COMPARISON BETWEEN LOW AND HIGH INSPIRATORY FLOW RATE OF INCENTIVE SPIROMETRY ON LUNG VOLUME, RESPIRATORY MUSCLE STRENGTH AND DYSPNEA SCORE AFTER CARDIAC SURGERY

A THESIS

BY

SA-NIT HOMRUEN

Presented in Partial Fulfillment of the Requirements for the

Master of Science in Physical Therapy

at Srinakharinwirot University

December 2559

COMPARISON BETWEEN LOW AND HIGH INSPIRATORY FLOW RATE OF INCENTIVE SPIROMETRY ON LUNG VOLUME, RESPIRATORY MUSCLE STRENGTH AND DYSPNEA SCORE AFTER CARDIAC SURGERY

A THESIS

BY

SA-NIT HOMRUEN

Presented in Partial Fulfillment of the Requirements for the

Master of Science in Physical Therapy

at Srinakharinwirot University

December 2559

COMPARISON BETWEEN LOW AND HIGH INSPIRATORY FLOW RATE OF INCENTIVE SPIROMETRY ON LUNG VOLUME, RESPIRATORY MUSCLE STRENGTH AND DYSPNEA SCORE AFTER CARDIAC SURGERY

AN ABSTRACT

BY

SA-NIT HOMRUEN

Presented in Partial Fulfillment of the Requirements for the

Master of Science in Physical Therapy

at Srinakharinwirot University

December 2559

Sa-nit Homruen (2016). *Comparison between low and high inspiratory flow rate of incentive spirometry on lung volume, respiratory muscle strength and dyspnea score after cardiac surgery.* Master thesis, M.Sc. (Physical Therapy). Bangkok: Graduate School, Srinakharinwirot University. Advisor: Asst. Prof. Dr. Sukalya Kritsnakriengkrai

The objective of this study was to compare the effects of high inspiratory flow rates (HF), low inspiratory flow rates (LF) of flow-oriented incentive spirometry (IS) and control of diaphragmatic breathing exercise (DBE) on vital capacity (VC), respiratory muscle strength (MIP, MEP) and dyspnea score. Secondary outcomes were pain score and length of hospital stay. The sixty-three patients undergoing cardiac surgery were randomly divided into three groups, the control group (n=21), LF group (n=21) and HF (n=21) groups. All of the variables were assessed on the pre-operative and the first to sixth post-operative day. Length of hospital stay and any complications were recorded. The data were analyzed using two-way mixed ANOVA. Bonferroni was used for Post hoc test. The VC of all the three groups showed significantly decrease on the first post-operative day (p=0.500) and gradually increased and nearly the baseline on the sixth post-operative day (p=0.270). The respiratory muscle strength dropped on the first post-operative day and increase to baseline. Had the dyspnea score significantly increased on the first post-operative day and then returned to the baseline on the fifth post-operative day for the HF groups and on the sixth post-operative day for the LF group but not reach the baseline for the control group. Pain score showed a significant increase on the first post-operative day and constantly decreasing from then on. On the sixth post-operative day, only pain score of HF group still remain (p=0.020). Length of hospital stay of control group seems to stay longer than the other two groups. However, there are no significant differences when comparing between groups. All of the variables did not show significant differences when compared between groups. This study concluded that in cardiac surgery patients, the IS training with HF and LF were not more effective in term of lung volume than the DBE. The use of IS with LF increased respiratory muscle strength faster than other groups. The dyspnea of using IS with HF returned to normal earlier than the use of IS with LF and the DBE although pain score was still higher in IS with HF. Incentive spirometry seemed to be effective to prevent lung complications after cardiac surgery.

การเปรียบเทียบการฝึก flow oriented incentive spirometry ระหว่างอัตราการสูดหายใจเข้าต่ำ และสูง ต่อความจุปอด กำลังกล้ามเนื้อหายใจ และ ระดับความเหนื่อย หลังการผ่าตัดหัวใจ

บทคัดย่อ

ของ

ศานิต หอมรื่น

เสนอต่อบัณฑิตวิทยาลัยมหาวิทยาลัยศรีนครินทรวิโรฒ เพื่อเป็นส่วนหนึ่งของการศึกษา ตามหลักสูตร ปริญญาวิทยาศาสตรมหาบัณฑิต สาขาวิชากายภาพบำบัด

ธันวาคม 2559

ศานิต หอมรื่น. (2559). การเปรียบเทียบการฝึก flow oriented incentive spirometry ระหว่างอัตราการสูดหายใจเข้าต่ำ และสูง ต่อความจุปอด กำลังกล้ามเนื้อหายใจ และ ระดับความเหนื่อย หลังการผ่าตัดหัวใจ. ปริญญานิพนธ์ วท.ม. (กายภาพบำบัด) กรุงเทพฯ: บัณฑิตวิทยาลัย มหาวิทยาลัยศรีนครินทรวิโรฒ. อาจารย์ที่ปรึกษาปริญญานิพนท์: ผู้ช่วยศาสตราจารย์ ดร. สุกัลยา กฤษณเกรียงไกร.

การศึกษานี้มีจุดประสงค์เพื่อเปรียบเทียบผลของการฝึก flow oriented incentive spirometry ระหว่างอัตราการสูดหายใจเข้าต่ำ(LF), สูง (HF) และ การหายใจโดยใช้กระบังลม ต่อความจุปอด กำลังกล้ามเนื้อหายใจ และ ระดับความเหนื่อย ในผู้ป่วยหลังการผ่าตัดหัวใจ 63 คน ผู้เข้าร่วมการศึกษานี้จะถูกสุ่มเข้าสู่แต่ละกลุ่ม กลุ่มละ 21 คน กลุ่มแรกคือกลุ่ม LF กลุ่มที่สองคือกลุ่ม HF และ กลุ่มควบคุม โดยตัวแปรทุกตัวแปรนั้นจะถูกวัด ก่อนและหลังการผ่าตัด ตั้งแต่วันที่ 1 ถึงวันที่ 6 ซึ่งข้อมูลจะถูกวิเคราะห์โดยใช้สถิติ two-way repeated ANOVA ผลการศึกษาพบว่า ความจุปอดของทั้งสามกลุ่มนั้นลดลงอย่างมีนัยสำคัญทางสถิติในวันแรกหลังการผ่าตัด แล้วจึงเพิ่มขึ้นใกล้เคียงกับค่าความจุปอดก่อนเข้ารับการผ่าตัดในวันที่ 6 หลังการผ่าตัด กำลังกล้ามเนื้อหายใจมีการลดลงในวันแรกเช่นเดียวกัน โดยกำลังกล้ามเนื้อหายใจเข้าของกลุ่ม LF นั้นมีการเพิ่มขึ้นจนกลับสู่ค่าที่วัดได้ก่อนการผ่าตัดในวันที่ 5 หลังการผ่าตัด (p=0.099) กลุ่มควบคุมนั้นกลับเข้าสู่ค่าที่วัดได้ในวันที่ 6 หลังการผ่าตัด (p=0.536) ในส่วนของกำลังกล้ามเนื้อหายใจออกของกลุ่ม LF และกลุ่มควบคุมนั้นมีกำลังกล้ามเนื้อหายใจเพิ่มขึ้นไม่ต่างจากก่อนการผ่าตัดในวันที่ 6 หลังการผ่าตัด แต่กลุ่ม HF นั้นมีการเพิ่มขึ้นของกำลังกล้ามเนื้อหายใจเข้าและออก แต่ยังไม่มีความต่างจากค่าที่วัดได้ก่อนการผ่าตัดในวันที่ 6 หลังการผ่าตัด (p=0.012) ระดับความเหนื่อยมีการเพิ่มขึ้นในวันแรกหลังการผ่าตัดในทุกกลุ่ม และลดลงเรื่อยๆ ในวันต่อมา ซึ่งกลุ่ม HF นั้นมีระดับความเหนื่อยไม่แตกต่างจากก่อนการผ่าตัดในวันที่ 5 หลังการผ่าตัด (p=0.418) และกลุ่ม LF มีระดับความเหนื่อยไม่แตกต่างจากก่อนการผ่าตัดในวันที่ 6 หลังการผ่าตัด (p=0.173) แต่กลุ่มควบคุมนั้นยังคงมีระดับความเหนื่อยแตกต่างจากก่อนการผ่าตัดในวันที่ 6 หลังการผ่าตัด (p=0.016) การศึกษาครั้งนี้สรุปได้ว่าการฝึก IS ด้วย LF หรือ HF มีผลต่อความจุปอดไม่แตกต่างจากการฝึกหายใจโดยใช้กระบังลม การฝึก IS ด้วย LF สามารถเพิ่มกำลังกล้ามเนื้อหายใจได้เร็วกว่าการฝึกแบบอื่น ระดับความเหนื่อยของการฝึก IS ด้วย HF ลดลงได้เร็วกว่าการฝึก IS ด้วย LF หรือการฝึกหายใจโดยใช้กระบังลมแม้ว่าระดับความปวดของการฝึก IS ด้วย HF จะยังคงสูงกว่า และการฝึก IS อาจช่วยป้องกันภาวะแทรกซ้อนทางปอดหลังการผ่าตัดหัวใจได้ดีกว่าการฝึกหายใจโดยใช้กระบังลม

The thesis titled

“Comparison between low and high inspiratory flow rate of incentive spirometry on lung volume, respiratory muscle strength and dyspnea score after cardiac surgery”

By

Sa-nit Homruen

Has been approved by the Graduate School as partial fulfillment of the requirements for the Master of Science Program in Physical Therapy of Srinakharinwirot University.

…… Dean of Graduate School

(Asst. Prof. Dr. Chatchai Ekpanyaskul)

December 2559

Thesis Committee Oral Defense Committee

..... Major-advisor .....Chair

(Asst. Prof. Dr. Sukalya Kritsnakriengkrai) (Assoc.Prof. Suwannee Jarungjitaree)

.....Committee

(Asst. Prof. Dr. Sukalya Kritsnakriengkrai)

.....Committee

(Dr. Kanogwun Thongchote)

Acknowledgements

This thesis would not have been possible without the guidance and the help of several people contributed in the completion of this study. First of all, I would like to express my thankful to my thesis advisor, Asst. Prof. Dr. Sukalya Kritsnakriengkrai, who offered her advice.

I would like to acknowledge the Central Chest Institute of Thailand for the facility support.

I sincerely thank to all of volunteers for devoting time to participate in this thesis. Finally, I would like to express my deepest gratitude to my friends from the Central Chest Institute of Thailand for support.

Sa-nit Homruen

TABLE OF CONTENTS

TABLE OF CONTENTS (continue)

TABLE OF CONTENTS (continue)

LIST OF TABLES

LIST OF FIGURE

LIST OF FIGURE (continue)

CHAPTER 1

INTRODUCTION

Background

Coronary artery disease is amount of blood supplying the cardiac muscles with oxygen and energy. The cardiac muscle may ischemia and infarction, that effect to increase cardiac workload and induce cardiac muscles injury. Valvular heart diseases are the abnormal structure of heart valve that effect to the cardiac output, stroke volume and may be effect to blood circulation. The common treatment to correct heart diseases is the cardiac surgery.

Cardiac surgery is the surgical treatment of heart disease conditions including coronary artery bypass grafting (CABG), correcting congenital heart disease, or treating valvular heart disease[1].

Median sternotomy is a common incision to open the thorax and induces respiratory dysfunction [2]. Patients undergoing cardiac surgery often develop pulmonary dysfunction with a significant reduction in lung volume and decrease respiratory muscle strength [3-4]. Atelectasis is the main pulmonary complication of postoperative cardiac surgery which associated with reduced lung capacity [5]. Thoracic surgery causes diaphragm muscle fiber weakness [6] resulting in decreasing inspiratory muscle strength [7]. Lung mechanics changing caused by the postoperative fear and pain which affecting the performance of periodic deep inspiration and effective cough that allowed accumulating secretion, collapsing lung and reducing gas exchange [8-12].

Physical therapy treatments for cardiac surgery patients are integral part in managing the care of patients. Both in pre and post operatively physical therapy contribute a significantly better prognosis. The preoperative physical therapy techniques aim to prevent pulmonary complications, and the postoperative management is to improve pulmonary expansion and bronchial hygiene [3-4, 12-14].

Incentive spirometry is commonly used for preventing and managing the postoperative pulmonary complications in cardiac surgery [15]. It is widely used in hospitals because of its low cost and easy to use. It is encourage through visual feedback to deep inspiration until total lung capacity and sustain at maximal inspiration (SMI). The maximal inspiration causes an

increase in lung volume. During inspiration period, inspiratory muscles are working to expand lung, it means that during the use of incentive spirometer, respiratory muscles are being trained.

The different types of devices, volume and flow oriented incentive spirometers are currently available. Volume oriented incentive spirometer actually measure and visually indicate the volume achieved during the SMI. Flow oriented incentive spirometer, on the other hand, measure and visually indicate inspiratory flow.

Several studies investigated the effect of using flow and volume oriented incentive spirometers on breathing pattern and showed that there were larger abdominal motion [16] and greater diaphragmatic mobility [17] during the use of volume oriented incentive spirometer. During the use of flow oriented incentive spirometer showed higher respiratory frequency and sternocleidomastoid activity [18]. The result from previous studies seemed to show that the use of volume oriented incentive spirometer induced breathing pattern better than flow incentive spirometer. However, Chang et al. 2010, indicated that not the type of device but the inspiratory flow rate during the use of incentive spirometer was a significant factor determining the resultant of breathing pattern. The study showed that using incentive spirometry with low inspiratory flow rate resulted in greater abdominal wall motion than using with high inspiratory flow rates [19].

The Cochrane systematic review of preoperative physical therapy for cardiac surgery patients demonstrated that the preoperative physical therapy with an exercise component reduced postoperative pulmonary complication including atelectasis, pneumonia and reduced length of hospital stay [20]. Freitas et al. 2012, has updated the systematic reviews to compare the effect of incentive spirometry for preventing postoperative pulmonary complications in adults undergoing CABG. The results showed that there was no evidence of benefit from incentive spirometry when compared with preoperative education or standard physical therapy for preventing postoperative pulmonary complication and reducing length of hospital stay. There was evidence that incentive spirometry was better than intermittent positive pressure breathing (IPPB) in increasing respiratory muscle strength [21]. However, the systematic reviews suggested that currently available trials of incentive spirometry contributed little to making decision on it use because of the small number of studies and the methodological limitation. A

large randomized controlled trial (RCT) to assess the benefits of incentive spirometry in patients with CABG is needed.

Although the evidence has not strongly supported the use of incentive spirometry for preventing pulmonary complication after cardiac surgery, incentive spirometry is still widely used among health professionals. In Thailand, most cardiac surgery patients are provided flow oriented incentive spirometer. To date, there have been no studies on the effectiveness of low or high inspiratory flow rate of incentive spirometry in cardiac surgery patients. The purpose of the current study is to compare the use of flow oriented incentive spirometry between with high and low inspiratory flow rate, in order to demonstrate the appropriateness treatment of incentive spirometry in clinical practice.

Research question

Are the effects of using flow oriented incentive spirometer with low inspiratory flow rate different from the effects of using it with high inspiratory flow rate on lung volume, respiratory muscle strength and dyspnea score in cardiac surgery patients?

Objectives

1. To compare the effects of two inspiratory flow rates (high and low) of flow oriented incentive spirometry and control of deep breathing on lung volume: vital capacity (VC) in cardiac surgery patients.

2. To compare the effects of two inspiratory flow rates (high and low) of flow oriented incentive spirometry and control of deep breathing on respiratory muscle strength: inspiratory muscle strength (MIP) and expiratory muscle strength (MEP) in cardiac surgery patients.

3. To compare the effects of two inspiratory flow rates (high and low) of flow oriented incentive spirometry and control of deep breathing on dyspnea score in cardiac surgery patients.

Hypothesis

1. Training of flow oriented incentive spirometry with low inspiratory flow rate can increase lung volume (VC) more than training with high inspiratory flow rate and control of deep breathing.

2. Training of flow oriented incentive spirometry with low inspiratory flow rate can increase MIP and MEP more than training with high inspiratory flow rate and control of deep breathing.

3. Dyspnea score when training flow oriented incentive spirometry with low inspiratory flow rate and control of deep breathing are lower than training with high inspiratory flow rate.

CHAPTER 2

LITERATURES REVIEW

1. Cardiac surgery

Cardiac surgery is the surgery on the heart or great vessels performed by cardiac surgeons. Frequently, it is done to treat complications of ischemic heart disease and atherosclerosis by CABG and treat valvular heart disease from various causes including endocarditis, rheumatic heart disease [1].

Coronary artery disease is usually caused by a cholesterol deposits or plaques inside the artery. These plaques are also called atheromass and they cause a thickening of the arterial wall and a narrowing of the arterial space through which blood flows to reach the heart. The amount of blood supplying to cardiac muscles with oxygen and energy. The most common therapeutic options are medical therapy including lifestyle modification, percutaneous coronary intervention, and CABG.

CABG is a highly effective treatment of coronary artery disease other than medicine treatment, medical intervention (percutaneous coronary intervention, PCI) and non-surgical treatment. It is better expect long lasting treatment for angina, reduce the incidence of sudden cardiac death and make patients longer live. There are two procedure of surgery, the surgery using an artificial lung and heart assist called the on-pump CABG and the conventional CABG or standard CABG.

Valvular heart diseases may be caused by congenital deformities, infection or disease such as rheumatic fever or coronary thrombosis. The defect of the cardiac valve may become stenosis, insufficient or prolapsed. Stenosis is a narrowing or constriction of a valve that prevents the valve to open completely. The abnormal deposits and scar of leaflets are often the cause. Valvular stenosis obstructs blood flow and the cardiac must contract forcefully in order to sustain cardiac output. Insufficiency imply to regurgitation or a leak back of blood into the heart through a valve whose leaflets fail to close completely. The hypertrophy of valve is the cause. Valvular dysfunction increases the work of the heart, requiring the chamber to pump harder to force blood through a stenosis valve or maintain adequate flow if blood is seeping back. However, abnormal valve structure results in turbulent blood flow, which

increases the hemodynamic stress on structure and lead to progressive damage and dysfunction [1].

Median sternotomy is a type of surgical procedure in a vertical incision along the sternum. The sternum has to be retracted progressively to avoid fractures of the bones with excessive postoperative pain due to costovertebral joint strain. The sternopericardial ligaments are freed from the posterior surface of the sternum using a towel. If the patient have too spastic, the anaesthetist used another dose of muscle relaxant drug. The relaxant drug induces respiratory dysfunction and involves respiratory muscle weakness. The wires can either be placed parasternally or through the sternal bone. It is important to avoid an override or shift of the sternal edges by placing the wires at a proper distance from each other. The sternum is responsible for the stability of the chest, which is the precondition of respiration [2]. If the sternum is not stability, that was effect to the pattern of respiration. That made to corrupt sternocostal joint and costovertebral joint movement.

2. Post-operative pulmonary complication

The cardiac surgery carries on with a particularly high risk of pulmonary complications [4-5]. The postoperative respiratory complications have been shown significant postoperative morbidity and mortality [22-23]. The important complications are atelectasis and pneumonia [24-25] associated with the surgical process. Postoperative pulmonary complications are clinically significant alterations in pulmonary function [8] and decrease respiratory muscle strength [6].

The etiologies of these pulmonary complications related to the process of surgery are associated with the anesthesia, surgical trauma, time of surgery, duration of using mechanical ventilator and surgical pain. The most frequent pulmonary complications during anesthesia are adverse drug effects and inadequate ventilation of the lung. The inadequate ventilation may be caused by difficulty tracheal intubation and breathing system disconnection during anesthesia, the respiratory obstructions is the common cause of inadequate ventilation and impairs gas exchange. Obstruction may occur at any point from gas delivery system through the airway and bronchi to the expiratory parts of the breathing system. The commonest sites for obstruction are the larynx (laryngospasm), bronchi (bronchospasm). Therefore, the reduction of functional residual capacity (FRC) and hypoventilation that occur during anesthesia make alveolar collapse or atelectasis [26-27].

Sedative drug is commonly used for patients being on mechanical ventilation. Minimal sedation is a drug induced cognitive function and coordination which may impair but unaffected to ventilation and cardiovascular function. Moderate sedation is a drug induced depression and consciousness will be responds purposefully following verbal commands. Cardiovascular function is usually maintained but unaffected to airway and spontaneous ventilation. Deep sedative is a drug induced depression and consciousness but will be responded purposefully following painful stimulation. The ability to maintain ventilator function independently may be impair and may require assistance in maintaining airway. Cardiovascular function is usually maintained. Sedative drug also produce a mild reduction muscle relaxant by reduction muscle tone.

Muscle relaxant drugs are the part of drug used in surgical process. Muscle relaxant drugs acts by blocking the function of the nicotinic receptor at neuromuscular junction and response to reduction muscle tone which implied to decrease the respiratory muscle strength [28].

The pain and fear of pain resulting from the surgical wound affect the performance of deep inspiration and effective coughing, which are associated with the changes in lung mechanics [8-9, 24, 29]. Postoperative sternal pain is commonly reported during hospital stay [8-10] and a worsening of pain correlates with the decreasing lung function and maximal inspiratory pressure (MIP) during 1st postoperative days [9].

3. Physical therapy for cardiac surgery

The physical therapy treatments for cardiac surgery patients are integral part in managing the care of patients. Both in pre and post operatively physical therapy contribute a significantly better prognosis. Before heart surgery, patients will receive pre-operative extensive education by the doctors, nurse and physical therapist. The preoperative physical therapy involves education and management for preventing postoperative pulmonary complication, including breathing training, coughing training, ambulation training and incentive spirometry. The postoperative physical therapy program is to prevent complications, decrease hospital length of stay and mortality from multiple factors including correct the ventilation by breathing exercise, improve lung volume by incentive spirometry, decrease secretion retention

by techniques for bronchial hygiene, and activate the activities of daily living (ADL) by early mobilization [12, 30].

There are several physical therapy techniques used for bronchial hygiene in cardiac surgery patient with median sternotomy. Coughing is the key in clearing the mucus of airways. A forced but not strained expiration, following a deep inspiration, may help a person cough. Huffing was a type of cough. It also involves taking a breath in and actively expiration. It is not a forceful as a cough but less tiring. Autogenic drainage was a respiratory self-drainage technique that utilizes controlled expiratory airflow as tidal breathing to mobilize secretions. Active cycle breathing technique (ACBT) was a simple technique of breathing to loosen and clear sputum, to improve ventilation and to maintain the lungs in good condition [31].

The Cochrane systematic review of preoperative physical therapy for cardiac surgery patients demonstrated that the preoperative physical therapy with an exercise component reduced postoperative pulmonary complication including atelectasis, pneumonia and reduced length of hospital stay [20].

4. Incentive spirometry

Incentive spirometer was constructed to increase the performance of the lung [32] and maintains the alveolar stability [33-35]. Maximal inspirations during performing incentive spirometer cause an increase in lung volume and an end inspiratory pause maintains the alveolar stability.

The procedures of training with incentive spirometry are normally slow inspiration to raise the ball and sustain maximal inspiration until total lung capacity [36]. Frequency and duration of using incentive spirometry are varied. Some suggestions have been made in clinical trials. Rafea et al. 2009 recommended 10 breaths every 1-2 hours during awake [37]. Renault et al. 2009 recommended 10 breaths 5 times a day [38] and Kundra et al. 2010 recommended 15 breaths every 4 hours [39]. On average of training with incentive spirometry from the previous studies are about 60 breaths per day.

4.1 Type of incentive spirometer

Incentive spirometer devices can generally be categorized as volume oriented devices and flow oriented devices.

4.1.1 Volume Oriented Device

A volume oriented incentive spirometer device is a true volume displacement incentive spirometry. A corrugated large-bore breathing hose and mouthpiece connect the patient to a flexible plastic bellows. During inspiration, as the patient draws air through the breathing hose, the bellows rises, the indicator on the device enclosure indicates the volumetric displacement. Once it reaches its maximum displacement for a given breath, the patient has to hold the bellows in place for 5 to 10 seconds (the end-inspiratory hold). After completion of the maneuver, allow gravity to return the bellows to its initial starting position (40). Volume oriented incentive spirometer has been demonstrated that it increased abdominal movement more than flow-oriented incentive spirometer [16]. However volume-oriented is not available in clinical practice in Thailand.

4.1.2 Flow Oriented Device

A flow oriented incentive spirometer, balls are enclosed in three connected plastic flow tubes. As the patient inspiration through the mouthpiece, pressure drops and causes the ball in the first tube to rise to a level equivalent to the flow around it. Each tube is calibrated such that all displacement of its ball equals a specific flow, as indicated on the wall of the tube. As flow exceeds the maximum for the first tube, the ball in the second tube rises, followed by that in the third tube. To maintain an end-inspiratory hold with this type of device, the patient is instructed to keep the indicator balls elevated to full displacement for as long as possible [40]. Volume measurements derived from flow oriented incentive spirometers should be treated only as rough estimates of actual inspired volume [40]. Since there is no conclusive evidence to support the use of one type or brand of incentive spirometer device over others, the decision as to which equipment is best currently must be based on empirical assessment of patient acceptance, ease of use, and cost [36]. However, most hospitals in Thailand provide flow oriented incentive spirometer to the cardiac surgery patients.

4.1.3 Contraindications

4.1.3.1 Patients who cannot be instructed or supervised to assure appropriate use of the device.

4.1.3.2 Patients in whom cooperation is absent or patients unable to understand or demonstrate proper use of the device such as very young patients and others with developmental delays, patients who are confused or delirious and heavily sedated or comatose.

4.1.3.3 Incentive spirometry is contraindicated in patients unable to deep breathe effectively due to pain, diaphragmatic dysfunction, or opiate analgesia.

4.1.3.4 Patients unable to generate adequate inspiration with a vital capacity 10 mL/kg or an inspiratory capacity 33% of predicted normal.

4.2 Comparison between volume and flow oriented incentive spirometry

Several studies have been conducted on the effect of volume oriented and flow oriented incentive spirometry on breathing pattern in healthy subjects. Parreira et al. 2005 showed that abdominal motion was larger during the use of volume oriented incentive spirometry compared to flow-oriented incentive spirometry [16]. Yamaguti et al. 2010 also showed that performing volume oriented incentive spirometry or diaphragmatic breathing exercise promoted greater diaphragmatic mobility than performing with flow oriented incentive spirometry [17]. The study of Tomich et al. 2007 demonstrated that during the use of flow oriented incentive spirometry showed higher respiratory frequency and sternocleidomastoid activity than the use of volume oriented incentive spirometry [18]. Rafea et al. 2009 demonstrated that training with volume oriented incentive spirometry improved FVC and FEV_1 more than flow oriented incentive spirometry training at the 7^{th} day after upper abdominal surgery [37]. From the results of the previous studies almost showed better outcomes of the volume oriented incentive spirometry than flow oriented incentive spirometry.

4.3 Comparison between high and low inspiratory flow rates of flow oriented incentive spirometry

Recently, Chang et al. 2010 indicated that the type of incentive spirometer, flow or volume, had little effect on breathing pattern. The inspiratory flow rate used during the use of incentive spirometry is the most significant factor. High inspiratory flow rates resulted in greater chest wall motion than low inspiratory flow rates, while low inspiratory flow rate increased abdominal wall motion more than high inspiratory flow rate (19). Therefore, the current study was designed to investigate the effect of different inspiratory flow rate of the flow oriented incentive spirometry.

