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Research Article

EFFECT OF DIAPHRAGMATIC BREATHING EXERCISE AND VOLUME-BASED INCENTIVE SPIROMETRY ON INSPIRATORY MUSCLE STRENGTH FOLLOWING OPEN UPPER ABDOMINAL SURGERY BASED ON DIGITAL MANOMETER READINGS

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A B S T R A C T

Background: The function of respiratory muscles is affected following abdominal surgery. Diaphragmatic breathing technique and incentive spirometers are used to reduce postoperative pulmonary complication, by increasing inspiratory capacity. Respiratory muscle strength is assessed by measuring maximum inspiratory pressure using digital manometer.

Materials and Methodology: 50 patients posted for abdominal surgery and satisfying the inclusion criteria were divided through simple random sampling into two groups. Group A-Diaphragmatic Breathing and Group B-Incentive Spirometry. Outcome measures were recorded as Maximum Inspiratory Pressure (MIP) on day-1 pre intervention and day 5 post intervention.

Conclusion: Volume based incentive spirometry has better results than diaphragmatic breathing in post open upper abdominal surgery cases.

INTRODUCTION

It is documented that the function of respiratory muscles is affected following abdominal surgery. The patient undergoing abdominal surgery has a characteristic post-operative mechanical abnormality in respiration most commonly atelectasis, retained secretions, aspiration, infection, pleural effusion, impaired pulmonary function, thromboembolism, and restrictive pattern of ventilation.[1]

There was a significant reduction of the Maximum Inspiratory pressure (MIP), Maximum Expiratory Pressure (MEP), and Peak Expiratory Flow (PEF) values at 24- and 48-hours post-operative compared to the pre-operative values. Intraoperative physiologic changes result both from anaesthesia (general or regional) and from the surgical procedure.

In the postoperative period, the physiologic changes result from the residual effects of the anaesthesia and surgery as well as from the effects of analgesia, pain, and the treatment necessary for any premorbid conditions. Pathophysiologic changes include airway obstruction, mucous hypersecretion with airway closure, chest wall restriction, respiratory muscle dysfunction, abnormal respiratory drive, and cardiac pump dysfunction [2]

Several studies have identified the factors that help predict the risk of development of postoperative pulmonary complications in these patients. The single most important one is the site of surgery. The closer an operation to the diaphragm,the more likely is the chance of developing postoperative pulmonary complications.[1]Furthermore, there have been reports that upper and lower abdominal surgeries have different respiratory consequences because each of these variables is affected differently.

In the majority of cases, there is a higher incidence of pulmonary complications following abdominal surgeries performed through a supraumbilical incision compared to an infraumbilical one. Some evidence suggests that the localization of the surgical incision in relation to the diaphragm, as well as the various levels of visceral manipulation involved in each procedure, could be to reason for the differences in the postoperative pulmonary function.[2]That is the reason why upper abdominal procedures are associated with a 20-40% incidence of postoperative pulmonary complications while lower abdominal surgery carries an incidence of 2-5%.[1]

The muscles of respiration are divided into three groups: the diaphragm, the intercostal and accessory muscles, and the abdominal muscles. All three groups have an inspiratory and expiratory function and work together in intricate ways.[3] The most important function of the respiratory muscles is breathing since they are the motor arm of the respiratory system.

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Breathing, a lifelong task, is born mainly by the inspiratory muscles, especially the diaphragm. The other inspiratory muscles play a minor role in quiet breathing but are activated when higher levels of ventilation are required. Except in extreme cases of ventilatory effort, the expiratory muscles are rarely used during breathing. A second function of the respiratory muscles is to perform explosive maneuvers such as coughing and vomiting. The respiratory muscles also have a role as stabilizers of the thorax and abdomen since they take part in the formation of the thoracic and abdominal walls. [4]

The diaphragmatic breathing technique combines the forward movement of the upper abdominal wall with some lateral movement of the lower ribs.[5]The control of diaphragmatic excursions is accomplished by consciously contracting the muscles of the anterior abdominal wall to obtain preferential descent of the diaphragm during inspiration.[6]Incentive spirometers are mechanical devices that were originally introduced in surgical patients by increasing inspiratory capacity, an attempt to reduce postoperative pulmonary complications. The device is activated by the patient's inspiratory effort.[7] Incentive spirometry devices encourage deep breathing and sustained inspiration which leads to collateral ventilation.[8]

