Original Article

Evaluation of Myocardial Function in Cases of Gestational Hypertension Using Myocardial Performance Index

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Abstract:

Background: Gestational hypertension represents a transient period of elevated blood pressure with special effects on the maternal left ventricle that is different from the effects observed in chronic essential hypertension; it affects a previously normal heart and lasts for a maximum of nine months associated with volume and pressure overload on the maternal heart. Tei index (also called myocardial performance index) was found to be a dependent combined index evaluating the systolic and diastolic function of the left ventricle and represents a sensitive indicator for many types of heart diseases.

Objective: to evaluate the effects of gestational hypertension on the maternal myocardial function during the third trimester by measuring the Tie index using transthoracic echocardiography.

Method: This study was performed in Baghdad teaching hospital in the time period from November 2015 to August 2016. The study included a total of 150 women; 100 women had gestational hypertension, in the third trimester of a singleton pregnancy and with a mean age (29.83 ± 5.33 year), gestational hypertension was identified as elevated systolic or diastolic blood pressure over 140/90 mmHg that emerges after the 20th week of gestation with proteinuria level lower than 300 mg/dl. Another 50 normotensive pregnant women with singleton pregnancy and mean age (28 ± 3.18 year) were used as controls. Left ventricular mass index (LVMI) and relative wall thickness (RWT) were measured to find the type of hypertrophy in gestational hypertension. Ejection fraction (EF) was measured with 2D directed M mode echocardiography, and isovolumic relaxation time (IVRT), isovolumic contraction rime (ICT) and ejection time (ET) were measured for both groups using pulse wave Doppler echocardiography in order to calculate the myocardial performance index which is also called "Tei index" and equals the sum of IVRT and IVCT divided by the ET (Tei index = IVRT+IVCT/ET).

Results: Left ventricular mass index and relative wall thickness were significantly higher in gestational hypertensive women, 41% of gestational hypertensive women had normal geometry and 59% had abnormal geometry (34% eccentric hypertrophy, 19% concentric hypertrophy and 6% concentric remodeling). IVRT and IVCT were significantly higher in gestational hypertensive women with p value of 0.0001 and P = 0.003. ET showed a non-significant lower values (p= 0.34) in gestational hypertensive women. Tei index was significantly higher in Gestational hypertension (P=0.011).

Conclusion: Women with gestational hypertension had altered myocardial function characterized by the higher Tei index values associated with eccentric hypertrophy which can be explained by the fact that gestational hypertension poses higher afterload on the left ventricle instead the state of low peripheral resistance that is ysually expected during normotensive pregnancy.

Keywords: Echocardiography; Gestational hypertension; Myocardial performance.

Introduction:

Gestational hypertension challenges the maternal heart to face an elevated afterload in a short duration, giving the heart little time to adapt well (1). Pregnancy itself causes volume overload on the maternal cardiovascular system by increasing the preload due to the higher plasma volume with water and sodium retention (2), the mother's heart undergoes several compensatory mechanisms; mainly the increased cardiac output associated with lower blood pressure and peripheral resistance (3) to provide oxygen and nutrients supply for the maternal and fetal tissues (4). LV geometry is altered according to the type stress encountered. In case of increased preload the LV adapts through increasing its cavity size without increasing the wall thickness resulting in eccentric type of hypertrophy, and when higher afterload is added it might increase its wall thickness with concentric hypertrophy (5). Gestational hypertension complicates about 6-10% of pregnancies and is defined as high blood pressure; systolic or diastolic with values that are equal or higher than 140/90 mmHg starting after the 20^{th} week of gestation without proteinuria (6). It can lead to several disturbances in the maternal left ventricular