4.4 Effect of incentive spirometry for postoperative pulmonary complication

Several studies have been evaluated the efficacy of incentive spirometry for postoperative pulmonary complication. Jenkins et al. 1989 showed that the addition of incentive spirometry to a regimen of early mobilization, huffing and coughing confers no extra benefit after uncomplicated CABG [(41)]. Crowe et al 1997, showed that the addition of incentive spirometry to physical therapy could not reduce atelectasis when compared to physical therapy alone [(42)]. Matte et al. 2000 showed that the incentive spirometry could prevent pulmonary complication after CABG [(43)]. The study of Oikkonen et al. 1991, showed that the incentive spirometry decreased the incidence of atelectasis after cardiac surgery [(44)]. Savci et al. 2006, showed that the incentive spirometry decreased atelectasis and increased aerated lung area after cardiac surgery [(45)]. The results of the effect of incentive spirometry were inconclusive in decreasing the post-operative pulmonary complication. The updated systematic reviews of the effect of incentive spirometry in adults undergoing CABG showed that there was no evidence of benefit from incentive spirometry when compared with preoperative education or standard physical therapy for preventing postoperative pulmonary complication and reducing length of hospital stay [(21)]. However, the systematic reviews suggested that currently available trials of incentive spirometry contributed little to making decision on it use because of the small number of studies and the methodological limitation. A large RCT to assess the benefits of incentive spirometry in patients with CABG is needed.

4.5 Effect of incentive spirometry for respiratory muscle strength

When the patients perform incentive spirometry, the lung will expand in the period of deep inspiration and inspiratory muscles are working to expand the lung. These mean that during training with incentive spirometry, respiratory muscles are being trained. There are few studies investigated the efficacy of incentive spirometry for the respiratory muscle strength after cardiac surgery. Renault et al. 2009, showed that inspiratory muscle strength was significant decreased on the 1st postoperative day and it was recovery from 2nd to 7th postoperative day. The effect of incentive spirometry was not significant different when compared to deep breathing exercise [38]. Romanini et al. 2007, showed that the incentive spirometry group increased inspiratory and expiratory muscle strength after myocardial revascularization, when compare with intermittent positive pressure breathing group [46]. The systematic review contrast result from previous studies has shown that incentive spirometry no improvement in the muscle strength between groups who received IS demonstrated by maximal inspiratory pressure and maximal expiratory pressure [21].

5. Measurement of respiratory systems

5.1 Pulmonary function test

Pulmonary function tests is the most common measurement of lung function, specifically the amount of lung volume and air flow which are resulting from the inspiration and expiration. The measurement during slow inspiration and expiration composes of lung capacity and lung volume (Figure 1). Functional residual capacity (FRC) is the volume in the lungs at the end expiratory position. Vital capacity (VC) is the volume of air breathed out after the maximal inspiration. Residual volume (RV) is the volume of air remaining in the lungs after a maximal expiration. Inspiratory reserve volume (IRV) is the maximal volume that can be inhaled from the end inspiratory level. Tidal volume (TV) is the volume of air moved into or out of the lungs during quiet breathing. Inspiratory capacity (IC) is the sum of IRV and TV, and Expiratory reserve volume (ERV) is the maximal volume of air that can be exhaled from the end-expiratory position [47-48]. The VC is the capacity change of the lung between a full inspiration and a maximal expiration [48-49]. In normal individual, FVC is equal to VC. In the case of airway obstruction, FVC is lower than VC. The VC maneuver may be performed in different ways assessing during inspiratory maneuver, starting from end-tidal volume the

subject expires maximally and subsequently makes a full inspiration. The VC of Thai peoples are usually 2.4 - 4.8 liters depending on age and high. It reduces in obstructive and restrictive defects [49].

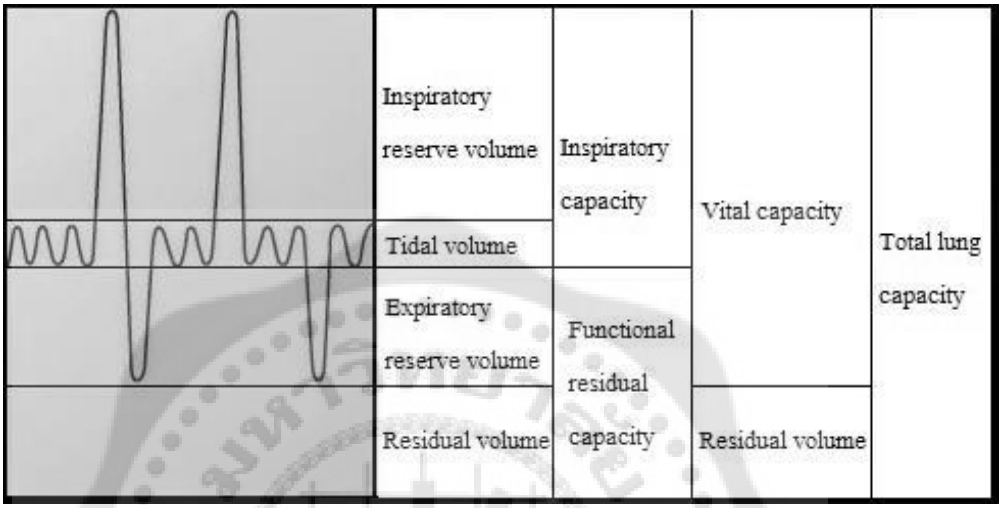


Figure 1 Normal spirogram [50]

5.2 Measurement of respiratory muscle strength

Respiratory muscle strength can be measured in airway pressure. Airway pressures are assessed by measuring the maximal inspiratory mouth pressure (MIP) and maximal expiratory mouth pressure (MEP). The pressure measured during these maneuvers reflects the pressure developed by the respiratory muscles, plus the passive elastic recoil pressure of the respiratory system including the lung and chest wall [48]. The values of MIP and MEP are an index of inspiratory and expiratory muscle strength respectively [51-52].

5.3 Dyspnea score

Borg's scale is commonly used for assessing dyspnea in cardiac surgery patient [53]. Borg's scale consists of a vertical scale labeled 6 to 20 with corresponding verbal expressions of progressively increasing sensation intensity and scale labeled also correlates with heart rate. For measurements of effort while using incentive spirometer, patients was instructed to point to the number on the Borg's scale that best indicated the intensity of their sensation of respiratory effort at that particular point in time. Dyspnea score in English and Thai version is shown in Appendix B.

CHAPTER 3

METHODS

1. Research Design

This study was a randomized controlled trial with double blind (subject and outcome assessor) and was registered in a publicly accessible clinical trial data base with the protocol number TCTR 20140528001.

2. Ethical consideration

This study was approved by the ethics committee of the Central Chest Institute of Thailand and approved on 7 January 2014.

3. Population

The participant admitted valvular disease or CABG surgery with median sternotomy for correcting disease. Patients were uncomplicated cardiac event, age equal or more than 40 years old, all gender was included, good communication and cooperation. Participants were excluded from this study if they had respiratory diseases, hemodynamic instability and the especially was undergoing invasive mechanical ventilation supports for a period exceeding 24 hours after admission to the intensive care unit.

4. Research setting

This research was set at the Central Chest Institute of Thailand, Nonthaburi, Thailand.

5. Sample size calculation

G Power program was used to calculate the sample size in this study. ANOVA with Repeated measures and interactions within-between factors was used to calculate with an expected statistical power of 0.8, alpha error probability of 0.05 and effect size of 0.29 (calculated from Chang et al. 2010). The determined sample size for this study was 42 subjects. 50% drop-out rate should be concerned and then in totally 63 patients or 21 patients per group were recruited.

6. Sampling techniques

The participants in this study were randomly by computer generated numbers and sealed envelopes and allocated into three groups (control group, low inspiratory flow rate group and high group)

7. Variable

Independent variable: two inspiratory flow rates (low and high) of flow-oriented IS

Dependent variable: VC, MIP, MEP, Dyspnea score

Control variable: physical therapy treatment

8. Outcome measures

Primary outcomes: VC, MIP, MEP and Dyspnea score

Secondary outcomes: length of hospital stay, pain score

9. Materials and research tools

Lung volume was measured using KoKo Spirometer from Feraris Respiratory, Inc., USA. The Respiratory muscle analyzer (RPM) from Micro Medical Ltd. England used to measure the respiratory muscle strength. Dyspnea score was rated using rate of perceived exertion (Borg's scale) chart**.** Visual analog scale (VAS) was used to rate of pain score. Flow oriented incentive spirometer used in this study was Triflo II. Teleflex medical. USA.

10. Intervention

All patients were received physical therapy treatment once a day at post-operative period.

Post-operative physical therapy treatment includes:

Day 1: Diaphragmatic breathing exercise, cough training, ROM exercise and bed mobility.

Day 2: Diaphragmatic breathing exercises, exercise intervention in each groups, cough training, ROM exercise, bed mobility, sitting, standing with exercise and walking (distance 10-20 m.), if these was a problem secretion retention, postural drainage was provided.

Day 3: Same as day 2 and ROM exercises in sitting position, increase walking distance to 50-100 m.

Day 4: Same as day 3 and increase walking distance to 100-150 m.

Day 5: Same as day 4 and increase walking distant to 150-200 m. or as tolerate.

Day 6: Same as day 5 and increase walking distant to 150-200 m. or as tolerate, up-down stair and discharge planning (home program).

The LF group received low inspiratory flow rate of flow oriented incentive spirometry in sitting position. Participants performed a slow breath keeping only the first ball on the top (600 ml/sec) for 5 breaths per set, 3 sets per time, 4 times per day at around 9 am, 11 am, 14 pm and 16 pm.

The HF group received high inspiratory flow rate of flow oriented incentive spirometry in sitting position. Participants performed a slow breath keeping 3 balls at the top (more than 600 to 1200 ml/sec) for 5 breaths per set, 3 sets per time, 4 times per day same time.

The control group received only physical therapy treatment without incentive spirometry. They performed a slow deep breathing for 5 breaths per set, 3 sets per time, 4 times per day same time.

The patients would discharge on 6^{th} or 7^{th} post-operative day. If the participants had to admit more than 7-10 days, the complication and length of hospital stay were recorded.

11. Experimental procedure

Patients who underwent cardiac surgery in the Central Chest Institute of Thailand were recruited. Patients were explained the objectives and procedures of the study. If they agreed to participate, they had to sign a consent form. The patients were randomly assigned to three groups.

Control group received chest physical therapy treatment without incentive spirometry.

Low inspiratory flow rate group (LF) received chest physical therapy treatment with low inspiratory flow rate of incentive spirometry.

High inspiratory flow rate group (HF) received chest physical therapy treatment with high inspiratory flow rate of incentive spirometry.

The treatment was provided by experience physical therapists. Lung volume (VC), respiratory muscle strength (MIP and MEP), dyspnea score (Borg's RPE scale) and pain score (VAS) were measured at pre and the first day to the sixth day of post-operation. If patient did not discharge on the seventh day after operation, the complication and duration of hospitalization were recorded. All outcomes were measured by an investigator blinded to study group's assignment.

12. Outcome measurement

12.1 Pulmonary function

Pulmonary function test was performed with spirometry according to the ATS. VC was measured in sitting position. Participant breathed in and out through a mouth piece was applied. The participants were instructed to breathe slowly 1-2 breaths and take a slow maximal inspiration follow by a slow maximal expiration. The cycle should be repeated again about 3 times not more than 8 times. The best value was recorded.

12.2 Respiratory muscle strength

Respiratory muscle strength was measured using the technique proposed by ATS. Patients were in a sitting position, normal inspiration, connected to maneuver and breathing through a one-way tube with a small hole preventing closure of the glottis. The participant was breathing out slowed to residual volume and then a big deep inspiration against the maneuver for the MIP test. The participants were breathing in slowed to total lung capacity

and then take a big expiration against the maneuver for the MEP test. Each maneuver was sustained for at least 1 second. The cycle should be repeated again about 3 times not more than 8 times. The highest value was recorded.

12.3 Dyspnea score

Borg's RPE scale labeled 6-20 to predict rate of dyspnea after using incentive spirometer was asked from the patients. The score was recorded. Thai version of Borg's RPE scale which was cross translated is shown in appendix A.

12.4 Pain score

Pain perception of the surgical wound was evaluated from patients using visual analog scale (VAS). VAS in Thai version is shown in Appendix B.

13. Data Analysis

Data was analyzed using SPSS version 11.5 program. Normal distributions of all data were assessed using Kolmogorov-Smirnov. ANOVA was used to compare the general characteristic data and length of hospital stay between groups. Chi-Square test was used to compare number of gender between groups. Two-way Mixed ANOVA was used to compare the main effect of all outcome measures between pre-operative day and the 1^{st} to 6^{th} post-operative day within group and between groups. Pair-wise multiple comparisons were made using Bonferroni. Significant difference was set at $p<0.05$.

CHAPTER 4

RESULTS

Ninety-nine patients who admitted for cardiac surgery between April 2014 and August 2014 were invited to participate in the study and underwent screening for the research inclusion criteria. Thirty-six patients were excluded because of hemodynamic instability (high blood pressure, abnormal EKG, N=21), using mechanical ventilation supports for a period exceeding 24 hours after admission to the intensive care unit (N=12) and subject denial to participate in this study (N=3). Sixty-three participants were successfully randomized into group of 21 (Figure 2). The general characteristics tested were shown normal distribution. The comparisons of general characteristics between groups were not difference (Table 1). The underlying diseases found that the HT and DM or both. The cardiac surgeries are the CABG and valve surgery or both. The underlying diseases and operation procedures are show in Table 2

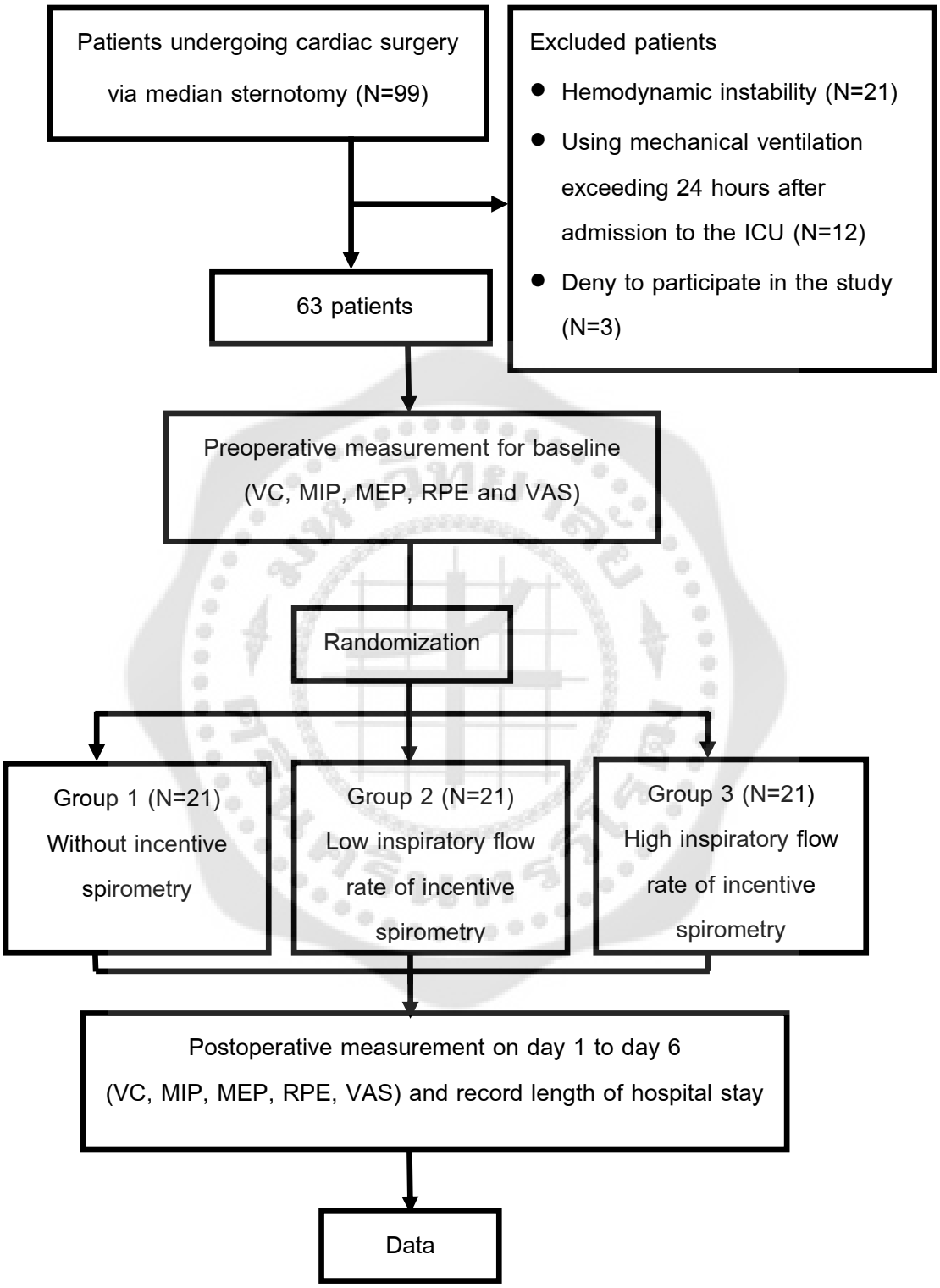


Figure 2 Flowchart demonstrating the research methodology

Table 1 Distribution of general characteristic and pre-operative data by groups

Variable	Control group (N=21)	LF group (N=21)	HF group (N=21)	P- values Between group
Men/ Women	14/7	13/8	9/12	1.00
Age (year)	60.38±8.26	55.28±9.87	56.0±9.64	0.16
Weight (kg.)	59.41±9.44	62.06±11.3	64.91±10.2	0.23
Height (cm.)	161.48±10.05	164.05±7.74	161.95±8.76	0.60
BMI (kg/m^2)	22.8±3.28	23.1±4.64	24.7±3.43	0.25
VC	63.00±19.29	68.24±11.80	63.33±19.47	0.50
MIP	46.45±17.68	61.10±26.96	60.62±29.00	0.15
MEP	62.23±20.10	66.67±27.73	60.00±25.01	0.68
Dyspnea score	6.29±0.72	6.62±1.50	6.95±1.63	0.28

Table 2 Distribution of underlying diseases and operation procedures by groups

Variable	Control group (N=21)	LF group (N=21)	HF group (N=21)
Underlying diseases			
No underlying disease	13	17	9
HT	5	3	6
DM	-	-	1
HT+DM	3	1	5
Operation procedures			
CABG	9	3	3
Valve surgery	10	17	16
CABG + Valve	2	1	2

HT: hypertension, DM: diabetic mellitus. CABG: Coronary arteries bypass grafting.

The vital capacity

The VC represents of the lung volume. There was a significant decrease on the 1st post-operative day and then gradually increasing over 6th day after operation ($p<0.01$). There were not significantly differences when comparing between three groups ($p<0.001$). The interaction between intervention and time failed to reach statistical significance ($p<0.001$).

The comparison between days and pre-operative day found that the 1st – 6th post-operative day were the significant decrease of vital capacity ($p<0.001$) in all 3 group. There was no significant difference when comparing between groups in all of the 6th days post-operation. The 1st and 2nd day in each group was not significant differences within groups ($p>0.05$) and between groups on 2nd post-operative day ($p=0.177$). The comparison between 2nd and 3rd days within groups were showed significant differences in control ($p<0.01$) and LF ($p<0.001$) groups, but not difference in HF ($p=0.10$). As well as the past, when comparison between groups were shown no significant difference between groups on the 3rd ($p=0.186$) post-operative day. The 3rd and 4th days were significant within all three group ($p<0.01$) but not significant difference between groups, when comparison on 4th post-operative day ($p=0.222$). The 4th and 5th were shown significant difference within the control group ($p=0.03$) but the other groups not shown the significant difference within groups ($p=1.000$) and between groups on 5th days ($p=0.124$). The 5th and 6th days were shown significant difference within the control group ($p=0.020$) but the other groups not shown the significant difference within groups ($p>0.05$) and between groups on 6th day ($p=0.270$).

On the 6th day, the patients were discharged from the hospital. The comparison between pre-operative and post-operative day 6th in each group were shown the significant difference within groups. All the groups were shown the coincided p-values ($p<0.01$).

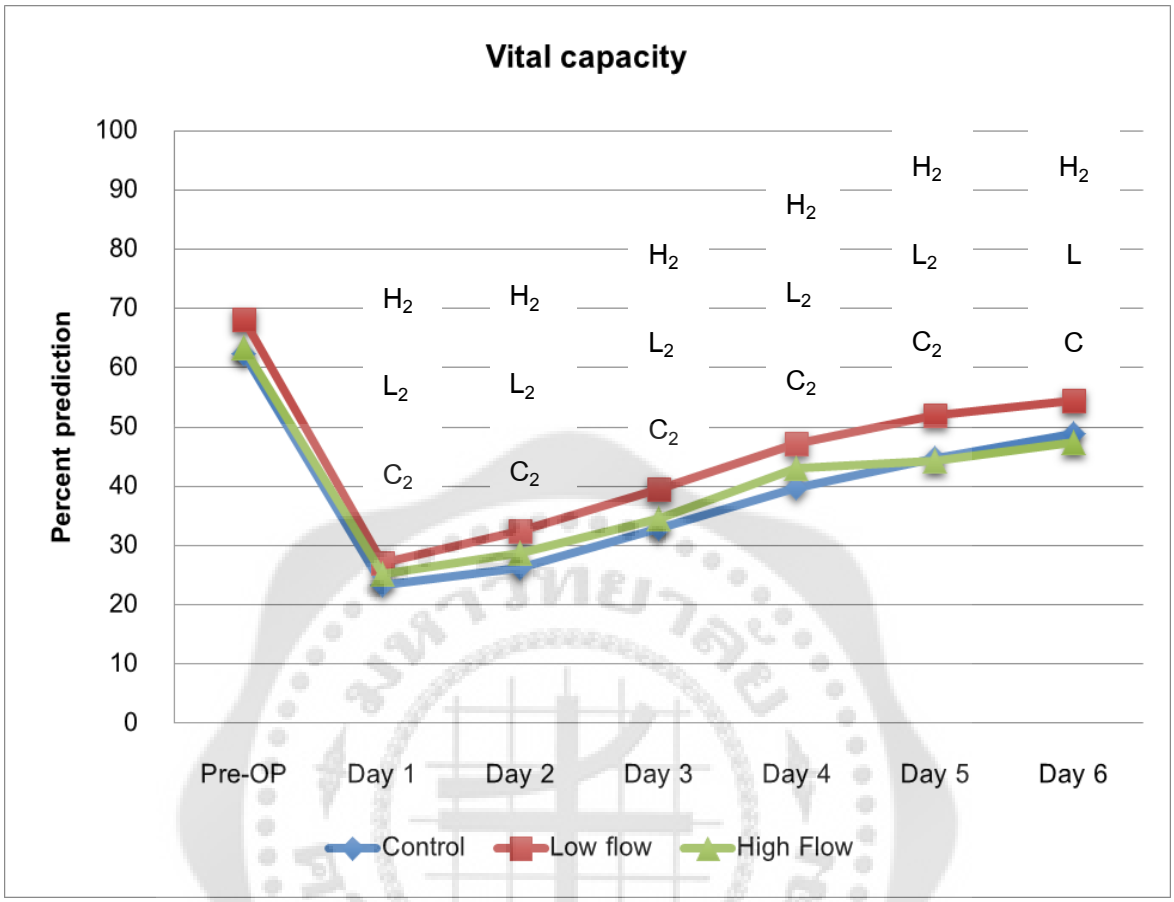


Figure 3 The comparison of VC from pre-operative day to the 6th post-operative day within and between groups

The p-value of significant difference:

Control group: (C) $p<0.05$, (C_1) $p<0.01$, (C_2) $p<0.001$

LF group: (L) $p<0.05$, (L_1) $p<0.01$, (L_2) $p<0.001$

HF group: (H) $p<0.05$, (H_1) $p<0.01$, (H_2) $p<0.001$

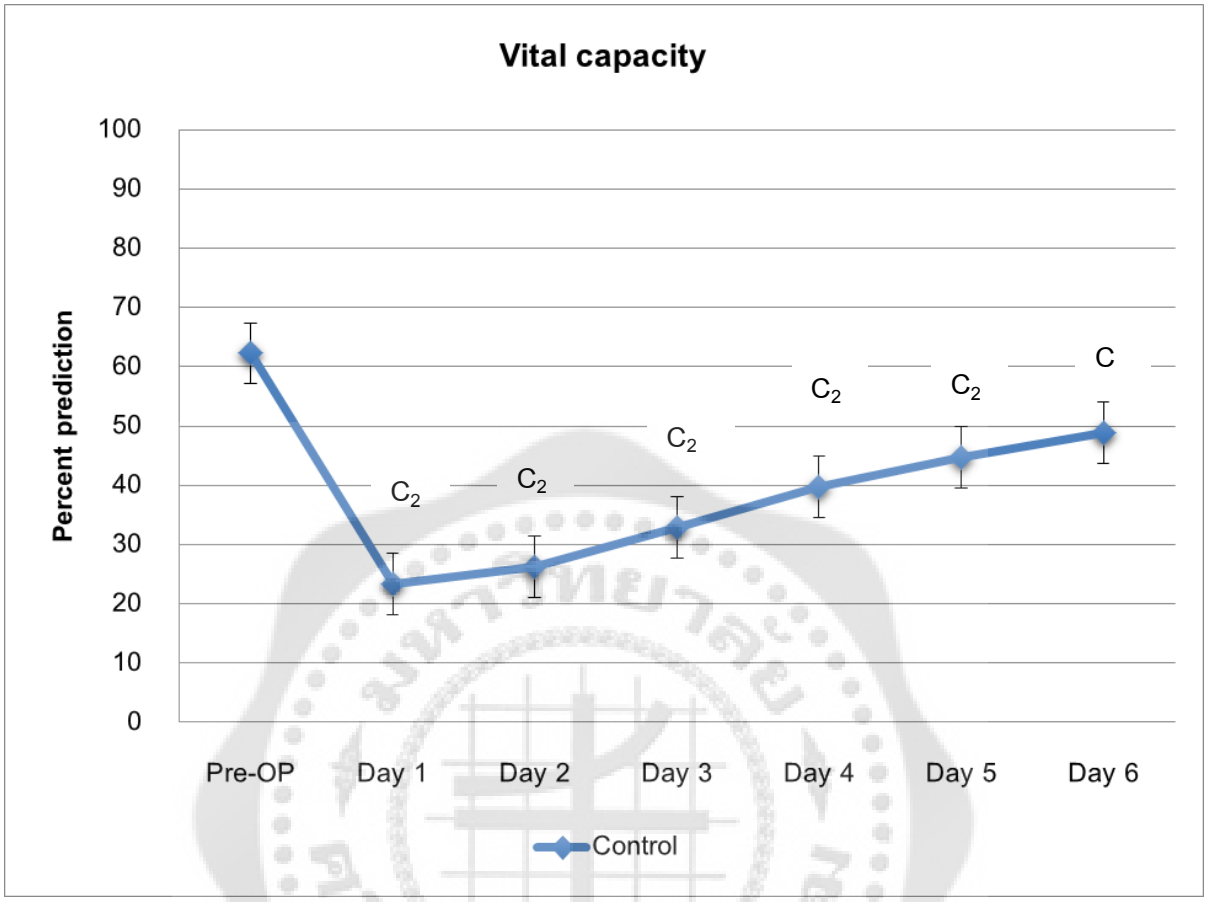


Figure 4: The comparison of VC from pre-operative day to the 6th post-operative day within groups of control group.

