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Incentive Spirometry in Postoperative Pulmonary Complications

Prakashkumar J. Patel

Assistant Professor, SPB Physiotherapy College, Surat, Gujarat, India

Abstract: ***Objective: The aim of this narrative review is to search the available literature to findeffectiveness of incentive spirometry in pulmonary complication after surgery. Methodology: Literature was searched with the use of many electronic databases (Google Scholar, CINAHL, Pubmed central and Oxford Press, Science direct, National Library of Medicine (Pubmed), Biomed Central). Additionally, more reference articles were searched to increase the search of accuracy. Conclusion: Despite its widespread use, it has remained challenging to demonstrate a clinical benefit in terms of either incidence of post operative pulmonary complications or hospital stay. Until evidence of benefit from well - designed clinicals trials becomes available, the routine use of IS in postoperative care is not supported by available literature.***

Keywords: Incentive Spirometry, Post - operative pulmonary complication, Thoracic Surgery, Abdominal Surgery.

1. Introduction

Respiration is carried out by movements of thorax and abdominal wall. Abdominal surgery involves division of abdominal muscles which results in pain and restriction of movements. This is also associated with changes in diaphragmatic function and atelectasis of the lung.[1- 2]

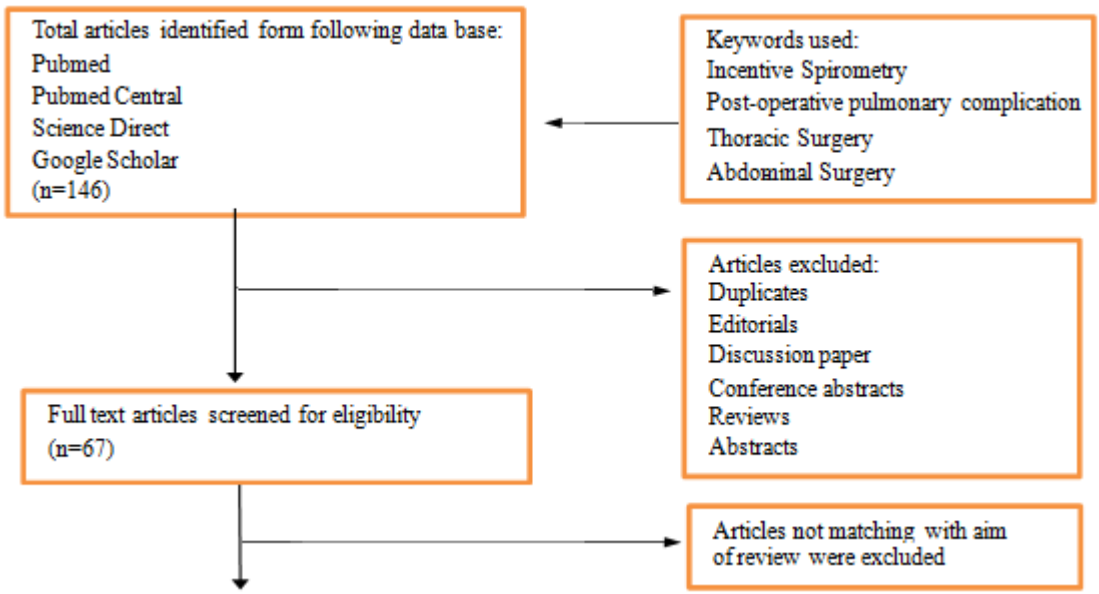
Postoperative pulmonary complications (PPCs) are the most common complication seen after thoracic surgery.[3]The incidence of PPCs after thoracic surgery has been reported to be between 19% and 59%.[4] It is recognized that there is a high incidence of atelectasis in patients undergoing any general anesthesia due to the high oxygen concentration used and reduced muscle tone, and that this can persist for several days. Atelectasis leads to secretion retention and regional hypoventilation, both of which can contribute to the development of PPCs. In thoracic surgery, this can be even more pronounced due to postoperative chest wall pain that, if not well controlled, leads to hypoventilation and impairs the resolution of atelectasis.[5]