Assessment of respiratory muscle strength is clinically useful for monitoring respiratory muscle weakness.[9] Measurement of respiratory muscle strength is used for the detection, diagnosis, and treatment of respiratory weakness. Most commonly, maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) are measured.[10] Respiratory muscle weakness has been reported in several conditions including cardiac disease, chronic respiratory diseases, and, most notably, neuromuscular diseases.[9]

To investigate respiratory muscle weakness, maximal static inspiratory pressure (MIP) and maximal expiratory pressure (MEP) from the mouth have traditionally been used. These measures are non-invasive, well-tolerated, simple to perform, and normal values for adults and children have been reported by several authors in different countries. The recommended instruments for measuring maximal respiratory pressures at the mouth are digital manometers.[9]

MATERIALS AND METHODS

The study design was a prospective comparativestudy, carried out at a tertiary care hospital in Miraj, Maharashtra, India, in 2021-22. A sample size of 50 (25 in each group) patients was recruited using a simple random sampling method.

Participants

The study was performed with the approval of the ethical committee of the College of Physiotherapy, Wanless Hospital, Miraj. Participants were briefed about the nature of the study and intervention. Their informed written consent was taken.

Inclusion criteria

- Age group 14-65 years
- Both male as well as female
- Patient with open upper abdominal surgery
- Without pre-existing cardiopulmonary complications

Exclusion criteria

- Fever
- Signs of infection like rising in temperature, oozing, pus formation at the site of incision
- On mechanical ventilation for more than 7 hours

Intervention

The subjects were screened and enrolled for this study based on inclusion and exclusion criteria. A brief introduction to the treatment procedure was explained to all the subjects. Demographic data were obtained from all the participants. Subjects were randomly assigned into two groups.

Group A received- Diaphragmatic breathing exercise while Group B received volume incentive spirometry. Maximum inspiratory pressure was measured with a digital manometer before the intervention and on day 5 after the intervention.

Group A (Diaphragmatic breathing)

The patient is asked to assume a semi-Fowler's position (back and head are fully supported and the abdominal wall is relaxed) and perform diaphragmatic breathing. The therapist will placehis hands just below the anterior costal margin, on the rectus abdominis, while the patient is instructed to inhale slowly and deeply through the nose, from functional residual capacity to total lung capacity with a three-second inspiratory hold. The patient is then instructed to relax the shoulders, and keep the upper chest quiet in order that the abdomen be raised a little. The patient is then instructed to exhale slowly through the mouth.
The patientis instructed to perform 3 sets of 5 deep breaths for 15 minutes twice daily every 5 days. On a postoperative day 5, maximum inspiratory pressure will be measured using a digital manometer.

Group B (Volume incentive spirometry)

In this group patients are positioned in half crook lying, shoulders relaxed, patients are asked to hold the incentive spirometer and to inspire with full effort through the mouthpiece such that the marker of the spirometer goes up. Initially, the flow rate is maintained as marked on the spirometer and gradually it is increased according to the capacity of the patient. After every 5 breaths, the patients are asked to breathe normally for a few breaths. Cycles will be repeated for a treatment duration of 15 min twice daily for five days. On a postoperative day 5, maximum inspiratory pressure will be measured using a digital manometer.

Outcome measures

Out measures include measurement of maximum inspiratory pressure using a digital manometer on day 1 before initiation of treatment, which will be followed by treatment, and on apostoperative day 5, using a digital manometer.

Statistical analysis

Statistical analysis was performed using Statistical Package for the Social Sciences [SPSS] software 24. The level of significance for Pre and Post Maximum Inspiratory pressure was performed by Mann Whitney Test.

RESULTS

For this study, 50 patients posted forabdominal surgery were divided through simple random sampling into two groups. Group A-Diaphragmatic Breathing and Group B-Incentive Spirometry. Outcome measures were recorded as Maximum

Inspiratory Pressure (MIP) on day-1 pre-intervention and day 5 post-intervention.

Based on the results of the test analysis at a 5% significance level, there is a significant statistical reliable difference between the pre &post-treatment values with a p-value is less than the 5% significance level(i.e. 0.001 < 0.05) in the study and therefore it justifies the improvements in health outcome post-intervention.

The statistical analysis using the Mann-Whitney test proved that the between-group effects for both Group A and B were statistically significant with a p-value of 0.015 which is less than a 5% level of significance. So we may reject H0. In other words, we can accept alternative hypothesis H1.

