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Original Research Article

THE EFFICACY OF INCENTIVE SPIROMETRY IN RESTORING BASELINE LUNG CAPACITY AFTER UPPER ABDOMINAL AND MIDLINE LAPAROTOMY: A RANDOMISED CASE CONTROL STUDY

Bikramjit Maity[1], Arunava Choudhury[2], Chandranath Banerjee[3]

[1]Assistant Professor, Department of General Surgery, Burdwan Medical College & Hospital, West Bengal, India.
[2]Senior Resident, Department of General Surgery, Burdwan medical College & Hospital, West Bengal, India.
[3]Associate Professor, Department of General Surgery, Burdwan medical College & Hospital, West Bengal, India.

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CorrespondingAuthor:
Dr. Poulomi Roy,
Email: dr.poulomiroy81@gmail.com

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Abstract

Background: Changes in pulmonary dynamics following laparotomy are well documented. Deep breathing exercises, with or without incentive spirometry, may help counteract postoperative decreased vital capacity. This study aims to determine the effect of the use of incentive spirometry on pulmonary function following elective abdominal surgery as measured by peak expiratory flow rate(PEFR). **Materials and Methods:** It was institution based randomized case control study. Study conducted in the department of General Surgery at Burdwan Medical College and Hospital, A total 80 cases were enrolled for the study, during the period March 2021 to August 2022. **Result:** Patients were then divided into a control group and a study group using computer generated randomization tables. The Control Group (CS) (n=40) received Chest Physiotherapy thrice a day starting from post-operative day 01 for a total duration of 5 days. The study group (IS) (n=40) received Incentive Spirometry every 4thhourly (6 times a day) following training by a physiotherapist in addition to Chest Physiotherapy thrice a day starting from post-operative day 01 for a total duration of 5 days. Above analysis we found that on POD1 the values of PFT in chest physiotherapy group (FVC =1.22±0.19 litre, FEV1 = 1.14 ±0.27 litre and PEFR = 1.53±0.32 litre/sec) was lower in comparison with incentive spirometry group (FVC =1.29±0.21 litre, FEV1 = 1.18 ±0.19 litre and PEFR = 1.62±0.40 litre/sec) however the difference was not statistically significant (p value = >0.05). **Conclusion:** The effectiveness of best-physiotherapy techniques such as deep breathing exercises and coughing and huffing techniques as well as spirometry in addition to early mobilization have been proved in the prevention and treatment of depressed cardiopulmonary function and post-operative pulmonary complications after thoracic or abdominal surgery.

INTRODUCTION

Routine abdominal operations are performed for the treatment and diagnosis of numerous illnesses.[1] Postoperative pulmonary complications (PPCs) following abdominal surgery are common and are responsible for increased morbidity and mortality, duration of hospital stay, and care-related costs.[2] Upper abdominal surgical operations are typically associated with a greater risk of complications than lower abdominal surgical procedures.[3] In upper abdomen surgery, the reported risk of postoperative pulmonary problems ranges from 17% to 88%.[4]
Atelectasis, hypoxemia, pneumonia, respiratory dysfunction, and pleural effusion are frequent postoperative pulmonary consequences.[5] Anesthesia (general or regional), the type of incision, and the surgical technique performed are the aspects that are directly associated to physiological changes. Changes in total pulmonary capacities and volumes, such as a decrease in the Forced Vital Capacity (FVC) and Forced Expiratory Volume in first second (FEV1), represent the alterations.[6]
A fundamental postoperative complication is a lack of lung inflation due to a change in breathing to a shallow, monotonous pattern without periodic sighs and temporary diaphragmatic dysfunction, caused by prolonged recumbent position, and impaired mucociliary clearance, as well as the decreased

cough effectiveness due to pain, which increases the risk of retained pulmonary secretions.[7]

Physical therapy for the chest plays a crucial role in the prevention and management of postoperative pulmonary problems. It consists of deep breathing exercises, mobilisation, postural drainage, percussion, and vibration or shaking, which were designed to improve bronchial drainage, as well as the use of mechanical breathing devices such as the Incentive Spirometer (IS), which has been introduced into clinical practise.[8]

