Med. J. Cairo Univ., Vol. 86, No. 1, March: 567-573, 2018
www.medicaljournalofcairouniversity.net

Pulmonary Functions after Mitral Valve Replacement

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Abstract

Background: Mitral valve replacement surgery has a great impact on pulmonary functions specially in patients with preoperative pulmonary hypertenstion. Spirometry test can be used to measure the changes in pulmonary function after mitral valve replacement surgery of cases with pulmonary hypertension.

Aim: To clarify pulmonary function changes after mitral valve replacement of cases.

Methods and Material: This study was carried out on forty-two patients subjected to mitral valve replacement surgery due to rheumatic mitral affection. Those patients divided into two groups, Group 1 included twelve patients subjected to mitral valve replacement having no preoperative pulmonary hypertension and Group 2 included thirty patients subjected to mitral valve replacement having pre-operative various degree of pulmonary hypertension. Group 2 are furtherly subdivided into three subgroups according to Systolic Pulmonary Artery Pressure (SPAP) during rest. Pulmonary functions evaluated two days pre-operatively, at discharge of patients, three and six months post-operatively.

Results: Pulmonary function tests impaired pre-operatively in association with severity of pulmonary hypertension and more impairment early after mirtal valve repacement was noticed and recovers gradually along six months later post-operatively with statistically significant among the severe pulmonary hypertension group.

Conclusions: There is no correlation between the reduction of pulmonary hypertension and the improvement of pulmonary functions, so we can't depend on pulmonary function as a predictor of reduction in pulmonary hypertension after mitral valve replacement surgery due to small sample size. Patients with severe pulmonary hypertension pre-operatively, showed statistically significant improvement in the pulmonary functions during the six months post-operatively.

Key Words: *Pulmonary function – Pulmonary hypertension – Mitral valve replacement.*

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Introduction

PULMONARY hypertension is a type of high blood pressure that affect pulmonary vasculature which begin at the venous side then become pulmonary arterial hypertension. Later on, the pulmonary arteriols become narrowed, blocked or destroyed making right ventricle working hard to pump blood through the lungs and finally right sided heart failure will occur [1].

Pulmonary hypertension is a classic pathophysiological consequence of mitral valve diseases: Incompetence, stenosis or mixed mitral diseases [2].

Reduced lung functions are common after open heart surgery. Lung volumes can remain depleted for three to four months after mitral valve replacement surgery [3].

Spirometry test is an objective, valid and reliable method to measure pulmonary function. In addition it's non invasive method that can be handled without any inconvenience to patients specially after mitral valve replacement surgery [4].

Aim and objectives:

The aim of the work is to clarify pulmonary function changes after mitral valve replacement of cases with pulmonary hypertension.

Material and Methods

After obtaining the research ethics committee approval (approval code: 2702/08/14) and the informed and written consent was taken from patients, a prospective randomized study was carried out in Tanta University Hospitals in Cardiothoracic Surgery Department, on forty-two patients subjected to mitral valve replacement surgery in

Tanta University Hospital from March 2015 Sep. 2016, were enrolled into the present study. All patients subjected to mitral valve replacement due to rheumatic affection with or without pulmonary hypertension were included. Patients with pulmonary hypertension due to non rheumatic mitral affection as ischemic or other causes, patients with recent history of native mitral valve endocarditis, patients subjected to complex aortic surgery, patients with organic non functional tricuspid valve affection, patients with chest comorbidities affecting pulmonary function like chronic obstructive pulnonary disease bronchial asthma and interstitial lung fibrosis, patients with unclear or multifactorial pulmonary hypertansion, Redo and emergency cardiac surgery subjected to mitral valve replacement surgery were excluded from the study. Patients were randomized into two groups by using sealed opaque envelop, Group I: included twelve patients subjected to mitral valve replacement having no pre-operative pulmonary hypertension and Group 2: Included thirty patients subjected to mitral valve replacement having preoperative various degree of pulmonary hypertension. Group 2: Are furtherly subdivided into three subgroups according to Systolic Pulmonary Artery Pressure (SPAP) as follow: Subgroup A including twelve patients with mild degree of pulmonary hypertension, Subgroup B including ten patients with moderate degree of pulmonary hypertension, Subgroup C including eight patients with severe degree of pulmonary hypertension. Pulmonary function tests were done two days pre-operatively, at discharge of patients, three and six months post-operatively. The following parameters were measured: Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV_1), Peak Expiratory Flow Rate (PEFR) and Maximum Voluntary Ventilation (MVV). Surgical techniques were applied to all patients with mitral valvular diseases underwent mitral valve replacement using the same procedures with the patient in supine position full median sternotomy was done. Standard cardiopulmonary bypass was instituted after heparinization using aortic and bicaval venous cannulation. Antegrade cold blood or crystalliod cardioplegia was used in all cases. Activated clotting time was maintained above 480 seconds using heparin. All patients underwent moderate hypothermic cardiopulmonary bypass. Mitral valve replacement was performed using mechanical valves in all cases Sorin or St.Jude type. The mitral valve exposed through a transverse incision in the left atrium in most of cases or through a transseptal approach in some patients. The chordal sparing technique (posterior leaflet preservation) of mitral valve replacement was done in all patients. The valve annulus was sized appropriately and interrupted, horizontal, everting, pledgeted mattress braided sutures are placed in the annulus. After the prosthetic valve was sutured in place, the leaflet motion was evaluated. Concomitant tricuspid valve repair with DeVega was done in 11 cases. Transesophageal echocardiography after removal of cross clamp was done. Rewarming was completed and conventional de-airing maneuvers were performed. All patients transferred safly to the Intensive Care Unit. A strict regime of chest physiotherapy and pain control was initiated after extubation.

