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Effectiveness of Preoperative Incentive Spirometry in Patients Following Elective Thoracotomy for Prevention of Postoperative Pulmonary Complication

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Abstract

Background: Thoracotomy can cause postoperative impairment of respiratory function and highly risk turns as Postoperative Pulmonary Complication (PPC). One of strategies to decrease risk of PPC in preoperative evaluation is lung expansion maneuvers include Incentive Spirometry (IS). Incentive Spirometry was breathing technique that sustained maximal inspiration, using device which give visual feedback. This study aims to know effectiveness of using preoperative IS in reducing incidence of PPC in thoracotomy patients.

Methods: Experimental study with post test only design. Comparing emerged PPC with Melbourne Group Scale Version 2 (MDG-2) criteria in elective posterolateral thoracotomy patients who given IS and non IS preoperative. Data were analyzed using chi square test.

Results: Total samples was 32 patients. There was 11 patients had PPC, which 6 recieved IS preoperatively. There was no relation between PPC with age, sex, height, smoking history proportion (p value>0,05). Chi square test showed there was no relation between using IS preoperative and PPC incidence(p>0,710).

Conclusions: IS preoperative was not effective in preventing PPC in elective thoracotomy patients.

Key words: thoracotomy, incentive spirometry, PPC

1. Introduction

Surgery is an indispensable part of modern healthcare globally.[1] more than 312 million major surgical procedures were performed globally in 2021, included thoracic and non-thoracic surgery, an estimated increase of 38,2% since 2004.[2] In practice, surgery is always considering the results and complications that may occur after surgery.[2]

Thoracic surgery or thoracotomy is a major surgical procedure that greatly affects the cardiorespiratory mechanism and vital functions of the heart and lungs.[3] Thoracotomy can cause postoperative impairment of respiratory function and highly risk turns as Postoperative Pulmonary Complication (PPC).[3,4] Postoperative Pulmonary Complications are the major cause or a contributing factor to the number of deaths following lung resection, accounting for up to 84% of all deaths.[4]

The incidence of PPC ranging from 2 to 40%, varies according to the previous diagnosis of the candidates for surgery, type of surgery and the definition of PPC.5 Similar to Agostini et al, the incidence of PPC following thoracic surgery was 19-59%. It's higher than incidence of PPC following upper (16-17%) or lower abdominal surgery (0-5%).[5]

The quality of perioperative treatment for patients undergoing thoracic surgery is the utmost importance for postoperative morbidity and mortality and length of stay.[6] despite advances in perioperative care, PPC continue to affect the recovery of surgical patients. Among surgical complications, PPC are the second most common type following complications related to surgical site infection.[7]

Postoperative Pulmonary Complication define as conditions that compromise the respiratory tract and that may adversely influence the patients' clinical conditions after surgery.[7] Despite Silva et al define as a second, unexpected, disease that appears up to 30 days after surgery, changing the patients' clinical status and making therapeutic intervention necessary.[8] According to Ana Fernandez et al in JAMA Surg Journal, PPC was emerged within the first postoperative week (seven days).[15] PPC include respiratory insufficiency, pneumonia, tracheal reintubation within 48 hours or tracheal intubation more than 48 hours due to the maintenance of mechanical ventilation due to acute respiratory failure, atelectasis, bronchospasm, exacerbation of chronic obstructive pulmonary disease (COPD), pneumothorax and pleural effusion.[7]

According to Ozkan et al in 2015, in Summary of Consensus Report on Preoperative Evaluation, one of strategies to decrease risk of PPC is lung expansion maneuvers. Lung expansion maneuvers

include Incentive Spirometry (IS), deep breathing exercises (DBE), and Inspiratory Muscle Training (IMT).[9]

Incentive Spirometry is one of breathing technique where deep breathing exercises are performed through a device offering visual feedback, both in term inspired flow and/or volume.[10,11] The addition of visual feedback is thought to improve breathing technique and improve patient motivation.[10]

In some studies, preoperative intervention for prevent PPC following thoracic surgery show varies results. It's believed that IS following thoracotomy can decrease PPC or length of stay, but some studies contra said that IS give little benefit.[10]

This study aims to know **e**ffectiveness of using preoperative IS in reducing incidence of PPC in elective thoracotomy patients in Dr. Mohammad Hoesin General Hospital Palembang.

