Assessment of Left Ventricular Function by Conventional Versus Speckle Tracking Echocardiography in Hypertensive Pregnant Patients

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Abstract

Background: Hypertensive disorders of pregnancy are associated with both immediate and long-term postpartum morbidity and mortality due to maladaptive cardiac remodeling. Echocardiography is a valuable tool to stratify risk and can guide management and counseling in the preclinical and clinical phases of Hypertensive pregnancy disorders (HPD). 2DSTE is anew promising tool for diagnosis of subclinical LVSD in HPD. **Aim of study:** to compare the efficacy of both conventional and speckle tracking echocardiography in evaluation of cardiac structural and functional changes in hypertensive pregnant patients. **Patients and Methods:** seventy-one female pregnant hypertensive patients including those with gestational hypertension, preeclampsia, chronic hypertension, and chronic hypertension with superimposed preeclampsia; plus an age matched control group of pregnant females without hypertension in Mansoura specialized medical hospital in the period from June 2019 to June 2021, after approval of both local ethical committee and institutional research board. All patients were assessed by careful history taking, clinical examination,12 lead surface ECG, Echocardiography for assessment of LV systolic function, (assessed by 2D global longitudinal strain (GLS) using speckle tracking echocardiography (STE), as well as 2D LVEF. **Results:** By conventional echo apart from significantly higher percentage of LVH and diastolic dysfunction in patients with chronic HTN, no other parameter showed clear statistically significant difference among HPDs categories. Moreover, both LVH and diastolic dysfunction evident by conventional echocardiography and TDI are relatively late manifestations of chronic HTN rather than early subclinical LV dysfunction targeted by our study. Our results showed statistically significant difference in GLS between control group and patient group as a whole, average GLS was found to be a significant parameter in distinguishing between the different categories of HPDs in our study cases P≤0.001. GLS was significantly affected in chronic HTN (-16.02±0.48), chronic HTN with superimposed preeclampsia (-16.26±1.28) and preeclampsia (-17.37±1.81), when compared to gestational HTN (-20.03±1.50). **Conclusion:** 2DSTE can assess GLS which is a new promising tool for diagnosis of LVSD in HPD rather than conventional echocardiography.

KeyWords: STE, GLS; pregnancy; hypertension; hypertensive pregnancy disorders.

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Relevant conflicts of interest/financial disclosures:

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Introduction:

Pregnancy induces dramatic cardiovascular changes in order to meet the maternal and growing fetal metabolic needs. Along with progressive placental growth, blood volume increases and peripheral vascular resistance decreases. Cardiac output and heart rate also increase during pregnancy. Such changes result in compensatory cardiac remodeling. In pregnancy complicated by hypertension, abnormal pressure overloading would lead to different cardiac remodeling compared to that of normal pregnancy. (1)

Hypertensive disorders of pregnancy (HDP) complicate 5% to 10% of pregnancies and are increasing with the rising prevalence of cardiometabolic diseases in younger women. (2) Uteroplacental insufficiency and a susceptible maternal vascular and metabolic phenotype converge as the underlying etiology. HDP include; gestational hypertension, preeclampsia, chronic hypertension, and chronic hypertension with superimposed preeclampsia. (3)

A speckle is a distinct acoustic pattern produced by ultrasonic probing of tissue that is unique to the patient. It is possible to measure myocardial strain and strain rate using speckle tracking, which is a semiautomated technique. This approach may be used to identify longitudinal, circumferential, and radial displacements, among other things (4).

Speckle tracking is a recently developed echocardiographic technique that analyzes the degree of myocardial deformation, known as strain, throughout the cardiac cycle. Speckle tracking, is obtained, by an automated measurement of the distance between speckles, with the advantage of being angle-independent and less prone to operator-related measurement errors. Speckle tracking allows for the measurement of longitudinal, radial and circumferential strain and these have been used to prognosticate changes in left ventricular function and geometry. (5)

In this study we examined changes in myocardial strain as measured by speckle-tracking echocardiography in women with preeclampsia, women with nonproteinuric hypertension and women without a hypertensive disorder. We hypothesize that global left systolic strain measures would prove more sensitive than conventional left ventricular ejection fraction in detecting early changes in systolic left ventricular function manifesting as subclinical disease prior to overt progression.

