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ORIGINAL ARTICLE

Assessment of Left Ventricular Geometry and Function in Preeclamptic and Chronic Arterial Hypertensive Pregnant Women

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Background The hemodynamic disorders of preeclampsia (PE); represent a very interesting model in which a pressure overload develops in a few weeks may induces cardiac changes similar to that detected in chronic arterial hypertension (CAH), which is characterized by a long-lasting pressure overload. Our aim is to assess the left ventricular geometry, systolic and diastolic function in PE in comparison to CAH pregnant patients.

Methods Twenty five consecutive pregnant women with preeclampsia (PE group) and 25 with chronic arterial hypertension (CAH group) were enrolled in their third trimester of gestation. Conventional M-Mode, 2D and Doppler echocardiography were performed for all patients. Left ventricular mass (LVM), relative left ventricular mass (rLVM), left ventricular mass index (LVMI), as well as relative wall thickness (RWT) were calculated to define the LV geometric pattern. Ejection fraction, fractional shortening, stroke volume and cardiac output were measured to evaluate the LV systolic function. Mitral inflow velocities were used to evaluate the diastolic function.

Results Both groups were well matched for their baseline characteristics apart from the age, weight and parity that were higher in (CAH) group ($p < 0.0001$). There were significant increase of LVM; 200.3±72.73vs. 153.6±34.26g, rLVM; 121.4±42.39vs. 95.6±21.84g, LVMI; 108.8±36.49vs. 86±19.19g/m^2, as well as RWT; 0.46±0.1vs. 0.35±0.1 ($P < 0.01$) in CAH group as compared to PE group. Concentric hypertrophy was the most common geometric abnormality detected in CAH group 44% vs. 12% (p= 0.012) while normal pattern was more evident in PE group 68% vs. 36% (p= 0.024). The concentric remodeling and eccentric hypertrophy pattern were similar in both groups. The ejection fraction, fractional shortening, stroke volume and the cardiac output were high but similar in both groups (p= N.S). The E/A ratio was >1 in both groups but it was statistically lower in CAH group, (p= 0.01).

Conclusions Preeclamptic pregnant women have evidence of abnormal left ventricle geometry but less than that detected in CAH with enhanced left ventricular systolic function. These structural and functional cardiac changes justify routine cardiologic assessment, even in the absence of cardiopulmonary symptoms.

Keywords Left ventricular geometry, Ventricular function, Hypertension, Pregnancy, Preeclampsia.
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INTRODUCTION

Pregnancy is a physiological condition in which chronic blood volume overload occurs and causes adaptive heart modifications which occur to allow an adequate supply of oxygen and nutrients to the fetus and the maternal tissues. Of the changes observed, the increase in cardiac output is the most important (1).

Systemic arterial hypertension is a disease that potentially causes structural and functional cardiac changes that are well defined in the literature. In addition, pregnancy; as a volume overload condition; causes already known morphological and functional cardiac changes. Therefore, it would seem reasonable to suppose

Abbreviations and Acronyms

BMI	: Body Mass Index
CAH	: Chronic Arterial Hypertension
CO	: Cardiac Output
DBP	: Diastolic Blood Pressure
EF	: Ejection Fraction
FS	: Fractional Shortening
HR	: Heart Rate
LAD	: Left Atrial Dimension
LVDD	: Left Ventricular Dimension in Diastole
LVM	: Left Ventricular Mass
LVMI	: Left Ventricular Mass Index
LVSD	: Left Ventricular Dimension in Systole
PE	: Preeclampsia
PWT	: Posterior Wall Thickness in Diastole
rLVM	: relative Left Ventricular Mass
RWT	: Relative Wall Thickness
SBP	: Systolic Blood Pressure
SV	: Stroke Volume
SWT	: Septal Wall Thickness in Diastole

that the association of these two conditions would have more drastic repercussions on the heart than pregnancy alone would. In preeclampsia; despite the brief period of hypertension; altered left ventricular structure and function are detected (2, 3). So understanding of maternal cardiovascular physiology provides an essential basis for discussing the interactions between pregnancy and heart disease (4).

Echocardiography allows the cardiac evaluation of pregnant women because it is a noninvasive procedure, with no maternal or fetal risks, and is sensitive enough to detect minor structural and functional cardiac changes (5). More controversial is whether or not myocardial contractile function also changes in pregnant hypertensive women. Ejection phase indices of left ventricular function have been variously reported to increase (6), remain constant (7), or decrease (8) in pregnant hypertensive women.

The aim of this study was to assess the echocardiographic structural and functional changes in pregnant women with preeclampsia as compared with CAH pregnant women.