Previous studies have suggested that between 17% and 88% of people having surgery on the upper abdomen will suffer complications that affect their lungs after the operation (postoperative pulmonary complications). The lung volume tends to fall after such surgeries. These complications can be made less likely and less severe with the careful use of treatments designed to encourage breathing in (inspiration) and thus increasing the volume of the lungs, as these volumes tend to fall after such surgeries. Incentive spirometers are mechanical devices developed to help people take long, deep, and slow breaths to increase lung inflation.[6]

There are 2 types of IS devices: flow - oriented and volume - oriented. Flow - oriented IS devices typically consist of 3 interconnected columns, each containing a lightweight plastic float that acts as a marker. The columns are connected to a mouthpiece through which the patient inhales. The deep - breathing exercise with this device involves the patient attempting to lift the float, through inspiratory flow, to a certain point in the columns for a certain amount of time. The volume - oriented device consists of a mouthpiece connected to a chamber with a visible scale. The deep - breathing exercise with this device involves the patient attempting to lift a marker as high as possible. Clinical practice guidelines recommend the volume - oriented devices to be used postoperatively because they are considered to impose lower work of breathing, pain, and fatigue.[7 - 8]

However, the solid evidence of routinely applying IS in pulmonary complication after surgery is limited. So, the aim of this narrative review is to search the available literature to findeffectiveness of incentive spirometry in pulmonary complication after surgery.

Search strategy and study selection:
A computer - based literature search was done using the Pubmed, Pubmed Central, Science direct and Google scholar. Relevant articles with full text published in English till 2023 were screened and included. Editorials, Commentaries, Discussion papers, Conference abstracts, Reviews and Duplicates were excluded. We included only studies with full text articles. After screening all the articles, 10 relevant articles were included in the review.



Studies includes (n=30)

2. Methodology

Chest therapy after surgery is directed towards maximal inspiration in an attempt to prevent over atelectasis and allow for the early re - expansion of collapsed alveoli. Adoption of incentive spirometry as a global method of prophylaxis, however, raises concerns that high risk patients may be receiving inadequate treatment and that important resources are being wasted on low - risk patients. J. C. Hall, R. A. Tarala et al. conducted a study to evaluate the prevention of respiratory complications after abdominal surgery by a comparison of a global policy of incentive spirometry with a regimen consisting of deep breathing exercises for low risk patients and incentive spirometry plus physiotherapy for high risk patients.456 patients undergoing abdominal surgery. Patients less than 60 years of age with an American Society of Anesthesia classification of 1 were considered to be at low risk. The incidence of respiratory complications was 15% (35/231) for patients in the incentive spirometry group and 12% (28/225) for patients in the mixed therapy group. It required similar amounts of staff time to provide incentive spirometry and deep breathing exercises for low - risk patients. The inclusion of physiotherapy for high - risk patients, however, resulted in the utilisation of an extra 30 minutes of staff time per when the use of resources is taken into account, the most efficient regimen of prophylaxis against respiratory complications after abdominal surgery is deep breathing exercises for low - risk patients and incentive spirometry for high - risk patients.[9]

