COMPARISON BETWEEN LOW AND HIGH INSPIRATORY FLOW RATE OF INCENTIVE SPIROMETRY ON LUNG VOLUME AND DYSPNEA SCORE AFTER CARDIAC SURGERY: A RANDOMIZED CONTROL TRIAL

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Abstract

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 deep breathing exercise (DBE) on vital capacity (VC) and dyspnea score. Sixty-three patients undergoing cardiac surgery were randomly divided into three groups of control (n=21), low inspiratory flow rates (n=21) and high inspiratory flow rates (n=21) groups. The VC and dyspnea score were assessed on the pre-operative and the 1st-6th post-operative day. Data were analyzed using two-way repeated ANOVA. The VC of all the three groups showed significantly decrease on the 1st post-operative day and gradually increase nearly reach to the baseline on the 6th post-operative day. The dyspnea score was significantly increased on the 1st post-operative day and then returned to baseline on the 5th post-operative day for the HF groups and on the 6th post-operative day for the LF group but not reach the baseline for the control group. Both the VC and dyspnea score did not showed 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 lung volume than the DBE. The dyspnea of using IS with HF was return to normal earlier than the IS with LF and the DBE.

Keyword: incentive spirometry, breathing exercise, inspiratory flow rate, lung volume, cardiac surgery

Introduction :

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 (DeTurk et al. 2004). Patients undergoing cardiac surgery often develop pulmonary complication with a significant reduction in lung volume (Westerdahl et al. 2005). Atelectasis is the main pulmonary complication of post-operative cardiac surgery which associated with reduced lung capacity (Brooks 1995). Fear and pain after operation affect the performance of deep inspiration and effective cough resulting in accumulation of secretion, lung collapse and decrease in gas exchange (Wynne et al. 2004; Baumgarten et al. 2009).

Physical therapy treatments for pre-and post-operative cardiac surgery contribute a significantly better prognosis. IS, one of the resources of physical therapy, is commonly used for preventing and managing the post-operative pulmonary complications in cardiac surgery (Freitas et al. 2012). An updated systematic reviews indicated that there was no evidence of benefit from IS when compared with pre-operative education or standard physical therapy for preventing post-operative pulmonary complication and reducing length of hospital stay in adults undergoing CABG. The systematic reviews found that currently available trials of IS contributed little to making decision on it use because of the small number of studies and the methodological limitation. A large randomized controlled trial to assess the benefits of IS in patients with CABG is needed.

There are two types of IS, volume and flow-oriented IS. Several previous studies indicated that the type of IS used may influence the breathing pattern. They found that volume-oriented IS promoted a larger abdominal motion (Parreira et al. 2005) and greater diaphragmatic mobility (Yamaguti et al. 2010) while flow-oriented IS induced higher respiratory frequency and sternocleidomastoid activity (Tomich et al. 2007). Recently, Chang et al. (2010) indicated that the inspiratory flow rate during the use of IS was a significant factor determining the resultant of breathing pattern. The study showed that using IS with low inspiratory flow rates (LF) resulted in greater abdominal wall motion than using with high inspiratory flow rates (HF).

Although the evidence has not strongly supported the use of IS for preventing pulmonary complication after cardiac surgery, the IS was still widely used among health professionals. To date, there have been no studies on the effectiveness of LF or HF of IS in cardiac surgery patients. The purpose of this study was to compare the effects of LF and HF of flow-oriented IS on VC and dyspnea score in cardiac surgery patients.

Methodology

This study was approved by the ethics committee of the Central Chest Institute of Thailand. The sample size was calculated from the effect size of 0.29 (Chang et al. 2010), statistical power 0.8 and alpha error probability of 0.05. The determined sample size for this study was 42 subjects. 50% drop-out rate was concerned and then in totally 63 patients or 21 patients per group were recruited.

Patients who admitted at the Central Chest Institute of Thailand for cardiac surgery with uncomplicated cardiac event, aged 40 years old or older were recruited. Exclusion criteria were patients who had hemodynamic instability, using mechanical ventilation supports for a period exceeding 24 hours after admission to the intensive care unit. Written inform consent was obtained from each participant. The included participants were randomized into three groups with computer generating number. VC and dyspnea score were measured on pre-operative day for baseline and post-operative day 1 to 6.

All participants received conventional physical therapy treatment in pre-and post-operative periods. The LF group received low inspiratory flow rate of flow-oriented IS by performing a slow breath keeping only the first ball on the top (600 ml/sec). The HF group received high inspiratory flow rate of flow-oriented IS by performing a slow breath keeping 3 balls at the top (1200 ml/sec). The control group received DBE. All three groups performed the same breathing exercise duration and frequency for 5 breaths per set, 3 sets per time, 4 times per day.

Data was analyzed using SPSS program. Normal distributions of all data were assessed using Kolmogorov-Smirnov. ANOVA was used to compare the general characteristic data between groups. Chi-Square test was used to compare number of gender between groups. Two-way repeated measure ANOVA was used to compare the main effect of all outcome measures between pre-operative day and the 1st to 6th post-operative day and between groups. Post-hoc data used Bonferroni to analyze between time points. The significant difference was set at $p<0.05$.

