Research Journal of Applied Sciences 13 (6): 363-368, 2018
ISSN: 1815-932X

Respiratory Fitness and Mental Health in Patients Who Had Undergoing Open Heart Surgery: A Preliminary Observational Study

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Abstract: Patients who had open heart surgery have been associated with adverse health problems including decreases in physical (e.g., decreased pulmonary function, respiratory muscle weakness) and mental health problems (e.g., depression and anxiety). However, little is known regarding the effect of median sternotomy on respiratory fitness and mental health in Thai patients who had open heart surgery. Therefore, the study was aimed to evaluate pulmonary function, respiratory muscle strength and mental health problems in patients undergoing open heart surgery. The prospective observational cohort study was designed with patients who undergoing open heart surgery, aged 35-70 years both males and females. Spirometry, respiratory muscle strength and the hospital anxiety depression scales questionnaire were performed pre and post-operative open heart surgery. A regression analysis was performed to determine whether mental health predicted pulmonary function and respiratory muscle strength. The 57 patients were conducted at initial and follow-up study an average age was 56.61±10.10 years old. Compare with pre-operative heart surgery, the mean respiratory function, respiratory muscle strength and mental health (depression and anxiety) were dramatically decreased after open heart surgery. In addition, post-operative Force Vital Capacity (FVC) value was related to age, gender, initial FVC, initial thoracic cirtometry and anxiety scores ($R^2 = 0.616$, $p<0.001$). Increasing chest wall and decreased anxiety would be an intervention to prevent pulmonary function decline after open heart surgery.

Key words: Open heart surgery, pulmonary function, respiratory muscle strength, anxiety, depression, pulmonary, gender

INTRODUCTION

Median sternotomy or an open heart surgery has been associated with several adverse health effects including decreases in physical (e.g., decreased pulmonary function, respiratory muscle weakness) and mental health problems (e.g., depression and anxiety). It has been reported, pulmonary complications such as poor pulmonary ventilation and impaired pulmonary function were noted in patient who had an open heart surgery (Apostolakis *et al*., 2010; Bartlett *et al*., 1973). During the 1st and the 3rd post-operative days, an average decreases in Forced Vital Capacity (FVC) and Forced Expiratory Volume in 1 sec (FEV_1) were 40-50 (Nicholson *et al*., 2002). In addition, the respiratory muscle was decreased in post-operative open heart surgery in several studies and inspiratory muscle training could reduce pulmonary complications (Barros *et al*., 2010; Riedi *et al*., 2010; Snowdon *et al*., 2014; Valkenet *et al*., 2013).

It has been reported that mental health problems are associated with respiratory function (i.e., lung function or respiratory muscle strength) in whether general population or patients e.g., obesity, COPD and asthma (Galant *et al*., 2012; Goodwin *et al*., 2003, 2006; Sarmento *et al*., 2012; Vogele and Leupoldt, 2008). Several studies have been found that high depression and anxiety among open heart surgery patients while pre-operative open heart surgery were observed (Bunker *et al*., 2003; Fitzsimons *et al*., 2003; Koivula *et al*., 2002; Krannich *et al*., 2007; Tully and Baker, 2012).

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However, a little is known the effect of median sternotomy or open heart surgery on mental health and respiratory function in patients who had undergoing open heart surgery. Therefore, the purpose of the present study was to determine whether mental health problems predicted pulmonary function and respiratory muscle strength.

MATERIALS AND METHODS

The prospective observational study was designed. Total of 65 consecutive participants who await an open heart surgery in the hospital were recruited from the Thammasat Medical Hospital aged 35-70 years with male and female volunteers. All participants underwent valve replacement (e.g., aortic, mitral, tricuspid or pulmonic valve replacement) or Coronary Artery Bypass Grafting (CABG). In addition, all participants gave informed consent before participation of the study. The ethics and protocol were approved by the Human Ethics Committee of Thammasat University with the Helsinki Declaration of 1975 as revised in 1983. The participants had no known congestive heart failure, high Blood Pressure (BP) more than 180/100 mmHg or uncontrollable BP, high resting heart rate (more than 100 beat per min). Participants who had unstable angina, uncontrolled cardiac arrhythmia, chronic cough or had a high temperature within 48 h prior to the test and had other operative treatment such as thoracotomy were excluded. According to the recommendation of the American College of Cardiology, severe heart dysfunction has been equivalence as Left Ventricle Ejection Friction (LVEF) <30%. Hence, the participants who had been reported the LVEF <30% were also excluded. Further, the participants who had the Rate Perceived Exertion (RPE) more than 13 from 20, chest pain, dyspnea during and after the evaluations were terminated the study.