The p-value of significant difference: (C) $p<0.05$, (C1) $p<0.01$, (C2) $p<0.001$

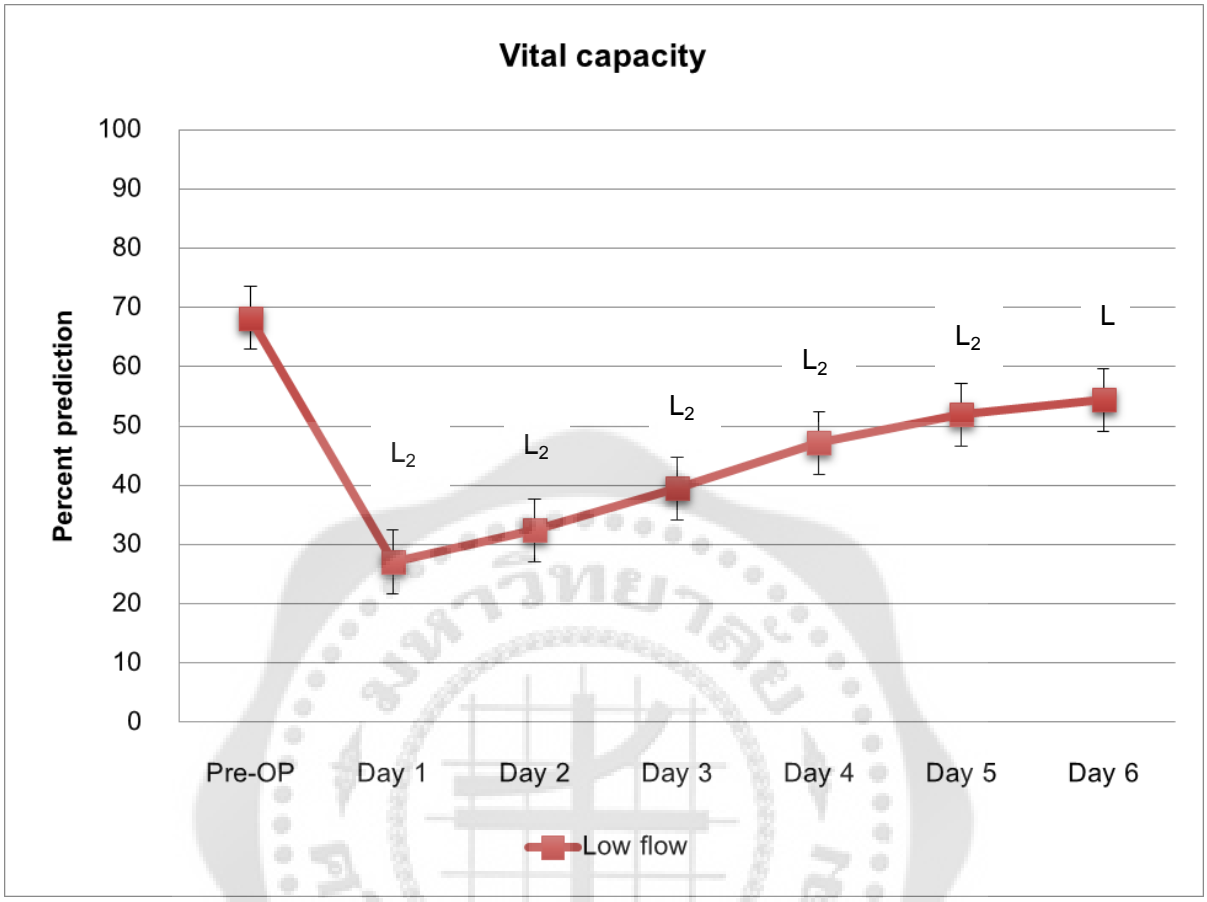


Figure 5 The comparison of VC from pre-operative day to the 6th post-operative day within groups of LF group.

The p-value of significant difference: (L) $p<0.05$, (L_1) $p<0.01$, (L_2) $p<0.001$

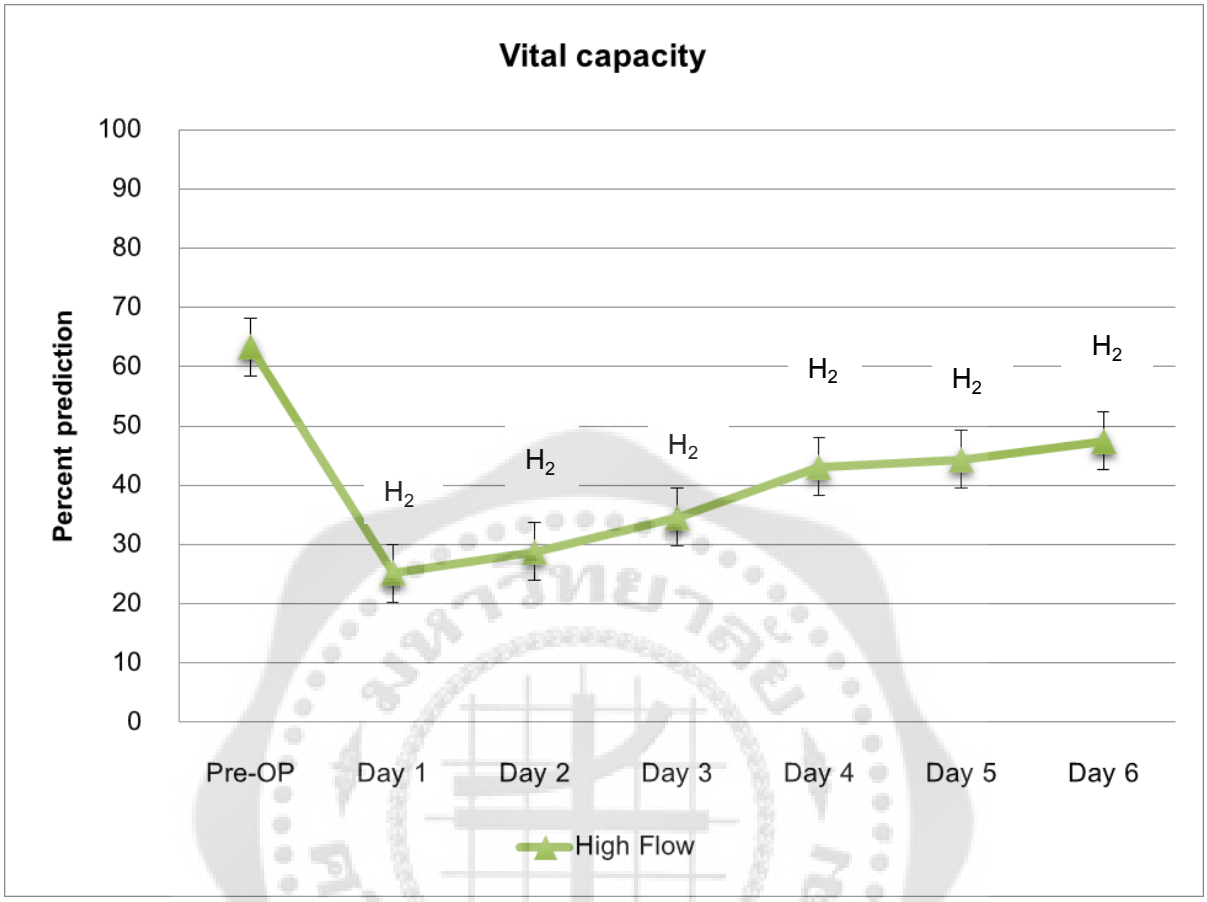


Figure 6 The comparison of VC from pre-operative day to the 6th post-operative day within groups of HF group.

The p-value of significant difference: (H) $p<0.05$, (H_1) $p<0.01$, (H_2) $p<0.001$

Table 3 The comparison between groups on each days of VC.

Day	Control group	LF group	HF group	p-value Between group
Pre-operative	63.00±19.29	68.24±11.80	63.33±19.47	0.496
Post-operative				
1st	23.77±7.98 ^{C2}	27.05±9.07 ^{L2}	25.14±7.41 ^{H2}	0.343
2nd	26.77±10.37 ^{C2}	32.38±10.73 ^{L2}	28.81±10.14 ^{H2}	0.177
3rd	33.05±11.16 ^{C2}	39.38±9.39 ^{L2}	34.62±13.47 ^{H2}	0.186
4th	39.55±14.25 ^{C2}	47.10±12.21 ^{L2}	43.05±13.74 ^{H2}	0.222
5th	44.77±14.42 ^{C2}	52.05±11.45 ^{L2}	44.38±13.97 ^{H2}	0.124
6th	49.18±15.94 ^{C}	54.33±10.46 ^{L}	47.38±15.92 ^{H2}	0.270

The p-value of significant difference:

Control group: (C) $p<0.05$, (C_1) $p<0.01$, (C_2) $p<0.001$

LF group: (L) $p<0.05$, (L_1) $p<0.01$, (L_2) $p<0.001$

HF group: (H) $p<0.05$, (H_1) $p<0.01$, (H_2) $p<0.001$

The respiratory muscle strength

The respiratory muscle strength demonstrated the dropped from pre-operative on the 1st post-operative day, but gradually increased up until the 6th post-operative day. The respiratory muscle strength of the LF and control group was return to baseline on the 6th post-operative day while the HF group was still significant lower than baseline. However there were not significantly differences when comparing between three groups (figure 7-14 and table 4-5).

The maximum inspiratory pressure

The maximum inspiratory pressure is representation of inspiratory muscle strength. The comparison of MIP between days within groups on pre-operative and the 1st post-operative day were shown the significant differences decrease within group ($p<0.01$) and not significant differences between the group on pre-operative day ($p=0.152$) and 1st post-operative day ($p=0.20$). The 1st and 2nd day in each group was not significant differences within groups ($p>0.05$) and between groups on 2nd post-operative day ($p=0.733$). The comparison between 2nd and 3rd days were not significant differences within all groups ($p>0.05$) and between groups on 3rd post-operative day ($p=0.32$). The 3rd and 4th days were significant within control ($p=0.02$) and LF group ($p<0.001$) but not significant difference in HF (HF: $p=0.078$) and between groups on 4th post-operative day ($p=0.057$). The 4th and 5th were not shown the significant difference within groups ($p>0.05$) and between groups on 5th days ($p=0.270$). The 5th and 6th days were not shown significant difference within all groups ($p>0.05$) and between groups on 6th day ($p=0.311$).

On the 6th day, before the patients were discharged from the hospital. The comparison between pre-operative and post-operative day 6th were not shown the significant difference within a control (C: $p=0.54$) and LF group (LF: $p=0.23$) but HF group was shown that the significant difference (HF: $p=0.03$).

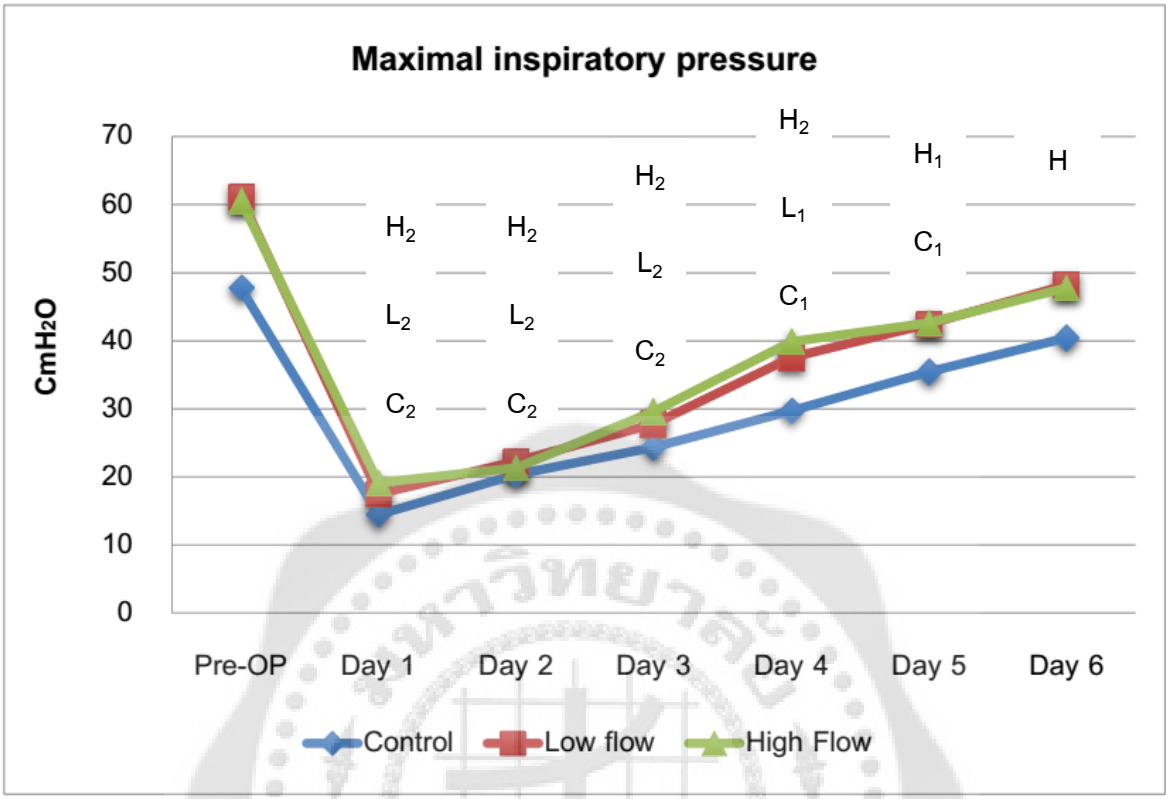


Figure 7 The change of MIP from pre-operative day to the 6th post-operative day within and between groups

The p-value of significant difference:

Control group: (C) $p<0.05$, (C_1) $p<0.01$, (C_2) $p<0.001$

LF group: (L) $p<0.05$, (L_1) $p<0.01$, (L_2) $p<0.001$

HF group: (H) $p<0.05$, (H_1) $p<0.01$, (H_2) $p<0.001$

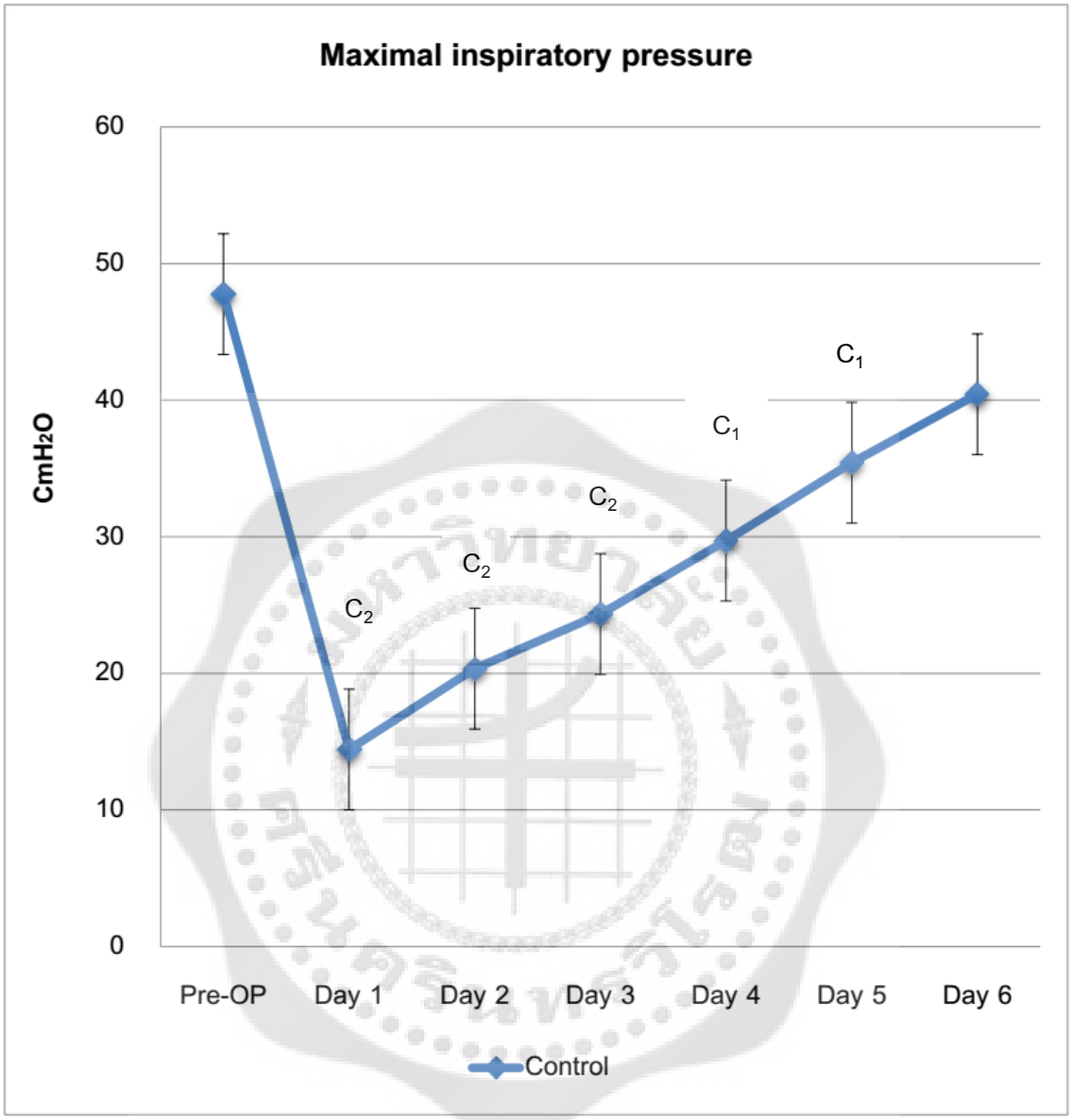


Figure 8 The comparison of MIP from pre-operative day to the 6th post-operative day within groups of control group.

The p-value of significant difference: (C) $p<0.05$, (C1) $p<0.01$, (C2) $p<0.001$.

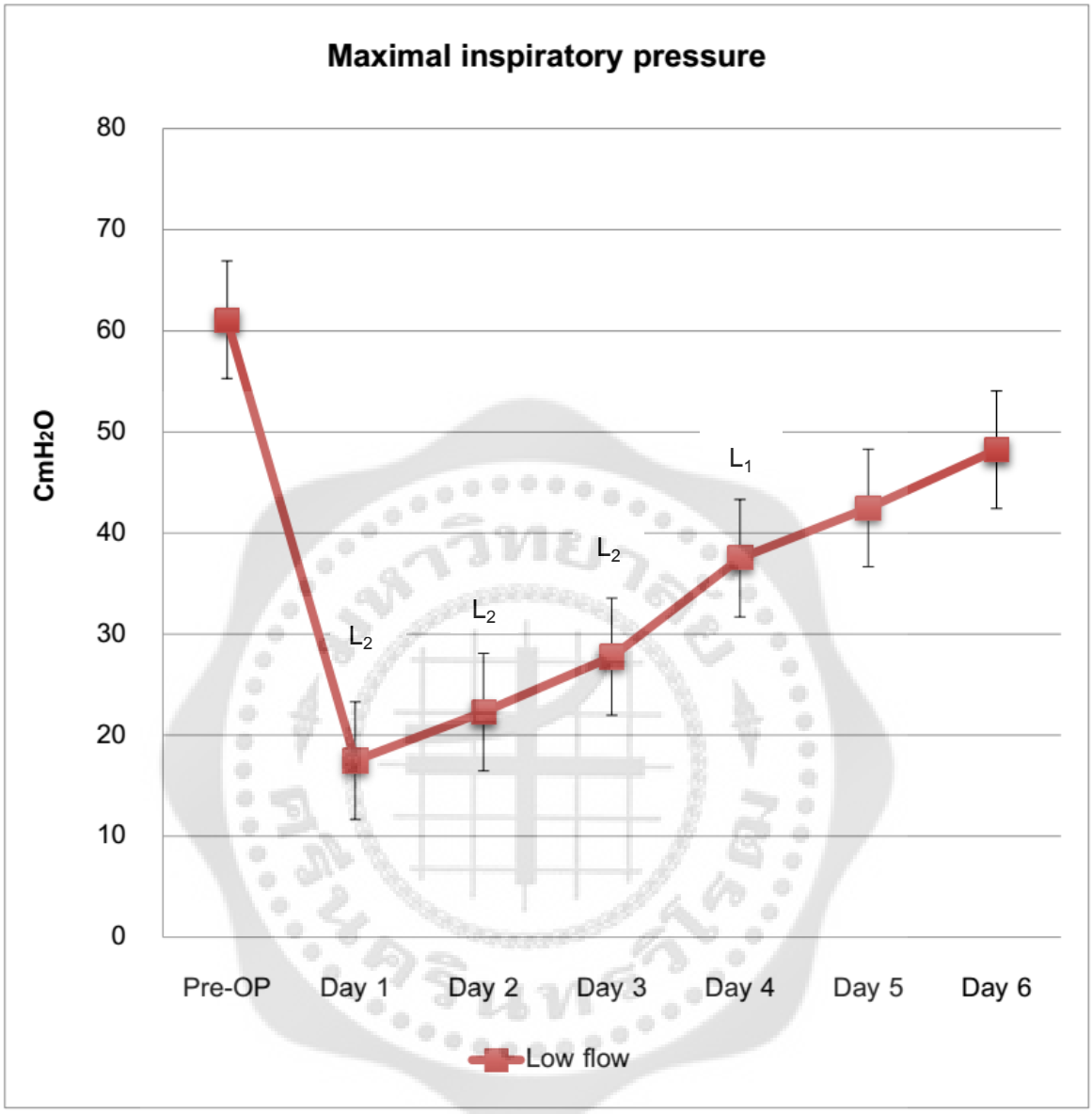


Figure 9 The comparison of MIP from pre-operative day to the 6th post-operative day within groups of LF group.

The p-value of significant difference: (L) $p<0.05$, (L_1) $p<0.01$, (L_2) $p<0.001$)

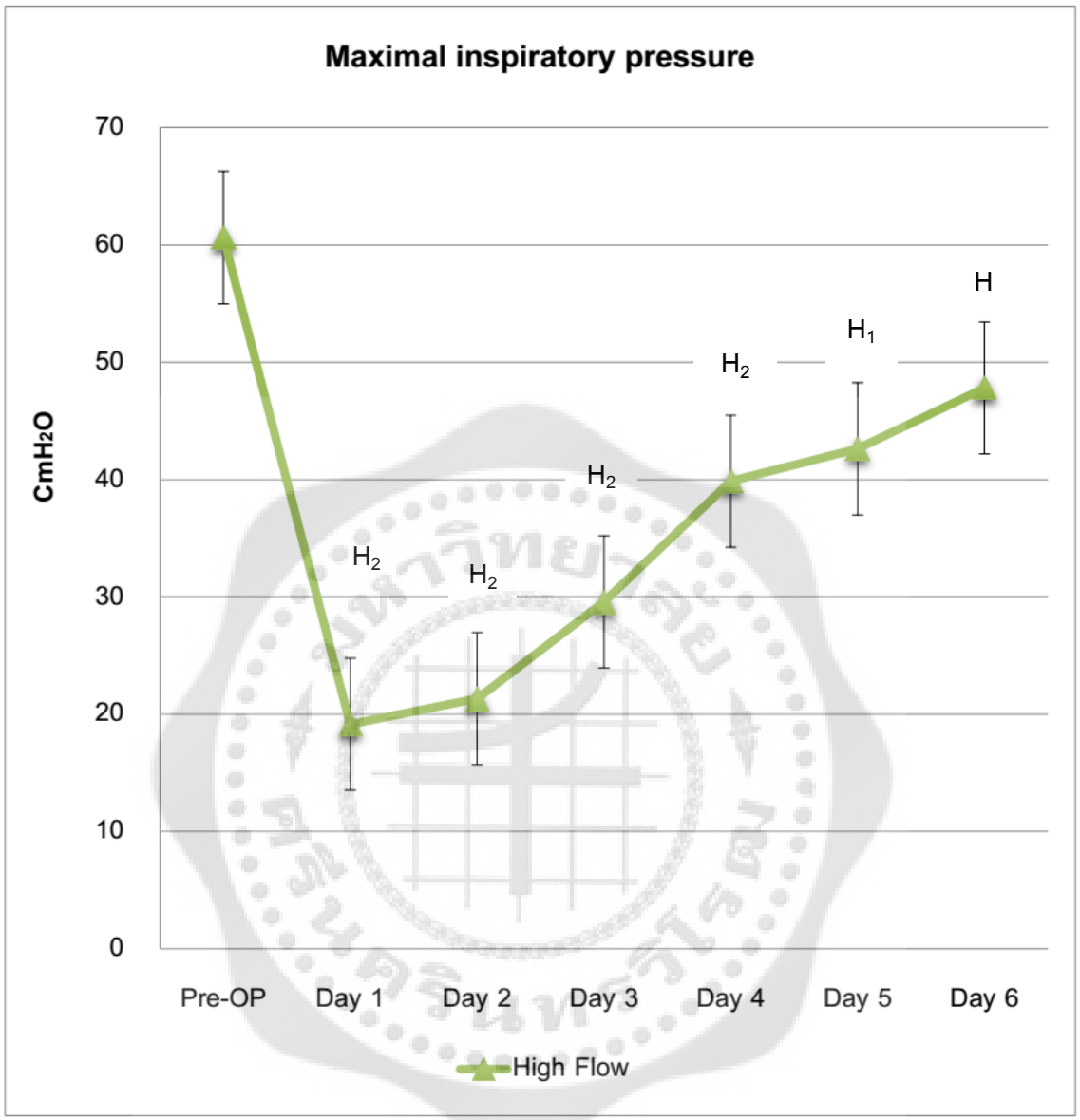


Figure 10 The comparison of MIP from pre-operative day to the 6th post-operative day within groups of HF group.

The p-value of significant difference: (H) $p<0.05$, (H_1) $p<0.01$, (H_2) $p<0.001$

Table 4 The comparison between groups on each days of MIP

Day	Control group	LF group	HF group	p-value Between group
Pre-operative	46.45±17.68	61.10±26.96	60.62±29.00	0.152
Post-operative				
1st	14.45±7.90 ^{C2}	17.48±6.54 ^{L2}	19.14±10.35 ^{H2}	0.196
2nd	21.00±9.10 ^{C2}	22.29±6.98 ^{L2}	21.33±8.17 ^{H2}	0.733
3rd	24.59±11.93 ^{C2}	27.76±6.33 ^{L2}	29.57±13.87 ^{H2}	0.317
4th	29.91±13.67 ^{C1}	37.52±8.96 ^{L1}	39.86±17.72 ^{H2}	0.057
5th	35.73±15.34 ^{C1}	42.48±12.77	42.62±19.70 ^{H1}	0.270
6th	40.91±15.61	48.24±15.58	47.81±22.94 ^{H}	0.311

The p-value of significant difference:

Control group: (C) $p<0.05$, (C_1) $p<0.01$, (C_2) $p<0.001$

LF group: (L) $p<0.05$, (L_1) $p<0.01$, (L_2) $p<0.001$

HF group: (H) $p<0.05$, (H_1) $p<0.01$, (H_2) $p<0.001$

The maximum expiratory pressure

The maximum expiratory pressure is representation expiratory muscle strength. The comparison of MEP between days within groups, pre-operative day and the 1st post-operative day were shown the significant differences decrease within each group ($p>0.05$) but not showed that the significant differences between group on pre-operative day ($p=0.675$) and the 1st post-operative day ($p=0.845$). 1st and 2nd day in each group was not significant differences within groups ($p>0.05$) and between groups on 2nd post-operative day ($p=0.791$). The comparison between 2nd and 3rd days were shown significant differences within LF group (LF: $p=0.02$) but not significant differences within control ($p=0.157$) and HF group ($p=1.000$) and between groups on 3rd post-operative day ($p=0.991$). The 3rd and 4th days were significant within LF group (LF: $p=0.018$) but not significant difference in control ($p=0.785$) and HF ($p=1.000$) and between groups on 4th post-operative day ($p=0.961$). The 4th and 5th were not shown the significant difference within groups ($p>0.05$) and between groups on 5th days ($p=0.979$). The 5th and 6th days were not shown significant difference within all groups ($p>0.05$) and between groups on 6th day ($p=0.924$).

On the 6th day, before the patients were discharged from the hospital. The comparison between pre-operative and post-operative day 6th were not shown the significant difference within a control (C: $p=0.221$) and LF group (LF: $p=0.121$) but HF group was shown that the significant difference (HF: $p=0.012$).