Another research by Chul Lim et al. with purpose of study was to evaluate the Incentive Spirometry (IS) and Deep Breathing Exercises (DBE) to prevent postoperative pulmonary complications after abdominal surgery in patients over 60 years of age. They prospectively randomized 90 patients into 1 of 3 groups: the control group (30 patients) received no respiratory treatment, the IS group (30 patients) was treated with incentive spirometry 4 times daily and DBE group (30 patients) carried out deep breathing exercises under supervision for 15 min 4 times daily. ABGA was taken at ward, PR (preop. room), RR (recovery room), POD1 day and POD2 day. X - ray taken at 24 h. and 48 h. after surgery. Pulmonary complications were defined as the development of 3 or more of 6 new findings: cough, sputum, dyspnea, chest discomfort, temperature greater than 38 *C, pulse rate more than 100 beats/min. PaO2 in the DBE group and IS group at PR were significantly increased than the values at ward, and the values of the PaO2 in the DBE group at RR and POD1 day, and those of IS group at PR and POD2 day were significantly higher than those of the control group ($p<0.05$). The frequency of development of pulmonary complications (43.3% in the control group, 20% in the DBE group, 20% in the IS group) and X - ray changes were comparable in the 3 groups (26.7%, 16.7%, 20% respectively). The DBE group showed the different incidence of postoperative pulmonary complications between upper and lower abdominal surgery (upper: lower= 35.7: 6.3%). they concluded that DBE and IS were effective in preventing postoperative pulmonary complications after abdominal surgery and lower abdominal surgery causes lesser postoperative pulmonary complications than upper abdominal surgery.[10]

Saja Ahmad Alwekhyan et al. conducted a study to assess the effect of nurse - guided use of incentive spirometer on postoperative oxygenation and pulmonary complications after coronary artery bypass graft surgery. A total of n = 89 eligible patients were randomized to either control or intervention group. Patients in the intervention group received bihourly nurse - guided incentive spirometry for 48 - h postextubation. The endpoints were: the number and duration of hypoxic events during the first 24 - hr post - surgery, pneumonia and pulmonary function parameters. Data were collected. Result show Patients in the intervention group had a significantly lower mean number of hypoxic events with shorter duration and shorter length of stay in the hospital and the ICU. Patients in the intervention group also had greater postoperative forced expiratory volume in 1 second. They concluded Nurse - guided use of the incentive spirometer reduces the risk of pulmonary complications and hospital length of stay after cardiac surgery.[11]

Following thoracotomy, patients frequently receive routine respiratory physiotherapy which may include incentive spirometry, a breathing technique characterised by deep breathing performed through a device offering visual feedback. This type of physiotherapy is recommended and considered important in the care of thoracic surgery patients, but high - quality evidence for specific interventions such as incentive spirometry remains lacking. Paula Agostini et al. did study on 180 patients undergoing thoracotomy and lung resection participated in a prospective single - blind randomised controlled trial. All patients received postoperative breathing exercises, airway clearance and early mobilisation; the control group performed thoracic expansion exercises and the intervention group performed incentive spirometry. No difference was observed between the intervention and control groups in the mean drop in forced expiratory volume in 1 s on postoperative day 4 (40% vs 41%), the frequency of postoperative pulmonary complications (12.5% vs 15%) or in any other secondary outcome measure. A high - risk subgroup (defined by ≥2 independent risk factors; age ≥75 years, American Society of Anaesthesiologists score ≥3, chronic obstructive pulmonary disease (COPD), smoking status, body mass index ≥30) also demonstrated no difference in outcomes, although a larger difference in the frequency of PPC was observed (14% vs 23%) indicating possible benefit of intervention (−7.4% to 2.6%). They concluded that Incentive spirometry did not improve overall recovery of lung function, frequency of PPC or length of stay. For patients at higher risk for the development of PPC, in particular those with COPD or current/recent ex - smokers, there were larger observed actual differences in the frequency of PPC in favour of the intervention, indicating that investigations regarding the physiotherapy management of these patients need to be developed further.[12]

