Original Article

Retrospective analysis of clinical and pulmonary data in valve surgery

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ABSTRACT

Objectives: The purpose of the current investigation was to assess the effect of surgery on clinical and pulmonary data in valve surgery (VS).

Methodology: As a result of retrospective review performed between January and December, 2004, 30 patients' data were studied. Preoperative patients' characteristics, cardiac profiles, coronary risk factors, operative and postoperative data, pulmonary function tests (PFT) and respiratory muscle strength (RMS) measurements were collected.

Results: Mean values of all predicted values of PFT and RMS were normal preoperatively. There was a significant decrease in FVC ($p<0.0001$), FEV_1 ($p<0.0001$), FMF ($p<0.0063$), FEF ($p<0.002$), P_{Imax} ($p<0.0001$), and P_{Emax} ($p<0.0126$) after surgery. Patients with atrial fibrillation (AF) had longer periods of intensive care unit (ICU) ($p<0.0001$). NYHA significantly correlated with preoperative PFT parameters [FVC ($p=0.0085$), FEV_1 ($p=0.0043$), FMF ($p=0.0055$)] and postoperative ICU stay ($p=0.0426$). Postoperatively, P_{Imax} significantly correlated with FVC ($p=0.0167$) and FEV_1 ($p=0.0143$).

Conclusions: The extent of functional status affected pulmonary functions in patients with valve disease. Postoperative AF had significant negative impact on ICU stay.

KEY WORDS: Pulmonary function tests, Respiratory muscle strength, Valvular heart surgery.

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INTRODUCTION

Median sternotomy, the standard incision in cardiac surgery, is assumed to have little or no significant effect on lung function although it causes changes in the mechanics of the thoracic cavity.[1] Patients undergoing cardiac surgery can have abnormal respiratory mechanics.[2] Measurement of lung volumes reveals changes in total lung capacity, vital capacity, residual volume and functional residual capacity which may persist for weeks to months postoperatively.[3]

Surgery may also affect respiratory muscle function by different mechanisms: (1) Sternotomy, (2) Anaesthesia and pharmacological agents.[4] Thus postoperative life threatening complications may subside.[4] Since pulmonary complications are one of the major causes of postoperative morbidity and mortality[5], proper assessment of respiratory muscle

function is of paramount importance. Impairment in PFTs following cardiac surgery has been demonstrated in previous studies.[6-10] But, none of these studies investigated the RMS in patients after VS.

The purpose of our study was to analyze the effect of surgery on PFT, RMS and the clinical outcome.

METHODOLOGY

Medical chart review of 50 consecutive patients who underwent VS between January and December 2004 was performed. Patients, with history of previous VS, with concomitant coronary artery bypass grafting (CABG), resection of ventricular aneurysm and with congestive heart failure were excluded. Thirty patients [male/female: 11/19 (range; 30-69 years)] with valve disease were found. VS was performed using median sternotomy in all cases. Standart cardiopulmonary bypass was instituted. All patients were ventilated overnight and extubated on the first postoperative day followed by a strict regime of chest physiotherapy. The following data were collected from the medical charts: Preoperative patients' characteristics, cardiac profiles, preoperative coronary risk factors, smoking history, operative and postoperative data. Patients' PFTs and RMSs were measured preoperatively (one week before surgery) and postoperatively (one week after surgery) by physical therapists.

The following parameters were obtained from medical charts: forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), FEV_1/FVC, forced expiratory flow between 25% and 75% of FVC (FMF), forced expiratory flow between 0.2 lt-1.2 lt of FVC (FEF) and RMS [maximal inspiratory pressure (P_{Imax}) and maximal expiratory pressure (P_{Emax})]. Data were classified according to Gold criteria.[8] Criteria for interpreting pulmonary functions were based on American Thoracic Society's recommendations.[11] Predicted values for spirometric measurements were from Kamburoff[12] and predicted values for maximal respiratory pressures were from Wilson.[13] Patients were not on bronchodilators while testing pulmonary functions.