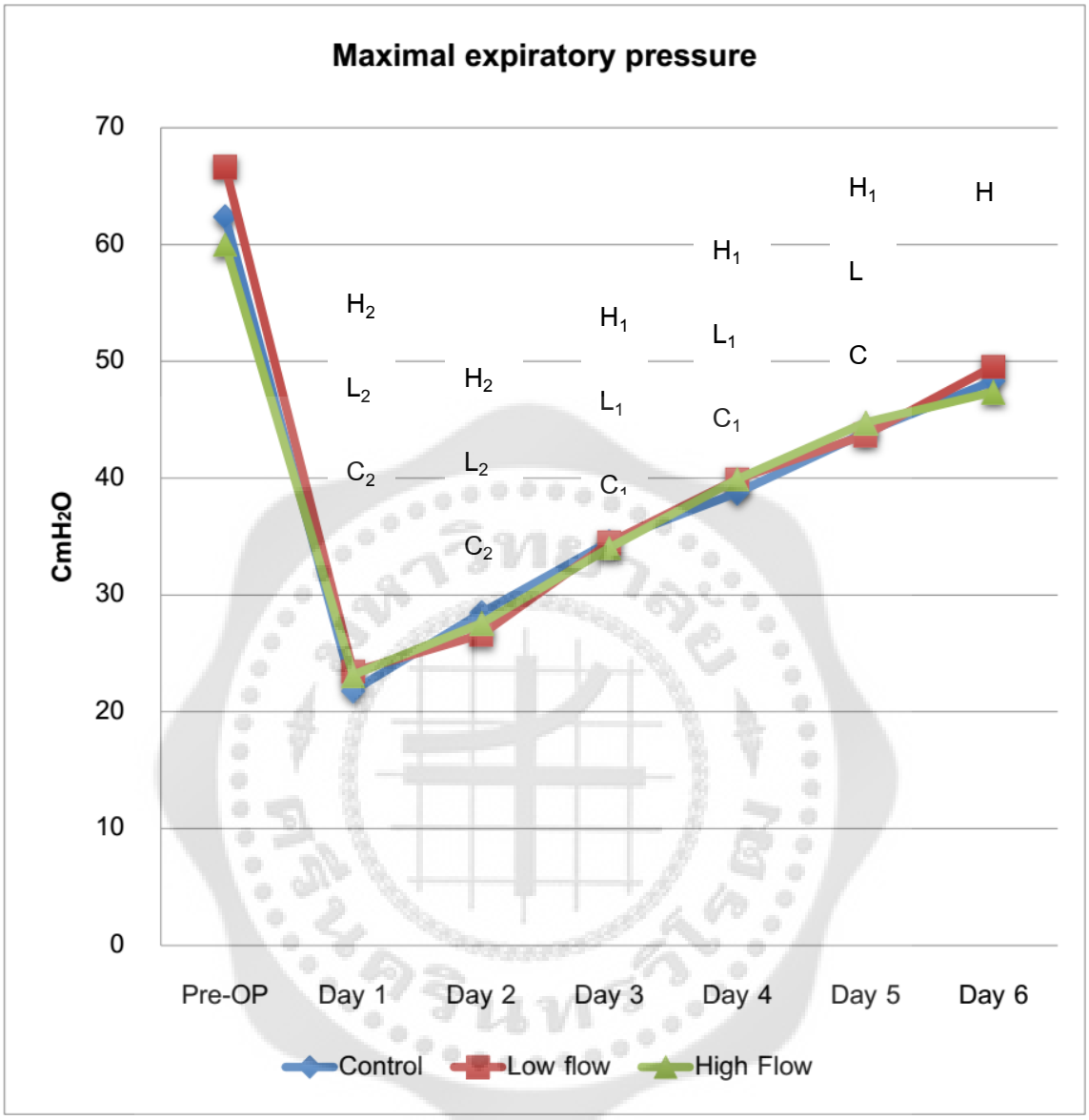


Figure 11 The change of MEP from pre-operative day to the 6th post-operative day within and between groups

The p-value of significant difference:

Control group: (C) $p<0.05$, (C_1) $p<0.01$, (C_2) $p<0.001$

LF group: (L) $p<0.05$, (L_1) $p<0.01$, (L_2) $p<0.001$

HF group: (H) $p<0.05$, (H_1) $p<0.01$, (H_2) $p<0.001$

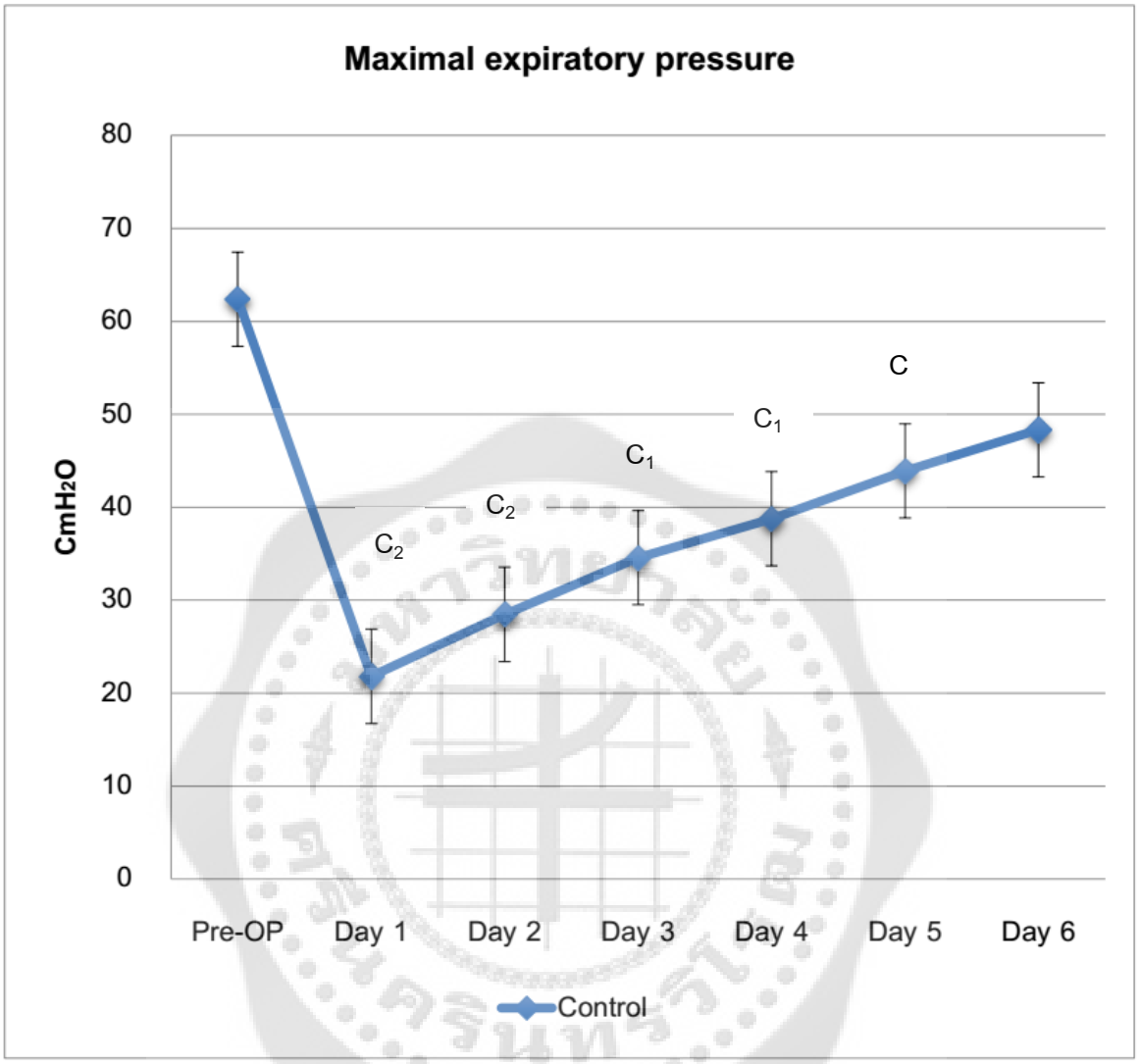


Figure 12 The comparison of MEP from pre-operative day to the 6th post-operative day within groups of control group.

The p-value of significant difference: (C) $p<0.05$, (C1) $p<0.01$, (C2) $p<0.001$.

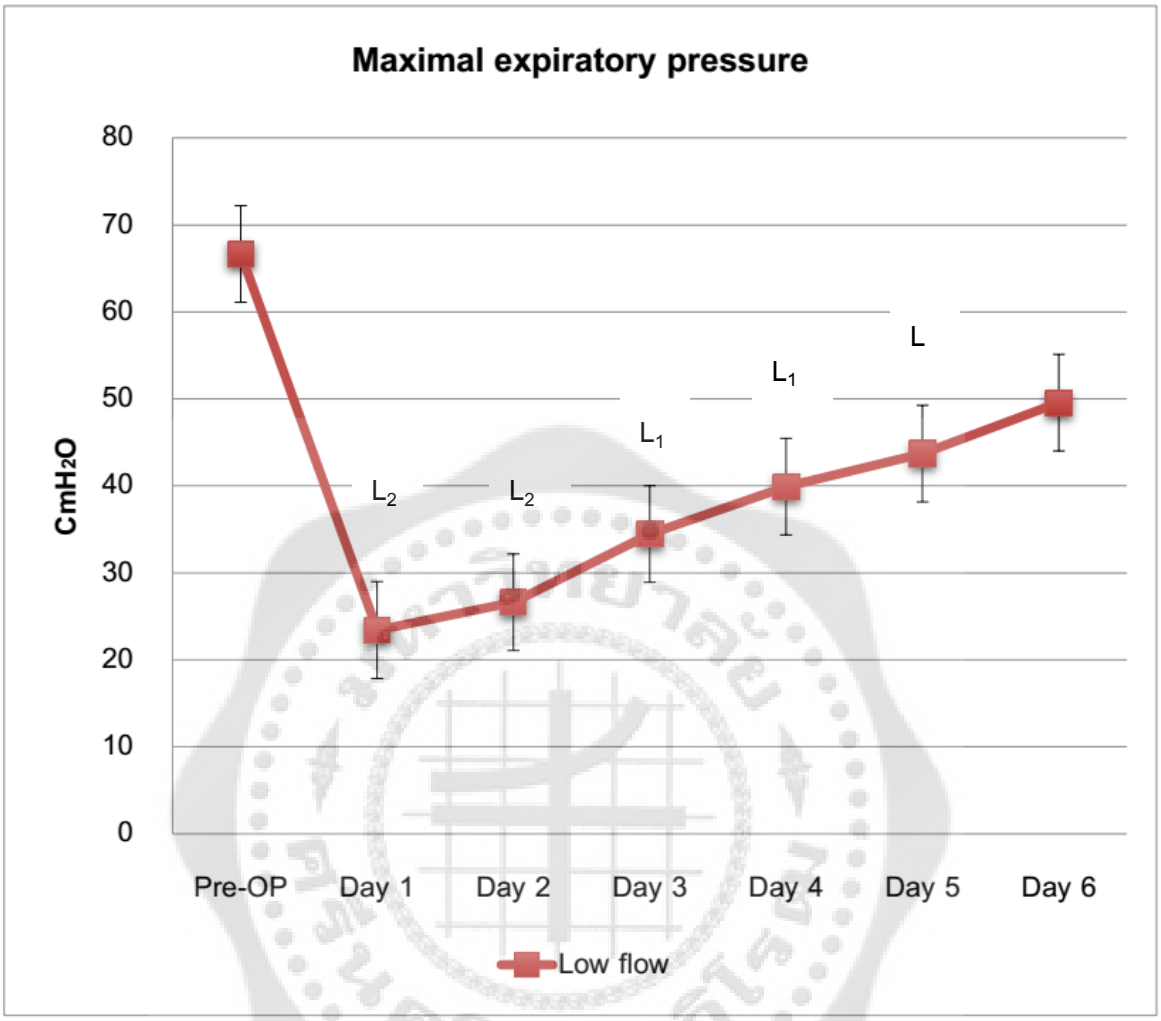


Figure 13 The comparison of MEP from pre-operative day to the 6th post-operative day within groups of LF group.

The p-value of significant difference: (L) $p<0.05$, (L_1) $p<0.01$, (L_2) $p<0.001$)

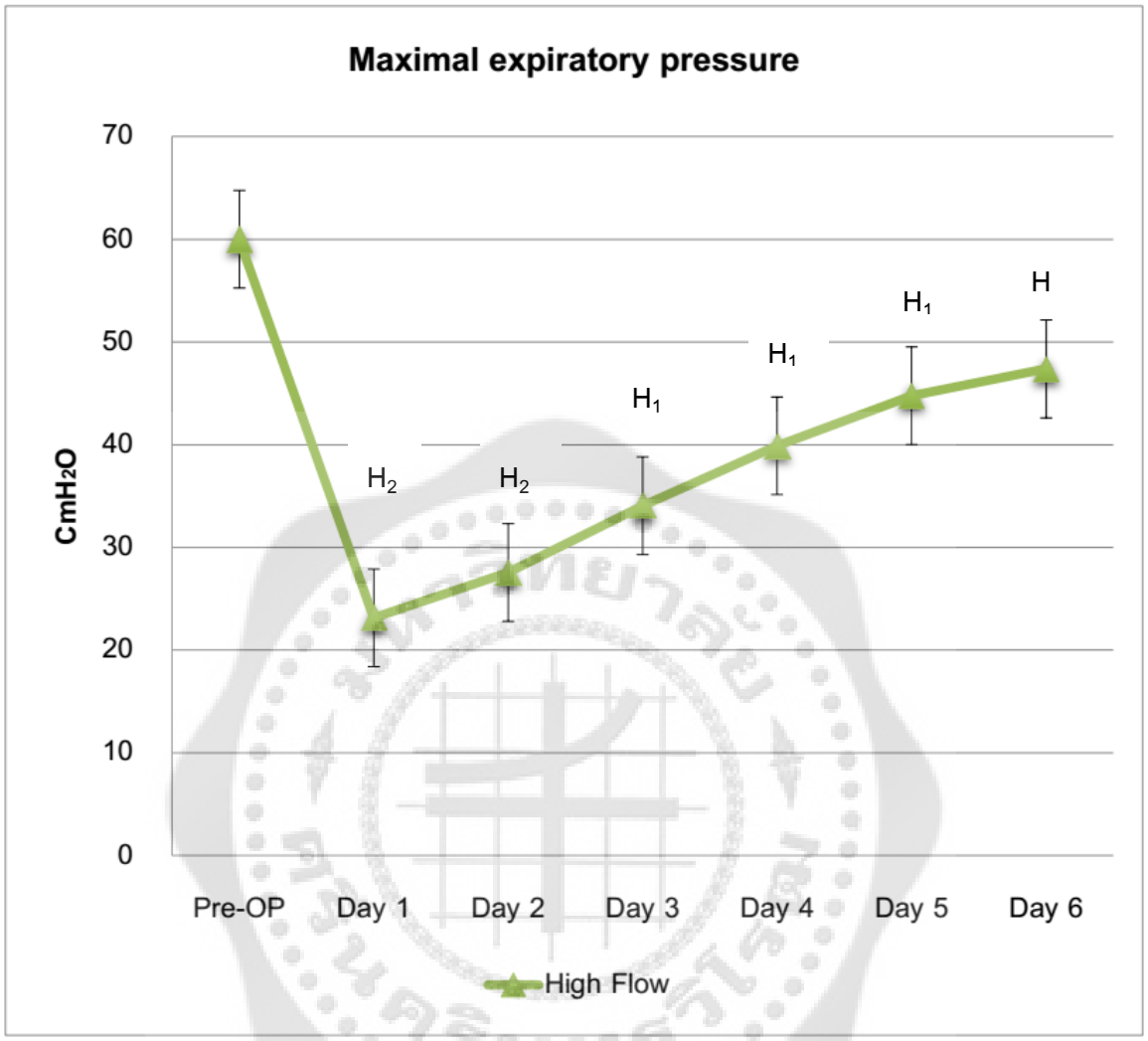


Figure 14 The comparison of MEP from pre-operative day to the 6th post-operative day within groups of HF group.

The p-value of significant difference: (H) $p<0.05$, (H_1) $p<0.01$, (H_2) $p<0.001$

Table 5 The comparison between groups on each days of MEP

Day	Control group	LF group	HF group	p-value Between group
Pre-operative	62.23±20.10	66.67±27.73	60.00±25.01	0.675
Post-operative				
1st	21.77±11.67 ^{C2}	23.43±8.77 ^{L2}	23.14±7.64 ^{H2}	0.845
2nd	28.73±8.34 ^{C2}	26.62±7.81 ^{L2}	27.57±9.90 ^{H2}	0.791
3rd	34.59±16.15 ^{C1}	34.48±8.06 ^{L1}	34.05±14.79 ^{H1}	0.991
4th	38.46±17.08 ^{C1}	39.91±9.11 ^{L1}	39.91±17.56 ^{H1}	0.961
5th	43.68±20.98 ^{C}	43.71±8.59 ^{L}	44.76±19.66 ^{H1}	0.979
6th	48.23±21.26	49.57±10.53	47.38±19.35 ^{H}	0.924

The p-value of significant difference:

Control group: (C) $p<0.05$, (C_1) $p<0.01$, (C_2) $p<0.001$

LF group: (L) $p<0.05$, (L_1) $p<0.01$, (L_2) $p<0.001$

HF group: (H) $p<0.05$, (H_1) $p<0.01$, (H_2) $p<0.001$

The dyspnea score

The dyspnea score in each group is shown in Figure 15-18. The dyspnea of using IS of all three groups were significant increased from baseline on the 1st post-operative day ($p<0.01$). On the 6th day, before the patients were discharged from the hospital. The dyspnea score was then gradually decreased and returned to baseline on the 5th post-operative day for the HF groups ($p=0.054$) and on the 6th post-operative day for the LF group ($p=0.173$) but not recovery to baseline for the control group ($p=0.16$). The comparison of dyspnea score between groups on the 6th post-operative day was not significantly difference ($p=0.667$).

The comparison of dyspnea score between days within groups, pre-operative day and the 1st post-operative day were shown the significant differences decrease within each group ($p<0.01$) but not showed that the significant differences between group on pre-operative day ($p=0.282$) and the 1st post-operative day ($p=0.475$). The 1st and 2nd day in all group was not significant differences within groups ($p=1.00$) and between groups on 2nd post-operative day ($p=0.893$). The comparison between 2nd and 3rd day in each group was not significant differences within groups ($p=1.00$) and between groups on 3rd post-operative day ($p=0.573$). The 3rd and 4th day in each group was not significant differences within groups ($p=1.00$) and between groups on 4th post-operative day ($p=0.926$). The 4th and 5th day in all group was not significant differences within groups ($p=1.00$) and between groups on 5th days ($p=0.908$). The 5th and 6th day in each group was not significant differences within groups ($p=1.00$) and between groups on 6th day ($p=0.667$).

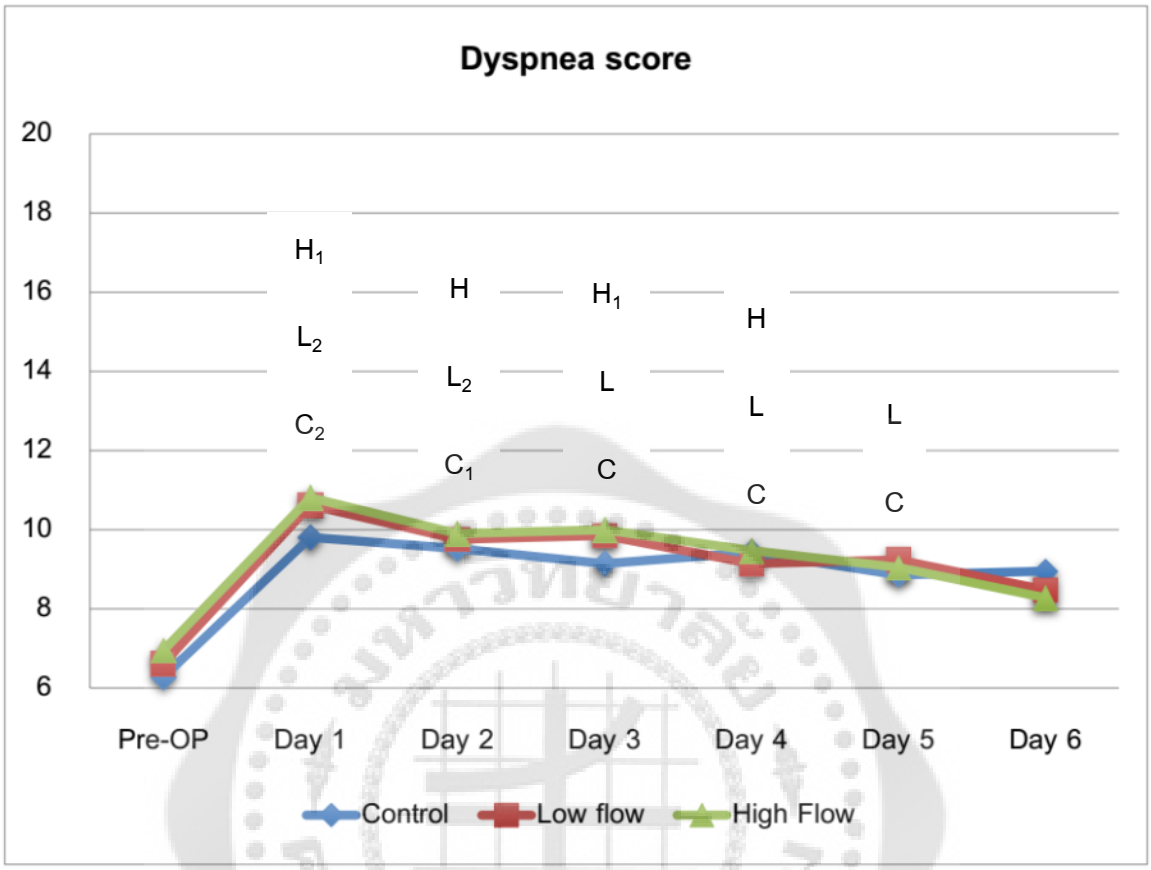


Figure 15 The change of Dyspnea score from pre-operative day to the 6th post-operative day within and between groups

The p-value of significant difference:

Control group: (C) $p<0.05$, (C_1) $p<0.01$, (C_2) $p<0.001$,

LF group: (L) $p<0.05$, (L_1) $p<0.01$, (L_2) $p<0.001$

HF group: (H) $p<0.05$, (H_1) $p<0.01$, (H_2) $p<0.001$

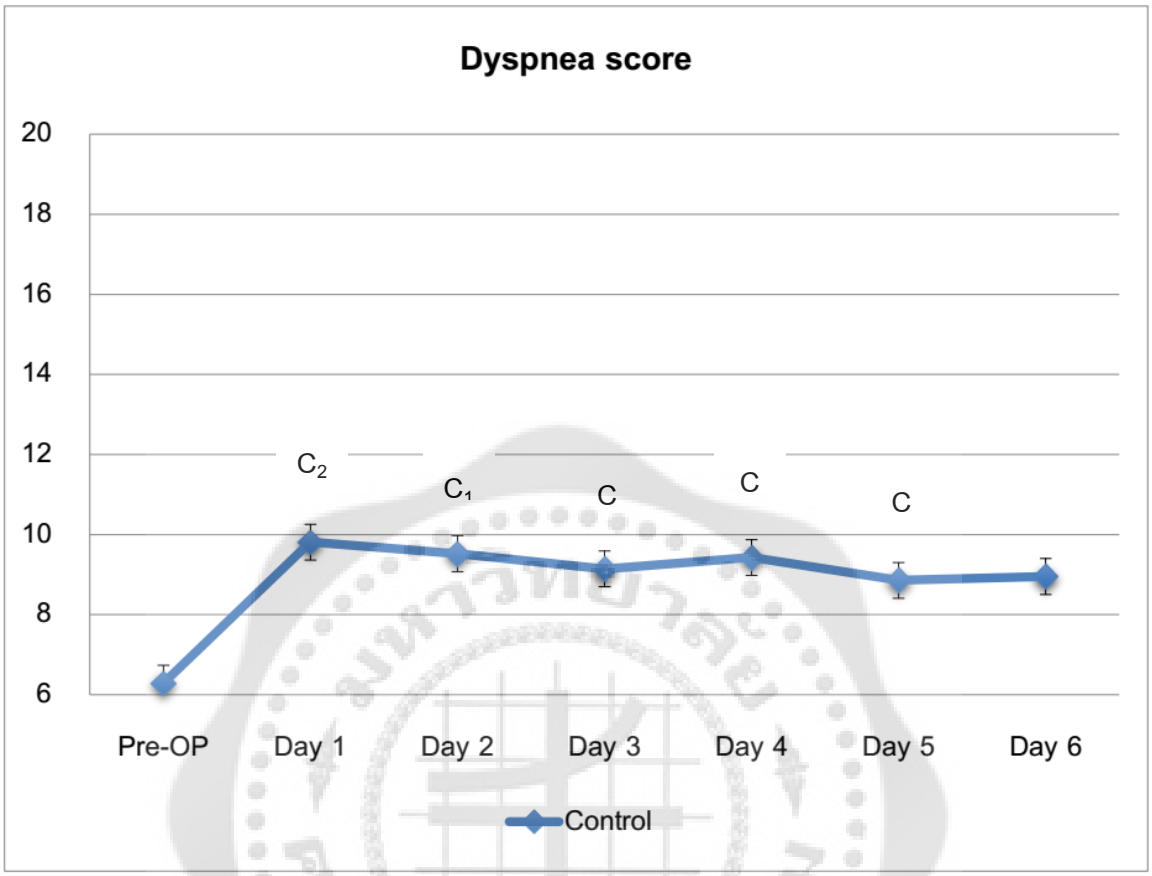


Figure 16 The comparison of Dyspnea score from pre-operative day to the 6th post-operative day within groups of control group.

The p-value of significant difference: (C) $p<0.05$, (C1) $p<0.01$, (C2) $p<0.001$.

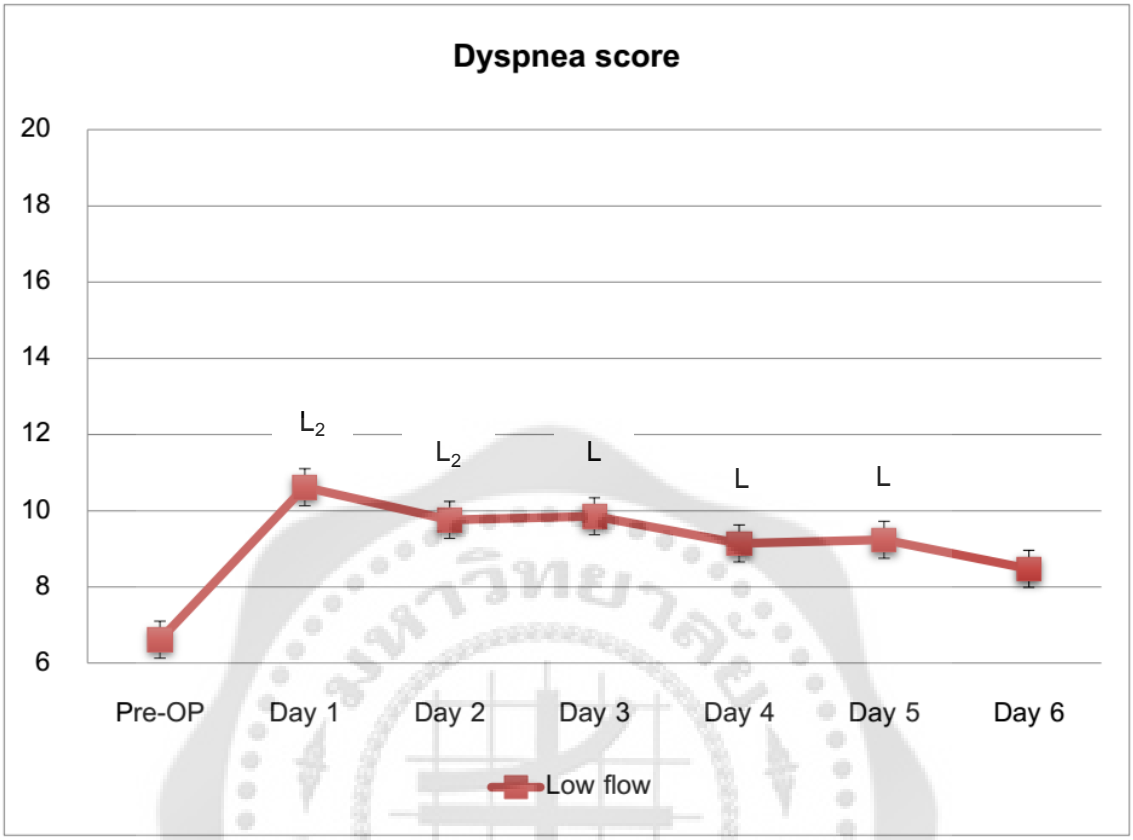


Figure 17 The comparison of Dyspnea score from pre-operative day to the 6th post-operative day within groups of LF group.