METHODS

Patient Selection:

The study comprised 50 consecutive pregnant hypertensive patients; 25 with preeclampsia (PE group) and 25 with chronic arterial hypertension (CAH group). They were enrolled in their third trimester of gestation from obstetric outpatient clinic and high risk pregnancy unit of Kasr El-Ani hospital; Cairo University and were evaluated in the cardiology department of the same hospital. Exclusion criteria included patients who had congenital or acquired heart diseases.

Clinical Evaluation:

All patients were subjected to complete history analysis and clinical examination, focusing on cardiac symptoms, duration of hypertension and history of previous preeclampsia. Blood pressure was measured with the woman in the sitting position using sphygmomanometer with appropriate cuff. Hypertension is defined as systolic blood pressure (SBP) ≥140mmHg and/or diastolic blood pressure (DBP) ≥90mmHg (at least two measurements were made and the average was recorded in 2 separate occasions) and/or taking anti-hypertensive treatment (9).

Laboratory Investigations:

All patients were subjected to the following laboratory workup; blood sample for hemoglobin level, blood urea, serum creatinine and fasting blood sugar and urine sample to test for proteinuria.

Echocardiographic Evaluation:

Echocardiographic examination were performed using Philips IE33 ultrasound machine with 2.5 and 3.5MHz transducers with pulsed and continuous wave Doppler and color flow imaging properties. The studies were recorded with simultaneous electrocardiographic tracings. During the procedure, the patients remained in the left lateral decubitus position with the head elevated at 30º after 20 minutes of rest.

M-Mode and 2D Echocardiography:

The M-mode measurements were obtained from the parasternal long and short-axis views. They included left atrial dimension, left ventricular internal end systolic (LVSD) and end diastolic (LVDD) dimensions as well as the ventricular septum thickness (SWT) and left ventricular posterior wall thickness (PWT) at end diastole. The left ventricular systolic function was evaluated from the calculated ejection fraction and fractional shortening (10).

Left ventricular mass (LVM) was calculated according to Devereux formula; $LVM (g)= 0.8\times1.04\times[(LVDD+SWT+PWT)^3–LVDD^3]+0.6$. Left ventricular mass index (LVMI) was calculated by dividing LVM by body surface area (g/m^2), while the relative left ventricular mass (rLVM) was estimated by dividing LVM by the height (g/m). Relative wall thickness (RWT) was calculated using the following formula: $RWT= (2\times PWT)/LVDD$ (10, 11).

Left ventricular geometric pattern was considered normal if LVMI ≤106g/m^2 and RWT ≤0.44. Concentric remodeling was diagnosed when LVMI ≤106g/m^2 and RWT >0.44; concentric hypertrophy was defined as an LVMI >106g/m^2 and a RWT >0.44; eccentric hypertrophy was diagnosed when LVMI >106g/m^2 and RWT ≤0.44 (12, 13).

Doppler Waveform Analysis:

Based on the analysis of blood flow through the left ventricular outflow tract obtained in the apical view, stroke volume (SV; mL) was calculated as (flow velocity interval×cross-sectional area) and then the cardiac output was calculated (Stroke volume×Heart rate).

The left ventricular diastolic function was evaluated through the pattern of the transmitral flow velocity in the apical 4-chamber view. The early and late ventricular filling waves (E and A waves) and E-wave deceleration time (dec. T) were measured. Then; the E/A ratio was calculated. Diastolic dysfunction was diagnosed based on E/A ratio below one associated with deceleration time >220ms, pseudo-normal or restrictive pattern (14).

Statistical Analysis

Data were statistically described in terms of range, mean±standard deviation (SD), frequencies (number and percentages of cases) when appropriate. Comparison between the PE and CAH groups was done using unpaired Student t-test for quantitative variables when normally distributed and Chi square test for comparing categorical data, p value ≤0.05 was considered statistically significant.

RESULTS

General Characteristics of the Studied Groups:

Gestational age at the time of examination was 32±3 weeks. Both groups were well matched for their baseline characteristics (Table 1). Age, weight and parity were higher in (CAH) group than in PE group (p <0.001), while SBP and DPB were insignificantly higher in the CAH group.

Echocardiographic Parameters:

The left atrial dimension, LVDD, and LVSD were similar in the two groups but both SWT and PWT were significantly greater in CAH women (p <0.001 and 0.004 respectively). The left ventricular systolic function parameters including the ejection fraction, fractional shortening, stroke volume and cardiac output were approximately similar in both groups. The LVM, rLVM, and LVMI as well as RWT, were significantly higher in CAH group than in PE group (Table 2).

Geometric Pattern of the Left Ventricle:

In PE group, 68% (17 of 25) patients showed a normal geometric pattern; while the others showed an altered geometric pattern. The latter was detected in 64% of patients in CAH group. Concentric hypertrophy was the most common geometric abnormality detected in CAH group (44% vs. 12%, p= 0.012), followed by concentric remodeling (Table 3).