Results :

Ninety-nine patients who admitted for cardiac surgery were invited to participate in the study and underwent screening for the research inclusion criteria. Thirty-six patients were excluded because of hemodynamic instability (N=21), using mechanical ventilation supports for a period exceeding 24 hours after admission to the intensive care unit (N=12) and denial to participate in this study (N=3). Sixty-three participants were successfully randomized into 21 participants per group. The general characteristics are shown in Table 1. There were no significant differences in age, weight, height and BMI when compared between three groups.

Table 1: Distribution of general characteristics data by groups

Variable	Control (N=21)	LF (N=21)	HF (N=21)	p-values (between groups)
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

The VC of all three groups showed a significant reduction on the 1st post-operative day when compared to pre-operative and it was still partially recovery on the 6th post-operative day as shown in Figure 1. There were no significant differences when comparing between groups at all of the time points.

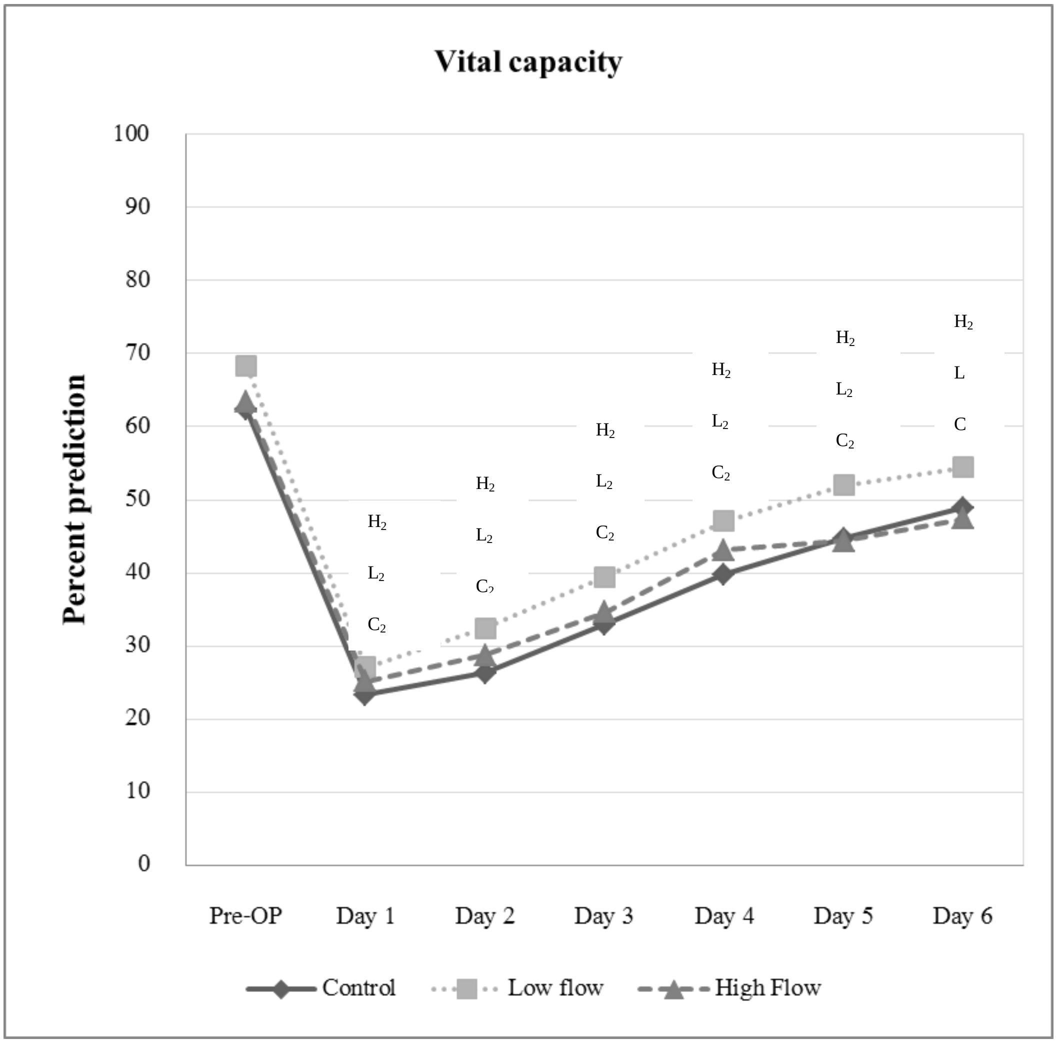

Figure 1: The vital capacity from pre-operative to the 6th post-operative day. Significant difference of the 1st-6th post-operative day vs. pre-operative day

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 in each group is shown in Figure 2. The dyspnea of using IS of all three groups were significant increased from baseline on the 1st post-operative day. The dyspnea score was then gradually decreased and returned to baseline on the 5th post-operative day for the HF groups and on the 6th post-operative day for the LF group but not recovery to baseline for the control group. The comparison of dyspnea score between groups was not significantly different.