Pre-and postoperative PFTs and RMS values were compared. The relationship between pre-and postoperative PFTs and RMS values were also investigated with the correlation between preoperative cardiac profiles and PFT/RMS parameters.

Statistical Analysis: Measured and predicted values of various spirometric parameters were expressed as the mean±standard deviation. The paired t-test was used to assess statistical significance of the differrence between matched samples. Comparisons between the groups were performed using the unpaired t-test. Pearson and Spearman correlation coefficient were used to evaluate associations. A p value of <0.05 was considered significant.

RESULTS

Preoperative patient characteristics, pre-and postoperative patients' data are shown in Table-I. Rheumatic fever history was present in ten patients (33.3%). Six patients (20%) were in NYHA (New York Heart Association functional classification) Class I, 17 patients (56.7%) in Class II, five patients (16.7%) in Class III, and two patients (6.6%) in Class IV. Mitral valve replacement (MVR) was performed in 17 cases (56.7%). Aortic valve replacement (AVR) was performed in 11 cases (36.7%) and AVR+MVR was performed in 2 cases (6.6%).

Intubation time was between 6-27 hours. No patient required reintubation. Twenty-one patients (70%) without AF were extubated following a mean intubation time of 10.4±4.6 hours, while the mean intubation time of patients with AF was 16.4±5.4 hours. ICU stay varied from 25 hours to 235 hours depending on AF presence. Nine patients who had AF (30%) were discharged from the ICU within 104.8±57.2 hours, while patients without AF were discharged in 36.5±11.6 hours. Postoperative total hospital stay was 7-16 days. Mean total hospital stay in patients without AF and with AF was 8.9±1.6 and 10.4±2.9 days, respectively. There was no significant difference in intubation time and postoperative total hospital stay between patients with or without AF. However patients with AF had longer periods of ICU ($p<0.0001$).

Only three patients had atelectasis and three patients had pleural effusion postoperatively. Pre-and postoperative mean spirometry, P_{Imax} and P_{Emax} values and statistical significance of differences between pre-and postoperative absolute values are presented in Table-II. Although mean values of all PFTs were normal when compared to percent of predicted values preoperatively, five patients had reduced $FEV_1/FVC<0.70$ and FEV_1% predicted, ten patients had reduced FVC% predicted. Postoperatively four patients had reduction in FEV_1/FVC and FEV_1% predicted, 24 patients had reduction in FVC% predicted and only three patients had normal PFT. There was a significant decrease in all mean absolute values of PFTs except FEV_1/FVC after surgery, when compared to preoperative values. Although preoperative mean value of

P_{Imax}%predicted was 94.1±24.2%, 17 patients had reduced P_{Imax}%predicted values. Preoperative mean values of P_{Emax}%predicted were 103.4±27.5%, 15 patients had reduced P_{Emax}% predicted values. Following surgery 26 patients had reduction in P_{Imax}%predicted values and 21 patients had lower values than normal in P_{Emax}%predicted. There was a significant decrease in mean absolute P_{Imax} and P_{Emax} values postoperatively when compared to preoperative values.

There was no correlation between preoperative PFTs and RMSs, but postoperatively, P_{Imax} significantly correlated with FVC (r=0.4334; p=0.0163) and FEV_1 (r=0.4425; p=0.0143). When analyzing the cardiac profile, no correlation was observed with ejection fraction [EF(%)] and pre-and postoperative PFTs, RMSs and postoperative data except postoperative ICU stay (r=-0.4742; p=0.0166) and intubation times (r=-0.4556; p=0.0379). NYHA significantly correlated with preoperative values of PFTs [FVC (r=-0.4717; p=0.0085), FEV_1 (r=-0.5059; p=0.0043), FMF (r=-0.4941; p=0.0055)] and postoperative ICU stay (r=0.3858; p=0.0426). There was no correlation between NYHA classification and preoperative RMS.

Table-I: Patients' characteristics, pre-and postoperative data.