Chun Hui et al. conducted a study on Volume Incentive Spirometry Reduces Pulmonary Complications in Patients After Open Abdominal Surgery: A Randomized Clinical Trial. A total of 58 patients who received open abdominal surgery were randomly assigned to the control group (n=29) undergoing diaphragmatic breathing exercises and the VIS group (n=29) undergoing VIS exercises. All the participants performed the six - minute walk test (6MWT) preoperatively to evaluate their functional capacity. Hemodynamic indexes, pulmonary function tests, and blood gas indexes were recorded before surgery and on the 1st, 3rd, and 5th postoperative day. Result showsthe functional capacity was not significantly different between the two groups during the preoperative period (P >0.05). At 3 days and 5 days postoperatively, patients in the VIS group had a significantly higher SpO2 than that in the control group (P <0.05). Pulmonary function test values were reduced in both two groups postoperatively when compared to the preoperative values but improved for three and five days afterward (P <0.05). Of note, the significantly elevated levels of peak expiratory flow (PEF), forced expiratory volume in the first second (FEV1), forced vital capacity (FVC), and FEV1/FVC ratio were observed on the 1st, 3rd, and 5th postoperative days in the VIS group compared with those in the control group (P <0.05). Besides, bass excess (BE), and pH values were significantly higher in the VIS group on the 1st postoperative day than those in the control group (P <0.05). they concluded Diaphragmatic breathing and VIS could improve postoperative pulmonary function, but VIS exercise might be a better option for improving hemodynamics, pulmonary function, and blood gas for patients after open abdominal surgery, hence lowering the incidence of postoperative pulmonary complications.[13]

Neeraj Vats did study on Effect of Deep Breathing Exercises and Incentive Spirometry in the Prevention of Post Operative Pulmonary Complications in the Patients of Cancer Esophagus undergoing Esophagectomy. Group 1 patients were given deep breathing exercises manually, group 2 patients were asked to do incentive spirometry only& group 3 was control group. Deep breathing exercises were given in lying position with the head end of bed raised to 30 - 40 degrees. Incentive spirometry was given in sitting position with foot supported. Chest expansions at axilla, nipple & xiphisternum, Single breath count, Peak expiratory flow rate & oxygen saturation were the dependant variables. It was found that deep breathing exercise and Incentive spirometry are more effective than no chest physiotherapy. The results of the study further suggests that comparison of the two modalities i. e., Incentive spirometry & deep breathing exercises revealed no statically significant difference among them.[14]

Previous study by Haddon Pantel et al. To determine the effect of postoperative IS on hypoxemia, arterial oxygen saturation (Sa_{O_2}) level, and pulmonary complications after bariatric surgery. A randomized noninferiority clinical trial enrolled patients undergoing bariatric surgery from May 1, 2015, to June 30, 2016. Patients were randomized to postoperative IS (control group) or clinical observation (test group). The controls received the standard of care with IS use 10 times every hour while awake. The test group did not receive an IS device or these orders. The primary outcome was frequency of hypoxemia, defined as an Sa_{O_2} level of less than 92% without supplementation at 6, 12, and 24 postoperative hours. Secondary outcomes were Sa_{O_2} levels at these times and the rate of 30 - day postoperative pulmonary complications. Result shows a total of 224 patients (50 men [22.3%] and 174 women [77.7%]; mean age, 45.6 years were enrolled, and 112 were randomized for each group. Baseline characteristics of the groups were similar. No significant differences in frequency of postoperative hypoxemia and SaO2 level between the control and test groups were found at 6, 12 or 24 postoperative hours. Rates of 30 - day postoperative pulmonary complications did not differ between groups (8 patients [7.1%] in the control group vs 4 [3.6%] in the test group; $P = .24$). they conclude that Postoperative IS did not demonstrate any effect on postoperative hypoxemia, Sa_{O_2} level, or postoperative pulmonary complications. Based on these findings, the routine use of IS is not recommended after bariatric surgery in its current implementation.[15]

Peter R. A. Malik et al. conducted study on Incentive Spirometry After Lung Resection. A single - blind prospective randomized controlled trial was conducted in adults undergoing lung resection. Individuals with previous lung surgery or home oxygen were excluded. Participants randomized to the control arm (PHY) received routine physiotherapy alone (deep breathing, ambulation and

