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Original Article

Using Pre-Operative Incentive Spirometer Reduces Chances of Basal Atelectasis in Patients Undergoing Upper Abdominal Surgeries – A Randomized Controlled Trial

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ABSTRACT

Objective: To compare frequency of basal atelectasis in patients undergoing upper abdominal surgery who are provided pre-operative incentive spirometry versus those not provided pre-operative incentive spirometry.

Study Design: Randomized controlled trial (NCT06115941).

Place and Duration of Study: Pak Emirates Military Hospital, Rawalpindi Pakistan, from Mar to Sep 2023.

Methodology: We included 74 patients who were scheduled for upper abdominal surgery and divided them into group-A "Pre-op spirometry group" and group-B "no pre-op spirometry group". Patients who underwent lower abdominal surgery were excluded. Patients were assessed at 48 hours after surgery for presence of basal atelectasis. Data was analyzed by statistical package for social sciences 22.

Results: In our study, mean age of the patients was 37.97±5.36 years. 51(68.92%) male and 23(31.08%) female subjects were included. No significant difference between groups was observed in terms of mean age, gender distribution, mean BMI and median duration of ventilator support (p>0.05). Frequency of basal atelectasis in "incentive spirometry "group-A was 3(8.11%) while in "no incentive spirometry" group-B it was 11(29.73%), (p=0.018).

Conclusion: Although Incentive Spirometry is utilized for management of basal atelectasis but it is also highly useful in reducing frequency of post-op basal atelectasis when used pre-operatively.

Keywords: Atelectasis, Preoperative Incentive Spirometry, Upper Abdominal Surgery.

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INTRODUCTION

Surgical procedures performed under general anesthesia carry a high risk of developing some complications that can either occur during surgery or during the early post-operative period. Amongst these, complications related to the respiratory system, in particular "atelectasis", is fairly common in upper abdominal surgeries with an incidence reaching >50% and is linked to accentuated post-surgical morbidity and fatality rates.[1,2] Pathophysiological process that dictates the development of these complications involves spontaneous collapsing of the alveoli secondary to mismatch of ventilation and perfusion or low levels of surfactant which not only causes excessive buildup of secretions in the alveoli but also significantly affects the respiratory function and reduces the functional residual capacity as well as vital capacity of a patient.[3]

There are several risk factors that increase the propensity of development of these complications including patient's habit of smoking, having chronic illness, emergency surgery, abdominal surgeries and advancing age.[4] Since pulmonary complications, especially atelectasis, adds to the morbidity of surgical patients, it is essential to devise and utilize various maneuvers that can help to reduce the incidence of this commonly occurring complication during the early post-surgery period. In this instance, one of the most commonly and conventionally used method is chest physiotherapy.[5] Another method is provision of "positive pressure ventilation" through BIPAP and CPAP.[6] Another important intervention that has been reported to help in improvement of respiratory functions in patients with chronic respiratory illnesses, in particular "chronic obstructive pulmonary disease (COPD)" is "incentive spirometry".[7] Incentive spirometry (IS) during the preoperative period is another method which has been considered as one of the effective method to reduce the frequency of complications, during the post-surgical period, related to respiratory system as it helps in recruiting collapsed alveoli by deep breathing exercise which helps

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normalization of respiratory function.[8] Contrarily, there are also studies which report no benefit of this intervention in this regard.[9]

Owing to this, it was decided to conduct this study with the objective of determining that whether or not, preoperative usage of incentive spirometer has the potential to minimize frequency of basal atelectasis in patients who underwent upper abdominal surgeries. Results from our study will help us making a decision based on evidence that whether regular pre-procedural practice of incentive spirometry can be opted as a standard of care in surgical patients to reduce the respiratory morbidities associated with surgery.