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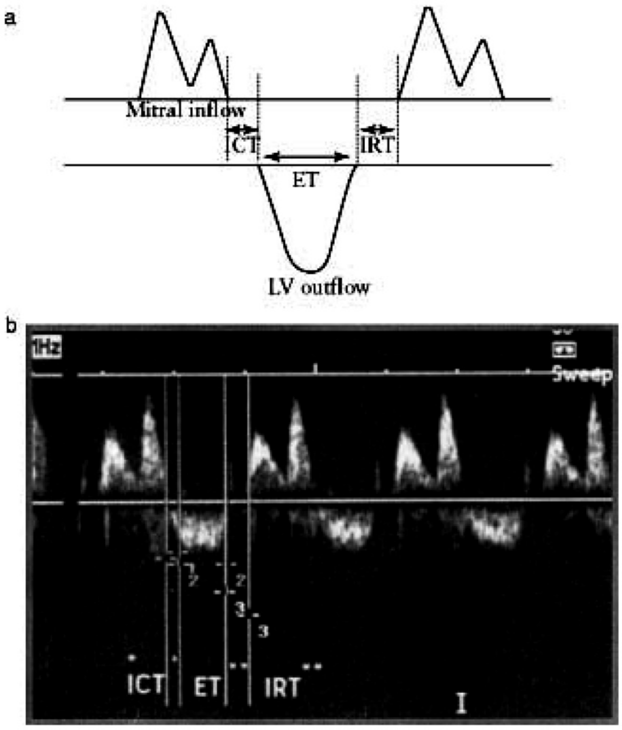
adaptive mechanisms mostly due to the high peripheral resistance leading to greater afterload on the left ventricle (7). In 1995, TeiChuwa calculated an index of myocardial performance known as "the Tei index or MPI index" which is a combined parameter used to evaluate the LV systolic and diastolic function (8). It is measured by using transthoracic echocardiography pulse wave Doppler in the apical four and five chamber views through calculating the ratio of three time intervals: the isovolumic relaxation time IVRT which is a sensitive marker of myocardial relaxation (represents the time interval between the aortic valve closure and mitral valve opening), the isovolumic contraction time IVCT (represented by the interval between the closure of the mitral valve to the opening of the aortic valve) and ejection time (includes the time period between the opening and closure of the aortic valve) as demonstrated in figure 1 below (9). The normal value of the Tei index equals (a mean of 0.39 ± 0.05) for the LV, and it is inversely related to LV function, the lower the value the better the LV function. Systolic dysfunction leads to prolongation of IVCT and shortening of ET, while diastolic dysfunction means prolongation of IVRT, ultimately, both dysfunctions will lead to an increase in MPI (10).



*ICT= isovolumic contraction time, ET= ejection time and IRT= isovolumic relaxation time.

Figure (1):- Panel A represents a diagram to explain Tei index parameters, panel B is pulse wave Doppler measurements of the same parameters. (11)

Methods:

The study was performed in Baghdad teaching hospital from November 2015 to August 2016, all patients were selected from those attending the obstetrics and gynecology department in the hospital. 100 gestational hypertensive women with singleton pregnancy in the third trimester were included, gestational hypertension was defined as high blood pressure; systolic or diastolic over 140/90 starting after the 20th week of pregnancy and not associated with proteinuria (6). Another 50 normotensive pregnant women with single pregnancy in the third trimester were included as controls. Inclusion criteria were: 1) age from 20 to 40 years. 2) Uncomplicated pregnancy (fetal or maternal complications). 3) Gestational age 30 weeks or more. 4) Blood pressure 140+ mmHg systolic, 90+ diastolic. 4) No proteinuria 5) No essential hypertension. 6) No ischemic or valvular heart disease. 7) No anemia. 8) Not diabetic. 9) No thyroid dysfunction and 10) not taking medication. Gestational age and absence of pregnancy complications was confirmed by ultrasound at the same hospital. All patients were submitted to a detailed medical history and examination focusing on hypertension risk factors. Blood pressure was measured after 15 minutes of rest in the left lateral decubitus position to avoid the effect of the gravid uterus on the inferior vena cava using an adult size mercury sphygmomanometer. Weight and height were also recorded to calculate their body mass index BMI and body surface area BSA. Transthoracic echocardiography was performed for all patients using PHILIPS CX10 diagnostic ultrasound system with a S5-1, 2.5 MHz transducer in the left lateral position with the arm under their head to bring the heart forward to the chest wall and lateral to the sternum, as recommended by the American society of echocardiography (12). To calculate the EF the parasternal long axis view was obtained by placing the transducer over the 3rd intercostal space with the indicator pointing to the patient's right shoulder and using two dimensional guided M mode echocardiography. Left ventricular mass index LVMI was calculated according to the formula (13):

LV mass= $\{0.8 \text{ X } [1.04 \text{ X } ((LVIDd + LVPWd + IVSd)^3 - (LVIDd)^3]\} + 0.6$

LVID: Left ventricle internal dimension in diastole.

LVPWD: Left ventricular posterior wall thickness in diastole.

IVSd: Interventricularseptal thickness in diastole.

The relative wall thickness= LVIDd/ 2*PWTd where PWTd is the LV posterior wall thickness in diastole.

