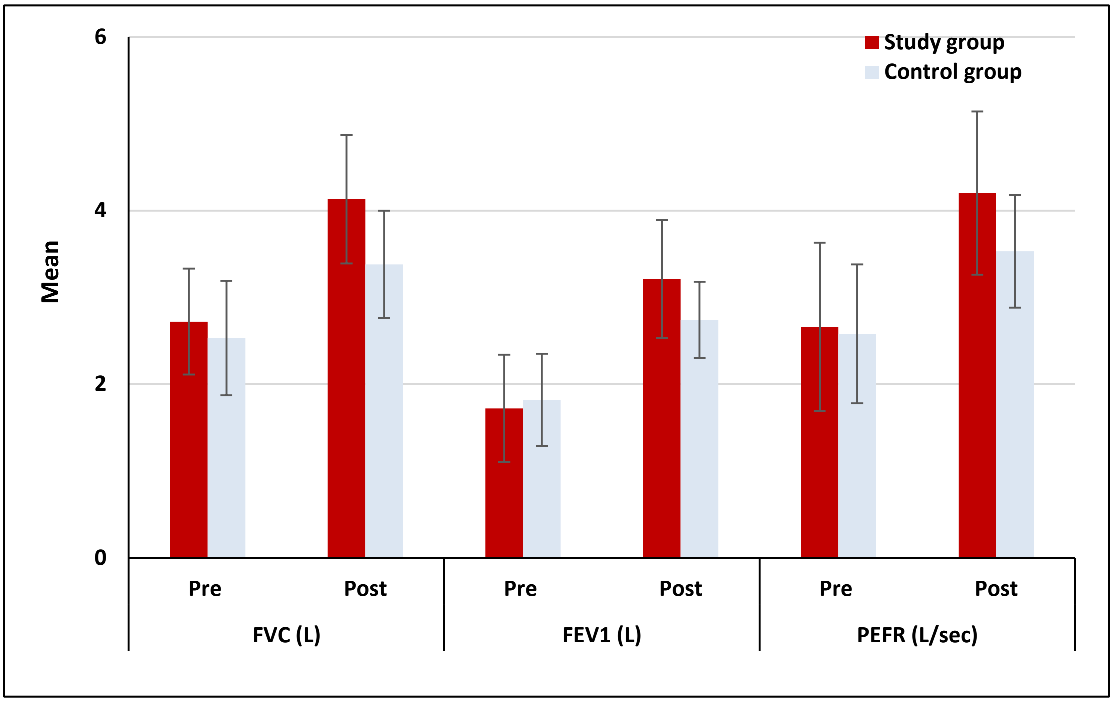

Figure 1. Mean FVC, FEV1 and PEFR before and after treatment of study and control groups.

DISCUSSION

Recovery from UAS is a difficult process requiring the collaboration of multiple professionals [17]. According to Vonlanthen et al, PPC constitute one of the most common problems that might arise following major abdominal surgery [18].

On this study, Applying the breath stacking approach in conjunction with traditional chest physiotherapy significantly improved FVC, FEV1, and PEFR in patients having pulmonary problems following UAS, according to the results of our study. by applying an inspiratory pressure, transmitted to the airways through an airtight facemask or mouthpiece, causing lung inflation, which is followed by a spontaneous or assisted forced expiratory maneuver this improve blood oxygenation during chest expansion it allows more surface area for oxygen diffusion in the blood by improving lung mechanics and gas exchange and improve cough efficacy , Patients who applied BS show improvement in cough, swallowing and increase inspiratory tidal volume , the maximum inspiratory capacity as well as expiratory flow.

Statistical analysis showed that both groups significantly improved FVC, FEV1, and PEFR, however the study group improved at a higher rate. In the study group, the percentage changes for FVC, FEV1, and PEFR were 51.84%, 86.63%, and 57.19%, respectively, compared to 33.60%, 50.55%, and 36.62% in the control group.

Regarding Chicayban et al., BS is currently used with good effects on pulmonary function and mechanics in patients with neuromuscular illnesses, acute lung damage, obesity, in children and those with tracheostomies, and throughout the postoperative period after abdominal and cardiac surgeries [19].