2. Methods

This was an experimental study with post test only design. Comparing emerged PPC following thoracotomy with or without IS intervention before surgery in patients undergo elective posterolateral thoracotomy who treated in Department of Surgery of Dr. Mohammad Hoesin General Hospital Palembang. This study started at July 2020.

The study population is all patients undergo thoracotomy in Department of Surgery of Dr. Mohammad Hoesin General Hospital Palembang.

The study samples are patients undergo elective posterolateral thoracotomy with lung resection in Department of Surgery of Dr. Mohammad Hoesin General Hospital Palembang who meet inclusion criteria.

Inclusion criteria in this study were patients who undergo thoracotomy in Dr. Mohammad Hoesin General Hospital Palembang aged ≥ 13 year and provided informed consent. Lung function test with FVC < 80 % and FEV1 < 80 %. Exclusion criteria of this study were not cooperating to use IS or not understanding the giving instruction and demonstration such as toddler, delirium stage, or sedative patients; patients who can't take deep breathing or pain while inspiration; patients with lung disease (ex. Tuberculosis pulmonal, respiratory tract infection, COPD, and atelectasis); patients with abnormal lung auscultation. Drop out criteria was inability to be followed due to death or acquired respiratory distress. Withdrawal criteria was patients stop and refuse to using the IS.

All patients in population were adding to be sample in this study with consecutive sampling technique. Independent variable for this study was incentive spirometry; dependent variable was PPC.

PPC was diagnosed with Melbourne Group Scale Version 2 (MDG-2) like seen in table 1.

Statistical analysis using SPSS 23 version. Analyzing difference of proportion PPC in group given IS preoperative and non-IS using chi square test. In numerical data to normalize distribution of lung capacity using Saphiro Wilk method due to sample less than 50 then analyze with independent sample T test or independent t test if the distribution is normal.

3. Results

In this study, 32 patients were included in this study. Table 1 shows that there are 16 patients receiving preoperative IS treatment and 16 patients not being treated. From a total of 32 patients, 11 patients developed PPC and 21 patients did not have PPC (table 2). Six of the 11 patients with PPC were patients who had received preoperative IS treatment and five patients who had not received treatment (table 3). Tables 1 and 2 show distribution data of the characteristic subjects based on preoperative IS and PPC.

Characteristic subject distribution analyzes with Fisher's exact test show in table 1. There were no differences in proportion of age, gender, history of smoking and height between given IS group and non-IS group (p value > 0,05). Showing similar result, characteristic subject distribution in PPC incidence (table 2) give no differences in proportion of age, gender, history of smoking and height with p value > 0,05. Data was analyzing with Fisher's exact test and chi square test. It showed that characteristic of each group was proportional.

Bivariate analysis to examine relation between IS and PPC using chi square test showed no significance relation statistically with p value 0,710 (table 3). There was no relation of preoperative IS and PPC incidence whether it given or non-given. It will not affect PPC outcome.