Incentive Spirometry (IS) is a technique for measuring lung expansion. It is intended to elicit sighing or yawning by compelling the patient to take slow, deep breaths for an extended period of time. It prevents and treats atelectasis in patients with a propensity for shallow breathing who are alert. It is a straightforward and reasonably secure way for doing so.[9]

MATERIALS AND METHODS

It was institution based randomized case control study. Study conducted in the department of General Surgery at Burdwan Medical College and Hospital, A total 80 cases were enrolled for the study, during the period March 2021 to August 2022. The purpose of the study was the effect of incentive spirometry on pulmonary function after elective upper abdominal and midline laparotomy in eastern Indian population. First the permission of the institutional Ethics committee was obtained before starting the study. Written informed consent was obtained from all participating patients. Patients undergoing elective abdominal surgery was enrolled in this study after application of inclusion and exclusion criteria. Baseline demographic data was recorded in the case report form. Associated clinical conditions, baseline clinical parameters including pulmonary function test was noted preoperatively. Relevant biochemical investigations was done. Radiological investigations like plain skiagram of chest was obtained. Type of surgery, time taken was noted during the surgery. Anaesthetic techniques and drugs used during surgery was noted. Any intraoperative and post-operative complications were also be noted.

The patient will be observed on POD1, POD3 and POD5. Clinical examination was done to detect any evidence of respiratory complications. All consenting patients was undergo peak flow measurements at the abovementioned days. All patients was receive the standard postoperative pain control and instructions for deep breathing, coughing, and early ambulation. Patients were instructed to fully inflate the incentive spirometer every hour. Peak flow measurements was end when the patient is discharged, if the patient became ineligible, or after 6 measurements if the peak flow measurements stabilized but discharge was delayed for non pulmonary complications.

Statistical Analysis

The data was analysed with the help of computer software Epi-info version 6.0.1 and SPSS 26.0 for windows. Descriptive statistics was performed in the collected data. Chi square test was used to ascertain statistical significance among the proportions. Incidence along with 95% confidence limits was calculated to express magnitude. A ‘P’ value of <0.05 will be considered as statistically significant unless proved otherwise. Confounding factors have to be dealt with appropriate methods of adjustment.

RESULTS

In the present study the age range varied from 16 to 75 years. Majority of the study subjects were aged from 31 to 60 years with a mean age of 43.80±13.08 years and 44.80±13.47 years respectively in physiotherapy and incentive spirometry group. There was no statistically significant difference between two groups regarding the age (p value = 0.840). Data is illustrated in [Table 1].

Table 1: Age Distribution

Age Group	Control Group (CS) (n=40)		Study Group (IS) (n=40)	
	Frequency	Percentage	Frequency	Percentage
18-30 years	8	20.0	6	15.0
31-40 years	10	25.0	9	22.5
41-50 years	10	25.0	12	30.0
51-60 years	8	20.0	8	20.0
61-70 years	2	5.0	3	7.5
71-80 years	2	5.0	2	5.0
Total	40	100.0	40	100.0
Mean Age	43.80±13.08		44.80±13.47	
P value	0.840			

Table 2: Sex Distribution

Sex	Control Group (CS) (n=40)		Study Group (IS) (n=40)	
	Frequency	Percentage	Frequency	Percentage
Male	28	70.0	31	77.5
Female	12	30.0	9	22.5
Total	40	100.0	40	100.0
Statistical Inference	Chi square: 0.581p value: 0.446			

Regarding gender distribution we found both physiotherapy and incentive spirometry group were comparable with a p value of 0.446. Data is shown in [Table 2].

Table 3: Anthropometric Variables

Variables	Control Group (CS) (n=40)		Study Group (IS) (n=40)		p value
	Mean	±SD	Mean	±SD	
Height (cm)	159.02	±5.77	160.10	±5.58	0.967
Weight (kg)	68.25	±7.28	72.17	±5.48	0.175
BMI (kg/m2)	27.04	±3.74	26.26	±3.05	0.135

Above analysis we found that mean levels of anthropometric variables such as height (cm), weight (kg) and BMI (kg/m2) were comparable between chest physiotherapy and incentive spirometry group (pvalue = >0.05). Data is shown in [Table 3].