Respiratory muscle (i.e., maximal inspiratory pressure; MIP and Maximal Expiratory Pressure, MEP) strength was assessed by a respiratory pressure meter which is a RPM01 (Micro Medical Ltd., United Kingdom). Spirometry was conducted to evaluate FVC and FEV_1. Chest wall mobility was measured by measuring the patient's chest circumference using a measuring tape at 2 levels: axillary (at the anterior axillary line) and thoracic (at the tip of the xiphoid process). The patients were asked to take a deep breath in and out while the tape was allowed the tape displacement. Further, another end of the tape was fixed on the midline of their body. The patients were requested to maintain the maximal inspiratory and expiratory for at least 2 sec. Three measures were recorded and then an average chest wall mobility was calculated for each the 2 levels (at axially and thoracic levels). Patients who had an open heart surgery with preoperative $FEV_1/FVC<0.70$ were defined as having airflow obstruction. Further, an indicator of being overweight is defined as $BMI\geq 23$ kg/m^2 which is calculated as body weight (kg) divided by height squared (m^2).

The participants were requested to complete a Hospital Anxiety and Depression Scale (HADS) which is 14 item HADS to measure depression and anxiety symptoms. HADS was developed by Zigmond and Snaith (1983) as a self-administrated health questionnaire. A cut-off of ≥8 on the depression and anxiety subscales of the HADS was used to indicate an individual who had depressive or anxiety symptoms. The internal consistency with Cronbach alpha coefficients were noted in anxiety subscale ranging from 0.68-0.93 and for depression subscale ranging from 0.67-0.90 (Bjelland *et al*., 2002; Nilchaikovit *et al*., 1996).

All participants were assessed the measurements (i.e., pulmonary function, respiratory muscle strength, chest expansion and HADS) prior to operative open heart surgery and before discharge within 48 h.

Statistical analysis: Descriptive data was presented as a percentage (%), mean and Standard Deviation (SD). Data was verified for normality of distribution (Komogorov siminov goodness of fitness test). Paired-sample t-tests were performed to examine changes in pulmonary function respiratory muscle strength, chest wall mobility and HADS scores from preoperative open heart surgery to post-operative open heart surgery. In addition, Pearson correlations were calculated to examine relationship between pulmonary function and respiratory muscle strength after post-operative heart surgery and depression and anxiety scores. Finally, a regression analyses was performed to determine whether depression and anxiety predicted pulmonary function and respiratory muscle strength.

RESULTS AND DISCUSSION

A total of 65 patients were recruited at initial study. However, only 57 patients eligible for the study were reassessments. Eight patients did not conduct the post-operative pulmonary function and respiratory muscle strength due to operative cancellation (n = 1), two patients had post-operative complications (septic, ischemic stroke) and discharge during weekend (n = 5). Therefore, analysis was based on 65 patients at preoperative heart disease and 57 patients at before hospital discharge.

The characteristics of the study participants are presented in Table 1. The mean age of the participants was 56.61±10.10 years with 31 males and 26 females. Airflow obstruction was defined as FEV_1/FVC<0.7, therefore, only 6 patients (10.53%) have been defined as airflow obstruction at pre-operative open heart surgery. The 26 overweight participants who had BMI≥23 kg/m^2 were noted in the study.

As shown in Table 2, there were significant dramatically decreased respiratory function (MIP = -30.85±23.37%, MEP = -24.99±18.14%, FVC = -35.23±18.32% and FEV_1 = -31.81±17.15%) values. However, symptoms of anxiety and depression scores were decreased after post-operative heart surgery (-2.38±3.73 and 1.57±3.77, respectively).

The anxiety scores were negatively associated with FVC values after post-operative open heart surgery but not in depression scores. Anxiety scores were also inversely related to FEV_1 but these relationships did not reach the conventional criteria ($p<0.05$) for statistical significance (Table 3).