The p-value of significant difference: (L) $p<0.05$, (L_1) $p<0.01$, (L_2) $p<0.001$

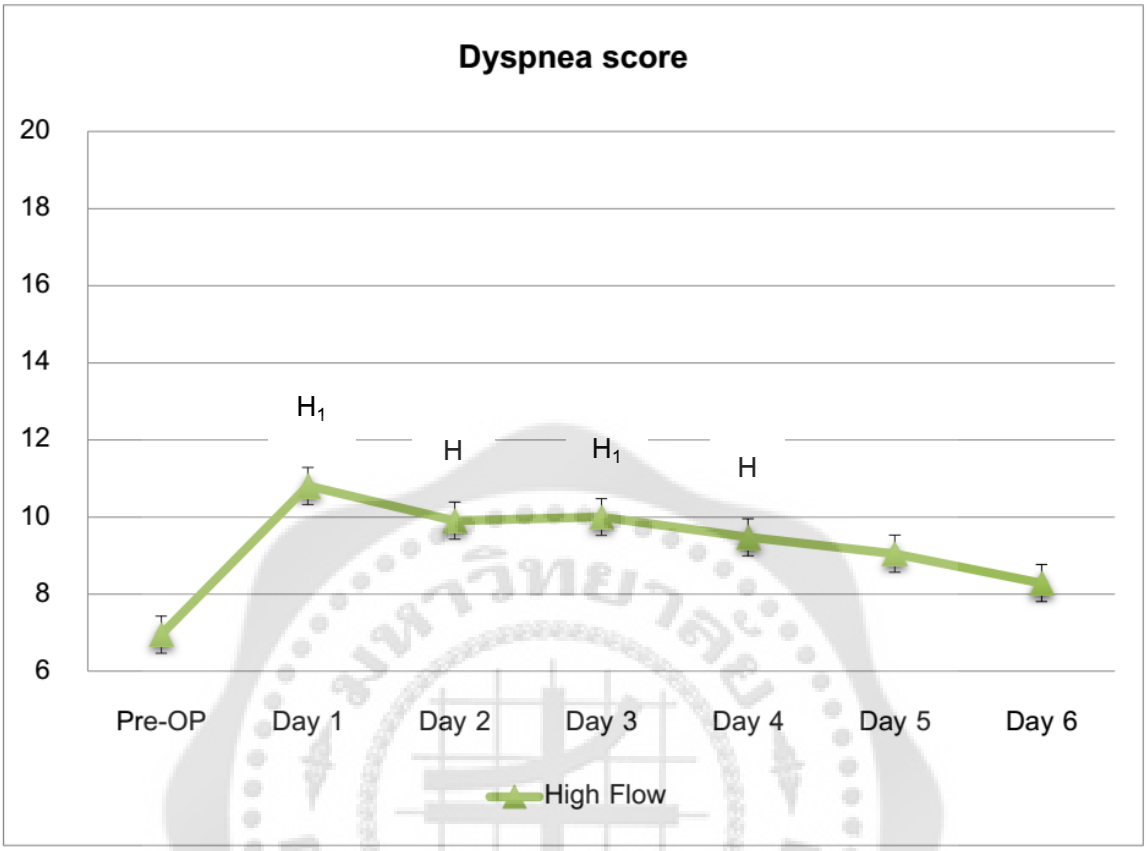


Figure 18 The comparison of Dyspnea score from pre-operative day to the 6th post-operative day within groups of HF group.

The p-value of significant difference: (H) $p<0.05$, (H_1) $p<0.01$, (H_2) $p<0.001$

Table 6 The comparison between groups on each days of dyspnea score.

Day	Control group	LF group	HF group	p-value Between group
Pre-operative	6.29±0.72	6.62±1.50	6.95±1.63	0.282
Post-operative				
1st	9.81±2.66 ^{C2}	10.62±2.62 ^{L2}	10.81±3.11 ^{H1}	0.475
2nd	9.52±3.27 ^{C1}	9.76±1.84 ^{L2}	9.90±2.57 ^{H}	0.893
3rd	9.14±3.04 ^{C}	9.86±2.67 ^{L}	10.00±2.70 ^{H1}	0.573
4th	9.43±3.59 ^{C}	9.14±2.59 ^{L}	9.48±2.64 ^{H}	0.926
5th	8.86±3.12 ^{C}	9.24±2.62 ^{L}	9.05±2.65	0.908
6th	8.95±2.85	8.48±2.46	8.29±2.00	0.667

The p-value of significant difference:

Control group: (C) $p<0.05$, (C_1) $p<0.01$, (C_2) $p<0.001$

LF group: (L) $p<0.05$, (L_1) $p<0.01$, (L_2) $p<0.001$

HF group: (H) $p<0.05$, (H_1) $p<0.01$, (H_2) $p<0.001$

The pain score

Pain score showed a significant increase on the 1st post-operative day and constantly decreasing from then on ($p<0.001$). On the 6th post-operative day, pain score still remain on the HF group ($p=0.020$). The trend of pain score throughout the period of 6th post-operative days is present on Figure 19-22.

The comparison of pain score between days within groups, pre-operative day and the 1st post-operative day were shown the significant differences decrease within each group ($p<0.01$) but not showed that the significant differences between group on pre-operative day ($p=0.210$) and the 1st post-operative day ($p=0.811$). The 1st and 2nd day in each group was not significant differences within groups ($p=1.00$) and between groups on 2nd post-operative day ($p=0.712$). The comparison between 2nd and 3rd day in each group was not significant differences within groups ($p>0.05$) and between groups on 3rd post-operative day ($p=0.754$). The 3rd and 4th day was shown significant differences in LF group ($p<0.01$) but not significant differences within groups in other groups ($p=1.00$) and between groups on 4th post-operative day ($p=0.906$). The 4th and 5th day in each group was not significant differences within groups ($p=1.00$) and between groups on 5th days ($p=0.697$). The 5th and 6th day was shown significant differences in HF group ($p=0.017$) but control ($p=0.05$) and LF ($p=0.165$) group was not significant differences within groups. When comparisons between groups was shown not significant differences on the 6th day ($p=0.566$).

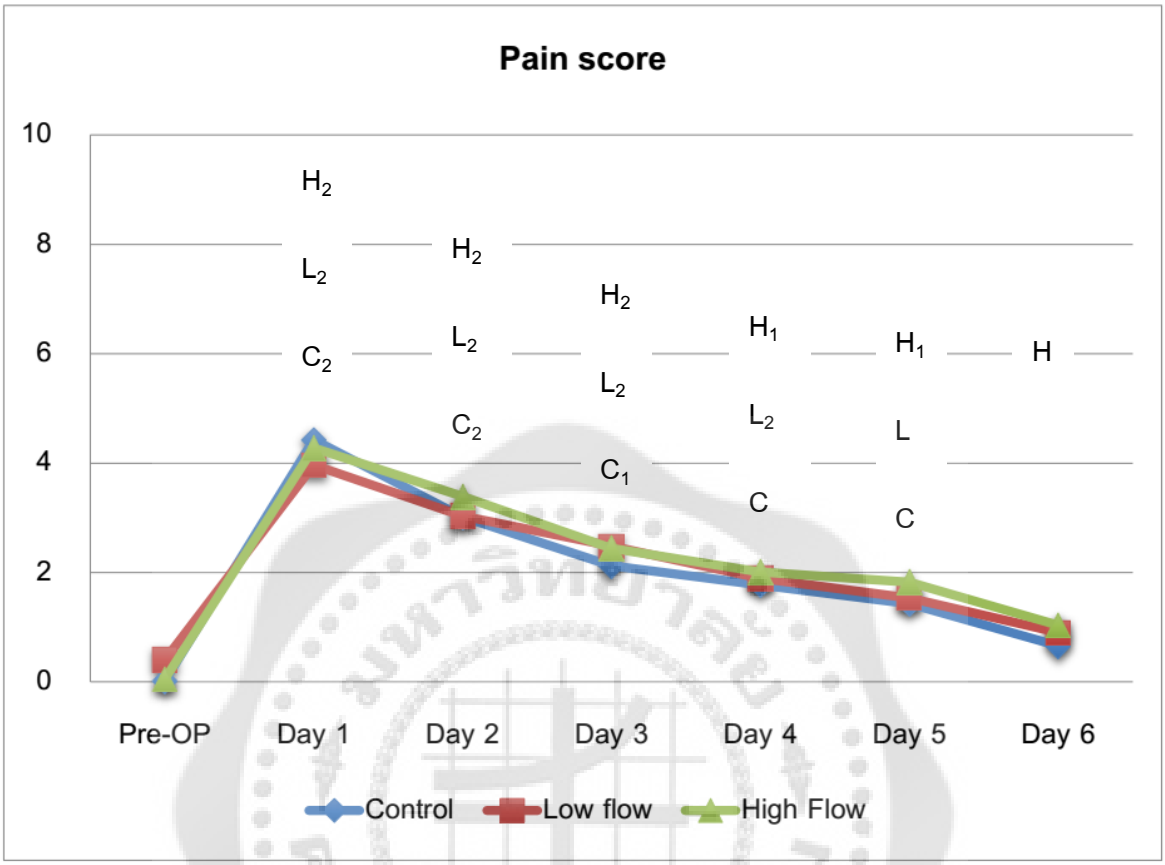


Figure 19 The change of pain score from pre-operative day to the 6th post-operative day within and between groups

The p-value of significant difference:

Control group: (C) $p<0.05$, (C_1) $p<0.01$, (C_2) $p<0.001$

LF group: (L) $p<0.05$, (L_1) $p<0.01$, (L_2) $p<0.001$

HF group: (H) $p<0.05$, (H_1) $p<0.01$, (H_2) $p<0.001$

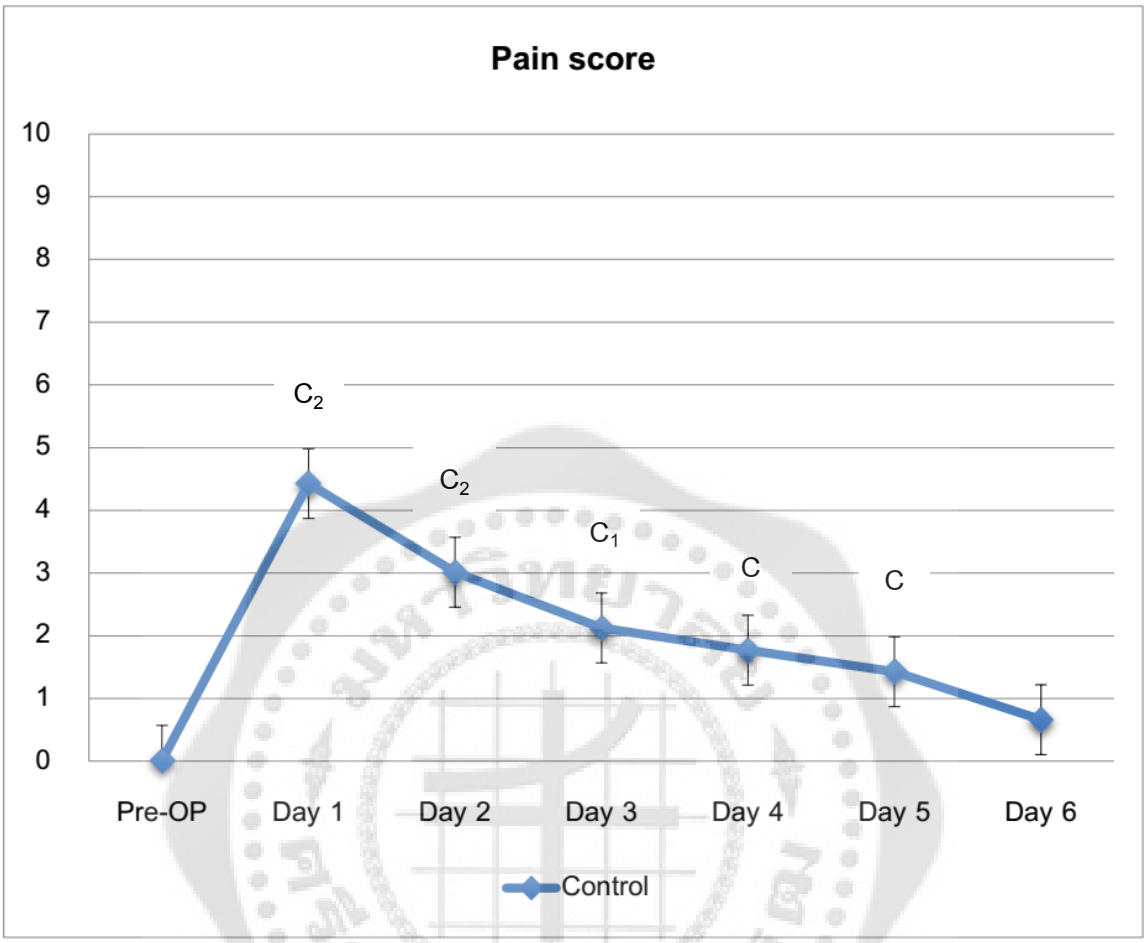


Figure 20 The comparison of Pain score from pre-operative day to the 6th post-operative day within groups of control group.

The p-value of significant difference: (C) $p<0.05$, (C1) $p<0.01$, (C2) $p<0.001$.

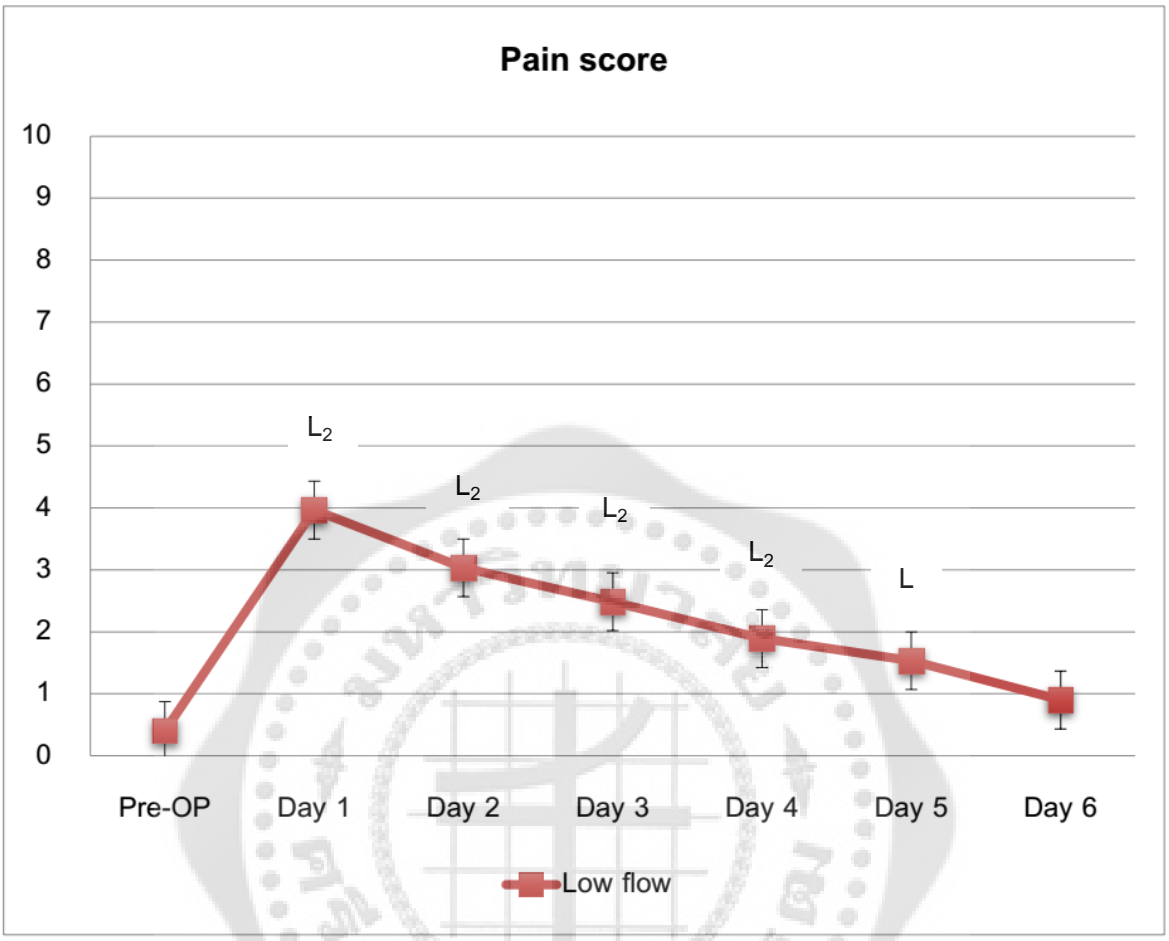


Figure 21 The comparison of Pain score from pre-operative day to the 6th post-operative day within groups of LF group.

The p-value of significant difference: (L) $p<0.05$, (L_1) $p<0.01$, (L_2) $p<0.001$

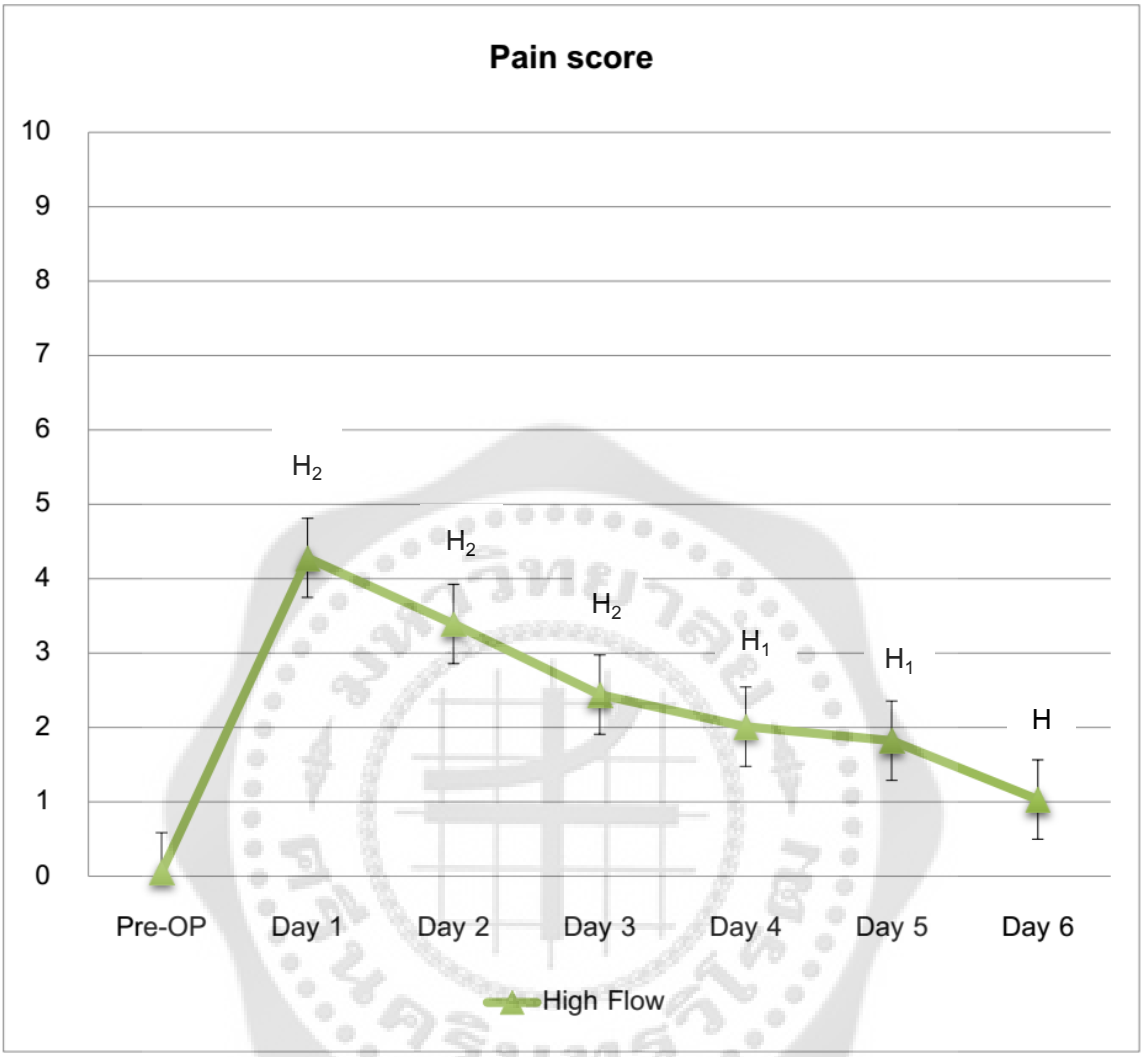


Figure 22 The comparison of Pain score from pre-operative day to the 6th post-operative day within groups of HF group.

The p-value of significant difference: (H) $p<0.05$, (H_1) $p<0.01$, (H_2) $p<0.001$

Table 7 The comparison between groups on each day of pain score.

Day	Control group	LF group	HF group	p-value Between group
Pre-operative	0.01±0.07	0.40±1.33	0.05±0.24	0.210
Post-operative				
1st	4.43±2.99 ^{C2}	3.97±1.59 ^{L2}	4.28±2.28 ^{H2}	0.811
2nd	3.01±1.88 ^{C2}	3.03±1.47 ^{L2}	3.39±1.61 ^{H2}	0.712
3rd	2.12±1.86 ^{C1}	2.49±1.41 ^{L2}	2.44±1.79 ^{H2}	0.754
4th	1.77±2.01 ^{C}	1.89±1.25 ^{L2}	2.01±1.85 ^{H1}	0.906
5th	1.43±1.58 ^{C}	1.53±1.51 ^{L}	1.82±1.58 ^{H1}	0.697
6th	0.66±1.04	0.90±1.27	1.03±1.09 ^{H}	0.566

The p-value of significant difference:

Control group: (C) $p<0.05$, (C_1) $p<0.01$, (C_2) $p<0.001$

LF group: (L) $p<0.05$, (L_1) $p<0.01$, (L_2) $p<0.001$

HF group: (H) $p<0.05$, (H_1) $p<0.01$, (H_2) $p<0.001$

The length of hospital stay

The average hospital stay with the complication for the control group was 44.00±32.52 days; the LF was group 20.33±6.42 days; and the HF group was 11.80±2.77 days. The patient description for post-operative complications in control group are 1 anemia, 1 HR arrhythmia, 1 secretion retention with lung collapse and 1 non healing median sternotomy with emphysema. LF group have 1 anemia and 2 uncontrolled hypertension. HF group have 2 anemia, 2 Median sternotomy infection and 1 Urinary infection. The control group seems to stay in the hospital longer than the other two groups. However, there are no significant differences when comparing between groups. They are shown in Table 8 and Figure 23.

Table 8 Post-operative complication

Groups	Complication (n)	Length of hospital stays (days)	Average (SD)
Control group	Anemia (1)	17	44.00 (35.52)
	HR arrhythmia (1)	15	
	Secretion retention with lung collapse (1)	54	
	Non healing median sternotomy with emphysema (1)	90	
LF group	Anemia (1)	13	20.33 (6.42)
	Uncontrolled hypertension (2)	23	
		25	
HF group	Anemia (2)	11	11.80 (2.77)
	Median sternotomy infection (2)	13	
		9	
	Urinary infection (1)	10	
		16	

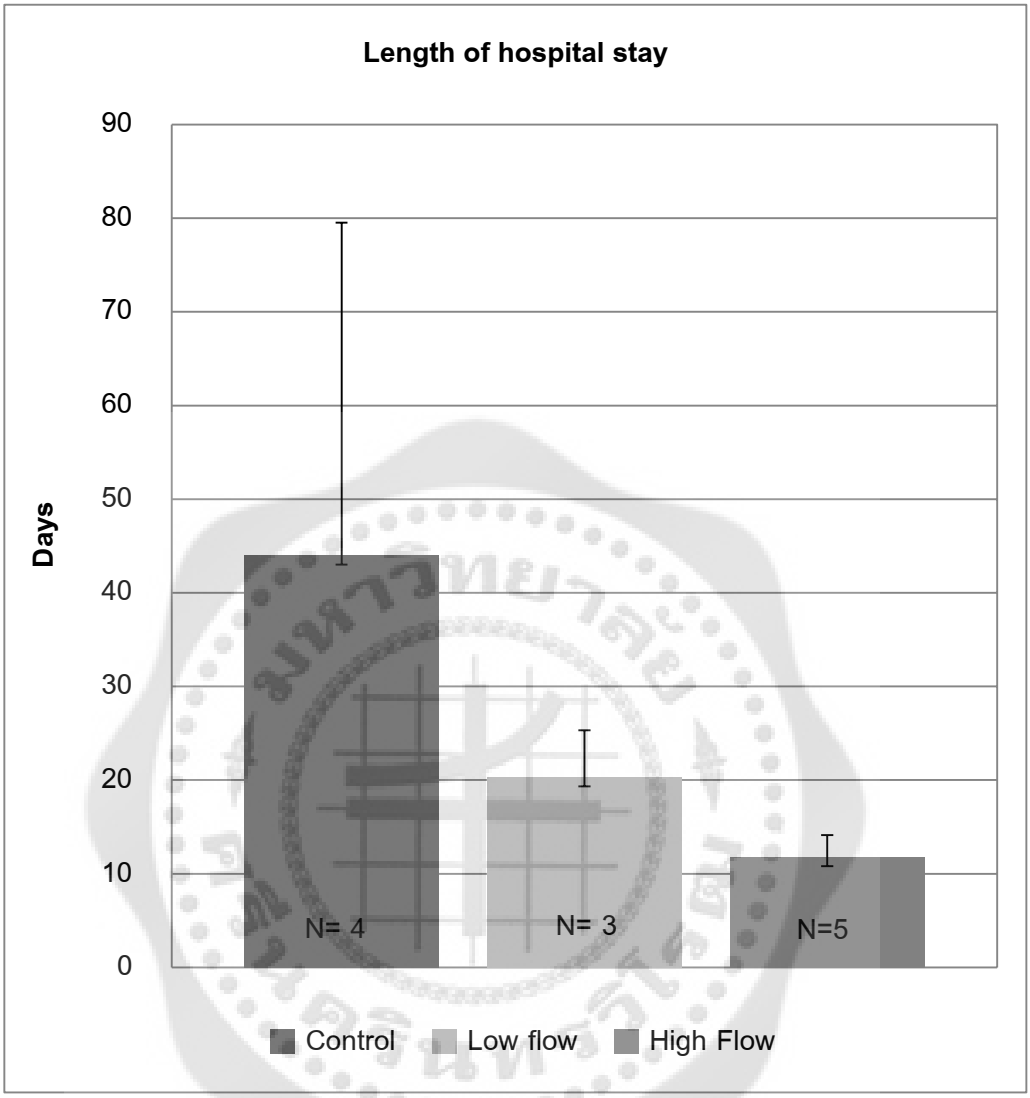


Figure 23 Mean of length of hospital stays in each group

CHAPTER 5

DISCUSSION

Incentive spirometry has been reported that it was not effective than deep breathing exercise in cardiac surgery patient. However Chang et al. 2010 found the flow rate was important. How showed about while HF Show using accessory muscle movement. So the objective of this study was to compare the effect of incentive spirometry between the trainings with LF and HF. This was based on the idea that the training with low inspiratory flow rate was better than the other training. According to the study of Chang et al. 2010, incentive spirometry with low inspiratory flow rate showed greater abdominal wall motion than using with high inspiratory flow rates [19]. The hypothesis concerning low and high inspiratory flow rates is high inspiratory flow rate may induce respiratory accessory muscle and dyspnea during performing while low inspiratory flow rate may induce lower dyspnea symptom with the use of incentive spirometry. Training with LF of IS in cardiac surgery patients may improve their lung volume and other outcomes more than HF of IS and the untrained group. However most of the results of the study were not showed any significant difference between LF of incentive spirometer or HF of incentive spirometer or DBE group.