Measurements: Demographic data (age, and sex) showed in (Table 1). Pulmonary functions measured by spirometry test with patients in a sitting position and used a nose clip. Compairing between the two groups as regard the forced expiratory volume in one second showed in (Table 2). Compairing between the subgroups as regard the forced expiratory volume in one second showed in (Table 3).

Statistical presentation and analysis was conducted by using SPSS software statistical computer package Version 13. p-value <0.05 was considered significant.

Results

Regarding the demographic data (Table 1) there was no statistically significant difference between both groups (p-value >0.05).

Compairing between the two groups the pulmonary function impaired more in Group 1 during hospital stay with statistically significant difference than Group 2 and gradully improved in both groups with statistically significant difference in Group 2 than Group 1. Collectively and compairing the preoperative and post-operative FEV_1, FEV_1 of Group 1 didn't change significantly incontrast to FEV_1 significantly change in Group 2 Fig. (1).

In Fig. (2) we founded that the pulmonary function improved in Subgroup C with statistically significant difference than other subgroups during the entire period of the study.

In (Table 4) we tested the correlation between the improvement of pulmonary function and the reduction of the pulmonary hypertension with no statistically significant (p-value >0.05).

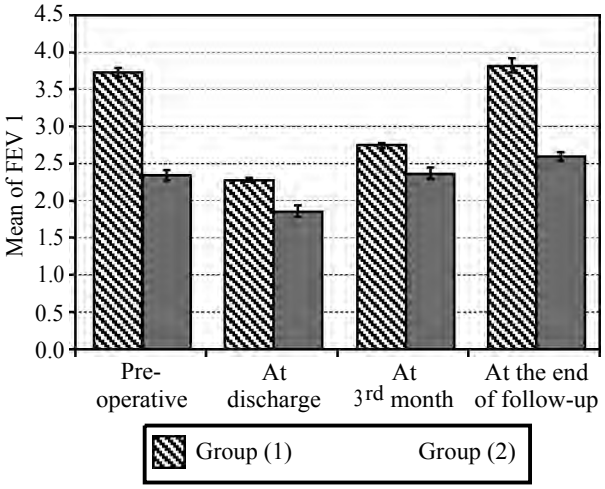

Fig. (1): Comparison between the two groups according to FEV_1.

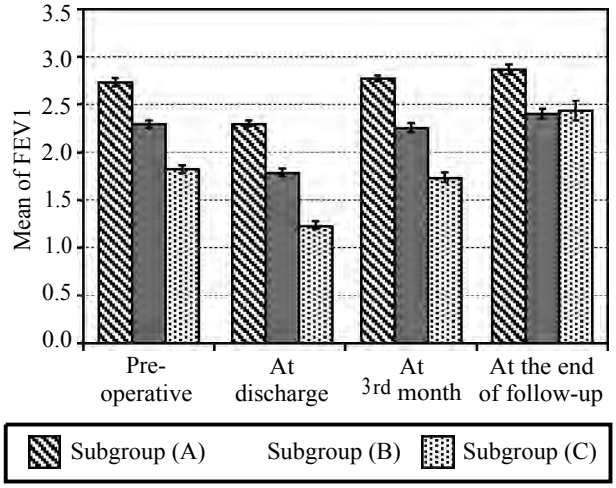

Fig. (2): Comparison between the subgroups according to FEV_1.