Finally, the study focused on whether mental health problems (i.e., depression and anxiety) predict changed values for respiratory function (i.e., FVC, FEV_1, MIP and MEP). The study found that post-operative FVC value was related to age, gender, initial FVC, initial thoracic cirtometry and anxiety scores (R^2 = 0.616, $p<0.001$) (Table 4).

The present study evaluated the effect of open heart surgery pre and post-operative heart surgery among patients who had open heart surgery on respiratory function and mental health. The results of the present study support and extend these findings by suggesting that post-operative open heart surgery leads to reduce respiratory function in patients who undergoing open-heart surgery.

Guizilini *et al.* (2004) reported that patients who had median sternotomy trend to present the reduction of pulmonary volumes and capacities approximately 30%. Also, Urell *et al.* (2012) reported that after open heart surgery the participant had a decrease pulmonary function by approximately 50% and it was <40% of predictive values after 2 days post-operative open surgery. Similarly, Nicholson *et al.* (2002) found that at

Table 1: Demographic data in patient undergoing open heart surgery (n = 57)

Parameters	Number (%)	Mean	SD
Gender			
Female	26 (45.61)	-	-
Male	31 (54.39)	-	-
Types of surgery		-	-
CABG	25 (43.86)	-	-
Valve replacement	29 (50.88)	-	-
Combined	3 (5.26)	-	-
Age (year)	-	56.61	10.10
BMI (kg/m^2)	-	23.80	3.88
Length of stay in hospital	-	8.47	6.68

CABG: Coronary Artery Bypass Grafting, BMI: Body Mass Index

Table 2: Compared pre and post-operative open heart surgery in respiratory muscle strength and pulmonary function among patients undergoing open heart surgery in (n = 57)

Parameters	Pre-operative (Mean±SD)	Post-operative (Mean±SD)	Mean difference	95% CI of the difference	t-test (56)	p-values
MIP (cmH_2O)	70.47 ± 25.740	47.33±19.620	23.14±18.510	18.23-28.05	9.4400	<0.001
MEP (cmH_2O)	74.95 ± 23.610	55.18±18.660	19.77±15.200	2.01-15.74	9.8180	<0.001
FVC (L)	2.21 ± 0.5800	1.42±0.5400	0.79±0.4600	0.67-0.910	12.8290	<0.001
FEV_1 (L/sec)	1.78 ± 0.4700	1.21±0.4400	0.57±0.3600	0.48-0.670	11.9900	<0.001
Axillary cirtometry	2.59 ± 0.7700	1.97±0.6900	0.62±0.7800	0.42-0.830	6.0140	<0.001
Thoracic cirtometry	2.64±0.98000	2.01±0.7500	0.64±0.7600	0.10-0.430	6.3080	<0.001
Anxiety	4.35±3.66000	1.97±0.6900	2.38±3.7300	1.39-3.370	4.8230	<0.0010
Depression	3.58±3.56000	2.01±0.7500	1.57±3.7700	0.57-2.570	3.1540	0.00300

MIP: Maximal Inspiratory Pressure, MEP: Maximal Expiratory Pressure, FVC: Forced Vital Capacity, FEV_1: Forced Expiratory Volume in 1 sec, CI: Confidence Interval

Table 3: Correlations between depression and anxiety scores and respiratory function after post-operative open heart surgery

	Anxiety		Depression	
Factors	R	p-values	R	p-values
FVC	-0.309	0.019	-0.232	0.083
FEV_1	-0.240	0.072	-0.193	0.150
MIP	-0.154	0.254	-0.188	0.161
MEP	-0.167	0.213	-0.127	0.348

MIP: Maximal Inspiratory Pressure, MEP: Maximal Expiratory Pressure, FVC: Forced Vital Capacity, FEV_1: Forced Expiratory Volume in 1 sec

Table 4: Results of multiple regression analyses predicting post-operative FVC from baseline characteristics

Parameters	B	SE	β	t-values	p-values	95% CI for B	R^2	F-values
Age	-0.014	0.005	-0.2590	-2.604	0.012	-0.025 to 0.003	-	-
Sex	-0.301	0.127	-0.2780	-2.374	0.021	-0.555 to 0.046	-	-
FVC (L)	0.363	0.107	0.3850	3.409	0.001	0.149 to 0.577	-	-
Thoracic cirtometry	0.175	0.052	0.3150	3.389	0.001	0.071 to 0.279	-	-
Anxiety	-0.026	0.013	-0.1900	-2.075	0.043	-0.052 to 0.001	0.616	16.361