Age (years)	50.6±13.8
Sex (male/female)	11/19
Height (cm)	161.4±9.6
Weight (kg)	67.4±10.6
BMI (kg/m2)	26.4±4.5
NYHA	2.1±0.8
EF (%)	55±10.04
Hipertension	10 (33.3%)
Hiperlipidemia	5 (16.7%)
Diabetus mellitus	6 (20%)
Obesity	7 (23.3%)
Ex-smoker	17 (56.7%)
Intubation (hours)	12.3±5.6
ICU stay (hours)	58.4±45.9*
Total hospital stay (days)	9.4±2.2

Data are presented as mean±SD, number of patients and /or percentage. *p<0.0001

DISCUSSION

Over the last decade there have been very few studies on lung function in mitral valve disease (VD) and none included measurement of RMS.[6,7,14,15] Only De Troyer et al[16] reported that, patients with mitral VD may have inspiratory muscle weakness, that contributes to the restriction of lung volume in cases of pulmonary vascular congestion and pressures generated by the inspiratory muscles were less negative than normal at any given lung volume by measuring lung recoil pressures. In our study, although most of the patients were in functional Class II, the finding of reduced preoperative P_{Imax} values in 56.7% of our patients reveals that patients with VD may have inspiratory muscle weakness.

Chandra et al[7] found that lung function was impaired preoperatively with a correlation between their pulmonary function and NYHA class (majority with restrictive pattern) in all 22 patients who underwent VS for rheumatic disease (Class III-IV NYHA). We found a similar significant correlation between the functional class and pulmonary function of our patients. Similarily Shenkman[6] found a decrease in pulmonary functions [10 patients with VS and congestive heart failure, Class III-IV NYHA (FVC%:75.8%, FEV_1%:68.2%, FEF50:60.9%)] preoperatively and stated that there was a significant inverse correlation between preoperative cardiac ischaemic and failure symptomatology and pre-and surgical PFTs.

Table-II: Pre-and postoperative PFT's, PImax and PEmax values.

	Preoperative (%predicted)	*Postoperative (%predicted)*	*%change#*
FVC (L)	3.0±0.9 (91.3±16.7%)	2.1±0.7 (63.2±18.1%)	-29.9±18.2*
FEV1 (L)	2.3±0.8 (88.9±24.8%)	1.7±0.5 (62.8±16.7%)	-26.7±19.3*
FEV1/FVC (%)	79.8±9.1	81.2±9.7	1.9±8.1 NS
FMF (L/sec)	2.4±1.2 (78.4±37.5%)	1.9±0.9 (59.5±27.3%)	-14.3±43.0**
FEF (L/sec)	5.9±2.7 (116.3±43.5%)	3.4±1.2 (68.9±30.3%)	-35.0±28.4***
PImax (cmH2O)	75.7±21.9 (94.1±24.2%)	53.6±21.4 (66.7±24.0%)	-22.1±19.1*
PEmax (cmH2O)	111.6±40.7 (103.4±27.5%)	91.8±25.3 (86.5±23.1%)	-19.8±40.8****

Values (absolute and percent of predicted) are presented as mean±SD.
#Differences between pre-and postoperative absolute values.
*p<0.0001; **p<0.0063; ***p<0.002, ****p<0.0126, NS: Non significant

About 76.7 percent of our study population was in Class I-II NHYA, EF values were higher than 50% and none had congestive heart failure. This may explain our higher preoperative PFT values [percent to predicted (%)] than the study of Shenkman et al.[6] Our preoperative PFTs were also better than Chandra et al.'s[7], whose patient population consists of only Class III and IV NYHA. Similarily Vaidya et al[14] also observed better preoperative spirometric parameters in their Class II nonsmoker patients. In a recent study, Saxena et al.[3] found a reduction in FVC, FEV_1, PEFR and DLCO preoperatively in patients from all the classes. The results of the above studies[3,6,7,14] and ours showed that assessment of functional class is very important in this patient population and according to our results this parameter significantly correlated with patients' PFT and postoperative ICU stay.