Table no 1 Difference between Mean and SD of Pre and Post-treatment score of group A

Pre		Post		Diff		Effect size	z –value	p –value
Mean	SD	Mean	SD	Mean	SD			
70.48	14.63	76.36	14.10	-5.88	2.40	2.45	12.232	0.001*

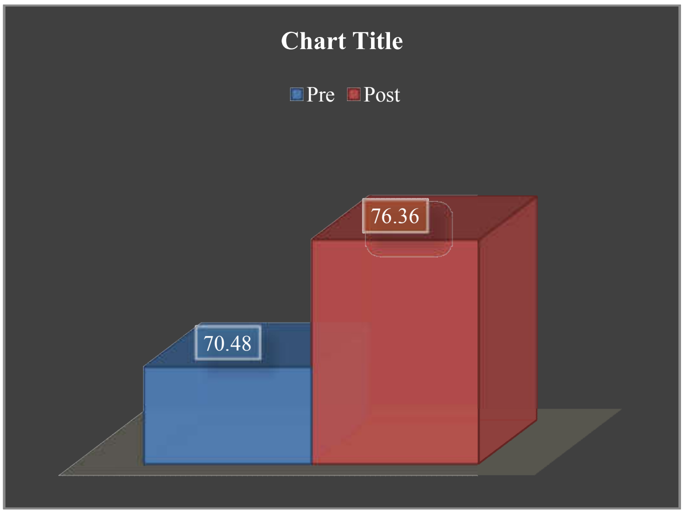

Figure 1 Difference between Mean and SD of Pre and Post-treatment score of group A

Table no.2 Difference between Mean and SD of Pre and Post-treatment score of Group B

Pre		Post		Diff		Effect size	z –value	p –value
Mean	SD	Mean	SD	Mean	SD			
76.16	14.52	86.56	14.38	-10.40	2.87	3.62	18.104	0.001*

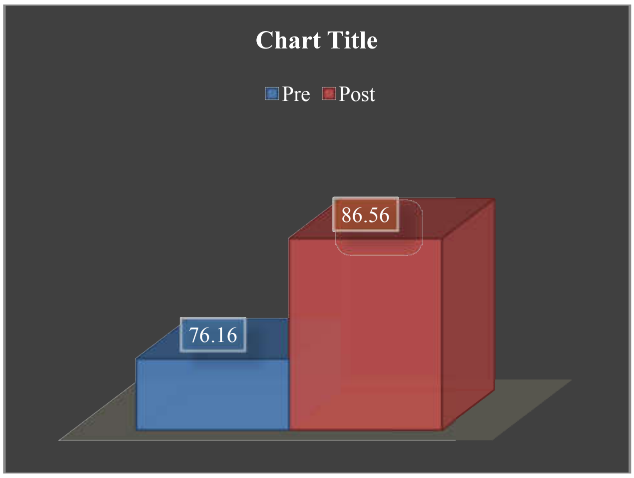

Figure 2 Difference between Mean and SD of Pre and Post-treatment score of Group B

Table No 3 Difference between Mean and SD of Pre and Post-treatment score of Group A and Group B

Time frame	Group	Mean	SD	z-value	p-value
Pre	Group-A	70.48	14.63	1.378	0.175
	Group-B	76.16	14.52		
Post	Group-A	76.36	14.10	2.533	0.015*
	Group-B	86.56	14.38		

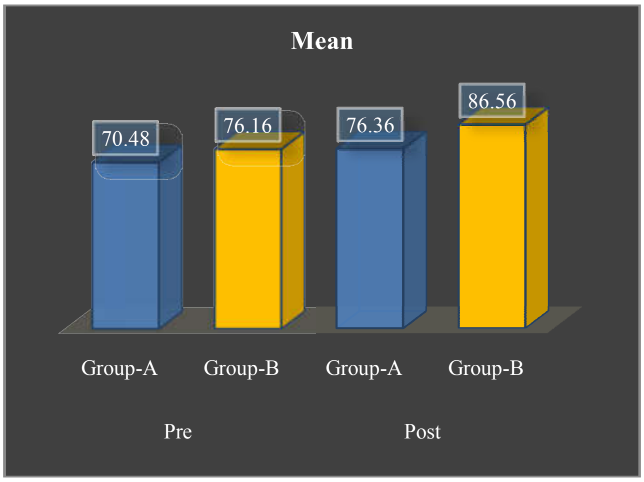

Figure 3 Difference between Mean and SD of Pre and Post-treatment score of Group A and Group B