1. Effect on lung volume

The current study focused on the effect on lung volume in cardiac surgery patients because the cardiac surgical procedure mainly limits the lung movement. Surgical trauma and anesthesia contribute to the changes in pulmonary mechanics, decrease in lung volume and respiratory muscle strength. The drugs used to stop heart and lungs from functioning during surgery caused to decrease diaphragm functioning [27]. The decreasing of lung expansion and impaired ventilation affected lung volume and contributed secretion retention. The surgical trauma from the waste product and pain or fear of pain also affected abnormal lung mechanisms. Anesthesia and surgical trauma contributed to changes in pulmonary mechanisms, decrease in lung volume and changes in production of surfactant, causing the secretion to decrease lung expansion and impair gas exchange. Moreover, the complications caused patient to not being able to receive the oxygen fully as the result increased dyspnea

score. All of the complications above also caused the patient to not being able to fully inhale and consequently change the breathing pattern for leave from pain from the decreased lung volume.

The results of this study show the significant decrease in VC on the 1st post-operative day and not fully returned to base line on the 6th post-operative day of all of the three groups are consistent with the previous studies [38]. Post-operative pain, drowsiness, and analgesia contributed to a slow and shallow breathing pattern, decreased in lung mobility and ventilation [8,11] In this situation, performing deep breathing is important to prevent lung complications [54] and IS may be appropriate for re-expansion the lung [31].

The comparing between the LF, HF and control of DBE groups did not show any significant difference on VC which consistent with the study by Renault et al. 2009 in CABG patients [38]. DBE is easy to perform as patients can control by themselves. IS helps to prevent atelectasis by deep breathing with a visual feedback [31]. The hypothesis of this study was from the results of Chang et al. 2010 that performing IS with LF in healthy individual induced more abdominal wall motion than HF [19] which may increase more lung volume than HF. However, the results of this study did not show as the hypothesis, this may be due to the different in study subjects. In our study, we found that on the first period of post-operation, the patients in HF group could not generate force to keep three balls to the top. Therefore, all three groups were trained of deep breathing exercise not far different pattern on the first period of post-operation.

2. Effect on respiratory muscle strength

The results of this study showed that the respiratory muscle strengths of all three interventions groups significantly decreased on 1st day, but this study cannot clearly confirm that the respiratory muscle increased strength by incentive spirometry or spontaneous recovery of patient. The pains and the diaphragmatic dysfunctions in addition from surgical procedure and anesthesia mainly cause to reduce the respiratory muscle strength on the first period of post-operation [11]. A few days after operation, pain was decrease from drug used or the wound healing process, then the respiratory muscle can produce more force. The breathing exercise after surgery generated lung expansion by recruiting the motor unit of respiratory muscle. The LF group and control of DBE group may aggravate pain less than HF group as

shown in the figure 7 that on the 6th post-operative day, the pain score of these 2 groups returned to baseline. The respiratory muscle strength then, return to normal while the HF groups was still lower MIP and MEP than the pre-operative day.

3. Effect on dyspnea

Dyspnea score was measured the feeling of patients when performing incentive spirometry. Surgical trauma affected lung volume and respiratory muscle strength.

On the 1st day after operation, the dyspnea score was increased. In all three groups this could be explained by the pain of the surgery wound limited the function of respiratory muscles [8]. On the first few days after operation the HF group could not greater force to hold all 3 balls to the top, the late period of admition the HF group could keep all 3 ball to the top of IS the dyspnea score in the HF group. While LF group had to hold only one ball to the top of IS. Even though the LF group control the force to keep only one ball than generate out of their force to all 3 balls. Therefore, the result of the current study found that the dyspnea score of the HF group recovery to baseline earlier than LF and control group.

4. Effect on pain

This study showed that the pain in each groups significantly increased on the 1st day after surgery. The cause of pain was increase by thoracic incision on surgical procedure [11]. The median sternotomy procedure was performed by cutting the sternum bone and several muscles to open the thoracic. The thoracic incision caused more pain to the patient. Anesthesia was out of effect after finishing the surgical process. When the patient woke up after operation, if the anesthesia was effective, the patient would feel a little pain However, when the anesthesia became ineffective, the pain was increasing. On the post-operative period in the hospital, the patient can request medicine from doctor or nurse to reduce pain. The surgical pain affected to the breathing pattern that patient could not take to fully deep breath. The change of pain pattern of all three groups are the same showing that the train of IS or DBE not effect to the recovery of pain. Mainly pain management of the cardiac surgery patients were the admit state of analgesic drug.

5. Effect on length of hospital stay

Usually, the patient who had no complications should stay in hospital for 7-10 days. The means of length of hospital stays for low and a HF group were in the normal length but for the control group were extended beyond the normal length. In the cases of complications occurring, the patient had to stay in the hospital for a longer time. The result observation in the duration of hospitalization found that the control group stayed longer than the other two groups. There was one patient in control group with non-healing surgical incision with emphysema had to be admitted for 90 days. Atelectasis was found in only one patient, but not in the other groups using incentive spirometry. The Crowe and Bradley studies showed the incentive spirometry may reduce the incidence of atelectasis [42]. Jenkin et al. 1989 compared incentive spirometry, deep breathing exercise and conventional therapy. It showed that there was no difference between groups in recovery of pulmonary function or incidence of pulmonary complications [41]

6. Study limitations

In interpreting these findings, a number of limitations should be acknowledged. Anesthetics effect and operation time were not recorded. The season of measurement on post-operative period was inaccurate between days. On the 1st day of post-operative, patients on the HF group cannot inspiration with the high inspiratory flow rate because of pain and anesthetic effect. The physical therapy routine treatment cannot control because of symptoms in each patients. However, further study examining the use of incentive spirometry in patient should consider the ability and symptoms are given specifically regarding the use of inspiratory flow during incentive spirometry and should find the minimum clinically important difference in patients.

7. Implication to practices

This study suggests the effects of trainings with low and high inspiratory flow rate was not difference in lung volume but the high inspiratory flow rate was easy to train than low inspiratory flow rate. Although the 1st post-operative period patient cannot inspiration with high inspiratory flow rate, but in the late period patient can inspiration easy and dyspnea lower than low inspiratory flow rate. However the high inspiratory flow rate may effect to surgical wound because of the high inspiratory flow rate induce the chest wall movement as Chang et al. 2010.

The use of IS with low and high inspiratory flow rates can be applies use in the each period of post-operative. Thus, from researcher aspect it is more likely beneficial to use both of the method. On the 1st post-operative day, the physical therapy may train with DBE to stimulate the respiratory function and start training IS with LF on the 2nd day, more over to stimulate the restoration of the respiratory muscle strength. When the pain was decreased, patient may train with HF to prevent lung atelectasis that may occur.

However, they should focus on the need to assess the frequency and the correct achievement of the technique since its effectiveness can be influenced by many factors. If the patient does not adapt or intentionally avoid performing one of the techniques, the other can be used with equal effectiveness. However, there is a need for frequent physiotherapeutic supervision.

8. Conclusion

This study suggested that all intervention techniques were equally effective in enhancing lung volume, respiratory muscles strength and dyspnea score. The used of incentive spirometry with high or low inspiratory flow rate technique is not different from deep breathing exercises. Consequently, according to the clinical indication, physical therapy can justifies using or not made no difference depend on the objective of treatment. If the physical therapy want to use visual feedback for stimulate attention of patients that should be use the IS.

References

1. DeTurk WE, Cahalin LP. Cardiovascular and pulmonary physical therapy: an evidence-based approach. New York: McGraw-Hill, Medical Publishing Division; 2004.
2. Diana R, Etem C, Herman T, Andrea G, Francesco M. Median sternotomy. Multimedia Manual of Cardio-Thoracic Surgery 2015; 1093
3. Chetta A, Bobbio A, Aiello M, Donno M, Castagnaro A, Comel A, et al. Changes in lung function and respiratory muscle strength after sternotomy vs. laparotomy in patients without ventilatory limitation. Eur Surg Res. 2006; 38(5):489-93.
4. Westerdahl E, Lindmark B, Eriksson T, Friberg O, HedenstiernaG, Tenling A. Deep-breathing exercises reduce atelectasis and improve pulmonary function after coronary arterial bypass surgery. Chest 2005; 128(5):3482-8.
5. Brooks JA. Postoperative atelectasis and pneumonia. Heart Lung 1995; 24: 94–115.
6. Welvaart WN, Paul MA, Stienen GJ, Van HW, Loer SA, Bouwman R, Niessen H, et al. Selective diaphragm muscle weakness after contractile inactivity during thoracic surgery. Ann Surg. 2011; 254(6):1044-9.
7. Matheus GB, Desanka D, Patrícia T, Cledycion EC, Maurício ML, Gustavo AR. Inspiratory muscle training improves tidal volume and vital capacity after CABG surgery. Rev Bras Cir Cardiovasc 2012; 27(3):362-9.
8. Baumgarten MC, Garcia GK, Frantzeski MH, Giacomazzi CM, Lagni VB, Dias AS, et al. Pain and pulmonary function in patients submitted to heart surgery via sternotomy. Rev Bras Cir Cardiovasc. 2009; 24(4):497-505.
9. Sasseron AB, Figueiredo LC, Trova K, Cardoso AL, Lima NM, Olmos SC, et al. Does the pain disturb the respiratory function after open heart surgery? Rev Bras Cir Cardiovasc. 2009; 24(4):490-6.
10. Mueller XM, Tinguely F, Tevaearai HT, Revelly JP, Chiolero R, Segesser LK. Pain location, distribution and intensity after cardiac surgery. Chest. 2000; 118(2):391-6.
11. Wynne R, Botti M. Postoperative pulmonary dysfunction in adults after cardiac surgery with cardiopulmonary bypass: clinical significance and implications for practice. Am J CritCare. 2004; 13(5):384-93.
12. Cavenaghi S, Ferreira LL, Marino HC, Lamari NM. Respiratory therapy in pre-and post-operative myocardial revascularization. Bras Cir Cardiovasc 2011; 26(3):455-61.

13. Westerdahl E, Moller M. Physiotherapy-supervised mobilization and exercise following cardiac surgery: a national questionnaire survey in Sweden. J Cardiothorac Surg. 2010, 5:67.

14. Westerdahl E, Olsen MF. Chest physiotherapy and breathing exercises for cardiac surgery patients in Sweden a national survey of practice. Monaldi archives for chest disease. 2011; 75(2):112-9.

15. Kulkarni SR, Fletcher E, McConnell AK, Poskitt KR, Whyman MR. Pre-operative inspiratory muscle training preserves postoperative inspiratory muscle strength following major abdominal surgery - a randomised pilot study. Ann R Coll Surg Engl. 2010 Nov; 92:700-7.

16. Parreira VF, Tomich GM, Britto RR, Sampaio R.F. Assessment of tidal volume and thoracoabdominal motion using volume and flow-oriented incentive spirometers in healthy subjects. Brazilian Journal of Medical and Biological Research 2005; 38: 1105-1112.

17. Yamaguti WP, Sakamoto ET, Panazzolo D, Peixoto CC, Cerri GG, Albuquerque AL. Diaphragmatic mobility in healthy subjects during incentive spirometry with a flow-oriented device and with a volume-oriented device. Bras Pneumol. 2010; 36(6):738-745.

18. Tomich GM, França DC, Diório AC, Britto RR, Sampaio RF, Parreira VF. Breathing pattern, thoracoabdominal motion and muscular activity during three breathing exercises. Braz J Med Biol Res. 2007; 40(10):1409-17.

19. Chang A, Kerry RP, Jessie M, Peter JT. Inspiratory flow rate, not type of incentive spirometry device, influences chest wall motion in healthy individuals. Physiother Theory Pract. 2010; 26(6):385-92.

20. Hulzebos HJ, Smit Y, Helders JM, Meeteren LU. Preoperative physical therapy for elective cardiac surgery patients. Cochrane Database of Systematic Reviews 2012.

21. Freitas FS, Soares GO, Cardoso JR, Atallah ÁN. Incentive spirometry for preventing pulmonary complications after coronary artery bypass graft. Cochrane Database of Systematic Reviews 2012.

22. William AN, Robinson WT, Martin HM, William OB, David LM, James DH. Postoperative respiratory insufficiency. Physiological Studies with Therapeutic Implications. Annual Meeting of the Southern Surgical Association, December 8-10, 1969.

23. Roukema JA, Hilvering C, Jeekel J, Jakimowicz J. The prevention of postoperative lung complications. Ned Tijdschr Geneeskd1988. 16; 132(3):101-5.

24. Komal R, Andrew B, Elankumaran P. Pulmonary atelectasis in anaesthesia and critical care. Continuing Education in Anaesthesia, Critical Care & Pain Advance Access published December 23, 2013

25. Jensen L, Yang L. Risk factors for postoperative pulmonary complications in coronary artery bypass graft surgery patients. Eur J Cardiovasc Nurs. 2007; 6(3):241-6.

26. Aitkenhead AR, Smith G, Rowbotham DJ. Text book of anaesthesia, Churchill Livingstone. Elsevier. 2007.

27. Hedenstierna G. respiratory physiology. Anesthesia. 7th ed. Philadelphia, Churchill Livingstone. 2009. 361-391.

28. Naguib M, Lien CA. pharmacology of muscle relaxants and their antagonists. 2010. 859-911

29. Williams JV, Tierney DF, Parker HR. Surface forces in the lung, atelectasis, and transpulmonary pressure. Journal of Applied Physiology 1966, 21: 819-827.

30. Joseph A, Daniel M. Early Mobilization in the Intensive Care Unit: A Systematic Review. Cardiopulmonary Physical Therapy Journal 2012. 23.

31. Agostini P, Nicola K. Autogenic drainage: the technique, physiological basis and evidence, Physiotherapy 2007, 93(2), 157-163.

32. Knelson JH, Howatt WF, DeMuth GR. Effect of respiratory pattern on alveolar gas exchange. Journal of Applied Physiology 1970, 29: 328-331.

33. Ward RJ, Danziger F, Bonica JJ, Allen GD, Bowes J. An evaluation of postoperative respiratory maneuvers. Surgery, Gyne-cology and Obstetrics 1966, 7: 51-54.

34. Wojciechowski WV. Incentive spirometers, secretion evacuation devices, and inspiratory muscle training devices. Core Text Book 1994.

35. Thomas JA, McIntosh JM. Are incentive spirometries, intermittent positive pressure breathing and deep breathing exercises effective in the prevention of postoperative pulmonary complications after upper abdominal surgery? A systematic overview and meta-analysis. Physical Therapy 1994, 74: 3-10.

36. Restrepo RD, Wettstein R, WittnebelL, Tracy M. AARC Clinical Practice Guideline: Incentive Spirometry. Respir Care 2011; 56(10):1600–1604.

37. Rafea A, Wagih K, Amin H, El-Sabagh R, Yousef S. Flow-oriented incentive spirometer versus volume-oriented incentive spirometer training on pulmonary ventilation after upper abdominal surgery 2009. EJB, 3(2).

38. Renault JA, Costa VR, Rosseti MB, Houri NM. Comparison between deep breathing exercises and incentive spirometry after CABG surgery. Rev Bras Cir Cardiovasc 2009; 24(2): 165-172.

39. Kundra P, Vitheeswaran M, Nagappa M, Sistia S. Effect of preoperative and postoperative incentive spirometry on lung functions after laparoscopic cholecystectomy. Surg Laparosc Endosc Percutan Tech 2010; 20(3):170-172.

40. Weindler J, Kiefer T. The efficacy of postoperative incentive spirometry is influenced by the device-specific imposed work of breathing. 2001. Chest, 119: 1858-1864.

41. Jenkins SC, Soutar SA, Loukota JM, Johnson LC, Moxham J. Physiotherapy after coronary artery surgery: are breathing exercises necessary? Thorax 1989;44:634-639

42. Crowe JM, Bradley CA. The effectiveness of incentive spirometry with physical therapy for high-risk patients after coronary artery bypasses surgery. 1997; PHYS THER. 77:260-268.

43. Matte P, Jacquet L, Dyck M, Goenen M. Effects of conventional physiotherapy, continuous positive airway pressure and non-invasive ventilatory support with bilevel positive airway pressure after coronary artery bypass grafting. Acta Anaesthesiol Scand. 2000; 75-81.

44. Oikkonen M, Karjalainen K, Kahara V, Ktiosa R, Schavikin L. Comparison of Incentive Spirometry and Intermittent Positive Pressure Breathing after Coronary Artery Bypass Graft. Chest 1991.

45. Savci S, Sakınç S, Arıkan H, Can Z, Buran Y, Kuralay E. Active cycle of breathing techniques and incentive spirometer in coronary artery bypass graft surgery. Fizyoterapi Rehabilitasyon. 2006; 17(2):61-69.

46. Romanini W, Muller AP, Carvalho AT, Olandoski M, Faria-Neto JR, Mendes FL, et al. The effects of intermittent positive pressure and incentive spirometry in the postoperative of myocardial revascularization. Bras Cardiol 2007; 89(2): 94-99.

47. Ratnovsky A, Elad D, Zaretsky U, Shiner R. A technique for global assessment of the respiratory muscle performance at different lung volume. Physiol 1999; 20: 37-51.

48. Luce JM, Culver BH. Respiratory muscle functions in health and disease. Chest 1982; 81(1):82-90.

49. Dejsomritrutai W, Nana A, Maranetra KN, Chuaychoo B, Maneechotesuwan K, Wongsurakiat P, et al. Reference spirometric values for healthy lifetime nonsmokers in Thailand. J Med Assoc Thai. 2000; 83: 457-466.

50. Maribe EN, Hoehn K. Anatomy and physiology. Pearson 2014, ISBN 10:0-321-88830-8.

51. Rendas A, Gamboa T, Ramilo T, Botelho A, Barbara C, Mota-Carmo M. Respiratory muscle function in physically active elderly women. Arch Gerontol Geriatr 1996; 123-30.

52. Roussos C, Macklem P. The respiratory muscle. N Engl J Med 1982; 23:786-97.

53. Borg G. Psychophysical bases of perceived exertion. Med SciSports Exerc 1982; 377-81.

54. Vraciu JK, Vraciu RA. Effectiveness of breathing exercises in preventing pulmonary complications following open heart surgery. Phys Ther. 1977; 57(12):1367-71.

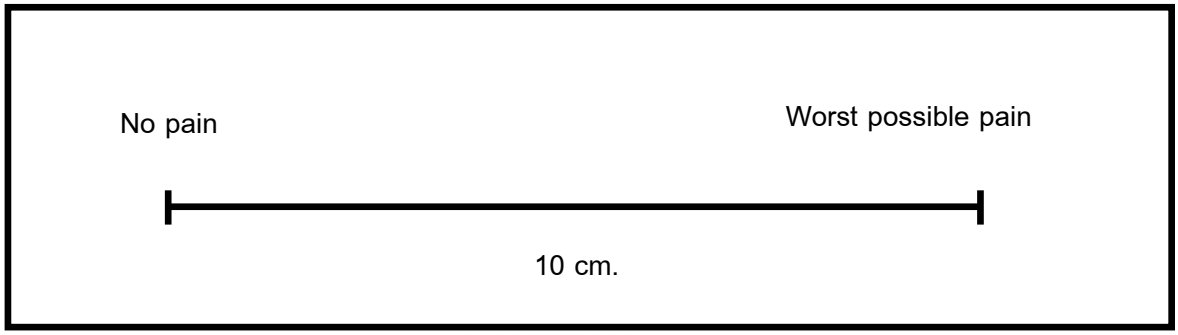
APPENDICES

APPENDIX A

Rating of perceived exertion (Borg's scale)		Thai version
6	Nothing at all	ไม่รู้สึกอะไร
7	Very very light	รู้สึกสบาย
8		
9	Very light	ไม่เหนื่อย
10		
11	Fairly light	เริ่มรู้สึกเหนื่อย
12		
13	Somewhat hard	ค่อนข้างเหนื่อย
14		
15	Hard	เหนื่อย
16		
17	Very hard	เหนื่อยมาก
18		
19	Very very hard	เหนื่อยมากที่สุด(หอบ)
20		

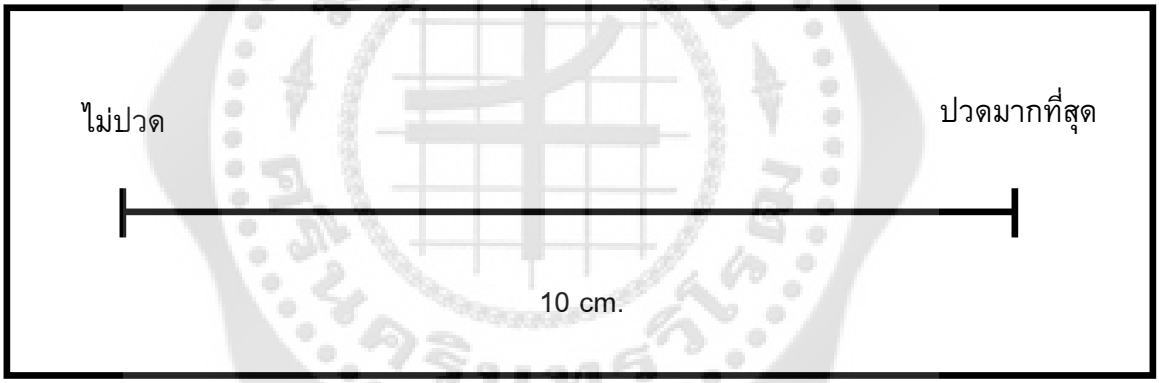
Dyspnea score (54)

APPENDIX B



Visual analog scale

(Adapted from Cox JM. Education today 2013)



Visual analog scale: Thai version

Appendix C

Comparison between pre- and post-operative days within groups of VC

Groups	Comparison between pre- and post-operative days within groups		Mean Difference	Std. Error	p-value
Control	Pre-operative	1st	38.95	3.96	<0.001
		2nd	35.95	3.50	<0.001
		3rd	29.29	3.60	<0.001
		4th	22.52	3.30	<0.001
		5th	17.52	2.74	<0.001
		6th	13.38	2.62	0.001
	1st	Pre-operative	-38.95	3.96	<0.001
		2nd	-3.00	1.65	1.001
		3rd	-9.67	2.15	0.005
		4th	-16.43	2.40	<0.001
		5th	-21.43	2.83	<0.001
		6th	-25.57	3.08	<0.001
	2nd	Pre-operative	-35.95	3.50	<0.001
		1st	3.00	1.65	1.001
		3rd	-6.67	1.35	0.002
		4th	-13.43	1.77	<0.001
		5th	-18.43	2.17	<0.001
		6th	-22.57	2.35	<0.001
	3rd	Pre-operative	-29.29	3.60	<0.001
		1st	9.67	2.15	0.005
		2nd	6.67	1.35	0.002
		4th	-6.76	1.63	0.010
		5th	-11.76	2.11	<0.001
		6th	-15.91	2.36	<0.001

	4th	Pre-operative	-22.52	3.30	<0.001
		1st	16.43	2.40	<0.001
		2nd	13.43	1.77	<0.001
		3rd	6.76	1.63	0.010
		5th	-5.00	1.34	0.028
		6th	-9.14	1.61	<0.001
	5th	Pre-operative	-17.52	2.74	<0.001
		1st	21.43	2.83	<0.001
		2nd	18.43	2.17	<0.001
		3rd	11.76	2.11	<0.001
		4th	5.00	1.34	0.028
		6th	-4.14	1.07	0.020
	6th	Pre-operative	-13.38	2.62	0.001
		1st	25.57	3.08	<0.001
		2nd	22.57	2.35	<0.001
		3rd	15.91	2.36	<0.001
		4th	9.14	1.61	<0.001
		5th	4.14	1.07	0.020
Low inspiratory flow rate	Pre-operative	1st	41.19	2.49	<0.001
		2nd	35.86	2.85	<0.001
		3rd	28.86	2.69	<0.001
		4th	21.14	2.54	<0.001
		5th	16.19	2.90	<0.001
		6th	13.91	2.61	0.001
	1st	Pre-operative	-41.19	2.49	<0.001
		2nd	-5.33	1.50	0.043
		3rd	-12.33	1.77	<0.001
		4th	-20.05	1.78	<0.001
		5th	-25.00	2.29	<0.001
		6th	-27.29	2.15	<0.001

	2nd	Pre-operative	-35.86	2.85	<0.001
		1st	5.33	1.50	0.043
		3rd	-7.00	1.54	0.004
		4th	-14.71	1.89	<0.001
		5th	-19.67	1.95	<0.001
		6th	-21.95	1.94	<0.001
	3rd	Pre-operative	-28.86	2.69	<0.001
		1st	12.33	1.77	<0.001
		2nd	7.00	1.54	0.004
		4th	-7.71	1.68	0.004
		5th	-12.67	1.71	<0.001
		6th	-14.95	1.59	<0.001
	4th	Pre-operative	-21.14	2.54	<0.001
		1st	20.05	1.78	<0.001
		2nd	14.71	1.89	<0.001
		3rd	7.71	1.68	0.004
		5th	-4.95	1.58	0.109
		6th	-7.24	1.47	0.002
	5th	Pre-operative	-16.19	2.90	<0.001
		1st	25.00	2.29	<0.001
		2nd	19.66	1.95	<0.001
		3rd	12.67	1.71	<0.001
		4th	4.95	1.58	0.109
		6th	-2.29	1.01	0.717
	6th	Pre-operative	-13.91	2.61	0.001
		1st	27.29	2.15	<0.001
		2nd	21.95	1.94	<0.001
		3rd	14.95	1.59	<0.001
		4th	7.24	1.47	0.002
		5th	2.29	1.01	0.717

High inspiratory flow rate	Pre-operative	1st	38.19	3.99	<0.001
		2nd	34.52	3.92	<0.001
		3rd	28.71	3.71	<0.001
		4th	20.29	2.92	<0.001
		5th	18.95	2.69	<0.001
		6th	15.95	2.82	<0.001
	1st	Pre-operative	-38.19	3.99	<0.001
		2nd	-3.67	1.37	0.305
		3rd	-9.48	2.42	0.018
		4th	-17.91	2.56	<0.001
		5th	-19.24	2.62	<0.001
		6th	-22.24	3.15	<0.001
	2nd	Pre-operative	-34.52	3.92	<0.001
		1st	3.67	1.37	0.305
		3rd	-5.81	1.82	0.097
		4th	-14.24	1.90	<0.001
		5th	-15.57	2.14	<0.001
		6th	-18.57	2.70	<0.001
	3rd	Pre-operative	-28.71	3.71	<0.001
		1st	9.48	2.42	0.018
		2nd	5.81	1.82	0.097
		4th	-8.43	1.80	0.003
		5th	-9.76	1.76	<0.001
		6th	-12.76	2.00	<0.001
	4th	Pre-operative	-20.29	2.92	<0.001
		1st	17.91	2.56	<0.001
		2nd	14.24	1.90	<0.001
		3rd	8.43	1.80	0.003
		5th	-1.33	0.90	1.001
		6th	-4.33	1.54	0.223

	5th	Pre-operative	-18.95	2.69	<0.001
		1st	19.24	2.62	<0.001
		2nd	15.57	2.14	<0.001
		3rd	9.76	1.76	<0.001
		4th	1.33	0.90	1.001
		6th	-3.00	1.40	0.924
	6th	Pre-operative	-15.95	2.82	<0.001
		1st	22.24	3.15	<0.001
		2nd	18.57	2.70	<0.001
		3rd	12.76	2.00	<0.001
		4th	4.33	1.54	0.223
		5th	3.00	1.40	0.924

