Effectiveness of Preoperative Incentive Spirometry in Patients Following Elective Thoracotomoy 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

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. 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. According to Ana Fernandez et al in JAMA Surg Journal, PPC was emerged within the first postoperative week (seven days). 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.

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).

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. The addition of visual feedback is thought to improve breathing technique and improve patient motivation.

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.

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

Patients And 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.

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%) | 0.300*   |
| 26 – 35 (yrs)              | 0 (0.00%) | 3 (18.75%) |          |
| 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

Table 2. Characteristic Subject based on Postoperative Pulmonary Complications

| Variables                  | PPC | P values |
|----------------------------|-----|----------|
|                            | No | Yes |          |
| Age                        |    |     |          |
| 16 – 25 (yrs)              | 2 (9.52%) | 1 (9.09%) | 0.104**  |
| 26 – 35 (yrs)              | 1 (4.76%) | 2 (18.18%) |          |
| 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          | Non Smoking          |
|------------------|----------------------|
| 16 (76.19%)      | 7 (63.64%)           |
| 5 (23.81%)       | 4 (36.36%)           |

| Height            |                           |
|-------------------|---------------------------|
| 151 – 160 cm      | 8 (38.10%)                |
| 161 – 170 cm      | 10 (47.62%)               |
| 171 – 180 cm      | 3 (14.29%)                |

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

**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*

### Discussion

Thoracic surgery and thoracotomy are major surgery that can impact cardio respiration mechanism and vital function of heart and lung. 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%.

Thoracic surgery can cause postoperative impairment of respiratory function and highly risk turns as PPC. 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. The complications included atelectasis, pneumonia, bronchospasm, emboli, ARDS, respiratory failure with prolonged mechanic ventilation, pleura disease, and diaphragm or chest wall disturbance. 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. Similar to Agostini et al, the incidence of PPC following thoracic surgery was 19-59%.
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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{10} Similar to study from Agostini P et al in 2013, they found no association between using of IS and incidence of PPC.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{23}
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.

References

1. Weiser TG, Haynes AB, Molina G, Lipsitz SR, Esquivel MM, Uribe-Leitz T, Fu R, Azad T, Chao TE, Berry WR, Gawande AA. Size and distribution of the global volume of surgery in 2012. Bulletin of the World Health Organization. 2016 Mar 1;94(3):201.
2. Vedula SS, Hager GD. Surgical data science: the new knowledge domain. Innov Surg Sci. 2017 Jan 30;2(3):109-21.
3. Softah A. Thoracotomies: indications, results and implications. Bahrain Medical Bulletin. 2006 Jun;28(2).
4. Agostini P, Cieslik H, Rathinam S, Bishay E, Kalkat MS, Rajesh PB, Steyn RS, Singh S, Naidu B. Postoperative pulmonary complications following thoracic surgery: are there any modifiable risk factors?. Thorax. 2010 Sep 1;65(9):815-8.
5. Carvalho CR, Paisani DM, Lunardi AC. Incentive spirometry in major surgeries: a systematic review. Brazilian Journal of Physical Therapy. 2011 Oct;15(5):343-50.
6. Halffeldt K, Dornschneider G, Schweiberer L, Richter C, Thetter O. Perioperative management in thoracic surgery. Langenbecks Archiv für Chirurgie. 1995 Feb 1;380(1):37-42.Journal of Physical Therapy. 2011 Oct;15(5):343-50.
7. Sogame LC, Vidotto MC, Jardim JR, Faresin SM. Incidence and risk factors for postoperative pulmonary complications in elective intracranial surgery. Journal of neurosurgery. 2008 Aug 1;109(2):222-7.
8. Silva DR, Gazzana MB, Knorst MM. Merit of preoperative clinical findings and functional pulmonary evaluation as predictors of postoperative pulmonary complications. Revista Da Associacao Medica Brasileira. 2010;56(5):551-7.
9. Ozkan M, Kirkil G, Dilektası AG, Sogut A, Sertogullarından B, Çetinkaya E, Coşkun F, Ulubay G, Yuksel H, Sezer M, Ozbudak O. Summary of consensus report on preoperative evaluation. Turkish thoracic journal. 2015 Jan;16(1):43.

10. Overend TJ, Anderson CM, Lucy SD, Bhatia C, Jonsson BI, Timmermans C. The effect of incentive spirometry on postoperative pulmonary complications: a systematic review. Chest. 2001 Sep 1;120(3):971-8.

11. Agostini P, Naidu B, Cieslik H, Steyn R, Rajesh PB, Bishay E, Kalkat MS, Singh S. Effectiveness of incentive spirometry in patients following thoracotomy and lung resection including those at high risk for developing pulmonary complications. Thorax. 2013 Jun 1;68(6):580-5.

12. Puruhito. Buku ajar primer : ilmu bedah toraks, kardiak, dan vaskular. Surabaya, Airlangga University Press. 2013.

13. Doherty GM. Current diagnosis and treatment: surgery ed 14th. MC Graw Hill. 2015; (18) 331-388.

14. Sengupta S. Post-operative pulmonary complications after thoracotomy. Indian journal of anaesthesia. 2015 Sep;59(9):618.