METHODOLODY

This randomized controlled trial (Reg. #: NCT06115941) was conducted at "Pak Emirates Military Hospital, Rawalpindi Pakistan, from Mar to Aug 2023 after obtaining approval from the ethical review committee of the "Pak Emirates Military Hospital (PEMH), Rawalpindi"; ERC #: A/28/EC/570/23). For calculation of sample size WHO sample size calculator 2.2b (Hypothesis testing for two population proportions) was used using formula:

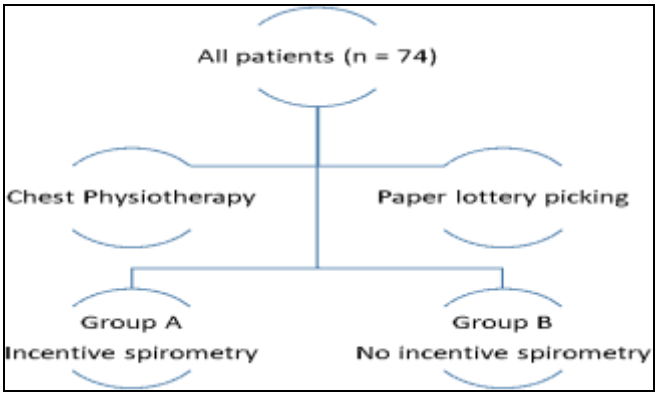
$$n = \frac{\left\{ z_{1-\alpha/2}\sqrt{2\bar{P}(1-\bar{P})} + z_{1-\beta}\sqrt{P_1(1-P_1)+P_2(1-P_2)} \right\}^2}{(P_1 - P_2)^2}$$

To calculate sample size 10% level of significance, 80% power of the test, anticipated frequency of post-operative basal atelectasis in incentive spirometry group 21.9% and anticipated frequency of post-operative basal atelectasis in no incentive spirometry group of 2.9%[10] were used. Based on these, calculated sample size was 74 (37 patients in each group).

Inclusion criteria: We included patients who were adults having an age above 18 years, either of male or female gender, ASA I-II status and underwent upper abdominal surgery (both open and laparoscopic).

Exclusion criteria: We excluded patients who underwent lower abdominal surgeries, ASA III-V status, co-morbidities like diabetes (HbA1C% ≥6.5%),[11] hypertension (persistent BP readings of >130/80)[12] and chronic lung condition (like asthma, chronic obstructive pulmonary disease, emphysema)], history of pulmonary tuberculosis and structural deformity of chest.

After patient selection through "non-probability consecutive sampling" baseline characteristics of our patients including age, gender and body mass index (BMI) were recorded. None of the patients had pre-operative assessment of pulmonary function through "pulmonary function test (PFT)".Once recorded, patients were randomly divided into two equal groups (each containing 37 patients). In group A or "incentive spirometry group"patients were directed to start incentive spirometry, 48 hours prior to surgery. They were given an incentive spirometer and were briefed that they should inhale into the mouth piece of spirometer to lift the balls to the roof of tube and hold for five seconds and then exhale. During this their bed was propped up at 45 degree angle. They were asked to perform 10 such breaths for 6 times in a day till surgery under direct supervision of researcher and this was charted in patient file. In group B or "no incentive spirometry group"patients were not asked to perform incentive spirometry. Patients in both group were provided with chest physiotherapy.



After this, all the included patients underwent upper abdominal surgery by expert surgical team under general anesthesia. Type of surgery (Laparoscopic Cholecystectomy/Open Cholecys-tectomy/perforated duodenal repair/ Epigastric Hernia Repair/Gastrojejunostomy) and duration for which patient was on ventilator support (in minutes) was documented. After surgery, all the patients were given adequate analgesia and antibiotics as per standard hospital protocol. Patients were assessed at 48 hours after surgery for presence of basal atelectasis which will be diagnosed clinically by presence of new onset respiratory symptoms "cough,crackles, tachypnea and reduced breath sounds at bases" and by chest X-ray "presence of basal opacification, crowded air bronchograms, crowded pulmonary vasculature and compensatory hyper-expansion of surrounding unaffected lung". Patients who developed "atelectasis"were managed through multi-

disciplinary approach under the care of consultant pulmonologist, physician and physiotherapist through combination of "chest physiotherapy","pulmonary rehabilitation" and volume & pressure controlled "positive pressure ventilation".