DISCUSSION

The main purpose of this study was to compare the effect of diaphragmatic breathing exercise, and volume incentive spirometry, on inspiratory muscle strength using a digital manometer in the patients undergoing open upper abdominal surgery. There were 50 patients in total who were divided into two groups with 25 in each group (A and B) and the two groups were homogenous in terms of demographic parameters. Group A was for diaphragmatic breathing exercises and group B was for volume-incentive spirometry. In the study, it was found that the diaphragmatic breathing exercise group, as well as the volume incentive spirometry group, improved the inspiratory muscle strength in the patients undergoing open upper abdominal surgery.

The study revealed decreased maximum inspiratory pressure than the normal (Female: MIP- 79 +/- 19 cmH2O, Male: MIP-117 +/- 25 cmH2O) following surgery for both the groups.

A possible explanation for the decrease in inspiratory muscle strength during the postoperative period in open upper abdominal surgeryis as follows. During the postoperative period, patients demonstrate shallow breathing without the intermittent which leads to a decrease in effective use of the inspiratory muscle. The the other possible reasons might be due to postoperative pain, site of surgery, anaesthetic, analgesic usage. The site of surgery involves trauma near the diaphragm and chest wall/ribs, leading to postoperative incisional pain and reflex inhibition of the phrenic nerve and diaphragmatic reflex paresis resulting in functional disturbance of respiratory muscle movement. Moreover, when patients remain lying down for long periods during the postoperative period their abdominal content limits diaphragmatic movement.

The present study showed that the diaphragmatic breathing exercise group was able to improve the maximum inspiratory pressure thus leading to a beneficial effect on inspiratory muscle strength. Possible reasons for improved inspiratory muscle strength in the diaphragmatic breathing exercise group are due to improvement in diaphragmatic descent and diaphragmatic ascent during inspiration and expiration, respectively following diaphragmatic breathing exercise. Slower deep inspiration confirms more even distribution of air throughout the lung, particularly in the dependent lung. The physiological effects of diaphragmatic breathing exercise are that breathing through full vital capacity and holding for 3–5 seconds guarantees full inflation of the lungs thus opening up alveoli which have low volume and stimulating the production of surfactant. Diaphragmatic breathing exercises will also reduce the activity of accessory muscles, ensure that breathing patterns are as close to normal as possible, and also reduce the work of breathing.

The results are in accordance with the findings of Grams et al. who evaluated the efficacy of diaphragmatic breathing exercises for the prevention of postoperative pulmonary complications and for the recovery of pulmonary mechanics and found that diaphragmatic breathing exercises appeared to be more effective.

The present study showed that the volume incentive spirometry group also had improved maximum inspiratory pressure which led to a beneficial effect on inspiratory muscle strength. After open upper abdominal surgery, it may be difficult to take a deep breath and if patients do not breathe deeply it may lead to effective use of the diaphragm reducing the maximum inspiratory pressure. The volume incentive spirometer is a mechanical device used to take slow, deep long breaths that assist patients to breathe to total lung capacity, by effectively using the diaphragm. The volume incentive spirometer the training volume is constant until it reaches the maximum inspiratory capacity (level pre-set by a physiotherapist). It provides a low level of resistance training while minimizing the potential fatigue to the diaphragm. The treated with incentive spirometry would have early recovery of the pulmonary volume

The present study revealed that both diaphragmatic breathing exercise and volume incentive spirometry are effective, but statistically, volume-incentive spirometry is being more effective in improving the inspiratory muscle strength following open upper abdominal surgery.

CONCLUSION

There was a significant difference between the pre and post maximum inspiratory pressure assessed with the digital manometer for both groups.P-value is 0.015, which is less than 5% level of significance.This study concluded that both diaphragmatic breathing exercise and volume-based incentive spirometry helps improve the maximum inspiratory pressure, but statistically volume incentive spirometry is more significant in improving the inspiratory muscle strength thus having a beneficial effect in the patients undergone with open upper abdominal surgery. This thereby suggests that both diaphragmatic breathing exercise and volume incentive spirometry can be used in clinical practice, but volume-incentive spirometry being statistically better intervention to improve inspiratory muscle strength in patients undergoing open upper abdominal surgery in order to prevent pulmonary complications.

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Conflict of Interest: The authors have no conflict of interest relevant to this article.

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