The type of LV hypertrophy was classified into four categories according to the American society of echocardiography guidelines (13):

1. Normal geometry was considered when the RWT <0.42 and LVMI ≤ 95 g/m^2
2. Concentric remodeling was considered when the RWT < 0.42 and LVMI ≤95 g/m^2

3. Concentric hypertrophy was considered when the RWT ≥0.42 and LVMI ≤95 g/m^2
4. Eccentric Hypertrophy was considered when the RWT <0.42 and LVMI ≤95 g/m^2

For Tei index calculation; IVRT, IVCT and ET were measured in the apical 5 chamber view by placing the transducer at the site of apical impulse with slight anterior angulation to open the aortic valve. Tei index was calculated according to the formula: Tei index = (IVRT+IVCT)/ET.

Results:

Table (1): Distribution of baseline parameters between cases and controls

Parameters	Age (years)		Weight (Kg)		Height (m)		BSA (m^2)		BMI (kg/m^2)	
	Cases	Ctrls	Cases	Ctrls	Cases	Ctrls	Cases	Ctrls	Cases	Ctrls
Mean	29.83± 5.33	28.00±3.182	89.88± 8.33	79.14± 6.117	1.59± .0573	1.57± 0.0573	1.991± .0974	1.861± .0886	35.97± 4.074	31.85± 2.912
Mean difference	1.83		10.74		.002		6.986		5.825	
P-value	.077		.000		. 477		.001		.001	
Ctrls: controls, Sd: Standard deviation, Degree of freedom = 98										

The results of this study had shown the mean age for cases was 29.83± 5.33 year compared to 28 ± 3.182 year for controls, with mean difference of 1.83 year, but this difference was statistically insignificant (p-value 0.07). Cases had a mean weight of 89.88 ± 8.33 kg compared to 79.14 ± 6.117 kg in controls with mean difference of 10.74 kg, and a significant statistical association between them (P = 0.001), regarding height there was a mean difference of 0.02 meter (2 cm) between cases (1.59 m) and controls (1.57 m) which was statistically not significant, as a result the cases' BMI and BSA were significantly higher in the cases group(p-value 0.001 for both), with mean of 35.97 ± 4.074 kg/m2 (morbid obesity) for the cases and controls had 31.85 ± 2.912 kg/m2 (obese), for BSA, the cases had a mean of 1.991 ± .0974 m2 compared to 1.861 ± .0886 m2 for controls.

Table (2): Assessment of LV systolic function with ejection fraction in cases and controls.

Prameters	Ejection fraction %	
	Cases	Ctrls
Mean	67.03±0.918	67.30 ±2.675
Mean difference	0.27	
P-value	0.32	
Ctrls: controls, Sd: Standard deviation, Degree of freedom = 98		

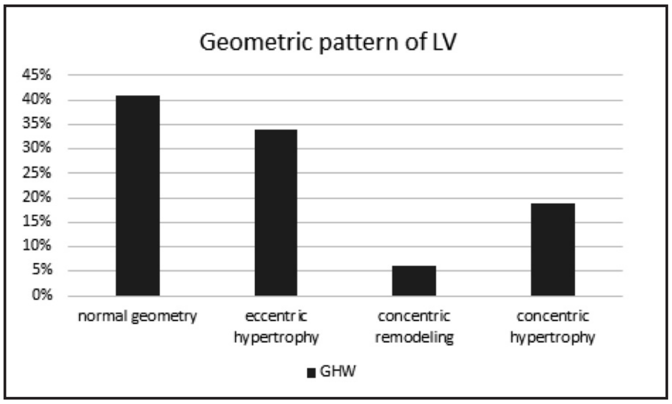
There was a non-significant association between cases and controls regarding the ejection fraction (cases had mean of 71.03 ±1.918 and controls 71.30±2.675) with mean difference of 0.27 and insignificant P value of 0.32.

Table (3) comparison of LVMI and RWT between cases and controls.

Parameter	LVMI (g/m^2)		RWT	
	Cases	Ctrls	Cases	Ctrls
Mean	94.74±12.47	80.56±15.96	0.395±0.04	0.355±0.046
Mean difference	14.18		0.05	
P- value	0.002		0.001	

*Ctrls: controls, LVMI: Left ventricular mass index, RWT: relative wall thickness.

According to table no. 3 regarding LV structure and geometry and their comparison between gestational hypertensive and normotensive women, gestational hypertensive women had significantly higher LVMI and RWT compared to normotensive pregnant women. (P=0.001 and P= 0.002).



***LV: the left ventricle, GHW: gestational hypertensive women**

Fig. 2 Geometric pattern of ventricular hypertrophy in gestational hypertension.

Figure no. 2 was based on the results in table no.3 to explain the pattern of distribution of LV geometry in gestational hypertensive women; 41% had normal geometry and 59% had abnormal geometry (34% eccentric hypertrophy, 19% concentric hypertrophy and 6% concentric remodeling).