The aim of this study:

This study was to compare the efficacy of both conventional and speckle tracking echocardiography in evaluation of cardiac structural and functional changes in hypertensive pregnant patients.

Patients and Methods

Study population

This descriptive observational comparative study was conducted at cardiology department, Specialized Medical Hospital, Mansoura University, in the period from June 2019 to June 2021, after approval of both local ethical committee and institutional research board.

The study included about 71 pregnant hypertensive patients including those with gestational hypertension, preeclampsia, chronic hypertension, and chronic hypertension with superimposed preeclampsia; plus an age matched control group of pregnant females without hypertension.

Exclusion criteria:

Patients with previously diagnosed LV dysfunction, Valvular heart disease, congenital heart disease, coronary artery disease, any form of cardiomyopathy including peripartum cardiomyopathy, Pacemaker dependent patients, Inherited arrhythmogenic syndromes, Professional athletes and patients with poor echocardiographic window with suboptimal image quality.

Ethics statement

Study protocol was approved by the Medical Research Ethics Committee, Faculty of Medicine, Mansoura University. Informed verbal consent was obtained from each patient in the study after assuring confidentiality.

Methodology

All patients were assessed by thorough history taking including; age and Obstetric history: Gravidity – parity – gestational age - past obstetric history – pregnancy complications - contraceptive use – menstrual history – assisted reproduction technique.

Clinical examination included: blood pressure, pulse, general examination and local cardiac examination

Investigations included: 12 lead surface electrocardiography (ECG), 2D conventional echocardiography, 2D speckle tracking echocardiography (STE) to assess LVEF and GLS respectively.

Transthoracic echocardiography

Patients were examined by a commercially available system (*Vivid 9, General Electric-Vingmed, Horton, Norway*).

LV systolic function was measured by 2D global longitudinal strain (GLS) using speckle tracking echocardiography (STE), as well as 2D LVEF using Simpson's biplane technique and classic M-mode echocardiography.

All subjects were examined in the left lateral decubitus position

2D Speckle tracking echocardiography

The process of STE analysis involved three basic steps. These included (i) the acquisition of optimal 2D images, (ii) image storage and (iii) poststudy analysis.

Image acquisition

Electrocardiogram gating with optimal signal demonstrating three cardiac cycles with nearly identical heart rates was confirmed in all subjects with normal sinus rhythm.

Image optimization

The best possible images were obtained to ensure high quality STE analysis.

Apical views

Three-plane strain study (AP4ch, AP2ch, APLAX) was used. The patient was placed in left lateral position. Foreshortening was avoided by choosing the apical window that demonstrates a more bullet-shaped ventricle with the highest base to apex length. The patient was asked to perform a breath hold at the same point for each image

The focus for these images was on obtaining high-quality gray scale images with proper gain settings in an LV focused view with the depth decreased to just below the mitral annulus.

Pay attention to the sector width was optimized not to eliminate any of the LV apex or walls from the imaging sector. Frame rates between 40 and 90 Hz were used for strain analysis.

Three cardiac cycles were recorded, giving multiple beat options to choose from for analysis. Once all three 2D views have been obtained, a continuous wave (CW) Doppler image with aortic valve closure (AVC) click was obtained.

Image storage

Images were stored on the echo machine's internal hard disk in a raw data format, and on-cart analysis requires a simple selection of images to proceed with analysis.

Conclusion of analysis

Segmental longitudinal peak systolic strain was measured in all views between aortic valve opening and closing for the 6 basal, 6 midventricular and 5 apical segments. The average longitudinal peak systolic strain of these segments was calculated automatically to provide GLS

Statistical analysis

- Data were analyzed using the Statistical Package of Social Science (SPSS) program for Windows (Standard version 26). The normality of data was first tested with one-sample Kolmogorov-Smirnov test.
- Qualitative data were described using number and percent. Association between categorical variables was tested using Chi-square test while fisher exact test and Monte carlo test were used when expected cell count less than 5. Continuous variables were presented as mean ± SD (standard deviation) for normally distributed data. The two groups were compared with independent t test while more than two groups were compared by ANOVA test.
- Level of significance: For all above mentioned statistical tests done, the threshold of significance is fixed at 5% level (p-value).
- **The results were considered:**

❖ Non-significant when the probability of error is more than 5% ($p > 0.05$).