15. Fernandez-Bustamante A, Frendl G, Sprung J, Kor DJ, Subramaniam B, Ruiz RM, Lee JW, Henderson WG, Moss A, Mehdiratta N, Colwell MM. Postoperative pulmonary complications, early mortality, and hospital stay following noncardiothoracic surgery: a multicenter study by the perioperative research network investigators. JAMA surgery. 2017 Feb 1;152(2):157-66.

16. Miskovic A, Lumb AB. Postoperative pulmonary complications. BJA: British Journal of Anaesthesia. 2017 Feb 10;118(3):317-34.

17. Parry S, Denehy L, Berney S, Browning L, Austin Health Post-Operative Surveillance Team. Clinical application of the Melbourne risk prediction tool in a high-risk upper abdominal surgical population: an observational cohort study. Physiotherapy. 2014 Mar 1;100(1):47-53.

18. Kelkar KV. Post-operative pulmonary complications after non-cardiothoracic surgery. Indian journal of anaesthesia. 2015 Sep;59(9):599.

19. Ashes C, Slinger P. Volume management and resuscitation in thoracic surgery. Current Anesthesiology Reports. 2014 Dec 1;4(4):386-96.
20. Agostini P, Singh S. Incentive spirometry following thoracic surgery: what should we be doing?. Physiotherapy. 2009 Jun 1;95(2):76-82.
21. Ferreira L, Tanaka K, Santos-Galduróz RF, Galduróz JC. Respiratory training as strategy to prevent cognitive decline in aging: A randomized controlled trial. Clinical interventions in aging. 2015;10:593.
22. Gallart L, Canet J. Post-operative pulmonary complications: understanding definitions and risk assessment. Best Practice & Research Clinical Anaesthesiology. 2015 Sep 1;29(3):315-30.
23. Do Nascimento JP, Modolo NS, Andrade S, Guimaraes MM, Braz LG, El Dib R. Incentive spirometry for prevention of postoperative pulmonary complications in upper abdominal surgery. Cochrane Database of Systemic Reviews. 2014(2).
24. Restrepo RD, Wettstein R, Wittnebel L, Tracy M. Incentive spirometry: 2011. Respir Care. 2011; 56(10):1600-4.
25. Hristara-Papadopolou A, Tsanakas J, Diomou G, Papadopoulou O. Current devices of respiratory physiotherapy. Hippokratia. 2008;12(4):211-20.
26. Kundra P, Vitheeswaran M, Nagappa M, Sistla S. Effect of preoperative and postoperative incentive spirometry on lung functions after laparoscopic cholecystectomy. Surgical Laparoscopy Endoscopy & Percutaneous Techniques. 2010 Jun 1;20(3):170-2.
27. Brunicardi, F., Andersen, D., Billiar, T., Dunn, D., Hunter, J., Matthews, J., & Pollock, R. 2014. Schwartz's principles of surgery, 10e. McGraw-hill.
28. Smith PR, Baig MA, Brito V, Bader F, Bergman MI, Alfonso A. Postoperative pulmonary complications after laparotomy. Respiration 2010; 80: 269–74.
29. Eltorai AE, Baird GL, Pangborn J, Eltorai AS, Antoci Jr V, Paquette K, Connors K, Barbaria J, Smeals KJ, Riley B, Patel SA. Financial impact of incentive spirometry. INQUIRY: The Journal of Health Care Organization, Provision, and Financing. 2018 Sep;p.55.
30. Tyson AF, Kendig CE, Mabedi C, Cairns BA, Charles AG. The effect of incentive spirometry on postoperative pulmonary function following laparotomy: a randomized clinical trial. JAMA surgery. 2015 Mar 1;150(3):229-36.
31. Paiva DN, Assmann LB, Bordin DF, Gass R, Jost RT, Bernardo-Filho M, et al. Inspiratory muscle training with threshold or incentive spirometry: Which is the most effective. Rev Port Pneumol. 2015;21(2):76–81.

32. Heydari, A. Farzad, M, Ahmadi Hosseini S. Comparing inspiratory resistive muscle training with incentive spirometry on rehabilitation of COPD patients. 2015;40(4):243-8

33. Hill K, Cecins NM, Eastwood PR, Jenkins SC. Inspiratory muscle training for patients with chronic obstructive pulmonary disease: a practical guide for clinicians. Arch Phys Med Rehabil. 2010;91(9):1466−70.

34. Santoso, S., Sutjana, I.D.P., Imron, M.A., Muliarta, I.M., Adiputra, I.N. and Dewi, N.N.A., Penambahan Incentive Spirometry Pada Deep Breathing Exercise Terhadap Peningkatan Kapasitas Fungsi Paru Pada Pasien Pascaoperasi Jantung Di Rumah Sakit Jantung Harapan Kita. Sport and Fitness Journal. 2020.p.62-71.

35. Olsen MF. Chest physical therapy in surgery: a theoretical model about who to treat. Breathe. 2005 Jun 1;1(4):308-14.