Short communication

The lung function in operated acquired mitral and aortic valve diseases without left ventricular failure – preliminary observations before operation

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Abstract

Introduction: The study has been designed to evaluate the influence of the operations on cardio-pulmonary by-pass, particulary with systemic normothermia and cold crystalloid cardioplegia on the function of heart and lungs.
Material and methods: 27 non-smokers 21-78 year old, 16 with aortic, 11 mitral valve diseases, 22 in NYHA III, 5 – IV class, randomly chosen pursuing excluding criteria before operation.
Bodypletysmography, spirometry, and diffusing capacity were compared to the control group, and with American Thoracic Society (ATS) norms.
Results: Following patients' data values were significantly worse: Vital Capacity ($p<0.05$) – sitting position, and in sitting and supine positions: Forced Vital Capacity ($p<0.001$), Alveollar Volume (VA, $p<0.05$), Hemoglobin standardized Lung Diffusing Capacity for Carbon monoxide (TLCOc; $p<0.05$), and body surface area standardized TLCOc (TLCOc/BSA; $p<0.001$), whereas TLCOc/VA – insignificantly. After changing the position from sitting to supine most changes are similar, but the patients lacked a fall in percent-normal Residual Volume (RV), unlike in RV % Total Lung Capacity.
Conclusions: Mild restrictive lung dysfunction is associated with acquired valve diseases before left ventricular failure develops, and respiratory adaptation to the supine position is almost unaffected.

Key words: bodypletysmography, lung diffusing capacity, sitting and supine positions, cardio-pulmonary by-pass.

Introduction

Despite the different level and mechanisms of advanced acquired left heart valve diseases, all of them impede pulmonary vein outflow. Therefore the authors assume that their similar in this aspect haemodynamics influences the lung function in a similar way, and it should be visible in patients who required an operation. Optimally, a heart operation is performed before left ventricular failure develops. On the other hand, the lung function in left ventricular failure and chronic heart failure was previously investigated, but no consensus was reached [1-6]. Little is known about disturbances in the lung function of the patients required a heart operation, let alone how an operation on cardio-pulmonary by-pass influences the lung function. Our prospective randomized clinical study is designed to evaluate the influence of the operations on cardio-pulmonary by-pass particularly with systemic normothermia and cold crystalloid cardioplegia on the function of organs which are the most prone to damage during the procedure: mainly the heart and lungs. The study obtained approval of The Bioethics Committee of the Medical University.

This article presents the first part of investigation: the external respiratory function in the patients required heart operations for acquired mitral or aortic valve diseases without left ventricular failure. This was the start point for further investigations.

Material and methods

Between February 2002 and November 2004, 332 patients with acquired valve diseases (117 mitral, 215 aortic) were qualified for their first heart operation. The excluding criteria were strictly pursued (smokers, patients with pulmonary diseases; left ventricle, kidney, or liver insufficiency; stroke; inability to co-operate; obesity, to be operated on moderate hypothermia; emergency operations and re-operations), and the 27 non-smokers were randomly chosen. They were 21-78 (54.3±6) year old, 19 male, 8 female, 16 with aortic, and 11 with mitral valve diseases (Table I), with the left ventricular ejection fraction LVEF=55.6±6.5% (42-66%), 22 in NYHA class III, 5 – NYHA class IV. The informed consent was signed.

The heart function was evaluated by Doppler echocardiography (Ultrasonocardiograph HP Sonos 2000). The pulmonary function was assessed by means of the bodypletysmograph (Master Laboratory Screen, Jaeger Toennis, Wuerzburg, Germany) according to the American Thoracic Society (ATS) [7]. Data obtained from bodypletysmography (sitting position), spirometry, and examination of the diffusing capacity for carbon monoxide and Helium (single breath method, sitting and supine position) were analyzed and compared to respective data in the control group consisting of healthy volunteers, and with the ATS norms for the sitting position [7]. The following parameters of the lung function were measured during bodypletysmography and spirometry:

- ITGV – intrathoracic gas volume,
- ERV – expiratory reserve volume,
- RV – residual volume,
- VC IN – vital capacity,
- TLC – total lung capacity,
- RV%TLC – residual volume in % of total lung capacity,
- R tot – total airway resistance,
- R IN – inspiratory airway resistance,
- R EX – expiratory airway resistance,
- FVC – forced vital capacity,
- FEV1 – forced expiratory volume after 1 sec.,
- FEV1%FVC – FEV1 in % of FVC,
- FEV1%VC – FEV1 in % of VC,
- PEF – peak expiratory flow,
- FEF75 – forced expiratory flow at 75% of FVC,
- FEF50 – forced expiratory flow at 50% of FVC,
- FEF25 – forced expiratory flow at 25% of FVC.

During a single breath diffusion examination, the following parameters were measured with helium or carbon monoxide:

- RV-He – residual volume,
- TLC-He – total lung capacity,
- RV%TLC – RV in % of TLC,
- FRC He – functional residual capacity,
- FRC%TLC He – FRC in % of TLC,
- FIHe – inspiratory concentration He,
- FAHe – expiratory concentration He,
- TLCO SB – diffusion capacity, single breath,
- Hb – patients' hemoglobin,
- TLCOc – TLCO, patient' hemoglobin-corrected,
- VA – alveolar volume,
- TLCO/VA – TLCO per VA,
- TLCOc/VA – TLCO, patient' hemoglobin-corrected per VA,
- BSA – body surface area,
- TLCO/BSA – diffusion capacity, BSA-corrected,
- TLCOc/BSA – TLCO, patient' hemoglobin and BSA-corrected,
- FICO – inspiratory concentration CO,
- FACO – expiratory concentration CO,
- TLC – VCIN (from previous spirometry measurement) + RV (from current TLCO-SB).