Table 4: Comparison of Various Laboratory Parameters at Baseline

Variables	Control Group (CS) (n=40)		Study Group (IS) (n=40)		p value
	Mean	±SD	Mean	±SD	
Hb% (gm%)	13.70	±1.38	13.82	±1.36	0.975
TLC (per micro litres)	8093.51	±2542.57	10417	±12794.44	0.185
ESR (mm/hr)	22.12	±5.49	18.82	±4.87	0.315
RBS (mg/dl)	127.52	±22.88	126.20	±24.22	0.965
Urea (mg/dl)	22.60	±5.60	21.30	±4.97	0.574
Creatinine (mg/dl)	0.87	±0.10	0.87	±0.12	0.433
Sodium (mEq/L)	140.10	±3.28	141.39	±2.91	0.535
Potassium (mEq/L)	4.35	±0.55	4.46	±0.47	0.321
Total Bilirubin (mg/dl)	0.80	±0.09	0.74	±0.09	0.440
Albumin (g/dl)	4.42	±0.65	4.42	±0.59	0.411
SGOT (IU/L)	36.47	±13.66	35.95	±14.57	0.600
SGPT (IU/L)	45.42	±13.53	44.90	±14.58	0.589
ALP (IU/L)	82.37	±30.17	80.57	±18.75	0.069

There was no statistically significant difference regarding the baseline values of different laboratory parameters that we have used in the present study between two groups (p value = >0.05). Data is illustrated in [Table 4].

Table 5: Comparison of Pulmonary Function Test at POD 1

Variables	Control Group (CS) (n=40)		Study Group (IS) (n=40)		p value
	Mean	±SD	Mean	±SD	
FVC (litre)	1.22	±0.19	1.29	±0.21	0.496
FEV_1 (litres)	1.14	±0.27	1.18	±0.19	0.290
PEFR (litres/sec)	1.53	±0.32	1.62	±0.40	0.096

[Table 5] presents the comparison of pulmonary function test betweenchest physiotherapy and incentive spirometry at postoperative day 1. Above analysis we found that on POD 1 the values of PFT in chest physiotherapy group (FVC =1.22±0.19 litre, FEV1 = 1.14 ±0.27 litre and PEFR = 1.53±0.32 litre/sec) was lower in comparison with incentive spirometry group (FVC =1.29±0.21 litre, FEV1 = 1.18 ±0.19 litre and PEFR = 1.62±0.40 litre/sec) however the difference was not statistically significant (p value = >0.05).

Table 6: Comparison of Pulmonary Function Test at POD 3

Variables	Control Group (CS) (n=40)		Study Group (IS) (n=40)		p value
	Mean	±SD	Mean	±SD	
FVC (litre)	1.19	±0.36	1.66	±0.26	0.008
FEV_1 (litres)	1.37	±0.33	1.49	±0.19	0.006
PEFR (litres/sec)	1.90	±0.41	2.38	±0.47	0.047

On post operative day 3 we found that mean levels of all the parameters of pulmonary function test was higher in incentive spirometry group (FVC =1.66±0.26 litre, FEV1 = 1.49 ±0.19 litre and PEFR = 2.38±0.47 litre/sec) in comparison to chest physiotherapy group (FVC =1.19±0.36 litre, FEV1 = 1.37 ±0.33 litre and PEFR = 1.90 ±0.41 litre/sec) and the difference was statistically significant (p value = <0.05). Data regarding the above is shown in [Table 6].

Table 7: Comparison of Pulmonary Function Test at POD 5

Variables	Control Group (CS) (n=40)		Study Group (IS) (n=40)		p value
	Mean	±SD	Mean	±SD	
FVC (litre)	1.78	±0.43	2.46	±0.39	0.021
FEV_1 (litres)	1.62	±0.34	1.92	±0.27	0.048
PEFR (litres/sec)	2.19	±0.54	2.93	±0.79	0.017

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The 3rd recording was done at 5thpostoperative day. On post-operative day 5 as well we found that mean levels of all the parameters of pulmonary function test was higher in incentive spirometry group (FVC =2.46±0.39 litre, FEV1 = 1.92 ±0.27 litre and PEFR = 2.93±0.79 litre/sec) in comparison to chest physiotherapy group (FVC =1.78 ±0.43 litre, FEV1 = 1.62 ±0.34 litre and PEFR = 2.19 ±0.54 litre/sec) and the difference was statistically significant (p value = <0.05). Data regarding the above is shown in [Table 7].