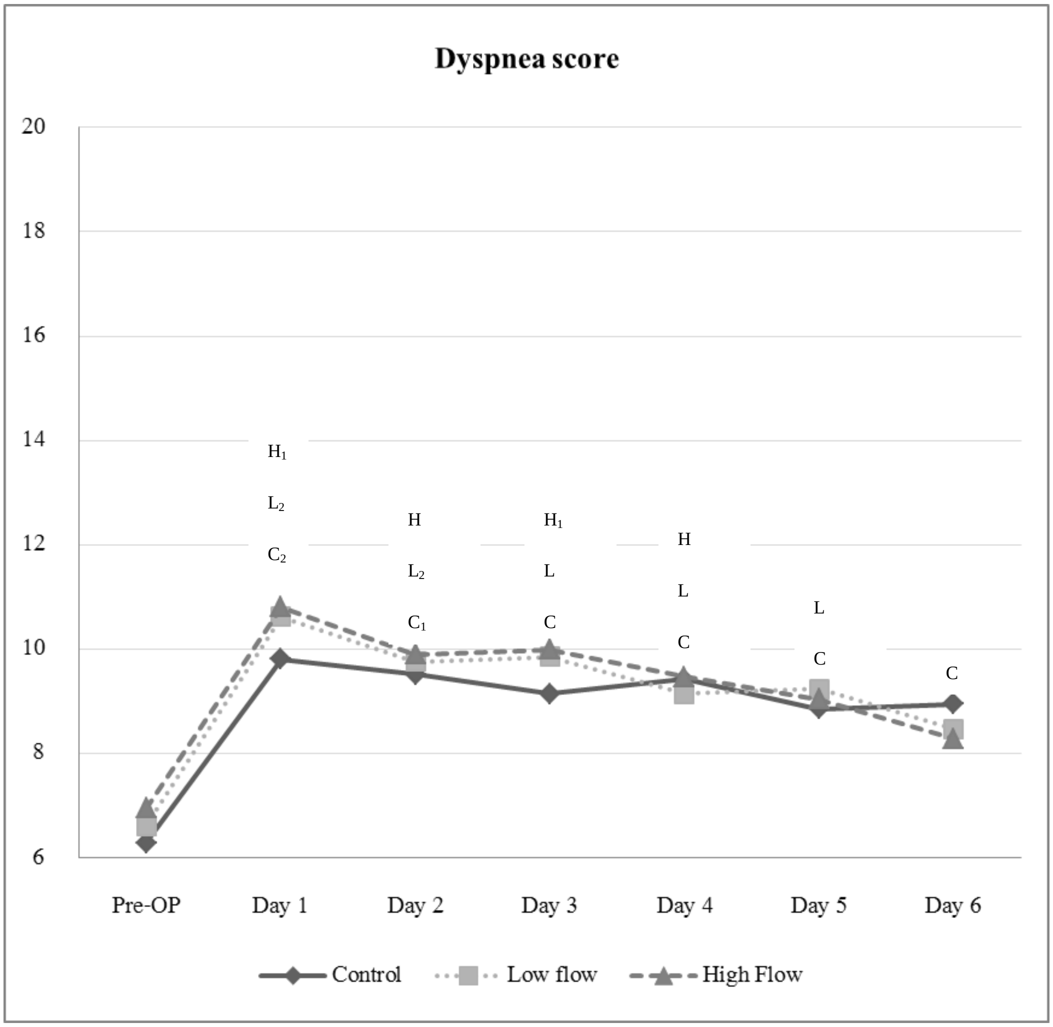

Figure 2: The Dyspnea score from pre-operative to the 6th post-operative day.

Significant difference of the 1st-6th post-operative day vs. pre-operative day

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) $p<0.001$

Discussion :

The results of 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 those of the previous studies (Dias et al. 2011; Renault et al. 2009). Post-operative pain, drowsiness, and analgesia contributed to a slow and shallow breathing pattern, decreased in lung mobility and ventilation (Wynne et al. 2004; Baumgarten et al. 2009) In this situation, performing deep breathing is important to prevent lung complications (Vraciu et al. 1977) and IS may be appropriate for re-expansion the lung (Agostini et al. 2009).

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 in CABG patients (Renault et al. 2009). DBE is easy to perform as patients can control by themselves. IS helps to prevent atelectasis by deep breathing with a visual feedback (Agostini et al. 2009). The hypothesis of this study was from the results of Chang that performing IS with LF in healthy individuals induced more abdominal wall motion than HF (Chang et al. 2010) 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.

The dyspnea score during performing IS found that all of the three groups showed increased in dyspnea on the 1st day after operation and gradually return to baseline. These also could explain by the pain of the surgery wound to limit the function of respiratory muscles (Baumgarten et al. 2009). The results of this study found that the dyspnea in the HF group was recovery to baseline earlier than the LF and control groups. It was possible that the patients in the HF group could generate the highest force as they could while in the LF group had to hold the force to keep only one ball to the top of the spirometer. The HF group may perform IS easier than the LF group in the late period of admission that pain was subside.

Conclusion

The training with low or high inspiratory flow rate of IS was not more effective than DBE on lung volume. The dyspnea during IS training with HF returned to baseline earlier than the LF and DBE.

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