Appendix D

Comparison between pre- and post-operative days within groups of MIP

Groups	Comparison between pre- and post-operative days within groups		Mean Difference	Std. Error	p-value
Control	Pre-operative	1st	33.33	3.80	<0.001
		2nd	27.43	3.57	<0.001
		3rd	23.43	3.74	<0.001
		4th	18.05	3.73	0.002
		5th	12.33	2.87	0.007
		6th	7.33	3.04	0.536
	1st	Pre-operative	-33.33	3.80	<0.001
		2nd	-5.91	1.74	0.059
		3rd	-9.91	2.35	0.009
		4th	-15.29	2.81	0.001
		5th	-21.00	3.13	<0.001
		6th	-26.00	3.25	<0.001
	2nd	Pre-operative	-27.43	3.57	<0.001
		1st	5.91	1.74	0.059
		3rd	-4.00	1.54	0.366
		4th	-9.38	1.84	0.001
		5th	-15.10	2.33	<0.001
		6th	-20.10	2.48	<0.001
	3rd	Pre-operative	-23.43	3.74	<0.001
		1st	9.91	2.35	0.009
		2nd	4.00	1.54	0.366
		4th	-5.38	1.38	0.019
		5th	-11.10	1.71	<0.001
		6th	-16.10	1.80	<0.001

	4th	Pre-operative	-18.05	3.73	0.002
		1st	15.29	2.81	0.001
		2nd	9.38	1.84	0.001
		3rd	5.38	1.38	0.019
		5th	-5.71	1.86	0.124
		6th	-10.71	1.72	<0.001
	5th	Pre-operative	-12.33	2.87	0.007
		1st	21.00	3.13	<0.001
		2nd	15.10	2.33	<0.001
		3rd	11.10	1.71	<0.001
		4th	5.71	1.86	0.124
		6th	-5.00	1.62	0.123
	6th	Pre-operative	-7.33	3.04	0.536
		1st	26.00	3.25	<0.001
		2nd	20.10	2.48	<0.001
		3rd	16.10	1.80	<0.001
		4th	10.71	1.72	<0.001
		5th	5.00	1.62	0.123
Low inspiratory flow rate	Pre-operative	1st	43.62	6.22	<0.001
		2nd	38.81	5.80	<0.001
		3rd	33.33	5.78	<0.001
		4th	23.57	5.48	0.007
		5th	18.62	5.85	0.099
		6th	12.86	4.59	0.233
	1st	Pre-operative	-43.62	6.22	<0.001
		2nd	-4.81	1.73	0.240
		3rd	-10.29	2.09	0.002
		4th	-20.05	2.40	<0.001
		5th	-25.00	3.28	<0.001
		6th	-30.76	3.85	<0.001

	2nd	Pre-operative	-38.81	5.80	<0.001
		1st	4.81	1.73	0.240
		3rd	-5.48	1.75	0.112
		4th	-15.24	1.54	<0.001
		5th	-20.19	2.85	<0.001
		6th	-25.95	3.31	<0.001
	3rd	Pre-operative	-33.33	5.78	<0.001
		1st	10.29	2.09	0.002
		2nd	5.48	1.75	0.112
		4th	-9.76	1.88	0.001
		5th	-14.71	2.39	<0.001
		6th	-20.48	3.06	<0.001
	4th	Pre-operative	-23.57	5.48	0.007
		1st	20.05	2.40	<0.001
		2nd	15.24	1.54	<0.001
		3rd	9.76	1.88	0.001
		5th	-4.95	2.01	0.482
		6th	-10.71	2.98	0.038
	5th	Pre-operative	-18.62	5.85	0.099
		1st	25.00	3.28	<0.001
		2nd	20.19	2.85	<0.001
		3rd	14.71	2.39	<0.001
		4th	4.95	2.01	0.482
		6th	-5.76	2.74	1.000
	6th	Pre-operative	-12.86	4.59	0.233
		1st	30.76	3.85	<0.001
		2nd	25.95	3.31	<0.001
		3rd	20.48	3.06	<0.001
		4th	10.71	2.98	0.038
		5th	5.76	2.74	1.000

High inspiratory flow rate	Pre-operative	1st	41.48	5.33	<0.001
		2nd	39.29	5.64	<0.001
		3rd	31.05	5.23	<0.001
		4th	20.76	3.77	<0.001
		5th	18.00	3.58	0.001
		6th	12.81	3.50	0.033
	1st	Pre-operative	-41.48	5.33	<0.001
		2nd	-2.19	1.61	1.000
		3rd	-10.43	2.48	0.009
		4th	-20.71	2.85	<0.001
		5th	-23.48	3.36	<0.001
		6th	-28.67	4.45	<0.001
	2nd	Pre-operative	-39.29	5.64	<0.001
		1st	2.19	1.61	1.000
		3rd	-8.24	2.51	0.078
		4th	-18.52	2.81	<0.001
		5th	-21.29	3.23	<0.001
		6th	-26.48	3.94	<0.001
	3rd	Pre-operative	-31.05	5.23	<0.001
		1st	10.43	2.48	0.009
		2nd	8.24	2.51	0.078
		4th	-10.29	3.01	0.058
		5th	-13.05	3.63	0.038
		6th	-18.24	4.18	0.006
	4th	Pre-operative	-20.76	3.77	<0.001
		1st	20.71	2.85	<0.001
		2nd	18.52	2.81	<0.001
		3rd	10.29	3.01	0.058
		5th	-2.76	1.51	1.000
		6th	-7.95	2.77	0.200

	5th	Pre-operative	-18.00	3.58	0.001
		1st	23.48	3.36	<0.001
		2nd	21.29	3.23	<0.001
		3rd	13.05	3.63	0.038
		4th	2.76	1.51	1.000
		6th	-5.19	1.84	0.223
	6th	Pre-operative	-12.81	3.50	0.033
		1st	28.67	4.45	<0.001
		2nd	26.48	3.94	<0.001
		3rd	18.24	4.18	0.006
		4th	7.95	2.77	0.200
		5th	5.19	1.84	0.223

Appendix E

Comparison between pre- and post-operative days within groups of MEP

Groups	Comparison between pre- and post-operative days within groups		Mean Difference	Std. Error	p-value
Control	Pre-operative	1st	40.57	4.47	<0.001
		2nd	33.91	4.47	<0.001
		3rd	27.81	5.35	0.001
		4th	23.62	4.69	0.001
		5th	18.48	4.76	0.020
		6th	14.05	4.98	0.221
	1st	Pre-operative	-40.57	4.47	<0.001
		2nd	-6.67	2.24	0.157
		3rd	-12.76	3.64	0.046
		4th	-16.95	3.89	0.006
		5th	-22.10	4.68	0.003
		6th	-26.52	4.75	<0.001
	2nd	Pre-operative	-33.91	4.47	<0.001
		1st	6.67	2.24	0.157
		3rd	-6.10	2.73	0.785
		4th	-10.29	3.01	0.058
		5th	-15.43	3.98	0.020
		6th	-19.86	3.90	0.001
	3rd	Pre-operative	-27.81	5.35	0.001
		1st	12.76	3.64	0.046
		2nd	6.10	2.73	0.785
		4th	-4.19	1.53	0.269
		5th	-9.33	2.30	0.013
		6th	-13.76	2.20	<0.001

	4th	Pre-operative	-23.62	4.69	0.001
		1st	16.95	3.89	0.006
		2nd	10.29	3.01	0.058
		3rd	4.19	1.53	0.269
		5th	-5.14	1.52	0.063
		6th	-9.57	1.69	<0.001
	5th	Pre-operative	-18.48	4.76	0.020
		1st	22.10	4.68	0.003
		2nd	15.43	3.98	0.020
		3rd	9.33	2.30	0.013
		4th	5.14	1.52	0.063
		6th	-4.43	1.07	0.010
	6th	Pre-operative	-14.05	4.98	0.221
		1st	26.52	4.75	<0.001
		2nd	19.86	3.90	0.001
		3rd	13.76	2.20	<0.001
		4th	9.57	1.69	<0.001
		5th	4.43	1.07	0.010
Low inspiratory flow rate	Pre-operative	1st	43.24	6.33	<0.001
		2nd	40.05	6.27	<0.001
		3rd	32.19	6.37	0.001
		4th	26.76	6.23	0.007
		5th	22.95	6.02	0.023
		6th	17.10	5.53	0.121
	1st	Pre-operative	-43.24	6.33	<0.001
		2nd	-3.19	1.65	1.000
		3rd	-11.05	2.20	0.001
		4th	-16.48	2.02	<0.001
		5th	-20.29	2.13	<0.001
		6th	-26.14	2.46	<0.001

2nd	Pre-operative	-40.05	6.27	<0.001
	1st	3.19	1.65	1.000
	3rd	-7.86	2.00	0.018
	4th	-13.29	1.81	<0.001
	5th	-17.10	1.93	<0.001
	6th	-22.95	2.52	<0.001
3rd	Pre-operative	-32.19	6.37	0.001
	1st	11.05	2.20	0.001
	2nd	7.86	2.00	0.018
	4th	-5.43	1.39	0.018
	5th	-9.24	1.56	<0.001
	6th	-15.10	1.94	<0.001
4th	Pre-operative	-26.76	6.23	0.007
	1st	16.48	2.02	<0.001
	2nd	13.29	1.81	<0.001
	3rd	5.43	1.39	0.018
	5th	-3.81	1.15	0.071
	6th	-9.67	1.97	0.002
5th	Pre-operative	-22.95	6.02	0.023
	1st	20.29	2.13	<0.001
	2nd	17.10	1.93	<0.001
	3rd	9.24	1.56	<0.001
	4th	3.81	1.15	0.071
	6th	-5.86	1.71	0.057
6th	Pre-operative	-17.10	5.53	0.121
	1st	26.14	2.46	<0.001
	2nd	22.95	2.52	<0.001
	3rd	15.10	1.94	<0.001
	4th	9.67	1.97	0.002
	5th	5.86	1.71	0.057

High inspiratory flow rate	Pre-operative	1st	36.86	5.27	<0.001
		2nd	32.43	5.54	<0.001
		3rd	25.95	4.92	0.001
		4th	20.10	4.01	0.001
		5th	15.24	3.57	0.008
		6th	12.62	3.09	0.012
	1st	Pre-operative	-36.86	5.27	<0.001
		2nd	-4.43	2.43	1.000
		3rd	-10.91	2.77	0.017
		4th	-16.76	3.56	0.003
		5th	-21.62	4.11	0.001
		6th	-24.24	3.91	<0.001
	2nd	Pre-operative	-32.43	5.54	<0.001
		1st	4.43	2.43	1.000
		3rd	-6.48	3.62	1.000
		4th	-12.33	4.11	0.147
		5th	-17.19	4.78	0.038
		6th	-19.81	4.69	0.009
	3rd	Pre-operative	-25.95	4.92	0.001
		1st	10.91	2.77	0.017
		2nd	6.48	3.62	1.000
		4th	-5.86	1.81	0.085
		5th	-10.71	3.01	0.041
		6th	-13.33	3.40	0.018
	4th	Pre-operative	-20.10	4.01	0.001
		1st	16.76	3.56	0.003
		2nd	12.33	4.11	0.147
		3rd	5.86	1.81	0.085
		5th	-4.86	2.13	0.701
		6th	-7.48	2.72	0.261

	5th	Pre-operative	-15.24	3.57	0.008
		1st	21.62	4.11	0.001
		2nd	17.19	4.78	0.038
		3rd	10.71	3.01	0.041
		4th	4.86	2.13	0.701
		6th	-2.62	1.61	1.000
	6th	Pre-operative	-12.62	3.09	0.012
		1st	24.24	3.91	<0.001
		2nd	19.81	4.69	0.009
		3rd	13.33	3.40	0.018
		4th	7.48	2.72	0.261
		5th	2.62	1.61	1.000

Appendix F

Comparison between pre- and post-operative days within groups of Dyspnea score

Groups	Comparison between pre- and post-operative days within groups		Mean Difference	Std. Error	p-value
Control	Pre-operative	1st	-3.52	0.62	<0.001
		2nd	-3.24	0.77	0.009
		3rd	-2.86	0.71	0.014
		4th	-3.14	0.82	0.022
		5th	-2.57	0.65	0.017
		6th	-2.67	0.67	0.016
	1st	Pre-operative	3.52	0.62	<0.001
		2nd	0.29	0.84	1.000
		3rd	0.67	0.85	1.000
		4th	0.38	0.70	1.000
		5th	0.95	0.83	1.000
		6th	0.86	0.80	1.000
	2nd	Pre-operative	3.24	0.77	0.009
		1st	-0.29	0.84	1.000
		3rd	0.38	0.75	1.000
		4th	0.10	0.76	1.000
		5th	0.67	0.78	1.000
		6th	0.57	0.75	1.000
	3rd	Pre-operative	2.86	0.71	0.014
		1st	-0.67	0.85	1.000
		2nd	-0.38	0.75	1.000
		4th	-0.29	0.90	1.000
		5th	0.29	0.64	1.000
		6th	0.19	0.59	1.000

	4th	Pre-operative	3.14	0.82	0.022
		1st	-0.38	0.70	1.000
		2nd	-0.10	0.76	1.000
		3rd	0.29	0.90	1.000
		5th	0.57	0.70	1.000
		6th	0.48	0.71	1.000
	5th	Pre-operative	2.57	0.65	0.017
		1st	-0.95	0.83	1.000
		2nd	-0.67	0.78	1.000
		3rd	-0.29	0.64	1.000
		4th	-0.57	0.70	1.000
		6th	-0.10	0.58	1.000
	6th	Pre-operative	2.67	0.67	0.016
		1st	-0.86	0.80	1.000
		2nd	-0.57	0.75	1.000
		3rd	-0.19	0.59	1.000
		4th	-0.48	0.71	1.000
		5th	0.10	0.58	1.000
Low inspiratory flow rate	Pre-operative	1st	-4.00	0.66	<0.001
		2nd	-3.14	0.44	<0.001
		3rd	-3.24	0.61	0.001
		4th	-2.52	0.53	0.003
		5th	-2.62	0.65	0.013
		6th	-1.86	0.63	0.173
	1st	Pre-operative	4.00	0.66	<0.001
		2nd	0.86	0.70	1.000
		3rd	0.76	0.78	1.000
		4th	1.48	0.84	1.000
		5th	1.38	0.95	1.000
		6th	2.14	0.94	0.706

2nd	Pre-operative	3.14	0.44	<0.001
	1st	-0.86	0.70	1.000
	3rd	-0.10	0.43	1.000
	4th	0.62	0.38	1.000
	5th	0.52	0.53	1.000
	6th	1.29	0.58	0.793
3rd	Pre-operative	3.24	0.61	0.001
	1st	-0.76	0.78	1.000
	2nd	0.10	0.43	1.000
	4th	0.71	0.50	1.000
	5th	0.62	0.70	1.000
	6th	1.38	0.74	1.000
4th	Pre-operative	2.52	0.53	0.003
	1st	-1.48	0.84	1.000
	2nd	-0.62	0.38	1.000
	3rd	-0.71	0.50	1.000
	5th	-0.10	0.60	1.000
	6th	0.67	0.72	1.000
5th	Pre-operative	2.62	0.65	0.013
	1st	-1.38	0.95	1.000
	2nd	-0.52	0.53	1.000
	3rd	-0.62	0.70	1.000
	4th	0.10	0.60	1.000
	6th	0.76	0.44	1.000
6th	Pre-operative	1.86	0.63	0.173
	1st	-2.14	0.94	0.706
	2nd	-1.29	0.58	0.793
	3rd	-1.38	0.74	1.000
	4th	-0.67	0.72	1.000
	5th	-0.76	0.44	1.000

High inspiratory flow rate	Pre-operative	1st	-3.86	0.78	0.002
		2nd	-2.95	0.71	0.010
		3rd	-3.05	0.65	0.003
		4th	-2.52	0.66	0.024
		5th	-2.10	0.61	0.054
		6th	-1.33	0.53	0.418
	1st	Pre-operative	3.86	0.78	0.002
		2nd	0.91	0.59	1.000
		3rd	0.81	0.68	1.000
		4th	1.33	0.72	1.000
		5th	1.76	0.81	0.879
		6th	2.52	0.73	0.050
	2nd	Pre-operative	2.95	0.71	0.010
		1st	-0.91	0.59	1.000
		3rd	-0.10	0.53	1.000
		4th	0.43	0.56	1.000
		5th	0.86	0.67	1.000
		6th	1.62	0.70	0.655
	3rd	Pre-operative	3.05	0.65	0.003
		1st	-0.81	0.68	1.000
		2nd	0.10	0.53	1.000
		4th	0.52	0.46	1.000
		5th	0.95	0.43	0.793
		6th	1.71	0.57	0.145
	4th	Pre-operative	2.52	0.66	0.024
		1st	-1.33	0.72	1.000
		2nd	-0.43	0.56	1.000
		3rd	-0.52	0.46	1.000
		5th	0.43	0.51	1.000

		6th	1.19	0.60	1.000
	5th	Pre-operative	2.10	0.61	0.054
		1st	-1.76	0.81	0.879
		2nd	-0.86	0.67	1.000
		3rd	-0.95	0.43	0.793
		4th	-0.43	0.51	1.000
		6th	0.76	0.58	1.000
	6th	Pre-operative	1.33	0.53	0.418
		1st	-2.52	0.73	0.050
		2nd	-1.62	0.70	0.655
		3rd	-1.71	0.57	0.145
		4th	-1.19	0.60	1.000
		5th	-0.76	0.58	1.000

Appendix G

Comparison between pre- and post-operative days within groups of Pain score

Groups	Comparison between pre- and post-operative days within groups		Mean Difference	Std. Error	p-value
Control	Pre-operative	1st	-4.41	0.65	<0.001
		2nd	-3.00	0.41	<0.001
		3rd	-2.11	0.41	0.001
		4th	-1.76	0.44	0.015
		5th	-1.41	0.34	0.011
		6th	-0.65	0.23	0.225
	1st	Pre-operative	4.41	0.65	<0.001
		2nd	1.41	0.44	0.089
		3rd	2.31	0.57	0.014
		4th	2.66	0.62	0.008
		5th	3.00	0.64	0.003
		6th	3.77	0.62	<0.001
	2nd	Pre-operative	3.00	0.41	<0.001
		1st	-1.41	0.44	0.089
		3rd	0.89	0.27	0.068
		4th	1.24	0.35	0.039
		5th	1.59	0.37	0.007
		6th	2.35	0.32	<0.001
	3rd	Pre-operative	2.11	0.41	0.001
		1st	-2.31	0.57	0.014
		2nd	-0.89	0.27	0.068
		4th	0.35	0.19	1.000
		5th	0.70	0.24	0.204
		6th	1.46	0.25	<0.001

	4th	Pre-operative	1.76	0.44	0.015
		1st	-2.66	0.62	0.008
		2nd	-1.24	0.35	0.039
		3rd	-0.35	0.19	1.000
		5th	0.34	0.22	1.000
		6th	1.11	0.23	0.003
	5th	Pre-operative	1.41	0.34	0.011
		1st	-3.00	0.64	0.003
		2nd	-1.59	0.37	0.007
		3rd	-0.70	0.24	0.204
		4th	-0.34	0.22	1.000
		6th	0.77	0.22	0.050
	6th	Pre-operative	0.65	0.23	0.225
		1st	-3.77	0.62	<0.001
		2nd	-2.35	0.32	<0.001
		3rd	-1.46	0.25	<0.001
		4th	-1.11	0.23	0.003
		5th	-0.77	0.22	0.050
Low inspiratory flow rate	Pre-operative	1st	-3.56	0.43	<0.001
		2nd	-2.63	0.39	<0.001
		3rd	-2.08	0.33	<0.001
		4th	-1.48	0.26	<0.001
		5th	-1.13	0.29	0.017
		6th	-0.50	0.24	1.000
	1st	Pre-operative	3.56	0.43	<0.001
		2nd	0.93	0.29	0.083
		3rd	1.48	0.28	0.001
		4th	2.08	0.25	<0.001
		5th	2.43	0.40	<0.001
		6th	3.07	0.40	<0.001

2nd	Pre-operative	2.63	0.39	<0.001
	1st	-0.93	0.29	0.083
	3rd	0.55	0.21	0.395
	4th	1.14	0.24	0.002
	5th	1.50	0.35	0.007
	6th	2.13	0.31	<0.001
3rd	Pre-operative	2.08	0.33	<0.001
	1st	-1.48	0.28	0.001
	2nd	-0.55	0.21	0.395
	4th	0.60	0.12	0.002
	5th	0.95	0.32	0.154
	6th	1.59	0.24	<0.001
4th	Pre-operative	1.49	0.26	<0.001
	1st	-2.08	0.25	<0.001
	2nd	-1.14	0.24	0.002
	3rd	-0.60	0.12	0.002
	5th	0.36	0.27	1.000
	6th	0.99	0.21	0.002
5th	Pre-operative	1.13	0.29	0.017
	1st	-2.43	0.40	<0.001
	2nd	-1.50	0.35	0.007
	3rd	-0.95	0.32	0.154
	4th	-0.36	0.27	1.000
	6th	0.63	0.21	0.165
6th	Pre-operative	0.50	0.24	1.000
	1st	-3.07	0.40	<0.001
	2nd	-2.13	0.31	<0.001
	3rd	-1.59	0.24	<0.001
	4th	-0.99	0.21	0.002
	5th	-0.63	0.21	0.165

High inspiratory flow rate	Pre-operative	1st	-4.23	0.48	<0.001
		2nd	-3.34	0.35	<0.001
		3rd	-2.39	0.38	<0.001
		4th	-1.96	0.42	0.003
		5th	-1.77	0.36	0.002
		6th	-0.98	0.25	0.020
	1st	Pre-operative	4.23	0.48	<0.001
		2nd	0.89	0.28	0.100
		3rd	1.84	0.43	0.008
		4th	2.27	0.59	0.022
		5th	2.46	0.59	0.011
		6th	3.25	0.54	<0.001
	2nd	Pre-operative	3.34	0.35	<0.001
		1st	-0.89	0.28	0.100
		3rd	0.95	0.27	0.041
		4th	1.38	0.40	0.056
		5th	1.57	0.42	0.027
		6th	2.36	0.37	<0.001
	3rd	Pre-operative	2.39	0.38	<0.001
		1st	-1.84	0.43	0.008
		2nd	-0.95	0.27	0.041
		4th	0.43	0.38	1.000
		5th	0.62	0.43	1.000
		6th	1.41	0.38	0.028
	4th	Pre-operative	1.96	0.42	0.003
		1st	-2.27	0.59	0.022
		2nd	-1.38	0.40	0.056
		3rd	-0.43	0.38	1.000
		5th	0.19	0.16	1.000
		6th	0.98	0.29	0.068

	5th	Pre-operative	1.77	0.36	0.002
		1st	-2.46	0.59	0.011
		2nd	-1.57	0.42	0.027
		3rd	-0.62	0.43	1.000
		4th	-0.19	0.16	1.000
		6th	0.79	0.20	0.017
	6th	Pre-operative	0.98	0.25	0.020
		1st	-3.25	0.54	<0.001
		2nd	-2.36	0.37	<0.001
		3rd	-1.41	0.38	0.028
		4th	-0.98	0.29	0.068
		5th	-0.79	0.20	0.017

Appendix H

แบบบันทึกข้อมูลการวิจัย

ชื่อ.....เพศ.....อายุ.....HN.....ตึก.....

อาชีพ.....

ส่วนสูง.....เซนติเมตร น้ำหนัก.....กิโลกรัม BMI.....kg/m^2

Diagnosis.....

Operative..... Operative date.....

Inclusion criteria	**Yes**	**No**
- Patients undergoing on-pump cardiac surgery with median sternotomy for correcting valaular disease or CABG - Equal or more than 40 years of age - Good communication and cooperation		
Exclusion criteria	**Yes**	**No**
- Uncomplicated cardiac event (Any severe or acute cardiovascular condition including acute MI, unstable angina, or cardiac arrest) - Respiratory diseases - History of cardiac arrest - Hemodynamic instability - Difficult to understand or perform the measures or physical therapeutic conducts		

Pre-operative			
Parameters	Predicted value	Date (__/__/__)	% Predicted
VC			
MIP (CmH_2O)			
MEP (CmH_2O)			
Pain score			
Dyspnea score			

ไม่ปวด ปวดมากที่สุด

Post-operative

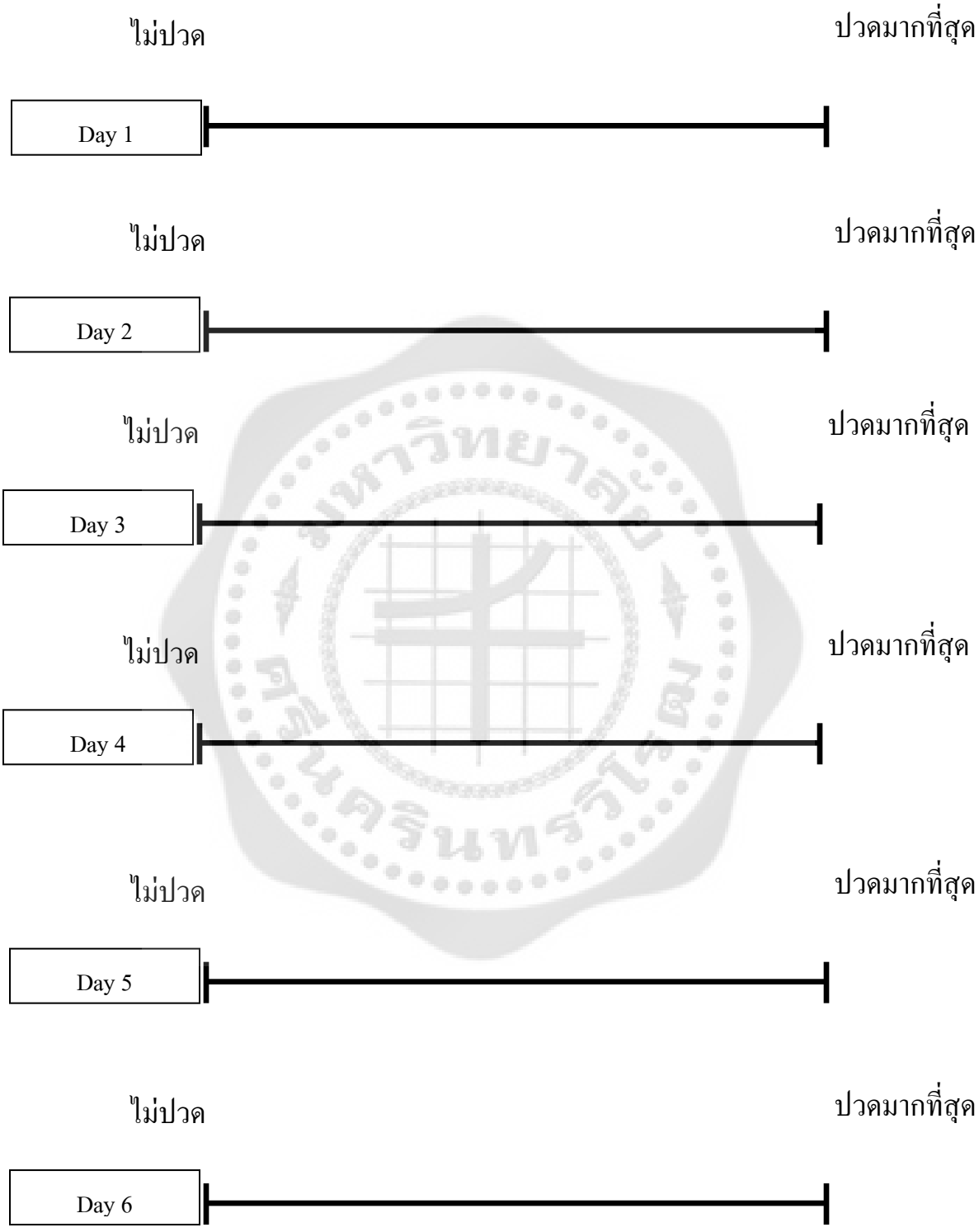
Exclusion criteria	**Yes**	**No**
- Undergoing invasive mechanical ventilation supports for a period exceeding 24 hours after admission to the intensive care unit - Hemodynamic instability - Reoperation		

