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Impact of pulmonary hypertension on biventricular functions tissue doppler echocardiographic study

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ABSTRACT

Background: Pulmonary hypertension (PH) essentially involves the right heart. Also left ventricular (LV) systolic and diastolic functions may be affected. Objectives: The aim of this study was to investigate the effect of pulmonary hypertension on both right and left ventricular systolic and diastolic functions by tissue doppler echocardiography.

Methods: A total of 50 patients with PH in Echocardiographic assessment at Echocardiographic Unit, Assuit University Hospital, Al-Azhar University and 20 controls were included in this study between May 2012 and June 2014. All patients underwent electrocardiography (ECG), conventional and tissue doppler echocardiography (TDI). The patients were divided into 3 subgroups according degree of PH: patients with mild PH (group Ia, n = 15), moderate PH (group Ib, n = 20) and severe PH (group Ic, n = 15).

Results: There is statistically significant difference between the two groups (cases and control) as regard mPAP, Pul.AAT, left ventricular diastolic function parameters (LV MV E/E′ and LV IVRT), right ventricular diastolic function parameters (RV TV E/E′ and RV IVRT), right ventricular tissue doppler derived MPI and ventricular dyssynchrony measured by IVDM, RV-LV LW time to onset intervals (Smo) and RV LW-Sept. time to onset methods. There is no statistically significant difference between the two groups (cases and control) as regard LV LW-Sept. time to onset (Smo) interval which assess Left intraventtricular synchronicity. There is statistically significant difference between the subgroups in group 1 (cases) as regard to LV diastolic function as measured by MV E/E′, DT and IVRT methods. RV diastolic function as measured by TV E/E′, DT and IVRT methods. RV systolic function as measured by RV FAC, IVA, TAPSE. Systolic velocity (S) wave and RV MPI methods. Means LV and RV functions are affected by increased pulmonary pressure and that effect become worse with increasing pulmonary pressure (increasing PH lead to increasing deterioration of LV and RV functions). There is no statistically significant difference between the subgroups in group 1 (cases) as regard LV systolic function measured by LV MPI and average systolic (S) wave methods.

Conclusion: TDI-derived methods more accurate and sensitive than conventional Echo pre-ejection period method for assessment of inter-ventricular mechanical delay.

Background

Pulmonary hypertension (PH) is a hemodynamic problem condition defined as an increase in a pulmonary artery systolic pressure (PASP) ⩾ 35 mmHg or mean pulmonary artery pressure (PAP) of ⩾25 mmHg at rest as assessed by right-heart catheterization (RHC) [1].

It is a progressive disorder characterized by the presence of precapillary PH due to relative blood flow obstruction proximal to the lung capillary bed and increased pulmonary vascular resistance (PVR). This results in right ventricular (RV) pressure overload, ultimately leading to right-heart failure and death [2].

Right ventricular overload, as a consequence of the increase of pulmonary vascular tension, can affect the left ventricular filling profile due to shift of interventricular septum into the left ventricular cavity that result in limitation of left ventricular cavity dimen-

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sions, its contractility and compliance and in consequence in the rise of the left ventricular diastolic pressure [3].

PH is a manifestation of various types of cardiopulmonary and systemic diseases. If there is no underlying reason for PH, it is called primary PH. Pulmonary artery catheterization is the gold standard test for the measurement of PAP; nevertheless, it is both invasive and costly. In contrast, echocardiography is a noninvasive technique that has been used traditionally to measure PAP [4]. It provides the anatomy of the right heart, non-invasive hemodynamic assessment, systolic and diastolic evaluation of the right heart, and serial follow-up for this patient population [5].

Tissue doppler imaging has been used to quantify myocardial velocities and strain to assess both global and regional LV and RV function [6].

Tissue doppler echocardiographic analysis can be displayed alone and on-line from one site, or in conjunction with color M-Mode or color two-dimensional echocardiography. The final graphic display includes one positive systolic (S) deflection, and two negative diastolic waveforms. The systolic waveform is preceded by regional isovolumic contraction time and the diastolic waves are preceded by regional isovolumic relaxation time. The first diastolic deflection represents the early rapid filling phase (E), which is followed by a period of diastasis, and a second late active filling phase (A) due to atrial contraction. Although similar to conventional Doppler these measures represent regional functions when the sample volume is located within the myocardium and global function when located within the mitral annulus [7].