❖ Significant when the probability of error is less than 5% ($p \le 0.05$).

❖ Highly significant when the probability of error is less than 0.1% ($p \le 0.001$).

- The smaller the p-value obtained, the more significant are the results.

Results

The present study is a cross-sectional observational comparative study that is carried out on 71 pregnant females aged 18-40 years in order to compare the efficacy of both conventional and speckle tracking echocardiography in evaluation of structural and functional changes in hypertensive pregnant patients referred to cardiology department at Specialized Medical Hospital, Mansoura University.

Patient demographics:

Table (1) and **Figure (1)** show age distribution of the studied cases. The mean age (±SD, in years) of the studied cases was 29.22±2.87 in the patient group and 27.90±3.49 in control group. AS regard to age, we subdivided our cases in both patient and control groups into two categories, cases over 30 years and the other category includes cases who are 30 and under 30 years old. Our results revealed no statistically significant difference between the patient and control group in terms of age and age categories ($p > 0.05$), excluding the effect of age on both conventional echocardiography and STE findings.

Table (1): Demographic data among the studied groups

Demographic data	Patients group (n=51)	Control group (n=20)	Test of significance	P value
Age (years) Mean ± SD Min-Max	29.22±2.87 24-37	27.90±3.49 20-33	t=1.57	0.123
Age categories ≤ 30 y >30 y	25 (49%) 26 (51%)	12 (60.0%) 8 (40.0%)	χ^2=0.678	0.410

t: student t test, X^2: Chi square test

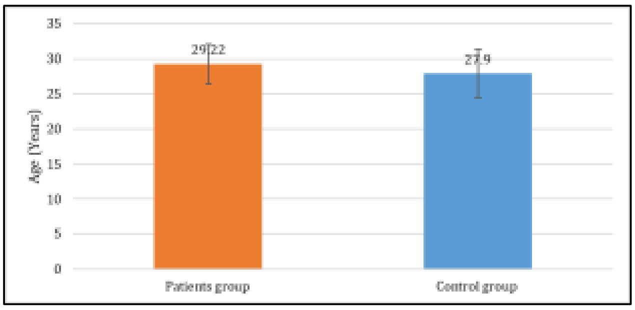

Figure (1): Age distribution among patients and control groups

Obstetric history among patients and control groups are displayed in **Table (2)**. There were statistically significant differences among the studied groups in terms of Gestational age and Past Gestational HTN ($p < 0.05$). The mean gestational age was (31.90±2.51) in patient group and (29.90±2.63) in control group. 11 cases in patient group had past gestational HTN compared to No cases in control group experienced past gestational HTN before. In contrast, gravidity, parity, previous preterm labor, pregnancy complications, assisted reproduction, and multiple pregnancy were not significantly different between patients and the control group ($p > 0.05$).

Table (2): Obstetric history among patients and control groups

Obstetric history	Patients group (n=51)	Control group (n=20)	Test of significance	P value
Gravidity G1 G2 G3 G4	19 (37.2%) 20 (39.2%) 8(15.7%) 4 (7.8%)	9 (45.0%) 5 (25.0%) 5 (25.0%) 1 (5.0%)	MC	0.373
Parity P0 P1 P2 P3	25 (49.1%) 17 (33.3%) 6 (11.7%) 3 (5.9%)	11 (55.0%) 6 (30.0%) 3 (15.0%) 0 (0%)	MC	0.902
Gestational age	31.90±2.51	29.90±2.63	t=2.88	0.006*
Past Gestational HTN	11 (21.5%)	0 (0.0%)	χ^2=4.49	0.034*
Previous Preterm labor	11 (21.5%)	4 (20.0%)	FET	1..0
Pregnancy complications≠	6 (11.8%)	3 (15%)	FET	1.0
Assisted reproduction	7 (13.7%)	2 (10.0%)	FET	1.0
Multiple pregnancy	8 (15.7%)	2 (10.0%)	FET	0.474