Table (1): Comparison between the two groups according to demographic data.

	Group I (n=12)		Group II (n=30)		Test of significance	*p*-value
	No.	%	No.	%		
Sex:						
Male	4	33.3	12	40	χ^2=	FE*p*=
Female	8	66.7	18	60	0.162	0.740
Age:						
Min.-max.	32-56		28-60		*t*=	0.721
Mean ± SEM.	42.33±2.44		43.60± 1.99		0.360	
Median	41.50		42			

Table (2): Comparison between the two groups according to FEV_1.

	Hospital tracing of FEV_1 of groups			
	Pre-operative FEV_1 (mean ± SE)	At discharge FEV_1 (mean ± SE)	Statistical significance within each group	Statistical significance between groups
Group (1)	3.73±0.06	2.29±0.03	<0.001*	<0.001 *
Group (2)	2.35±0.07	1.86±0.08	<0.001*	
	First 3 months follow-up of FEV_1			
	At discharge FEV_1 (mean ± SE)	At 3rd month FEV_1 (mean ± SE)	Statistical significance within each group	Statistical significance between groups
Group (1)	2.29±0.03	2.76±0.03	<0.001*	<0.001 *
Group (2)	1.86±0.08	2.37±0.08	<0.001 *	
	FEV_1 tracing to the end of follow-up			
	At 3rd month FEV_1 (mean ± SE)	At the end of follow-up FEV_1 (mean ± SE)	Statistical significance within each group	Statistical significance between groups
Group (1)	2.76±0.03	3.82±0.09	<0.001 *	<0.001 *
Group (2)	2.37±0.08	2.60±0.06	0.002*	
	FEV_1 tracing of the entire period of follow-up			
	Pre-operative FEV_1 (mean ± SE)	At the end of follow-up FEV_1 (mean ± SE)	Statistical significance within each group	Significance
Group (1)	3.73±0.06	3.82±0.09	1000	<0.001 *
Group (2)	2.35±0.07	2.60±0.06	0.001 *	

Table (3): Comparison between the subgroups according to FEV_1.

	Hospital tracing of FEV_1			
	Pre-operative FEV_1 (mean ± SE)	At discharge FEV_1 (mean ± SE)	Statistical significance within each subgroup	Statistical significance between subgroups
Subgroup (A)	2.74±0.04	2.31±0.03	<0.001*	p_1<0.001 *
Subgroup (B)	2.30±0.04	1.80±0.04	<0.001*	p_2<0.001 *
Subgroup (C)	1.83±0.04	1.25±0.04	<0.001*	p_3<0.001 *
	First 3 months follow-up of FEV_1			
	At discharge FEV_1 (mean ± SE)	At 3rd month FEV_1 (mean ± SE)	Statistical significance within each subgroup	Statistical significance between subgroups
Subgroup (A)	2.31±0.03	2.78±0.03	<0.001*	p_1<0.001 *
Subgroup (B)	1.80±0.04	2.27±0.04	<0.001*	p_2<0.001 *
Subgroup (C)	1.25±0.04	1.75±0.05	<0.001 *	p_3<0.001 *
	FEV_1 tracing to the end of follow-up			
	At 3rd month FEV_1 (mean ± SE)	At the end of follow-up FEV_1 (mean ± SE)	Statistical significance within each subgroup	Statistical significance between subgroups
Subgroup (A)	2.78±0.03	2.87±0.05	0.964	p_1<0.001 *
Subgroup (B)	2.27±0.04	2.41±0.05	0.663	p_2<0.001 *
Subgroup (C)	1.75±0.05	2.44±0.10	0.004*	p_3<0.001 *
	FEV_1 tracing of the entire period of follow-up			
	Pre-operative FEV_1 (mean ± SE)	At the end of follow-up FEV_1 (mean ± SE)	Statistical significance within each subgroup	Significance
Subgroup (A)	2.74±0.04	2.87±0.05	0.237	p_1<0.001 *
Subgroup (B)	2.30±0.04	2.41±0.05	0.978	p_2<0.001 *
Subgroup (C)	1.83±0.04	2.44±0.10	0.002*	p_3=0.708

*: Statistically significant at $p \leq 0.05$.

Table (4): Correlation between % reduction of SPAP and different parameters of pulmonary function tests.