"The statistical package for social sciences (SPSS) version 22 software was used for statistical analysis of the data. Normality of test will be checked using Shapiro-Wilk test which showed that age, BMI and duration of hospital stay were normally distributed while duration of ventilatory support was non-normal data. For qualitative variables frequency and percentages were used, whereas for quantitative data mean ± standard deviation and median (IQR) were used. Qualitative variables were compared between groups with the use of chi-square test. Quantitative variable (age, BMI and duration of hospital stay) were compared between groups using Student t-test while (duration of ventilatory support) were compared between groups using Mann-Whittney U-test. A *p*-value of ≤0.05 was considered significant".

RESULTS

In this study, a total of 74 patients were included. Mean age of the patients was 37.97±5.36 years. 51(68.92%) of the patients were male while remaining 23(31.08%) of the study participants were female. Mean BMI was 31.33±4.40kg/m2. 39(52.70%) patients were smokers while 35(47.30%) were non-smokers. Most frequently performed surgery was Laparoscopic cholecystectomy 55(74.32%) followed by perforated duodenal repair 7(9.46%), Open cholecystectomy 5(6.76%), Epigastric hernia repair 4(5.41%) and gastrojejunostomy 3(4.05%). Median (IQR) duration of ventilatory support was 46(31–312) minutes. These baseline characteristics are tabulated below in Table-I.

These baseline characteristics between study groups were compared. Mean age in "incentive spirometry" group (A) was 38.24±5.77 years while in "no incentive spirometry" group (B) it was 37.70±4.98 years, (*p*=0.668). In terms of gender distribution, there was no significant difference between groups (*p*=0.451). Mean BMI in "incentive spirometry" group (A) was 31.11±4.58 kg/m2 and in "no incentive spirometry" group (B) it was 31.55±4.26 kg/m2, (*p*=0.667). Median duration of ventilator support in "incentive spirometry" group (A) was 45(34–312) minutes while in "no incentive spirometry" group (B) it was 47(31–274), (*p*=0.673). This comparison is tabulated below in Table-II.

Table-I: Baseline Characteristics (n=74)

Characteristic	n(%)
Mean age (years)	37.97±5.36
Gender	
Male	51(68.92%)
Female	23(31.08%)
Mean BMI (kg/m2)	31.33±4.40kg/m2
Smoking	
Yes	39(52.70%)
No	35(47.30%)
Type of Surgery	
Laparoscopic Cholecystectomy	55(74.32%)
Perforated duodenal repair	7(9.46%)
Open Cholecystectomy	5(6.76%)
Epigastric Hernia	4(5.41%)
Gastrojejunostomy	3(4.05%)
Median duration of ventilatory support (minutes)	46(31–312) minutes

Table-II: Comparison of Baseline Characteristics between Groups (n=74)

Parameter	Post-op Incentive spirometry group A (n=37)	No post-op incentive spirometry group B (n=37)	*p*-value
Mean age (years)	38.24±5.77	37.70±4.98	0.668
Gender			
Male	27(72.97%)	24(64.86%)	0.451
Female	10(27.03%)	13(35.14%)	
Mean BMI (kg/m2)	31.11±4.58	31.55±4.26	0.667
Smoking			
Yes	18(48.65%)	21(56.76%)	0.485
No	19(51.35%)	16(43.24%)	
Median duration of ventilator support (minutes)	45(34–312)	47(31–274)	0.673

Upon comparison of frequency of basal atelectasis in patients who underwent upper abdominal surgery, it was found that in "incentive spirometry" group (A) it was 3(8.11%) while in "no incentive spirometry" group (B) it was 11(29.73%), (*p*=0.018). Mean duration of hospital stay in "incentive spirometry" group (A) it was 7.08±1.63 days while in "no incentive spirometry" group (B) it was 9.54±1.12 days, (*p*<0.001). None of the patients developed any other respiratory complication in this study. Frequency of post-operative fever in "incentive spirometry" group (A) it was 1(2.70%) while in "no incentive spirometry" group (B) it was 6(16.22%), (*p*=0.049). In addition to comparison of aforementioned data, comparison of x-ray findings between groups is demonstrated below in Table-III.