Parameters	Predicted value	Days					
		1	2	3	4	5	6
VC							
MIP (CmH_2O)							
MEP (CmH_2O)							
Pain score							
Dyspnea score							

Dischard (__/__/__)

Comment……

Pain score


ไม่ปวด
ปวดมากที่สุด
Day 1
ไม่ปวด
ปวดมากที่สุด
Day 2
ไม่ปวด
ปวดมากที่สุด
Day 3
ไม่ปวด
ปวดมากที่สุด
Day 4
ไม่ปวด
ปวดมากที่สุด
Day 5
ไม่ปวด
ปวดมากที่สุด
Day 6

เลขที่ 008/2557

คณะกรรมการจริยธรรมเพื่อการวิจัยสถาบันโรคทรวงอก

กรมการแพทย์

กระทรวงสาธารณสุข

โครงการวิจัย : "การเปรียบเทียบการฝึก flow oriented incentive spirometry ระหว่างอัตราการสูดหายใจเข้าต่ำ และสูง ต่อสมรรถภาพปอด กำลังกล้ามเนื้อหายใจ ระดับความเหนื่อย และ ระยะทางการเดินหกนาที หลังการผ่าตัดหัวใจ "(Comparison between low and high inspiratory flow rates of flow-oriented incentive spirometry on pulmonary function, respiratory muscle strength, dyspnea score and six minute walk distance after cardiac surgery)

ผู้ดำเนินการวิจัย : ผู้ช่วยศาสตราจารย์ ดร. สุกัลยา กฤษณเกรียงไกร สังกัด สาขากายภาพบำบัด คณะสหเวชศาสตร์ มหาวิทยาลัยศรีนครินทรวิโรฒ

สถานที่ทำการวิจัย : สถาบันโรคทรวงอก

เอกสารที่ได้รับการพิจารณามีดังนี้

1. แบบเสนอขอรับการพิจารณาจริยธรรมการวิจัยจากศูนย์การวิจัยทางคลินิก งานจริยธรรมเพื่อการวิจัย สถาบันโรคทรวงอก
2. โครงร่างงานวิจัย
3. หนังสือให้ความยินยอมเข้าร่วมในโครงการวิจัย
4. คำชี้แจงอาสาสมัคร(Information sheet)

คณะกรรมการจริยธรรมเพื่อการวิจัยสถาบันโรคทรวงอก กรมการแพทย์ กระทรวงสาธารณสุข อนุมัติในแง่จริยธรรมให้ดำเนินการศึกษาวิจัยเรื่องข้างต้นได้

..... ประธานกรรมการ

(นายแพทย์ชูศักดิ์ เกษมศานต์)

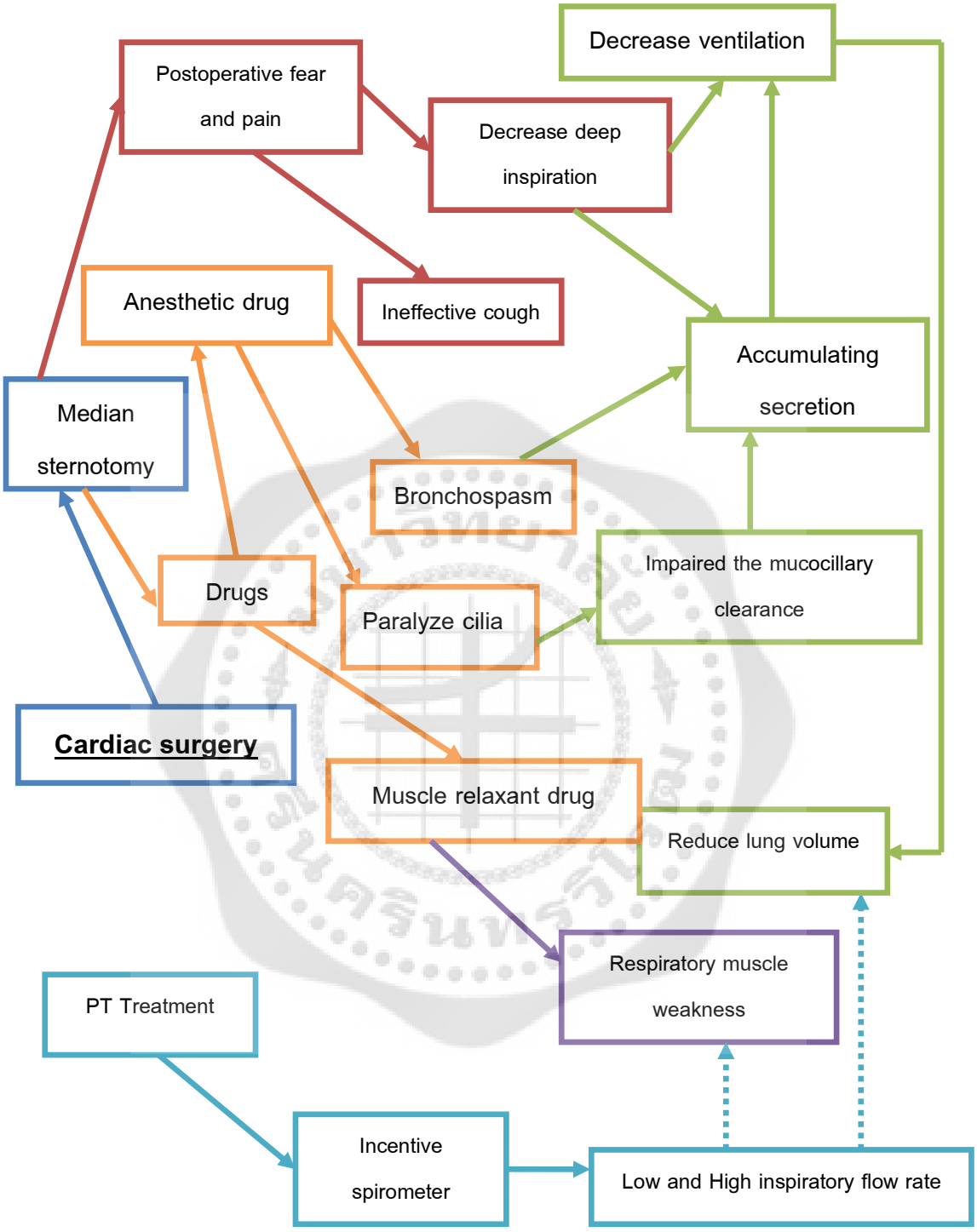
..... เลขานุการกรรมการ

(นายแพทย์เฉลียว พูลศิริปัญญา)

รับรองวันที่ : 07 ส.ค. 2557

วันหมดอายุ : 06 ส.ค. 2558

Appendix J



Conceptual framework

Appendix K

The raw data of vital capacity

Group	Predicted value	VCP	%	VC1	%	VC2	%	VC3	%	VC4	%	VC5	%	VC6	%
A	1.98	1.03	52	0.59	30	0.59	30	0.41	21	0.8	40	0.82	41	0.84	42
A	3.63	2.49	69	0.98	27	0.9	25	0.99	27	1.27	35	1.83	50	2.04	56
A	2.64	2.94	112	0.79	30	1.41	53	1.31	50	1.7	64	2.08	79	2.36	89
A	3.09	2.34	76	0.38	12	1.07	35	1.61	52	1.58	51	1.72	56	1.98	64
A	3.45	1.53	44	0.17	5	0.17	5	0.48	14	0.47	14	0.96	28	0.96	28
A	3.32	1.28	39	0.5	15	0.76	23	0.96	29	1.13	34	1.57	47	1.62	49
C	2.41	1.51	61	0.63	26	0.63	26	0.76	32	1.19	49	1.22	51	1.4	58
A	2.9	1.74	60	0.59	20	0.59	20	0.92	32	0.88	30	1.03	36	1.2	41
C	3.81	2.17	57	1.05	28	1.26	33	1.46	38	1.65	43	1.75	46	2.12	56
A	3.55	2.12	60	0.66	19	0.87	25	1.01	28	0.99	28	1.11	31	1.12	32
A	2.15	1.68	78	0.5	23	0.55	26	0.77	36	1.05	49	1.18	55	1.45	67
A	3.99	1.03	26	0.77	19	0.7	18	1.09	27	1.11	28	1.23	31	1.18	30
A	3.61	1.66	46	0.93	26	0.77	21	0.98	27	1.31	36	1.21	34	1.62	45
C	2.7	1.65	61	0.68	25	0.51	19	0.81	30	0.86	32	0.96	36	1.07	40
B	3.71	2.69	73	0.76	20	0.78	21	0.78	21	1.52	41	1.71	46	1.97	53
B	3.24	1.86	57	0.85	26	1.36	42	1.36	42	1.69	52	1.8	56	1.99	61
C	2.53	0.72	29	0.75	30	0.83	33	0.65	26	0.75	30	0.75	30	0.84	33
C	2.5	1.54	62	0.69	28	0.69	28	0.77	31	0.8	32	0.88	35	0.93	37
C	2.57	1.57	61	0.83	32	0.83	32	1.01	39	1.01	39	0.98	38	1.2	47
C	3.46	2.41	70	0.7	20	0.7	20	0.7	20	1.05	30	1.12	32	1.12	32
C	3.24	1.63	50	0.4	12	0.59	18	1.21	37	1.14	35	1.14	35	1.16	36
C	2.41	2.02	84	0.41	17	0.79	33	1.42	59	1.42	59	1.55	64	2.06	85
A	1.9	1.28	67	0.62	33	0.62	33	0.86	45	0.85	45	0.85	45	0.96	51
B	3.2	2.15	67	0.88	28	0.94	29	1.54	48	1.54	48	1.8	56	2.03	63
B	3.81	2.47	65	0.54	14	0.6	16	0.92	24	0.98	26	1.33	35	1.33	35
B	2.92	2.07	71	1.08	37	1.5	51	1.58	54	1.68	58	1.74	60	1.82	62
B	3.45	2.74	79	0.7	20	0.84	24	1.59	46	1.77	51	1.97	57	2.07	60
B	2.97	1.91	64	0.53	18	0.54	18	1.17	39	1.2	40	1.3	44	1.29	43
A	3.74	1.59	42	0.51	14	0.58	16	0.78	21	1.04	28	1.07	29	1.18	32
C	2.09	1.56	75	0.37	18	0.4	19	0.36	17	0.84	40	0.91	44	0.9	43
B	2.45	1.27	52	0.54	22	0.54	22	0.64	26	0.76	31	0.78	32	0.89	36
B	3.06	2.5	82	0.75	25	0.79	26	0.91	30	1.07	35	1.23	40	1.48	48
C	3.19	2.04	64	0.69	22	0.83	26	0.98	31	1.5	47	1.45	45	1.63	51
A	2.25	1.55	69	0.72	32	0.75	33	1.05	47	1.19	53	1.3	58	1.27	56
C	2.42	0.92	38	0.61	25	0.46	19	0.57	24	0.56	23	0.75	31	0.78	32
B	4.04	1.73	43	0.62	15	0.67	17	0.98	24	1.08	27	1.75	43	1.56	39
C	3.18	1.77	56	0.73	23	0.97	31	1.01	32	1.48	47	1.5	47	1.31	41
C	2.37	1.23	52	0.81	34	1.2	51	1.16	49	1.36	57	1.22	51	1.22	51
B	2.64	1.88	71	0.95	36	1.38	52	1.24	47	1.25	47	1.45	55	1.38	52

Group	Predicted value	VCP	%	VC1	%	VC2	%	VC3	%	VC4	%	VC5	%	VC6	%
B	2.56	1.55	61	0.62	24	0.79	31	0.98	38	0.91	36	0.96	38	1.02	40
C	3.29	3.38	103	0.92	28	1.08	33	1.06	32	1.99	60	1.85	56	2.2	67
B	3.79	2.05	54	1.21	32	1.2	32	1.71	45	1.86	49	2.15	57	2.19	58
B	1.53	1.38	90	0.6	39	0.57	37	0.67	44	1.03	67	0.73	48	0.82	54
C	2.83	2.98	105	1.27	45	1.61	57	2.15	76	2.33	82	2.45	87	2.39	84
B	3.44	1.82	53	0.55	16	1.05	31	1.33	39	1.4	41	1.6	47	1.96	57
B	2.52	2.03	81	0.92	37	1.11	44	1.17	46	1.33	53	1.64	65	1.65	65
B	4.06	3.28	81	0.8	20	1.48	36	1.63	40	1.92	47	2.53	62	2.42	60
A	3.06	2.05	67	0.65	21	0.6	20	0.6	20	0.9	29	1.12	37	1.34	44
A	2.72	1.67	61	0.96	35	1.2	44	1.44	53	1.75	64	1.53	56	1.64	60
C	3.54	2.6	73	1	28	1.1	31	1.35	38	1.92	54	1.91	54	1.89	53
B	2.99	2.09	70	1.24	41	1.41	47	1.48	49	2.15	72	2.29	77	2.04	68
A	2.77	2.29	83	0.95	34	0.94	34	1.18	43	1.91	69	1.96	71	2.08	75
B	3.14	2.41	77	0.9	29	1.13	36	1.54	49	1.84	59	1.94	62	2.07	66
C	3.78	1.17	29	0.5	13	0.64	17	0.84	22	1.24	33	1.06	28	1.1	29
C	4.02	2.78	69	1.2	30	0.96	24	1.52	38	1.62	40	1.59	40	1.83	46
B	3.77	2.71	72	1.67	44	1.31	35	1.38	37	1.97	52	1.77	47	2.02	54
A	1.72	1.08	63	0.48	28	0.42	24	0.51	30	0.56	33	0.57	33	0.8	47
A	3.38	2.98	88	0.67	20	0.58	17	1.07	32	1.57	46	2.01	59	1.86	55
A	3.29	1.35	41	0.86	26	1.02	31	1.21	37	1.24	38	1.29	39	1.29	39
B	3.83	2.67	70	0.96	25	1.27	33	1.48	39	2.2	57	2.53	66	2.57	67
C	2.37	1.72	73	0.52	22	0.6	25	0.76	32	0.96	41	1.24	52	1.04	44
A	2.63	1.7	65	0.54	21	0.52	20	0.58	22	0.55	21	0.65	25	0.67	25
C	3.08	1.79	58	0.69	22	0.91	30	0.74	24	0.94	31	0.91	30	0.93	30

Appendix L

The raw data of maximum inspiratory pressure

Group	MIP-P	MIP-1	MIP-2	MIP-3	MIP-4	MIP-5	MIP-6
A	33	8	18	18	22	28	34
A	55	26	21	31	37	50	49
A	43	20	26	37	50	37	61
A	21	6	13	31	30	33	32
A	53	9	8	6	8	25	19
A	64	9	30	35	43	49	62
C	36	18	18	29	34	33	37
A	44	18	18	12	17	20	27
C	92	37	42	46	58	70	80
A	55	31	31	42	40	57	60
A	48	6	10	11	15	26	34
A	60	21	40	43	54	65	60
A	42	18	18	21	25	27	45
C	27	5	14	17	18	27	31
B	113	21	27	27	49	50	58
B	65	19	26	26	41	44	46
C	11	7	21	24	33	33	33
C	63	13	13	21	22	26	37
C	51	8	8	12	12	16	25
C	82	19	19	19	49	62	62
C	47	13	15	18	28	28	29
C	68	18	24	41	41	57	77
A	34	20	23	21	23	23	21
B	37	10	16	39	39	74	71
B	55	4	7	14	19	25	25
B	43	18	18	30	35	38	47
B	110	14	20	31	40	48	80
B	92	18	20	36	47	41	52
A	61	9	24	45	49	59	64
C	29	11	10	10	19	26	21
B	37	18	24	22	40	42	40

Group	MIP-P	MIP-1	MIP-2	MIP-3	MIP-4	MIP-5	MIP-6
B	53	15	24	31	32	39	33
C	60	13	29	37	35	34	59
A	43	13	15	16	25	22	35
C	34	18	16	24	25	19	16
B	80	17	17	30	28	45	55
C	52	22	22	41	44	38	32
C	58	32	30	41	49	51	51
B	43	28	24	23	31	31	33
B	50	16	25	37	38	43	45
C	120	13	28	31	80	83	99
B	59	15	17	25	52	67	51
B	24	21	17	19	26	19	24
C	115	32	20	72	66	63	66
B	46	11	26	32	39	36	42
B	56	34	24	22	35	47	46
B	119	12	29	26	40	43	80
A	63	7	12	17	8	27	33
A	65	32	28	37	38	50	50
C	79	22	25	33	49	62	75
B	39	25	15	27	22	24	44
A	83	12	22	23	45	48	52
B	71	17	28	35	43	47	35
C	31	18	24	26	35	30	33
C	64	19	19	29	36	38	47
B	49	22	42	30	52	52	63
A	25	8	11	11	13	11	20
A	62	6	13	15	26	38	40
A	36	11	34	29	36	39	39
B	42	12	22	21	40	37	43
C	97	47	34	29	69	73	67
A	13	13	12	10	20	10	12
C	57	17	17	21	35	26	27

Appendix M

The raw data of maximum expiratory pressure

Group	MEP-P	MEP-1	MEP-2	MEP-3	MEP-4	MEP-5	MEP-6
A	55	16	26	25	26	31	32
A	82	42	35	39	44	55	64
A	51	14	44	37	44	41	52
A	43	12	28	38	28	30	42
A	38	10	25	19	25	35	36
A	76	16	35	39	52	60	67
C	36	26	26	29	33	36	39
A	72	18	18	11	17	26	31
C	83	20	38	33	38	39	52
A	65	48	43	54	53	60	65
A	47	10	15	21	21	26	34
A	72	15	37	89	98	117	123
A	88	41	33	33	41	46	53
C	54	14	25	26	34	52	48
B	153	29	29	29	44	48	51
B	63	26	34	34	45	44	42
C	24	16	29	24	27	27	30
C	54	17	17	24	24	34	42
C	51	15	15	26	26	23	32
C	80	22	22	22	28	65	65
C	46	19	19	24	31	31	31
C	73	32	32	41	41	54	77
A	47	21	21	30	35	35	31
B	56	17	29	44	44	45	51
B	67	6	5	18	18	32	39
B	42	16	32	46	51	58	59
B	91	19	24	32	45	54	60
B	63	17	15	39	40	47	40
A	30	17	17	32	31	35	34
C	34	10	13	19	25	33	32
B	61	26	28	36	47	50	50

Group	MEP-P	MEP-1	MEP-2	MEP-3	MEP-4	MEP-5	MEP-6
B	51	23	17	36	41	43	50
C	38	21	38	33	43	42	45
A	47	29	34	34	40	30	34
C	32	23	18	31	33	26	25
B	84	20	17	33	32	33	63
C	53	25	44	42	39	36	31
C	50	33	39	37	45	45	46
B	43	31	27	27	34	35	41
B	56	34	35	49	49	53	57
C	123	14	33	38	75	84	84
B	56	34	36	32	50	50	56
B	38	15	29	26	34	29	26
C	94	35	15	90	98	105	96
B	56	21	27	30	35	34	41
B	42	30	29	32	46	54	57
B	100	9	31	29	27	40	50
A	81	18	31	33	33	37	42
A	74	34	32	49	50	58	64
C	97	39	26	30	45	50	65
B	54	26	22	45	40	42	49
A	117	18	22	24	49	62	57
B	70	43	37	34	34	46	54
C	71	24	47	45	48	47	44
C	51	28	21	26	27	33	35
B	110	28	30	47	54	50	71
A	41	12	21	20	23	21	34
A	73	7	23	24	24	32	33
A	58	38	37	50	46	59	59
B	44	22	26	26	28	31	34
C	44	29	31	33	33	40	38
A	53	22	21	25	34	26	28
C	72	24	31	42	45	38	38

Appendix N

The raw data of pain score

Group	Pre-OP	D1	D2	D3	D4	D5	D6
A	0	2.7	4.5	4.5	1.9	1.9	0.8
A	0	2.9	2.8	1.2	0.5	0.3	0
A	0	7.3	2.1	0.8	0.2	0.2	0.2
A	0	4.8	1.7	0.8	0.8	0.8	0.2
A	0.3	3.6	2.5	1.5	1.2	3.3	0
A	0	1	0	0.4	0.3	0.3	0
C	0	4.9	4.9	4.9	2.9	1.6	0.4
A	0	3.1	3.1	5.3	6.8	4.5	3
C	0	5.7	4.6	2.9	1.6	2.8	1.8
A	0	3	2.3	1.7	0.7	0.6	0.2
A	0	10	5.3	4.3	4.3	4.4	1.8
A	0	5.1	3.6	0.2	0.1	0.1	0
A	0	2.7	1.1	0.9	0.5	0.3	0.4
C	0	7.5	4.8	2.2	0	0	0
B	0	3.3	1.6	1.5	0.8	0.3	0.1
B	0	5	2.6	2.4	2.5	1.2	1.2
C	0	0	0	0.8	0	0	0
C	0	3.1	3	1.9	1.8	1.3	1.2
C	0	4.1	4.1	1.3	4.1	4	1.6
C	1.1	7.6	4	4	0	0.1	0.1
C	0	3.3	2.2	1.4	3.5	3.4	0.8
C	0	8.1	5	1.6	1.6	0.9	0.3
A	0	4.5	2.6	1.7	0.8	0.8	0.3
B	0	2.9	1.8	0.8	0.8	0.5	0.2
B	0	3.3	3.3	3.1	1.5	0.5	0.5
B	0	1.7	1.4	1.3	1.2	0.6	0.2
B	0	3.2	2.4	1.5	0.8	0.4	0
B	5.9	4.9	4.1	4.7	4.7	4.7	3.8
A	0	9.3	8	6.2	6.7	3.8	3.8
C	0	6.1	7	8.1	6.9	4.6	2.7
B	0	7.4	4.7	4.2	4	2.5	1.8

Group	Pre-OP	D1	D2	D3	D4	D5	D6
B	0.8	3.1	2.1	1.3	1.3	2.5	1.6
C	0	2.1	2.2	2.1	0.9	0.6	0
A	0	0	2.4	0	0.7	0.5	0.5
C	0	5	3.5	3.3	3.1	3.1	1.9
B	1.8	3.8	3.8	4.1	3.5	3.5	3.3
C	0	1	0.7	1.4	0.7	1.7	1.4
C	0	7.3	4.4	4.1	2.2	1.2	0
B	0	3.7	5.1	5	3	4	3.8
B	0	1.6	1	0.6	0.4	0.2	0
C	0	4	3.9	1.9	0.7	0.7	0.3
B	0	4.8	2.7	1.5	1.5	4.7	0
B	0	1.7	1.3	1	0.6	0.4	0.4
C	0	1.3	2	0.5	0.3	0.2	0.1
B	0	4.6	7	3	2.2	1.4	0.8
B	0	4.2	3.2	4.2	3	0.7	0.2
B	0	7.8	4.3	4.2	3.2	0.5	0
A	0	1.1	1	1.3	1.9	1.5	1
A	0	2	1.5	1.2	0.7	0	0
C	0	5.1	3.5	3.4	4.2	4	3.9
B	0	3.9	3.4	1.9	1.3	1.1	0
A	0	9	4.9	2	1.7	0.2	0.1
B	0	3.1	1.7	1.1	0.3	0.2	0
C	0	5.1	4.4	2.6	1.2	1.8	2.1
C	0	2.3	2.3	1	4.8	4.8	2.1
B	0	5	3	2.2	1.7	1.6	1
A	0	5.7	2.7	1.8	1.9	1.9	0
A	0	9	5	3.4	1.5	0.4	0.2
A	0	1.2	1.2	0.4	0	0.2	0
B	0	4.3	3.2	2.6	1.4	0.7	0
C	0	3	2.9	1.6	1.2	1	1
A	0	5	5	5	4	4	1.4
C	0	3.3	1.8	0.3	0.5	0.5	0

Appendix O

The raw data of dyspnea score

Group	Pre-OP	D1	D2	D3	D4	D5	D6
A	6	6	9	13	7	6	9
A	7	11	11	7	11	11	11
A	6	6	6	6	7	7	7
A	6	9	9	9	9	7	7
A	6	17	13	13	11	9	9
A	6	9	7	6	6	6	6
C	6	11	11	9	11	9	11
A	6	9	17	17	17	17	17
C	6	9	9	6	6	6	6
A	6	11	7	11	7	7	13
A	6	11	10	11	9	11	8
A	9	7	7	7	6	11	6
A	6	9	7	7	7	7	11
C	6	17	9	11	9	7	11
B	7	9	8	8	6	6	11
B	7	14	9	9	11	11	11
C	9	16	14	11	9	9	9
C	6	11	11	7	7	7	7
C	9	15	15	17	17	17	9
C	6	11	13	13	13	9	9
C	6	9	11	11	9	9	11
C	6	17	13	9	9	6	6
A	6	9	11	11	10	10	9
B	6	11	9	7	7	6	6
B	6	9	7	7	7	7	7
B	11	11	9	6	7	8	6
B	6	14	9	15	7	7	6
B	6	9	9	9	9	9	9
A	6	9	9	6	11	6	11
C	6	13	9	14	11	11	9
B	6	11	11	11	11	9	7

Group	Pre-OP	D1	D2	D3	D4	D5	D6
B	6	11	12	11	11	9	9
C	7	9	11	11	11	11	9
A	7	12	7	7	6	7	6
C	7	11	8	9	9	9	6
B	6	9	9	7	9	11	9
C	11	9	6	11	6	11	11
C	7	9	9	9	9	6	6
B	6	9	9	9	9	14	9
B	6	9	9	9	9	7	7
C	6	9	11	11	11	9	6
B	6	11	9	11	7	6	6
B	6	9	9	9	9	9	9
C	6	9	9	11	11	9	11
B	6	7	11	11	7	15	15
B	11	11	14	17	17	11	9
B	6	14	12	11	9	11	11
A	6	9	9	9	9	11	9
A	6	9	11	11	7	11	11
C	6	6	6	6	6	6	6
B	7	6	11	11	12	12	12
A	6	9	7	11	7	6	6
B	6	13	13	11	11	9	6
C	11	7	7	7	9	6	7
C	7	11	6	7	11	11	9
B	6	9	9	11	11	11	7
A	6	15	13	6	19	9	9
A	6	7	17	7	7	6	6
A	6	11	6	6	11	6	6
B	6	17	7	7	6	6	6
C	6	9	11	11	6	11	6
A	7	11	7	11	14	15	11
C	6	9	9	9	9	11	9

Appendix P

The raw data of length of hospital stay

Group	Length of hospital stay	Group	Length of hospital stay	Group	Length of hospital stay
A	54	B	7	C	16
A	7	C	8	B	8
A	9	A	15	A	90
A	7	C	10	C	16
A	7	B	10		
A	7	C	7		
C	7	C	7		
A	7	B	9		
C	7	B	12		
A	8	C	7		
A	7	B	7		
A	7	B	25		
A	7	C	8		
C	7	B	23		
B	7	B	9		
B	7	B	7		
C	9	A	15		
C	13	A	9		
C	11	C	8		
C	7	B	10		
C	8	A	7		
C	8	B	7		
A	10	C	7		
B	7	C	7		
B	9	B	9		
B	8	A	17		
B	7	A	10		
B	13	A	6		
A	9	B	7		
C	9	C	7		

VITA

VITA

Name: Sa-nit Homruen

Date of Birth: May 21, 1986

Place of Birth: Chiang Mai

Address: 119/17, Suthep, Muang Chiang Mai, Chiang Mai, 50200.

Educational Background:

2005 Secondary Certificate

Nawamintrachutit Payap School

2009 Bachelor of Science Program (Physical Therapy)

Rangsit University

2016 Master of Science Program (Physical Therapy)

Srinakharinwirot University