Table 8: Complication Rate

Complication Rate	Control Group (CS) (n=40)		Study Group (IS) (n=40)	
	Frequency	Percentage	Frequency	Percentage
Yes	25	62.5	9	22.5
No	15	37.5	31	77.5
Total	40	100.0	40	100.0
Statistical Inference	Chi-square value- 13.0946 P value- 0.0002			

[Table 8] presents the incidence of pulmonary complications among two groups. In chest physiotherapy group the incidence of pulmonary complication was 62.5% (25 cases) while in incentive spirometry group it was 22.5% (9cases) which was significantly lower than chest physiotherapy group (p value = 0.0002). There was no case of pneumonia in any of the studied group.

DISCUSSION

In the present study the age range varied from 16 to 75 years. Majority of the study subjects were aged from 31 to 60 years with a mean age of 43.80±13.08 years and 44.80±13.47 years respectively in physiotherapy and incentive spirometry group. There was no statistically significant difference between two groups regarding the age (p value = 0.840). Regarding gender distribution we found both physiotherapy and incentive spirometry group were comparable with a p value of 0.446.

Above analysis we found that mean levels of anthropometric variables such as height (cm), weight (kg) and BMI (kg/m2) were comparable between chest physiotherapy and incentive spirometry group (p value = >0.05). There was no statistically significant difference regarding the baseline values of different laboratory parameters that we have used in the present study between two groups (p value = >0.05). Above analysis we found that on POD 1 the values of PFT in chest physiotherapy group (FVC =1.22±0.19 litre, FEV1 = 1.14 ±0.27 litre and PEFR = 1.53±0.32 litre/sec) was lower in comparison with incentive spirometry group (FVC =1.29±0.21 litre, FEV1 = 1.18 ±0.19 litre and PEFR = 1.62±0.40 litre/sec) however the difference was not statistically significant (p value = >0.05). On post operative day 3 we found that mean levels of all the parameters of pulmonary function test was higher in incentive spirometry group (FVC =1.66±0.26 litre, FEV1 = 1.49 ±0.19 litre and PEFR = 2.38±0.47 litre/sec) in comparison to chest physiotherapy group (FVC =1.19±0.36 litre, FEV1 = 1.37 ±0.33 litre and PEFR = 1.90 ±0.41 litre/sec) and the difference was statistically significant (p value = <0.05).The 3rd recording was done at 5th postoperative day. On post operative day 5 as well we found that mean levels of all the parameters of pulmonary function test was higher in incentive spirometry group (FVC =2.46±0.39 litre, FEV1 = 1.92 ±0.27 litre and PEFR = 2.93±0.79 litre/sec) in comparison to chest physiotherapy group (FVC =1.78 ±0.43 litre, FEV1 = 1.62 ±0.34 litre and PEFR = 2.19 ±0.54 litre/sec) and the difference was statistically significant (p value = <0.05). In chest physiotherapy group the incidence of pulmonary complication was 62.5% (25 cases) while in incentive spirometry group it was 22.5% (9cases) which was significantly lower than chest physiotherapy group (p value = 0.0002). There was no case of pneumonia in any of the studied group.

Based on the above observation we can suggest that incentive spirometry provides significant improvement in FVC, FEV1 and PEFR in comparison to chest physiotherapy. It also reduces the postoperative pulmonary complication rate.

Earlier studies showthat the volumetric incentive spirometer is better in case of cardiac and thoracic surgeries because it provides the appropriate feedback for a slow sustained inspiration and volume.[10]Studies show that slow sustained inspirations are much more effective to promote lung expansion rather than fast inspirations.[11]Studies also show that diaphragmatic breathing exercise encourages more diaphragmatic movement.

