Original Article

Right Ventricular and Septal Function in Patients with Pulmonary Hypertension

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Objective: **Pulmonary hypertension (PHT) exacerbates the functions of both ventricles. This prospective, randomised study was planned to investigate the effects of PHT on kinetics of both ventricles and the septum.**

Methods: **Twenty-five patients were randomly selected among the patients who had been planned to undergo mitral valve replacement (MVR) because of isolated mitral stenosis and divided into two groups according to their preoperative pulmonary artery pressure (PAP) values. Blood pool gated single photon emission tomography (BPGS) and transthoracic echocardiography were performed. Ventricles' regional, global and functional parameters were also assessed by using pulsed wave Doppler tissue imaging (DTI).**

Results: **Preoperative and postoperative PAP of the group 1 (PAP < 50 mmHg) were 40.0 ± 2.8 and 30.0 ± 2.6 mmHg ($p = 0.03$), group 2 (PAP ≥ 50 mmHg) were 71.9 ± 4.7 and 50.6 ± 3.5 mmHg ($p < 0.05$). The global right and left ventricle scores were decreased after the operation. The decrement was only significant in group 2. Considering the septal kinetics, right ventricle septal score was decreased from 7.6 to 3.3 ($p < 0.05$) in group 1, from 3.8 to 1.6 ($p < 0.05$) in group 2 postoperatively.**

Conclusion: **Following MVR, a decrement in PAP values, and an improvement in ventricular function, especially in the right ventricular and septal kinetics were achieved. Furthermore, it was found that both DTI and BPGS techniques are beneficial to investigate the functional changes postoperatively and in the follow-up period of the patients who undergo mitral valve surgery.**

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Keywords. Pulmonary artery hypertension; Mitral stenosis; Mitral valve replacement; Doppler tissue imaging; Blood pool SPECT

Introduction

Pulmonary hypertension (PHT) is one of the frequent and serious complications of mitral valve disease which increases the perioperative risk in patients undergoing mitral valve surgery [1], with a reported mortality as high as 31% [2]. Not surprisingly, the impact of PHT on morbidity and mortality is highly dependent on its degree of severity, and even mild PHT is not necessarily benign since it is associated with significantly worse exercise capacity, and it brings about an increment in mortality and morbidity [3]. The major consequence of PHT is a deterioration in the right ventricular function, which generally results from chronic pressure overload, and associated volume overload [3–5]. If the right ventricle fails to cope with the raised pulmonary pressure, symptoms of right ventricular failure develop (jugular vein distension > 10 cm, ascites, or oedema extending above the knees) and the patients' survival is reckoned to be limited to virtually six months [1,3]. Thus, reduction of pulmonary artery pressure (PAP) constitutes a crucial goal of mitral valve replacement (MVR). Surgical relief of the mechanical cause of PHT and the regression of the reversible components generally reduce PAP [3,5,6].

The present imaging techniques are too limited to be the gold standard for evaluation of right ventricular right ventricular function. Although the echocardiographic assessment of left ventricular function is simple, the evaluation of right ventricular (RV) function is complicated because of the intricate anatomy. RV systole comprises a complex pattern of contraction of the RV myocardium along its long and short axes as well as a rotation along its longitudinal axis besides the interventricular septal movement [7,8]. In recent years, myocardial velocities measured

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by Doppler tissue imaging (DTI) have been harnessed to appraise both left and right ventricular functions [7,9–12].

A host of recent advances in imaging techniques constitute a tendency to investigate cardiac function by absolute indices of cardiac volumes or of cardiac performance. Blood pool gated single photon emission tomography (BPGS), a three dimensional analogue of the conventional gated blood pool method, boasts an ability to image left and right ventricles separately via hindering the overlap of other cardiac chambers, and enhances assessment of regional wall motion and myocardial volumes [13]. Thus, we used both DTI and GSPECT to investigate the right ventricular and septal functions of the patients with isolated mitral stenosis with or without pulmonary hypertension before MVR and during the follow-up.