Present study's results indicate that except for FEV_1/FVC, all mechanical PFTs significantly deteriorate after surgery. Normal postoperative FEV_1/FVC supports the role of thoracic wall's surgical trauma in the development of postoperative pulmonary function impairment. Similarily other studies have also demonstrated variable degrees of impairment in all parameters of PFT early after mitral VS.[3,6,7,14] Mechanism of pulmonary function impairment in this patient population is not well understood. Shenkman[6] found a decrease in FVC, FEV_1, FEF_{50}, FEF_{75}, PEFR, MVV after cardiac surgery [CABG 74%, VS or valvuloplasty 20% and combined procedures 6%] and pointed a direct correlation between postoperative values of FVC and FEF_{50} and FEF_{75}. Similarily postoperative FVC was directly related to postoperative FEV_1 ($r=0.9406$; $p<0.0001$), FMF ($r=0.4828$; $p=0.0069$), FEF ($r=0.7606$; $p=0.001$) and indirectly related to FEV_1/FVC ($r=-0.3878$; $p=0.0342$). Our study also demonstrates a significant decrease in P_{Imax}, in addition to the impairment found in PFT parameters after VS. Few studies investigated the RMS after CABG but to our knowledge, there is no study which investigated RMS after VS.

Chetta et al[17] demonstrated that the percent decreases in FVC significantly correlated with the percent decreases in P_{Imax} and P_{Emax} following sternotomy. We found that VS could reduce P_{Imax} and P_{Emax} by 22.1% and 19.8%, respectively, according to baseline values. Besides, postoperatively, P_{Imax} significantly correlated with FVC ($r=0.4334$; $p=0.0163$) and FEV_1 ($r=0.4425$; $p=0.0143$).

There have been no large series to determine postoperative complications in VS patients. Jain et al[18] found that among 63 patients who had CABG with only saphenous veins grafts and/or VS, the incidence of atelectasis was 54% and effusion 35%. Authors also concluded that, there was no significant difference in pulmonary abnormalities between the saphenous vein grafting and the VS groups. In contrast to their higher complication rates, our study showed that postoperative complications were lower (atelectasis: 10%; pleural effusion: 10%), in our patients with normal preoperative pulmonary functions and who received postoperative chest physiotherapy. Besides having lower pulmonary complications, another point to note is our lower incidence of AF (30%) compared to Janusz et al.[19] (38-64%).

Lell et al[20] found that patients having VS need 12.7 hours of mechanical ventilation and their ICU stay was 26.2±3.29 hours postoperatively. Similarly, in our patient population, which was comparable with the above study in patient's mean age, intubation time was 10.4±4.6 hours and ICU stay 36.5±11.6 hours in patients without AF. Although AF incidence in our study was lower than the prior studies[19,21], patients who had AF required significantly longer periods of ICU stay.

Although our study has some limitations such as; consisting of a small group of patients with mostly NYHA Class II patients with valvular heart disease we believe it is important due to the following reasons:

1. No other previous study has examined the effect of the valvular heart disease and VS on RMS.
2. There have been no other large or small series to determine the effect of postoperative complications on clinical course.
3. There has been no study showing the effect of AF on postoperative clinical course of the patients.
4. Recognition of the importance of preoperative normal pulmonary functions and postoperative chest physiotherapy on lower pulmonary complication incidences in VS patients.

In conclusion, the present study shows that the decrease in pulmonary functions and RMS may be observed even in NYHA Class II patients with mitral and aortic valve disease, but they still maintain their normal values according to percent of predicted. The functional status of the patients was significantly related with pulmonary functions. In this study population, although the clinical outcome of the patients was good, VS caused impairment in both pulmonary functions and respiratory muscles

in the early postoperative period. Further studies are needed to investigate the respiratory muscle weakness in Class III and IV patients with valve disease with longer duration of follow-up.

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Authors' Contributions:

SO completed the study design, writing manuscript and literature research.
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MZ data collection, analysis and interpretation of data concerning respiratory function.
KM data collection, analysis and interpretation of data concerning respiratory function.
ACH analysis and interpretation of data concerning surgery.
RM statistical analysis.
ZY analysis and interpretation of data concerning cardiology.
HNG study design and management, writing and editing of the manuscript, review and final approval of manuscript.