Left Ventricular Systolic and Diastolic Functions:

The whole echocardiographic parameters of systolic function were similar in both groups. None of patients in either group had abnormal mitral flow, however, the E/A ratio tended to be significantly lower in the CAH group (1.1±0.28 vs. 1.38±0.29) (p= 0.01).

Table 1: Patient characteristics and clinical data:

	PE (N= 25)		CAH (N= 25)		P Value
	Mean	**S.D.**	**Mean**	**S.D.**	
Age (y)	28.60	5.78	37.72	4.37	0.0001
Height (cm)	160.40	7.5	163.9	6.20	NS
Weight (kg)	73.92	7.7	93.54	11.87	0.0001
BMI	26.99	5.4	27.20	1.99	NS
HR (BPM)	86.84	9.59	88.84	9.46	NS
SBP (mmHg)	152.80	12.83	159.4	12.06	NS
DBP (mmHg)	96.00	5.6	97.56	9.09	NS
No of pregnancy	2.56	1.325	4.17	1.072	0.0001
Gestational age (w)	32.04	3.40	31.90	3.00	NS

Table 2: Echocardiographic parameters:

	PE (N= 25)		CAH (N= 25)		P Value
	Mean	**S.D.**	**Mean**	**S.D.**	
LVDD (cm)	4.86	0.28	4.76	0.28	NS
LVSD (cm)	3.2	0.34	3.10	0.28	NS
SWT (cm)	0.9	0.17	1.16	0.33	0.001
PWT (cm)	0.89	0.23	1.09	0.24	0.004
LAD (cm)	3.40	0.18	3.49	0.18	NS
FS%	34.2	4.9	34.9	4.7	NS
E F%	69.7	6.9	70.7	5.3	NS
SV (ml)	79.4	12.5	76.6	15.3	NS
CO (L/m)	8.3	2.55	9.00	2.69	NS
LVM (g)	153.6	34.26	200.3	72.37	0.005
rLVM	95.6	21.84	121.4	42.39	0.009
LVMI	86.00	19.19	108.8	36.49	0.008
RWT	0.35	0.1	0.46	0.1	0.001

Table 3: LV geometric patterns between both groups:

	PE (N= 25)	CAH (N= 25)	P value
	N (%)	N (%)	
Concentric hypertrophy	3 (12)	11 (44)	0.012
Concentric remodeling	3 (12)	4 (16)	NS
Eccentric hypertrophy	2 (8)	1 (4)	NS
Normal geometry	17 (68)	9 (36)	0.024

DISCUSSION

Hypertensive disorders in pregnancy remain a major cause of maternal, fetal, and neonatal morbidity and mortality in developing and in developed countries, overall, pre-eclampsia complicates 5–7% of pregnancies, but increases to 25% in women with pre-existing hypertension (15). The present study aimed at assessing morphological and functional cardiac changes in pregnant women with preeclampsia as compared with CAH pregnant women.

This study showed that the cardiac changes in pregnant women with CAH were significant as compared with those found in preeclamptic pregnant women. It was interesting to find structural modifications of the heart in patients with pregnancy induced hypertension, particularly because the duration of the disease thought to be too brief to induce structural cardiac changes, It should be emphasized that the pregnant women in both groups underwent echocardiography during the same trimester of pregnancy and they were well matched for their baseline characteristics.

The significantly higher age and body weight found in the CAH group were expected. This may be explained by the incidence of primary arterial hypertension, which most of the time begins during the third decade of life, and therefore, pregnant women with CAH are older than preclamptic pregnant women.

Echocardiographic Parameters:

We found that the mean values for left ventricular dimensions were high but within normal levels and were similar in both groups, while the SWT and PWT were greater significantly in CAH than PE group, this was the same observation of de Mattia et al. (1), who found that chronic hypertensive pregnant women had significant increase in wall thickness in comparison to normotensive pregnant control. Simmons et al. (16) stated that both SWT and PWT values were greater in preeclamptic women than normotensive women in the third trimester, but this difference had partly resolved in the postpartum period.

The LVM, rLVM, and LVMI as well as RWT were elevated in both groups but these structural modifications of the heart in patients with CAH appeared to be higher than in those with preeclampsia. The hypertrophy process appeared to be exaggerated in the CAH women; as indicating in by the values of the LVM and RWT which appear greater than in preeclamptic women. These findings are in concord with data reported by de Mattia et al. (1) as there was significant left ventricular hypertrophy observed in the CAH group as compared with that of the control group. These changes were contributed to combined increases in ventricular wall thickness and ventricular diameter.