Table 1. Characteristic Subject based on Preoperative Incentive Spirometry

Variables	Chest Physiotherapy		P values
	Non IS	Given IS	
Age			
16 – 25 (yrs)	1 (6.25%)	2 (12.50%)	
26 – 35 (yrs)	0 (0.00%)	3 (18.75%)	0.300*
36 – 45 (yrs)	1 (6.25%)	1 (6.25%)	
≥ 46 (yrs)	14 (87.5%)	10 (62.5%)	
Gender			
Male	11 (68.75%)	15 (93.75%)	0.172*
Female	5 (31.25%)	1 (6.25%)	
History of Smoking			
Smoking	10 (62.50%)	13 (81.25%)	0.433*
Non Smoking	6 (37.50%)	3 (18.75%)	
Height			
151 – 160 cm	9 (56.25%)	4 (25.00%)	0.228*
161 – 170 cm	6 (37.50%)	9 (56.25%)	
171 – 180 cm	1 (6.25%)	3 (18.75%)	

Note: *Fisher's Exact

Tabel 2. Characteristic Subject based on Postoperative Pulmonary Complications

Variables	PPC		P values
	No	Yes	
Age			
16 – 25 (yrs)	2 (9.52%)	1 (9.09%)	
26 – 35 (yrs)	1 (4.76%)	2 (18.18%)	0.104**
36 – 45 (yrs)	0 (0.00%)	2 (18.18%)	
≥ 46 (yrs)	18 (85.71%)	6 (54.55%)	
Gender			
Male	16 (76.19%)	10 (90.91%)	0.637**
Female	5 (23.81%)	1 (9.09%)	
History of Smoking			
Smoking	16 (76.19%)	7 (63.64%)	0.681**
Non Smoking	5 (23.81%)	4 (36.36%)	
Height			
151 – 160 cm	8 (38.10%)	5 (45.45%)	
161 – 170 cm	10 (47.62%)	5 (45.45%)	1.000**
171 – 180 cm	3 (14.29%)	1 (9.09%)	

Note: *Chi-square test; **Fisher's Exact

Table 3. Relation of Preoperative Incentive Spirometry and PPC following Thoracotomy

Intervention	PPC		P values
	Yes	No	
Non-IS	5 (45.45%)	11 (52.38%)	0.710*
Given IS	6 (54.55%)	10 (47.62%)	

Note: *Chi-square test

4. Discussion

Thoracic surgery and thoracotomy are major surgery that can impact cardio respiration mechanism and vital function of heart and lung.[3] Overall severe thoracic injury accounts for 20-25% of death from trauma. Some studies found that thoracic trauma following thoracotomy was as much as 14,4% with mortality rate of 17,6% while those who were not performed thoracotomy were as much as 85,6% with mortality percentage of 5,4%.[3]

Thoracic surgery can cause postoperative impairment of respiratory function and highly risk turns as PPC.[3,4] Postoperative Pulmonary Complications are the major cause or a contributing factor to the number of deaths following lung resection, accounting for up to 84% of all deaths.[4] The complications included atelectasis, pneumonia, bronchospasm, emboli, ARDS, respiratory failure with prolonged mechanic ventilation, pleura disease, and diaphragm or chest wall disturbance.[5] Atelectasis was the most common complication of PPC. The incidence of PPC ranging from 2 to 40%, varies according to the previous diagnosis of the candidates for surgery, type of surgery and the definition of PPC.[5] Similar to Agostini et al, the incidence of PPC following thoracic surgery was 19-59%.[5]

The incidence of PPC increases in patients who undergo surgical procedures at the age of > 60 years. Patients aged 60-69 years have a 2,1 times greater risk of PPC events than patients aged < 60 years; patients aged 70-79 years 3,1 times greater compared to patients aged < 60 years; and patients aged > 80 years had a 5,1 times greater risk than patients aged < 50 years.[16,34]

Smoking can change the physiology of the respiratory system, such as decreasing lung capacity, decreasing ciliary function, and increasing mucus production. According to Olsen et al in 2005, there is no relationship between smoking frequency and the incidence of PPC.[35]

In prevention of PPC, chest physiotherapy is necessary. Chest physiotherapy make the lungs expand slowly and absorb more oxygen.[2] Chest physiotherapy can include IS, DBE, intermittent positive pressure breathing, chest physical therapy, aerosol therapy and most recently CPAP. The most common use of chest physiotherapy incentive spirometry.[2,3] According to Ozkan et al in 2015, in