The BS triggers a medical condition equal to dynamic hyperventilation. Hemetrio et al. demonstrated that this happens after a series of repeated inspirations that significantly increase air retention, pushing the patient's tolerance for pulmonary hyperinflation to its limit [20]. Surgical procedure influences oxygen consumption, amount of oxygenated blood, volume of secretions expelled from the lungs, and volume. The BS approach encourages the patient to breathe in slowly and stack breaths as tolerated, followed by a brief hold before a slow expiration, allowing the lungs to have more oxygen than typical inspiration [21].

The results are in line with what the authors reported. Fernandes et al. found that using BS with conventional physiotherapy following UAS enabled patients to improve their pulmonary function, had better oxygenation, and had lower respiratory rate when they were discharged from the hospital. There was a statistically significant improvement in FVC across all groups, with the BS group (BSG) showing the most improvement. When comparing the BSG and CG groups, it is clear that BS had a positive effect on FEV, FEV/FVC ratio, PEFR, as well as FEF25-75% [12].

The findings of Mckim et al. indicate that there is a correlation between the recovery of FVC and the rise in the amount of mobilized air [22], found that BS improved FEV1 and FEV1/FVC ratio, which implies that this approach can mobilize greater amounts of lung tissue.

Previous research by Rafiq et al. showed that the BS technique's ability to generate larger expiratory flows is correlated with the moment of maximal insufflation. This could explain why PEF and FEF25-75% rise following the technique. The explosive stage of coughing is enhanced when the inspiratory volume is large enough to cause the lungs retract, the chest wall to distend, and the expiratory muscles to stretch. In other words, the higher the inspiratory volume, the higher the elastic recoil pressure as well as PEF will be. This is why previous data clearly shows that the maneuver had a good impact on the development of PEF and FEF25-75% [13].

In a crossover clinical research, Dias et al. demonstrated that BS had a greater immediate effect than incentive spirometry in producing and maintaining inspiratory volumes on the first postoperative day following UAS [23].

Marbate et al in experimental study demonstrated the BS technique is a beneficial method for enhancing post-cardiothoracic surgery peak expiratory flow rate (PEFR) as well as oxygen saturation (SpO2) measurements [24].

In addition, as compared to normal and incentive spirometry methods, bs increased inspiratory volumes among days 1 and 5 after surgery, but it had no impact on FVC at the same time [12].

It is logical to assume that respiratory muscles may benefit from BS following UAS, as stated by Santa et al. However, future studies should look at how it affects muscle strength as an end result. Lung volume expansion, thoracic and lung compliance, in addition to alveolar recruitment all contribute to decreased energy requirements, which in turn reduces RR as a consequence to the BS procedure [11].

Patients who have difficulty producing high volumes and maintaining the inspired volume may benefit from the BS method as a potential treatment for avoiding these problems. Dias found similar results when they compared incentive spirometry to BS in their study of patients after UAS [25]. The authors discovered that patients who were treated with BS had a reduced post-operative decline in lung capacity, and that this technique enabled more lung expansion and greater preservation of inspiratory volume. A type of BS that incorporates a one-way valve, a mask or mouthpiece, as well as a bag to be used for manual resuscitation has also been suggested for the purpose of improving cough in patients having neuromuscular diseases or spontaneously ventilated patients who are intubated by increasing the maximum inspiratory capacity as well as expiratory flow [26] [27]. In contrast it was found that Crowe et al concluded that patients with acute atelectasis didn’t benefit more from a combination of BS and traditional PT than from traditional PT alone. The method of BS used in this investigation was completely safe. [28].

In another study, the average inspiratory volumes did not significantly differ between the EI and BS techniques in 35 patients evaluated pre-cardiac surgery, and went on to be higher during the course of the BS in the postoperative period [23]. Dorça et al stated, However, no differences were noted for FVC. The breath stacking technique can increase inspired volumes that lead to greater peak cough flow, allowing for improvements in mucus clearance and reduction in atelectasis [29].

CONCLUSION

The outcome results of this trial reported improvement pulmonary function, improve their lung volumes, maximal breathing pressures, as well as peripheral oxygenation in both groups, with more benefits in the group that received breath stacking.

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