Pregnancy complications: urinary tract infection, hyperemesis, FET: Fisher exact test, MC: Monte carlo test,*significant p≤0.05

Categories of hypertensive pregnant females are demonstrated in **Table (3)**. Gestational HTN was found among almost half of the cases in patient group (N= 24 (47.1%). While, Preeclampsia, Chronic HTN with superimposed preeclampsia and Chronic HTN were seen in 7 patients (13.7 %), 10 patient (19.6%) and 10 patients (19.6%), respectively.

Table (3): Categories of hypertensive pregnant females

Category of HDP	Patients group (n=51)
Gestational HTN	24 (47.1%)
Preeclampsia	7 (13.7%)
Chronic HTN with superimposed preeclampsia	10 (19.6%)
Chronic HTN	10 (19.6%)

HTN; hypertension

Table (4) demonstrated conventional echocardiography parameters among patients and control groups. It is noted that inter-ventricular septum thickness in diastole (IVSd) and posterior wall thickness in diastole (PWTd) were considerably significant parameters in distinguishing hypertensive pregnant patients (9.29±1.57 and 9.17±1.53) from the normotensive pregnant patient group (8.15±1.04 and 8.15±0.87). Inter-ventricular septum thickness and posterior wall thickness were increased in hypertensive pregnant females. There were statistically significant differences in these parameter values among the studied groups (P ≤0.01).

Whereas, although there were differences in values of the other conventional echocardiography parameters in terms of left ventricular internal dimension in diastole (LVIDd), left ventricular internal dimension in systole (LVIDs), FS, EF, E wave velocity, A wave velocity, E/A ratio, E wave dec time, e', E/e', and diastolic dysfunction findings, these differences were not considered to be statistically significant (P > 0.05).

Additionally, 23 cases (45%) had normal diastolic function in the patient group and 13 cases (65%) in the control group. While Grade I and II diastolic dysfunction were seen in 23 cases (45%) and 5 cases in the patient group and in 7 cases in the control group, respectively. No cases in the control group presented with grade II diastolic dysfunction.

Table (4): Conventional echocardiography among patients and control:

Conventional echocardiography	Patients group (n=51)	Control group (n=20)	Test of significance	P value
IVSd (mm)	9.29±1.57	8.15±1.04	t=2.95	0.005*
LVIDd (mm)	50.22±3.05	50.55±3.44	t=0.381	0.704
PWTd (mm)	9.17±1.53	8.15±0.87	t=2.76	0.008*
LVIDs (mm)	30.15±2.02	31.15±2.74	t=1.62	0.111
FS (%)	39.634±4.15	38.15±4.53	t=1.27	0.208
EF (%)	69.68±3.78	68.95±3.88	t=0.705	0.484
E wave velocity (m/s)	0.719±0.18	0.715±0.14	t=0.096	0.924
A wave velocity (m/s)	0.541±0.19	0.56±0.19	t=0.341	0.735
E/A ratio	1.57±0.77	1.50±0.78	t=0.317	0.753
E wave DT (ms)	203.90±38.82	213.50±39.17	t=0.904	0.370
e' velocity (cm/s)	7.28±2.94	7.10±2.24	t=0.242	0.810
E/e'	10.97±2.67	10.95±2.74	t=0.035	0.972
Diastolic function Normal Grade I diastolic dysfunction Grade II diastolic dysfunction	 23 (45%) 23 (45%) 5 (10%)	 13 (65.0%) 7 (35.0%) 0 (0%)	MC	0.546

DT; deceleration time, EF; ejection fraction, **FS;** fractional shortening, **IVSd;** interventricular septum thickness in diastole, **LVIDd;** left ventricular internal dimension in diastole, LVIDs; left ventricular internal dimension in systole, **PWTd;** posterior wall thickness in diastole.