Summary of Consensus Report on Preoperative Evaluation, one of strategies to decrease risk of PPC is lung expansion maneuvers. Lung expansion maneuvers include Incentive Spirometry (IS), deep breathing exercises (DBE), and Inspiratory Muscle Training (IMT).[9]

One method to increase lung function capacity is using incentive spirometry. Incentive spirometry is a breathing technique that is carried out through a device that can provide a visual feedback, inspired flow and volume, a visual feedback will improve breathing exercise techniques and patient motivation. In this technique, the ability to increase lung volume will be greater. Breathing exercises with IS will provide inspiratory volume direction so that it will help provide the right volume dose of exercise and the patient will be more consistent with exercise, so that breathing exercises with IS can improve lung function.[29]

Incentive spirometry is designed to help patients take long, slow, and deep breaths. This will result in a decrease in intra-pleural pressure, increased lung expansion and gas exchange. This is done by using a device that helps the patient visually during inspiration at a predetermined flow or volume and maintains the inspiration for 5 seconds. Incentive spirometry increases lung volume and intra-alveolar pressure at the end of inspiration, thereby improving breathing capacity. The increase in intra-alveolar pressure is directly proportional to the force of contraction of the respiratory muscles, including the diaphragm and auxiliary respiratory muscles. This explains that IS exercise can increase the strength of the respiratory muscles because to reach the total lung capacity requires strong respiratory muscle activity.[30,31] Several studies have recommended the frequency of using IS, namely 10 breaths every 1-2 hours, 10 breaths 5 times a day, 15 breaths every 4 hours. Heydari et al, conducted a study with a frequency of using IS as much as 10-15 breaths per session 2 times a day (morning and evening) 4 times a week.[32]

Incentive spirometry can also function on airway clearance although there is little evidence to support this. This is especially important in patients undergoing surgical procedures. The breathing exercise triggers the mobilization of secretions and opens the collapsed part of the lung. In addition, IS also provides lung exercises, keeping them active, especially during postoperative healing. This is supported by research conducted by Weiner et al. It was concluded that lung function was significantly improved in patients who received IS and BMI exercises before and after surgery.[32]

The relation between preoperative IS and PPC using chi-square test showed not significance statistically ($p = 0.710$). This is consistent with a study conducted by Overend TJ et al in 2001, it was found that the use of IS could not reduce the incidence of PPC in patients with heart or upper abdominal surgery.[10] Similar to study from Agostini P et al in 2013, they found no association between using of IS and incidence of PPC.[11]

Although IS provides additional visual feedback, various factors can affect exercise so that pulmonary function has not improved significantly. Some of these factors include psychological and technical factors. The technical factor is the short intervention time. Psychological factors such as pain complaints related to underlying diseases greatly affect the exercise and evaluation program.[34]

One of the most important factors in breathing exercises is maintaining the Zone of Apposition (ZOA), which is the area of the diaphragm that covers the cylindrical part (the dome-shaped part of the diaphragm) that is directly related to the inside of the lower ribs. Zone of Apposition is very important because it is controlled by the abdominal muscles and regulates diaphragmatic pressure.[14]

According to Olsen's research in 2005, surgical procedures affect the occurrence of PPC due to disruption of the respiratory muscles, especially the diaphragm. Abdominal surgery has a risk of developing PPC when compared to non-abdominal surgery.[35] In addition, according to Paulo's 2014 study regarding the administration of IS compared to without IS against PPC in patients undergoing abdominal surgery, there was no significant difference (RR value 0.59) in PPC prevention and IS administration compared to DBE showed RR value of 0.67.[23]

5. Conclusion

From the results of the study after giving incentive spirometry treatment to post-thoracotomy patients, it can be concluded that preoperative incentive spirometry is not effective in preventing PPC in elective posterolateral thoracotomy patients.

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