The statistical analysis was made by means of the commercially available program „Statistica" with appropriate tests (non parametric Wilcoxon-Mann-Whitney's, and Wilcoxon signed rank tests for this part of the study).

Results

Bodypletysmography, spirometry and diffusion data of the control group did not differ statistically from the norms given by the ATS. The following patients' data values were significantly worse than in

Table I. Patients' characteristics; IT – tricuspid insufficiency, IM – mitral insufficiency, CAD – coronary artery disease, E – endocarditis

Diseased valve	Total	Prevailing		Associated				
		Insufficiency	Stenosis	IT	IM	CAD	ASD	E
Aortic	16	3	13	–	1	1	–	2
Mitral	11	5	6	3		1	1	–

Table II. Significant differences in patients with valve diseases before the operation versus healthy persons. Legend: ac. – actual value, pr. – predicted (normal) value for the sitting position according to the ATS, % ac./pr. – relative actual value in percent of predicted, av. – average value, N – normal value according to ATS, % av./N -average value in percent of the normal one

Patients versus healthy persons – significant differences before the operation						
Position	Sitting		p	Supine		p
Parameter	Patients	Control		Patients	Control	
VC % ac./pr.	115.6±14.2	125.4±11.4	<0.05	–	–	
FVC % ac./pr.	111.1±12.5	122.5±10.4	<0.001	–	–	
% av./N TLCOc	86.4±14.5	101.6±12.6	<0.05	92.3±15.9	107.6±13.4	<0.05
% av./N VA	102±9.9	111.1±11.5	<0.05	98.8±11.1	107.7±9.5	<0.05
% av./N TLCOc/VA	85.9±14	94.7±14	NS	96.2±14.3	103.2±14.4	NS
av. TLCOc/BSA	4.1±0.9	5.8±0.5	<0.001	4.4±1	5.6±0.7	<0.05
% av./N TLC He	102.1±9.5	110.8±11.1	<0.05	99±10.8	107.5±9.1	<0.05

Table III. Differences and similarities in adaptation to the supine position between healthy persons and patients with valve diseases. Legend: ↑ – a rise of the value after changing the position; ↓ – a fall of the value after changing the position

Diffusion	Supine versus sitting position			
	Healthy	p	Patients	p
% av./N TLCO	↑	<0.05	↑	<0.001
% av./N TLCOc	↑	<0.05	↑	<0.001
% av./N VA	↓	<0.01	↓	<0.001
% av./N TLCOc/VA	↑	<0.001	↑	<0.001
av. TLCOc/BSA	↑	<0.05	↑	<0.001
av. RV He	↓	<0.05	↓	<0.05
% av./N RV He	↓	<0.05		NS
% av./N TLC He	↓	<0.01	↓	<0.001
% av./N RV % TLC He		NS	↓	<0.001
% av./N FRC He	↓	<0.01	↓	<0.001
% av./N FRC % TLC He	↓	<0.01	↓	<0.001

the control group (Table II): from bodypletysmography (in the sitting position): Vital Capacity in % actual/predicted; from spirometry (sitting and supine positions): Forced Vital Capacity in % actual/predicted, % average/normal Alveolar Volume; from diffusion (sitting and supine positions): % average/normal Total Lung Diffusing Capacity for Carbon Monoxide standardized for Hemoglobin, average Total Lung Diffusing Capacity for Carbon Monoxide standardized for Hemoglobin and Body Surface Area, and % average/normal Total Lung Capacity for Helium. Interestingly, % av./N TLCOc/VA was insignificantly lower in the patients' group. There were similarities connected with changing the position from sitting to supine in both groups as follows (Table III): a similar significant rise in % av./N TLCOc (<0.05), and in % av./N TLCOc/VA ($p<0.001$); a similar significant fall in % av./N VA ($p<0.01$), % av./N TLC He ($p<0.01$ vs $p<0.001$), % av./N Functional Residual Capacity He (% av./N FRC He, $p<0.001$ vs $p<0.01$), and % av./N FRC % TLC He ($p<0.001$ vs $p<0.01$). There were two differences: in the patients group a significant fall in av./N RV % TLC He, and absence of a significant fall in % av./N RV He (Table III).

Discussion

The authors proved their presumption that advanced left heart valve diseases influence the pulmonary function before left ventricle insufficiency develops. At this state of the diseases required operation the impeded pulmonary veins outflow causes restrictive pulmonary changes (significantly worse values of VC, FVC, TLC, VA, and TLCO in the patients than in the control group). These changes, although significant, are less than 30% of the predicted values, therefore are considered to be mild.

Hitherto the studies investigated the pulmonary function in patients with chronic heart or left ventricular failure for different reasons, in a retrospective way, and with different excluding/including criteria [1-5]. Therefore their results and conclusions are different, ranging from normal throughout restrictive, to restrictive combined with obstructive changes. Similar remarks refer for studies considering the lung function connected with postural changes [6]. In our patients, respiratory adaptation to the supine position was essentially unaffected (Table III).

Conclusions: In the patients requiring an operation for acquired valve diseases without left ventricular failure, associated lung function disturbances are present. These are mild restrictive changes, including diminished Total Lung Diffusing Capacity (mainly membrane related), whereas adaptation to the supine position remains essentially unaffected.

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