shoulder exercises). Those randomized to the intervention arm (PHY/IS) received IS in addition to routine physiotherapy. A total of 387 participants (n = 195 PHY/IS; n = 192 PHY) were randomized between 2014 and 2017. Baseline characteristics were comparable for both arms. The majority of patients underwent a pulmonary lobectomy (PHY/IS = 59.5%, PHY = 61.0%;), with no difference in the rates of minimally invasive and open procedures. There were no differences in the incidence of PPC at 30 days postoperatively (PHY/IS = 12.3%, PHY = 13.0%; p = 0.88). There were no differences in rates of pneumonia (PHY/IS = 4.6%, PHY = 7.8%; p = 0.21), mechanical ventilation (PHY/IS = 2.1%, PHY = 1.0%; p = 0.41), home oxygen (PHY/IS = 13.8%, PHY = 14.6%; p = 0.89), hospital length of stay (PHY/IS = 4 days, PHY = 4 days; p = 0.34), or rate of readmission to hospital (PHY/IS = 10.3%, PHY = 9.9%; p = 1.00). they concluded that addition of IS to routine postoperative physiotherapy does not reduce the incidence of PPC after lung resection.[16]

To investigate the additional effect of incentive spirometry to chest physiotherapy to prevent postoperative pulmonary complications after thoracic surgery for lung and esophageal resections. Gosselink et al. carried a study on67 patients (age, 59 ± 13 yrs; forced expiratory volume in 1 sec, 93% ± 22% predicted) undergoing elective thoracic surgery for lung (n = 40) or esophagus (n = 27) resection. Group A was given Physiotherapy (breathing exercises, huffing, and coughing) plus incentive spirometry (IS). Group B was compared with PT alone. Lung function, body temperature, chest radiograph, white blood cell count, and number of hospital and intensive care unit days were all measured. Pulmonary function was significantly reduced after surgery (55% of the initial value) and improved significantly in the postoperative period in both groups. However, no differences were observed in the recovery of pulmonary function between the groups. The overall score of the chest radiograph, based on the presence of atelectasis, was similar in both treatment groups. Eight patients (12%) (three patients with lobectomy and five with esophagus resection) developed a pulmonary complication (abnormal chest radiograph, elevated body temperature and white blood cell count), four in each treatment group. Adding IS to regular PT did not reduce hospital or intensive care unit stay. Pulmonary complications after lung and esophagus surgery were relatively low. The addition of IS to PT did not further reduce pulmonary complications or hospital stay. Although we cannot rule out beneficial effects in a subgroup of high - risk patients, routine use of IS after thoracic surgery seems to be ineffective.[17]

Although the use of incentive spirometry with a deep breathing exercise (DBE) is widely used in clinical practice in patients who have undergone coronary artery bypass graft (CABG) surgery, the effect of this combination therapy has not been conclusively elucidated. Study was done to investigate the effect of postoperative combined incentive spirometry and DBE versus DBE alone on inspiratory muscle strength following CABG. This randomised clinical trial was conducted in patients scheduled to undergo CABG surgery. The study group received incentive spirometry and DBE, and the control group received DBE only. Maximal inspiratory pressure (MIP) before surgery and at day 4 after surgery was assessed by a respiratory pressure meter. Secondary outcomes, including postoperative pulmonary complication and duration of postoperative hospitalisation, were obtained from the medical records. They concluded that Patients in the study group had significantly better recovery of inspiratory muscle strength on day 4 post - CABG than patients in the control group. But there was no significant difference between groups for either postoperative pulmonary complications or length of hospital stay.[18]

3. Conclusion

IS help prevent lung complications by expanding lungs, strengthening your respiratory muscles and keeping mucus clear from your chest. So IS is commonly used to reduce post operative pulmonary complications. Currently, we have limited evidence to support its benefits. There is a lack of consensus on optimal protocols for its use. Despite its widespread use, it has remained challenging to demonstrate a clinical benefit in terms of either incidence of post operative pulmonary complications or hospital stay. Until evidence of benefit from well - designed clinicals trials becomes available, the routine use of IS in postoperative care is not supported by high level of evidence. Despite the paucity of efficacy and adherence data, IS often prescribed in an effort to do something to reduce postoperative pulmonary complications. Respiratory therapist can play an integral role in educating providers about evidence supporting IS. Further study is needed to determine which specific patient groups, if any, might benefit from IS.

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