Table-III: Comparison of Post-Operative Parameters between Groups (n=74)

Parameter	Post-op Incentive spirometry group A (n=37)	No post-op incentive spirometry group B (n=37)	*p*-value
Post-operative fever	1(2.70%)	6(16.22%)	0.049
Duration of hospital stay	7.08±1.63 days	9.54±1.12 days	<0.001
Basal Atelectasis	3(8.11%)	11(29.73%)	0.018
Other respiratory complications	0(0%)	0(0%)	___
X-ray findings			
Basal opacification	3(8.11%)	11(29.73%)	0.018
Crowded air bronchograms	3(8.11%)	11(29.73%)	0.018
Crowded pulmonary vasculature	2(5.41%)	9(24.32%)	0.022
Compensatory hyper-expansion of unaffected lung	3(8.11%)	5(13.51%)	0.454

DISCUSSION

The Greek term for "incomplete expansion" is "atelectasis" which is a fairly common complication that accounts for majority of the admissions in the intensive care units (ICU) after surgery and is associated with increased risk of death during post-surgical time.[13,14] It is now more precisely described as a condition in which air cannot reach the tissue of the lungs due to an impediment of the airways leading to impaired exchange gaseous exchange of varying degrees.[15] There is an improved understanding of mechanism of atelectasis primarily as a consequence of the growing amount of surgeries being carried out nowadays a strong relationship has been reported between "atelectasis" and "general anesthesia (GA)".[16] Despite being easily identifiable and avoidable it is frequently disregarded which results in dire consequences in the form of elevated respiratory morbidity as well as postoperative fatality. Pre-op and afterwards goals of breathing interventions and exercise are to delay the onset of atelectasis, prevent it, and enhance the clearance of the airways.[17] Utilizing treatment methods that improve the volume of the lungs can lessen the risk of atelectasis and the seriousness of associated repercussions. Incentives spirometry, which was the main focus of our study, has been used since its inception as a crucial component of pulmonary rehabilitation after surgery to avoid and cure respiratory problems.[18]

In current study, it was found that in terms of baseline parameters, there no statistical difference between study groups in terms of age of the patients, their gender distribution, body mass indices as well as in terms of duration for which they remained on ventilator during their surgery. This finding was in coherence with what was observed in a study conducted by Gilani *et al.*,[19] in which no such difference was observed. In this study, it was found that the use of "pre-operative incentive spirometer" is associated with significant reduction in the frequency of development of "basal atelectasis" during the recovery period after surgery. This finding was also congruent with Gilani *et al.*,[19] and with Sweity *et al.*,[20] both of which reported almost similar results. However, in contrast to present study, their studies included patients who underwent cardiac surgeries as compared to our study in which patients of upper abdominal surgery were included. In terms of post-op fever, very small proportion of patients developed fever after surgery which was contrasting to a study conducted by Lim *et al.*,[1] who reported that almost half of the patients who underwent upper abdominal surgery developed fever post-operatively. Duration of hospital stay was significantly less in patients who had post-op "incentive spirometry". This was congruent with the findings of a study conducted by Chang *et al.*,[21] who reported use of "incentive spirometer" effectively reduces length of stay at hospital.

This study is unique from other studies conducted for evaluation of role of pre-operative "incentive spirometery" to reduce the frequency of development of "basal atelectasis" during the recovery period after surgery in the aspect that most of these studies are performed only on cardiac surgery patients while this is performed on patients who underwent upper abdominal surgery. Based on the findings of present study, our preliminary recommendation is to maximize the implementation of pre-operative use of "incentive spirometer" as standard of care. Secondly, we also recommend that large scale studies with extended sample size should be conducted in future in patients undergoing various types of surgeries to optimally understanding the role of this highly useful intervention.

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LIMITATIONS OF STUDY

Single center study, limited follow up period and limited sample size were few limitations of our study.

CONCLUSION

In conclusion, although incentive spirometry is utilized for management of basal atelectasis but it is also highly useful in reducing frequency of post-op basal atelectasis when used pre-operatively.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

MN & MA: Data acquisition, data analysis, critical review, approval of the final version to be published.

BS & SDH: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

MA & MJ: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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