Thomson et al. (17) did not find a significant change in mass index between normal pregnant control and pregnancy-induced hypertensive women, which could be explained by the low number of patients in this study. On the contrary, and similar to our results, Vazquez Blanco et al. (3) showed that patients with pregnancy-induced hypertension had a significant increase in left ventricular mass, which reflects an increase in septal and posterior wall thickness without changes in left ventricular diastolic diameter. Similarly, Simmons et al. (16) observed that the process of left ventricular hypertrophy appeared to be exaggerated in the preeclamptic women, where the LVM and ratio of wall thickness to cavity dimension were greater than in normotensive pregnancy.

Geometric Pattern of the Left Ventricle:

This study showed that concentric hypertrophy was the most common geometric abnormality in the CAH pregnant women (44%), and was expressed in only 12% of the PE women. This type of geometric pattern is expected in those patients with a long standing increase in afterload and less frequently observed in pregnancy-induced hypertension. This may be explained by the fact that the latter is a short lasting phenomenon. Our findings are supported by the data of de Mattia et al. (1), who found that the myocardial hypertrophy observed in the CAH pregnant group was of the concentric type.

Simmons et al. (16) showed a significant increase in the left ventricular wall thickness in preeclamptic than normotensive women in the third trimester. These preeclamptic women exhibited features of concentric hypertrophy in response to the increased afterload of systemic hypertension. This pattern was an early observation of Veille et al. (18). In addition, it was reported that preeclamptic exhibited resolution of ventricular hypertrophy by 15 weeks postpartum, but wall thickness and mass remained greater than in the normotensive women. Unfortunately we did not have follow up data to see the regression of these changes, but with further decline in blood pressure in the subsequent months a further resolution of the ventricular hypertrophy is expected.

Several published studies discussed the different ways by which the left ventricle adapts to arterial hypertension. According to some reports (19, 20); left ventricular concentric hypertrophy is the most common

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observation, which similar to our results. However, there are exceptions to this rule. In a previous work (21), it was observed that concentric and eccentric patterns appeared with a similar frequency. Others (11) have remarked that eccentric hypertrophy and concentric remodeling are more common than concentric hypertrophy.

The fact that patients with chronic arterial hypertension are exposed to long lasting pressure overload could explain the significant changes in left ventricular geometry with time, but we and others (2, 3) were surprised to find structural modifications of the heart in patients with pregnancy induced hypertension, particularly because the duration of the disease could be thought to be too short to induce structural cardiac changes.

Systolic Function:

In the present study we found that ejection fraction, fractional shortening, stroke volume and the cardiac output were high but similar in both groups with no statistically significant difference.

The improvement in cardiac performance reflected in the increased stroke volume and cardiac output in particular could be explained by the significant increase in blood volume activating the Frank Starling mechanism, the increase in ventricular mass, the reduction in afterload, and the stimulation of the sympathetic autonomic nervous system.

The changes in the left ventricular function associated with pregnancy show major controversy in the literature and many reports describe a variable changes in the systolic function especially among high-risk patients with pregnancy-related hypertensive disorders, in particular, patients with preeclampsia (17). Some authors have suggested an increased contractile performance of the left ventricle during pregnancy in some women, whereas others have shown either no significant changes or even a slight depression of the indexes of left ventricular contractility (6, 22, 23).

Diastolic Function:

Although the E/A ratio was >1 in both groups but it was statistically lower in CAH group, de Mattia et al. (1); who assessed the structural and functional cardiac changes in one hundred pregnant women with CAH in comparison to normotensive pregnant women, they observed a significant increase in A velocity, however there was no difference in the E/A ratio between both groups.

On the other hand, Borghi et al. (22) in their study concluded that the ratio of the E/A was reduced among pregnant women compared with nonpregnant control subjects and the differences were enhanced in patients with preeclampsia. Furthermore, a recent study (24), where Doppler tissue imaging was performed to assess the diastolic function in thirty-five pregnant women with preeclampsia and 30 with normal pregnancy, a higher septal and lateral E/E' ratio were seen in the preeclamptic group which indicated that in pregnancies complicated by preeclampsia, the diastolic LV function is impaired.

LIMITATIONS

The relatively small sample size, more sensitive parameters could be used to assess the changes in diastolic and systolic functions, follow up of our population could give us more information about the expected regression of these shown abnormalities during the postpartum period.

CONCLUSION

Pregnant women with CAH and PE have structural and functional cardiac abnormalities with preserved left ventricular systolic function. CAH patients have evidence of abnormal left ventricle geometry more than PE patients, mostly of the concentric type. Routine cardiologic assessment is recommended for hypertensive pregnant women, even in the absence of cardiopulmonary symptoms.

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