	% change of SPAP	
	r	*p*
% change of FVC	–0.290	0.486
% change of FEV_1	0.078	0.854
% change of PEF	0.109	0.798
% change of MVV	0.054	0.898

Discussion

Pulmonary Hypertension (PH) is a pathophysiological disorder that may involve multiple clinical conditions and can complicate the majority of cardiovascular and respiratory diseases. It is defined as an increase in mean Pulmonary Arterial Pressure (PAPm) ≥25mmHg at rest as assessed by Right Heart Catheterization (RHC) [5].

We study pulmonary function changes of cases with various degree of pulmonary hypertension subjected to mitral valve replacement by means of spirometry.

Our motive to study pulmonary function changes after mitral valve replacement of cases with pulmonary hypertension is to find out if there is a statistical correlation between the reduction of pulmonary hypertension on one side, and the improvement of pulmonary function after mitral valve replacement on the other side as all previous studies concerning about deterioration of the pulmonary function in cases with mitral valve disease.

Overall, there are no much studies conerning pulmonary function changes after mitral valve replacement, so shall we take a pulmonary function as a tool of prediction of pulmonary hypertension reduction after mitral valve replacement or not. Spirometry test had been used as it is an objective, valid and reliable method to measure the pulmonary function tests. In addition, it is a non invasive method that can be handled without any inconvenience to the patient specially after mitral valve replacement surgery and it's real simple tool to discover alot of information and follow-up of patients [4,6].

Pre-operatively, we noticed in our study that group I had pulmonary functions within normal range in contrast with Group II which had pre-operative pulmonary function impairment and more impaired in severe pulmonary hypertension group (Subgroup C) as those patients had a relative co-morbidities than others and the pulmonary hypertension makes changes in distribution of perfusion which indicate diminished perfusion in the dependant lung zone as a result of constricted vasculature and organic sequal from pulmonary hypertension.

Several studies have found impairment of pulmonary functions in mitral valve disease. Zhi-Cheng Jing et al., [7], assessing pulmonary functions in patients with pulmonary hypertension through a multicenter study on 190 patients with pulmonary hypertension and 56 patients without pulmonary hypertension and founded significantly reduction in pulmonary hypertension patients compaired with patients having no pulmonary arterial hypertension and referred that to prepheral airway obstruction due to pulmonary hypertension.

Chatterji et al., [8], founded that FVC values were reduced in direct proportion to pulmonary artery pressure and FEV_1 and PEFR were uniformly reduced in patients with various degree of pulmonary hypertension.

At discharge of patients pulmonary functions were significantly reduced in both groups as several factors involved in that reduction such as AF, long bypass time, chest drains, long time on mechanical ventilation and long hospital stay post-operatively. Our results were consistent with the results of the previous studies, which found a decrease in spirometric parameters early after mitral valve replacement.

Pasquina et al., [9], reported that the causes of reduction in pulmonary function early after mitral valve replacement are probably multifactorial and may involve a combination of surgery, anaesthesia, median sternotomy, hypothermia for myocardial protection, immobilisation, phrenic nerve injury and cardiopulmonary bypass. Also chest drains alter pulmonary function.

El-Sobkey et al., [10], compaired pulmonary function changes 2 days preoperative and 10 days post-operative in open heart surgery on 40 patients 55% were males showed that early postoperative reduction of FVC, FEV_1 and MVV with no definite causative factor appeared to be responsible for those results although several factors suggested as cold cardiolegia and median sternotomy will affect respiratory mechanics.

Charlotte et al., [11], studied lung function before and two days after open heart surgery on 107 individuals with 80% were male and 8% were smokers, founded that decreased FVC and FEV_1 immediatly postoperative by 40-50% on the first to third post-operative days in comparison to pre-operative values. She referred that results to post-operative atelectasis, obesity, general health status, smoking history and age of patients.

Three and six months after mitral valve replacement we found significant improvement gradually in the pulmonary function in both groups with statistically significant difference inbetween pre-operative and six months post-operative values in Group II this may be due to pre-operative more impaired pulmonary function in that group and so after surgery the improvement will appeared. Also, the Subgroup C continue improving in pulmonary function at six months postoperatively with statistically significant difference to the other subgroups as they all improved at three months post-operative with more significant in Subgroup C. Therefore, the Subgroup C showing statistically significant improvement during the entire period of our study than other subgroups.

Chandra et al., [4], studied spirometric changes pre-operative, before discharge and three months following open heart surgery for rheumatic mitral valve disease on 22 patients were 50% males, 16 patients had preoperative various degree of pulmonary hypertension, and patients with lung diseases were excluded, founded that there was reduction in the pulmonary function in all cases pre-operatively and further deterioration was seen early after surgery mainly in smokers and overall improvement in spirometric parameters (FVC, FEV_1, PEFR, MVV) at three months of follow-up after mitral valve replacement, although the values remained lower than the predicted and these results coincident with our results.