Materials and Methods

The study population consisted of 25 patients with isolated mitral stenosis who underwent MVR with St. Jude Medical mechanical valves. The patients were recruited into our study randomly. Written informed consent was obtained from all patients. Patients were grouped according to their preoperative PAP values as group 1 (13 patients, PAP < 50 mmHg) and group 2 (12 patients, PAP $\geq$ 50 mmHg). Chart review was conducted and the demographic and clinic variables were noted down. Routine general physical examinations were performed for all patients and those who had atherosclerotic coronary artery disease, another accompanying valve disease and/or a mitral regurgitation >1+ echocardiographically at the time of surgery, were ruled out from the study. All of the patients had rheumatic mitral valve stenosis. Operative data recorded included both the cross-clamp and the cardiopulmonary bypass durations. The patients were followed-up for three months after MVR. Transthoracic echocardiography, BPGS and DTI were performed before MVR and at the postoperative third month.

Transthoracic Echocardiography

All patients were examined in the left lateral decubitis position by M-mode, two-dimensional, Doppler and DTI echocardiography through an Aloka SSD-5500 (Aloka Holding Europe AG, Switzerland) echocardiography device with a 3.5 MHz transducer. A one-lead electrocardiogram was recorded continuously. Mitral valve area was calculated by the pressure half time method [14,15]. Peak and mean diastolic transmitral gradients were measured by continuous wave Doppler echocardiography. TR jet flow was evaluated from apical, subcostal and parasternal views. PAP was measured with continuous-wave Doppler. The final estimate of the pulmonary artery systolic pressure was obtained by adding the clinically determined mean jugular venous pressure to the pressure gradient between the right ventricle and atrium [16,17]. Left atrial diameter was calculated through the parasternal long axis view achieved by M-mode echocardiography [18].

The echocardiographic variables including left ventricular end-diastolic diameter (LVEDD), left ventricular end-systolic diameter (LVESD), PAP, mitral valve area and systolic/diastolic transmitral gradients were measured and compared between the groups.

Blood Pool Gated Single Photon Emission Tomography (BPGS)

Gated blood pool procedure was performed using in vivo 99mTc labelled red blood cells with a pyrophosphate (pyp) commercial kit. For the technique of in vivo labelling, pyp was injected into patents via an intravenous (IV) line. After 15–20 min, 25–30 mCi 99mTc-pertecnetat was injected from the same IV line and the IV line was washed with 10 ml of SF. All acquisitions were done on a dual-head Optima NX (General Electric) gamma camera system with a high-resolution collimator. Acquisition parameters were as follows; 32 steps per 180°, 90 s per step, 16 frames per cardiac cycle, 64 × 64 matrix, an energy window 20% with 140 keV photopeak. All BPGS data were reconstructed by Butterworth filter (order, 5; cutoff, 0.25 pixel^{-1}; pixel size 6.7 mm) using Xeleris computer system (GE Electric). The data were processed on the computer (Xeleris, GE Electric) with the BPGS programme, an automatic software algorithm defined by Van Kriekinge-Germano et al. (Cedars-Sinai Medical Centre). The method is based on activity and temporal gradients (geometric method). The algorithm determines an ellipsoid coordinate system for the left ventricle and then computes a statistic estimate of the endocardial surface by the use of counts and count gradients.

The following measurements were calculated utilising GSPECT: left ventricular ejection fraction (LVEF), RVEF, LV end-systolic volume, LV end-diastolic volume, RV end-systolic volume, RV end-diastolic volume, LV stroke volume, and RV stroke volume. Furthermore, we divided the heart into nine segments and scored the septal kinetics and the segmental left and right ventricular contractility (normal = 0, hypokinesia = 1, akinesia = 2, dyskinesia = 3, aneurysm = 4).

DTI

Pulsed wave DTI was performed by activating the DTI function in the same echocardiographic device. In the apical four-chamber view, the DTI cursor was placed at the lateral side of the mitral annulus and RV free wall side of the tricuspid annulus. The filter settings were kept low (50 Hz), gains were adjusted at the minimal optimal level to minimise noise and eliminate the signal produced by the transmitral flows, and 3 mm sample volume was used. A Doppler velocity range of −20 to 20 cm/s was selected. The maximum systolic and diastolic velocities were measured online at a sweep speed of 50 mm/s. Every effort was made to align to pulsed wave cursor so that the Doppler angle of incidence was as close to ‘0’ as possible to the direction of motion of the mitral and tricuspid annulus. Three major velocities were recorded: the positive systolic velocity when the tricuspid ring moved towards the cardiac apex, and two negative diastolic velocities when the mitral annulus and tricuspid annulus moved towards the base, away from the apex. Systolic (S), early diastolic (E) and late