FVC: Forced Vital Capacity

24 h post-operative open heart surgery, lung volumes were dramatically decreased to approximately 40-50% of their preoperative values and these values were still dropped to 50-60% of preoperative values at 72 h. In addition, reductions in FEV1 and FVC also reported after a 5 days post-operative CABG surgery and persisted for 6-8 weeks post-operatively. They concluded that decreases in pulmonary function independent of preoperative were resulted from sternotomy. Morsch *et al*. (2009) reported that respiratory muscle strength was relatively dropped to an approximately 34% for MEP and 36% for MIP after post-operative open heart surgery. Likely, the present study showed the decreased MEP 25 and 31% for MIP. Stein *et al*. (2009) observed that respiratory muscle strength, FVC and FEV_1 were reduced by the 7th post-operative day of CABG and concluded that a reduction in respiratory muscle and improve the pulmonary function after CABG could be recovery by cardiac rehabilitation program including respiratory muscle training.

Regarding the mental health problems, the results of the present study are consistency with Chunta (2009) that are depression and anxiety scores were decreased post-operatively. Further, Tully and Baker (2012) reviewed that approximately 30-40% of patients who had CABG surgery experience symptoms of depression and anxiety and contribute to increased risk for mortality and morbidity after CABG surgery. The high anticipatory-anxiety and depression scores in patients have been noted that might be because the perceptions of emotional stress (Viars, 2009; Vingerhoets, 1998). Further, high preoperative mental health problems were associated with the patient stay in hospital after surgery in the present study. Therefore, the study suggest that psychological support prior to median sternotomy would be benefit for reducing risk of complication, e.g., pulmonary complications and length of in hospital which might be an risk factors for increased mortality and morbidity in patients who had operative open heart surgery.

Further, the results indicate that participants with increased anxiety exhibited reduced FVC after post-operative open heart surgery. In addition, decreased anxiety scores and improve chest wall mobility (thoracic cirtometry value) predicted FVC values after controlling for age, sex and baseline FVC values. Therefore, the present study would suggest that one mechanism linking pulmonary function in patients who had undergoing open heart surgery may involve psychological well-being (i.e., anxiety) and chest wall mobility. One factor that might be affected on respiratory function is that chest wall mobility or abdominal motion. It has been reported that decreased pulmonary function is related to mean respiratory movement that is an average abdominal motion decreased to 57% of preoperative values after 1 week post-operative open heart surgery. In addition, lower thoracic motion decreased to 72% and the average upper thoracic motion decreased to 87% (Ragnarsdottir *et al*., 2004). Chest wall mobility is related to pulmonary function and respiratory muscle strength higher chest wall mobility higher lung function and respiratory muscle strength (Kaneko *et al*., 2016; Lanza *et al*., 2013; Lee *et al*., 2012; Malaguti *et al*., 2009). Thus, the results of the present study suggest that the effects of chest wall mobility (i.e., thoracic cirtometry) may be attributed at least in part to a decrease in respiratory function by which a decreased FVC. Therefore, breathing exercise such as thoracic expansion exercise, diagrammatic breathing exercise may be an alternative to prevent decreased respiratory function in patients with open heart surgery.

CONCLUSION

In summary, respiratory muscle strength and pulmonary function were reduced in patients who undergoing open heart surgery. Therefore, increasing chest mobility (i.e., thoracic expansion exercise) and decreased anxiety would be an intervention for the prevention of impaired respiratory function after open heart surgery.

LIMITATIONS

There are a number of limitations with the present study. Firstly, the study had a relatively small sample size. In addition, much research has found that the pain scale might be associated with post-operative respiratory function and may contribute to decreased respiratory function (i.e., respiratory pressure, lung volume and peak expiratory flow). Thus, post-operative pain perception should be assessed.

ACKNOWLEDGEMENTS

Researchers acknowledge the help of Physical Therapy Center, Thammasat University hospital, Traumatic Ward II at Thammasat University Hospital and the staff for their kindly support. In addition, we would also like to thank the participants in the hospital.

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