Saxena et al., [12], study the pulmonary function changes preoperatively, one week, one month and 3 months post mitral valve replacement on 25 patients with male to female 10:15 and the age ranging from 14 to 50 years, he founded that the pulmonary functions deteriorate immediately after surgery and then recover gradually over 3 months above the pre-operative level, however they remain below the predicted values which runnig with our results.

We test in our study if there is correlation between the reduction of Systolic Pulmonary Artery Pressure (SPAP) and improvment in pulmonary

function parameters and found no correlation between them due to small sample size.

Arunthari et al., [13], study correlation of pulmonary function variables with hemodynamic measurements in patients with pulmonary arterial hypertension and through relationship between the DLCO and pulmonary arterial pressures can be strengthened by normalizing the DLCO to spirometric variables and concluded that in patients with suspected PAH, invasive hemodynamic measurements of PAH do not correlate with PFT variables, even when corrected for spirometric volumes.

Limitations:

Small sample size, one center study, this study doesn't contain all the measurements of the pulmonary function as Dlco, no exclusion of idiopathic pulmonary hypertension and lack of data about right ventricular function and measurment.

Conclusions:

There is no correlation between the reduction of pulmonary hypertension and the improvement of pulmonary functions, so we can't depend on pulmonary function as a predictor of reduction in pulmonary hypertension after mitral valve replacement surgery due to small sample size. Patients with severe pulmonary hypertension preoperatively, showed statistically significant improvement in the pulmonary functions during the entire period of the study.

N.B.: This research was carried out without funding.

Conflicts of interest:

No conflicts of interest declared.

Authors' contributions:

All authors had equal role in design, work, statistical analysis and manuscript writing.

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التغيرات الطارئة على وظائف الرئة بعد إستبدال الصمام الميترالى

إرتفاع ضغط الدم الرئوى يعنى إرتفاع فى متوسط ضغط الشريان الرئوى أكثر من ٢٥مم زئبقى أثناء الراحة وأكثر من ٣٠مم زئبقى أثناء المجهود. غالبا ما يتصف إرتفاع ضغط الدم الرئوى بإستمرارية وزيادة مقاومة الجهاز الوعائى الرئوى التى ينتج عنها فشل البطين الأيمن.

أمراض الصمام الميترالى تحدث إرتفاع فى ضغط الدم الرئوى خلال زيادة حجم أو ضغط الأذين الأيسر ومن خلاله يحدث إرتفاع فى ضغط الدم الرئوى فى بداية مراحله قد يأخذ فقط الأوردة الرئوية ولكن بعد فترة يحدث إرتفاع بضغط الشريان الرئوى ويصاحبه تغيرات مورفولوجية فى الجهاز الوعائى بما قد ينتج عن توالى زيادة مقاومة الجهاز الوعائى الرئوى ومزيد من المضاعفات.

إنخفاض وظائف الرئة شائعة بعد عملية القلب المفتوح. أحجام الرئة قد تظل منخفضة لمدة ٣-٤ شهور ما بعد إجراء العملية الجراحية. أيضا مرض الداء الرئوى المسد المزمن، والحالة الصحية العامة، وتاريخ التدخين وعمر المريض هم عوامل مرتبطة بزيادة خطورة إختلال أحجام الرئة بعد عمليات القلب. تداخلات ما بعد العملية الجراحية مثل تمارين التنفس والحركة المبكرة للمريض قد يحد من إنخفاض وظائف التنفس بعد عمليات القلب.

إختبارات وظائف الرئة هى عبارة عن مجموعة من الإختبارات التى تقيس كيفية دخول وخروج الهواء من الرئتين وكيفية حركة الغازات مثل الأوكسجين من الجو إلى داخل الجسم.

مقياس التنفس السبيرومتر قد تم إستخدامه لأنه طريقة واقعية، صحيحة ومصدوقة لقياس وظائف الرئة. بالإضافة لأنه طريقة غير مضرة حيث يمكن إستخدامه بيد المريض بدون أى إزعاج للمريض خصوصا بعد العملية.

وظائف الرئة التى سوف تقاس هى حجم الزفير الأقصى بالثانية الأولى وسرعة جريان الهواء الزفيرى الجهدى والسعة الحيوية القسرية والحد الأقصى للتهوية الطوعية.