We have studied the impact of pulmonary hypertension on both right and left ventricular systolic and diastolic functions.

Patients and methods

The study included 70 subjects undergoing Echocardiographic assessment at Echocardiographic Unit, Azhar Assiut University Hospital between May 2012 and June 2015. The study protocol was approved by the local ethics committees, and all patients gave adequate informed consent

Those subjects were classified into two groups:

Study group (I)

Included 50 patients [34 (62%) males and 16 (38%) females], with age from 45 to 65 years old with mean age 54.6, all patients have pulmonary hypertension. Which is further subdivided into: Group Ia (15 patients with mild pulmonary hypertension), Group Ib (20 patient with moderate pulmonary hypertension and Group Ic (15 patients with severe pulmonary hypertension).

Control group (II)

Included 20 healthy subjects [12 (60%) males and 8 (40%) females], with age from 40 to 65 years old with mean age 52.9 year.

Inclusion criteria

All patients included in this study have echocardiographic criteria that enforce the possibility of PH which include the following:

- Right Ventricular size more than half of Left ventricular size.
- RVOT acceleration time <105 ms.
- RV isovolumic Relaxation time >75 ms.
- -Tricuspid Regurge Velocity >2.6 m/s.
- TAPSE <20 mm.
- End diastolic PR velocity >1 m/s.
- Inferior vena cava diameter >20 mm and <50% inspiratoy collapse.
- Increase RV wall thickness.
- Dilated main pulmonary artery.

Patients with PH proved by echocardiography (estimating pulmonary artery systolic pressure obtained from measuring degree of tricuspid valve regurge and then calculating mean pulmonary artery pressure (mPAP) by using the following formula: mean PAP = 0.61 × (systolic PAP + 2 mmHg) and classified according to that as follows: mild PH (mPAP = 25–35 mmHg), moderate PH (mPAP = 36–45 mmHg) and severe PH (mPAP > 45 mmHg)

Exclusion criteria

Any hemodynamically unstable patients or patients with end stage renal or liver diseases, known ischemic heart disease, hypertension, Diabetes mellitus, aortic valve disease, mitral regurge, right ventricular outflow obstruction, congenital defects or patients with non sinus rhythm were excluded from current study.

Methods

All patients were assessed clinically, including the evaluation of cardiovascular risk factors (HTN, PVD, signs of CHF) and complete general, cardiac and chest examination. Laboratory (including fasting blood sugar, serum creatinine, serum calcium level and serum cholesterol level), pulmonary function test, 12-lead resting ECG, chest X-ray and complete transthoracic echocardiographic examination were done.

Echocardiographic evaluation

Complete Transthoracic Echocardiographic examination using Vivid 7 phased array system equipped including conventional echocardiography and tissue doppler echocardiography, all echocardiographic examinations performed after 20–30 min of rest with the patient in quiet respiration in the partial left lateral decubitus position, using a 2–4 MHz transducer, and accompanied by recording resting electrocardiography, the following views were used;

- Parasternal long and short axis view.
- Apical four and two chamber views.
- Subcostal view in some patients with poor echo window.

All echocardiographic parameters measured according to the American Society of Echocardiography values for each parameter obtained by averaging measurements from three successive cardiac cycles. RVSP can be reliably determined from peak TR jet velocity, using the simplified Bernoulli equation and combining this value with an estimate of the RA pressure: RVSP = 4(V)2 + RA pressure, where V is the peak velocity (in meters per second) of the tricuspid valve regurgitant jet, and RA pressure is estimated from IVC diameter and respiratory changes. In the echocardiography laboratory, SPAP is more commonly measured and reported. Normal resting values are usually defined as a peak TR gradient of $\leqslant$2.8–2.9 m/s or a peak systolic pressure of 35 or 36 mmHg, assuming an RA pressure of 3–5 mmHg [8].

Mean PA pressure can be estimated by using pulmonary AT measured by pulsed Doppler of the pulmonary artery in systole, whereby mean PA pressure = 79 − (0.45 × AT) [9].

LV systolic function was measured by calculating Ejection Fraction(EF) using; M-mode method: Measuring the dimension of left ventricle, from the leading edge of septal endocardial echo to the leading edge of posterior wall of endocardium By using Tiecheol's equation: Ejection Fraction (EF) (%) = $(LVIDd^3 - LVISd^3)/LVIDd^3 \times 100$

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