Table (3): Comparison of myocardial performance index parameters between the groups.

Parameters	isovolumetric relaxation time (Sec)		isovolumetriccontraction time (sec)		ejection time (sec)		index of myocardial performance (Tei index	
	Cases	Ctrls	Cases	Ctrls	Cases	Ctrls	Cases	Ctrls
Mean	91.14± 7.657	65.52±9.507	40.70±4.550	37.57±3.581	289.98±26.00	297.93±21.03	0.56 ± 0.0748	0.37±0.041
Mean difference	25.62		3.13		7.95		0.19	
P-value	0.00013		0.00003		0.347		0.011	
Ctrls: controls, Sd: Standard deviation, Degree of freedom = 98								

The analysis of the echocardiographic parameters for MPI measurements revealed that IVRT in cases (91.14±7.657) was significantly higher than controls (65.52±9.507) with mean difference of 25.62 and P value 0.00013, IVCT was also significantly higher in cases (40.70±4.550) than controls (37.570±3.581) as there was a mean difference of 3.13 and P value 0.00003. Ejection time had a non-significant lower value in cases (289.98±26.00 for cases and 297.93±21.03 for controls) with mean difference that equals 7.95 and P value 0.347. MPI was significantly higher in cases (0.56 ±0.07487) than controls (0.37 ± 0.0419) with mean difference 0.19 and P value 0.011.

Discussion:

Increased blood volume and preload with decreased peripheral resistance are among the established facts during pregnancy leading to several cardiovascular adaptations (14). Increased weight gain during pregnancy is directly related to the development of gestational hypertension probably because it might create an unfavorable environment for the development of the placental arteries with further impact on the maternal large arteries (15), this study comes in agreement with this fact, as gestational hypertensive women had significantly higher body mass index and body surface area. This might be attributed to the volume overload on the heart (16). A similar results were also found by Shin and Song (17). The extensive LV remodeling during pregnancy made it difficult to predict its performance (18).In the current study, LV systolic function measurement by M mode derived ejection fraction showed a non-significant change between normotensive and gestational hypertensive women, and this result was in agreement with previous studies of Novelli and colleagues (19) and Szenczi and Rigor Jr. (20) while, Mi-Jeong Kim et al. suggested that there was a significant increase in EF during gestational hypertension, it's noteworthy to mention that they used themodified Simpson's method from apical 4-chambers and 2-chambers views to measure the EF (21). This study found that during gestational hypertension LV responded to the hemodynamic changes of increased preload and afterload by increasing the LV cavity size without increasing the wall thickness resulting in eccentric type of hypertrophy in gestational hypertensive women which comes in agreement with Mi-Jeong Kim at coworkers (21). On the contrary, Thombson et al, found insignificant changes regarding the LV geometry (22). Many echocardiographic parameters have been used to assess the diastolic function in gestational hypertension with many discrepancies even in normal pregnancies but there is agreement that the diastolic function tends to alter in gestational hypertension (23). As Tei index evaluation represents a combined index of systolic and diastolic function in gestational hypertension that is relatively independent on the ventricle geometry or volume (8), the present study used the index for myocardial function evaluation and found a significant increase in both, IVRT and IVCT, while ET time showed a non-significant decrease in gestational hypertensive women leading to significantly higher values of Tei index. IVRT is a sensitive indicator of myocardial relaxation while IVCT relates directly to myocardial contraction (24). The effects of elevated volume and pressure load on the heart in gestational hypertensive women might have led to inappropriate LV remodeling together with the higher venous preload in pregnancy led to impaired relaxation and reduced contractility (25). In addition Tei index tends to have higher values in concentric hypertrophy (17) although the main type of hypertrophy found in this study was eccentric but the presence of hypertrophy may explain the higher Tei index value. Similar findings were found by Melchiorre et al. (26) and KyoungIm Cho and his colleagues (17). On the contrary, Simmons and her colleagues (27) found shortened IVRT and attributed it to the increased heart rate in pregnancy.

Conclusion:
the maternal LV responds to the volume overload of pregnancy and pressure overload of gestational hypertension by eccentric LV hypertrophy associated with preserved systolic function and increased Tei index, and that reveals some degree of myocardial dysfunction especially diastolic (impaired relaxation) which need further assessment in postpartum period for the reversibility of these changes.

Authors' contribution:
ZainabAbdeulkhaleq Al-Rikabi: performed the study project including selection of the subjects, examination and writing the research.
Ghassan T. Saeed: work and protocol designer and provider of support and revision during the research writing.
Ghazi Farhan Haji: provided the observation and training in using the echocardiography machine and data collection.

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