Gastaldi et al. studied thirty-six subjects, in order to assess the effect of respiratory kinesiotherapy on respiratory muscle strength and pulmonary function following laparoscopic cholecystectomy. Subjects were randomly sorted into two groups: the exercise and the control. Three breathing exercises were performed by seventeen subjects while other nineteen served as a control group. All the subjects were assessed for Maximal Inspiratory Pressure (MIP) and Maximal Expiratory Pressure (MEP), PEF, and spirometry (FVC, FEV1, and FEV1/FVC). Both groups registered a decrease in all variables on the first day after surgery. On the second postoperative day, the exercise group showed decreased values for all variables. Thevalues then normalized. However, values of all variables for the control group begin to normalize only on the fifth postoperative day.[10]

El-Marakby et al. carried out a study on two experimental groups of patients in order to evaluate the effects of aerobic exercise training and incentive spirometry in controlling pulmonary complications following laparoscopic cholecystectomy. One group was given aerobic walking raining and incentive spirometry as well as traditional physical therapy (Group A); the other (Group B)was given traditional physical therapy. Results indicated a significant reduction in heart rate, SaO2, and inspiratory capacity for both groups. The researchers concluded that aerobic exercise and incentive spirometry were beneficial in reducing the postoperative pulmonary complications after laparoscopic cholecystectomy.[11]

Kundra et al. carried out a comparative study on the effect of preoperative and postoperative incentive spirometry on the pulmonary function of fifty patients who had undergone laparoscopic cholecystectomy. The study group had to carry out incentive spirometry fifteen times before surgery, every four hours, for one week. However, the control group underwent incentive spirometry only during the postoperative period. Pulmonary function was recorded before surgery and 6, 24, and 48 hours postoperatively and at the time of discharge. Result showed that pulmonary function improvement was seen after preoperative incentive Spirometry. The authors concluded that pulmonary function iswell-preserved with preoperative than postoperative incentive spirometry.[12]

FagevikOls´en et al. reviewed forty-four studies in order to evaluate the effects of chest physiotherapy interventions in laparoscopic and open abdominal surgery. But the results showed that breathing exercises were efficacious in preventing postoperative pulmonary complications in patients undergoing open surgery. The review also showed that laparoscopic procedures impair respiratory function to a considerably lower degree than open surgery.[13]

Cattano et al. studied forty-one morbidly obese to assess use of incentive spirometry preoperatively which could help patients to preserve their pulmonary function (inspiratory capacity) better in the postoperative period following laparoscopic bariatric surgery. Subjects were randomly sorted into two groups (the exercise and the control group).The exercise group used the incentive spirometer for ten breaths, five times per day. The control group used incentive spirometer three breaths, once per day. Pulmonary function (inspiratory capacity) was recorded at the day of surgery and postoperative day 1. The author concluded that preoperative use of the incentive spirometer does not lead to significant improvement of pulmonary function (inspiratory capacity).[14]

M. B. Dikshit et al carried out a study on two experimental groups of patients in order to evaluate the effects of aerobic exercise training and incentive spirometry in controlling pulmonary complications following laparoscopic cholecystectomy. Results indicated significant reduction in heart rate, Sa02 and inspiratory capacity for both groups. The researchers concluded that chest exercise and incentive spirometry were beneficial in reducing the post-operative pulmonary complications after laparoscopic cholecystectomy.[15]

CONCLUSION

The effectiveness of best-physiotherapy techniques such as deep breathing exercises and coughing and huffing techniques as well as spirometry in addition to early mobilization have been proved in the prevention and treatment of depressed cardiopulmonary function and post-operative pulmonary complications after thoracic or abdominal surgery.

Hence the present study was carried out with the purpose to assess the efficacy of Incentive Spirometry compared to Chest Physiotherapy in restoring the Baseline Peak Expiratory Flow rate in patients undergoing upper abdominal and midline laparotomy. We also compared the incidence of post-operative pneumonia in patients using Incentive Spirometry to those undergoing Chest Physiotherapy.

Based on our observation we can suggest that incentive spirometry provides significant improvement in FVC, FEV1 and PEFR in comparison to chest physiotherapy. It also reduces the postoperative pulmonary complication rate.

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