Table (5) and **Figure (2)** showed the GLS among patients and control groups. When compared across groups on the Speckle Tracking Echocardiography (STE), the average GLS showed a significant decrease and less negative deformation in the left ventricle in the hypertensive pregnant female group (-18.63±2.23) compared to the normotensive pregnant female group (-20.06±3.01). This indicates that GLS is a significant STE parameter in assessing the early deterioration of left ventricle in hypertensive pregnant females (P = 0.041).

Table (5): Comparison of Global Longitudinal Strain between patient and control groups:

GLS	Patients group (n=51)	Control group (n=20)	Test of significance	P value
A4C view	-18.87±2.69	-21.31±1.46	t=3.76	≤0.001*
APLAX view	-17.45±6.77	-20.76±1.59	t=2.15	0.036*
AP2C view	-18.72±2.47	-18.94±1.31	t=0.377	0.707
Average GLS	-18.63±2.23	-20.06±3.01	t=2.08	0.041*

AP2C view; apical 2 chamber view, **A4C view;** apical 4 chamber view, **APLAX view;** apical long axis view, **GLS;** global longitudinal strain.

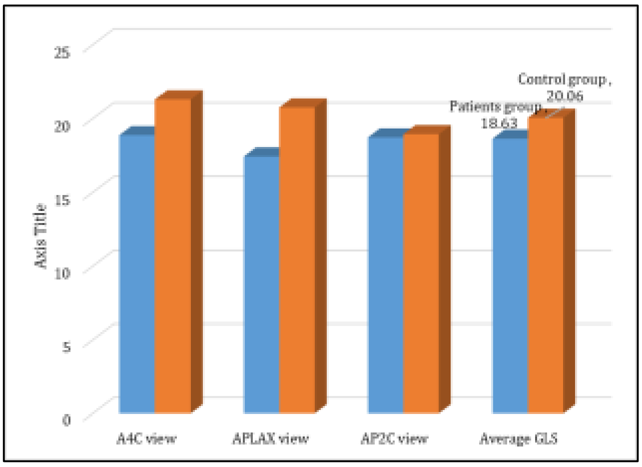

Figure (2): Comparison of Global Longitudinal Strain between patient and control groups

AP2C view; apical 2 chamber view, **A4C view;** apical 4 chamber view, **APLAX view;** apical long axis view, **GLS;** global longitudinal strain.

Table (6) compared different types of hypertensive pregnancy disorders (HPD) in our cases according to conventional echocardiography parameters. Apart from significantly higher percentage of LVH and diastolic dysfunction in patients with chronic HTN, no other parameter showed clear statistically significant difference

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among HPDs categories. Moreover, both LVH and diastolic dysfunction evident by conventional echocardiography and TDI are relatively late manifestations of chronic HTN rather than early subclinical LV dysfunction targeted by our study.

Table (6): Comparison of conventional echocardiographic findings among categories of hypertensive pregnancy disorders:

ECHO	Gestational HTN (n=24)	Preeclampsia (n=7)	Chronic HTN with superimposed preeclampsia (n=10)	Chronic HTN (n=10)	Test of significance (p value)
IVSd	8.37±1.13	9.57±0.78 a	11.00±0.71 ab	11.60±0.55 ab	F=20.91 P≤0.001*
LVIDd	49.42±2.84	51.14±3.34	53.40±2.61 a	49.60±2.07 c	F=3.07 P=0.04*
PWTd	8.29±0.99	9.28±0.95 a	11.0±1.0 ab	11.40±0.55 ab	F=22.11 P≤0.001*
LVIDs	29.91±2.30	30.00±2.00	30.60±1.34	31.0±1.0	F=0.478 P=0.699
FS	39.33±4.74	41.86±2.97	39.40±3.84	38.20±1.79	F=0.909 P=0.446
EF	69.37±4.41	71.43±2.51	70.20±3.03	68.20±1.79	F=0.829 P=0.487
E wave velocity	0.787±0.16	0.70±0.14	0.62±0.28 a	0.52±0.04 a	F=4.28 P=0.011*
A wave velocity	0.458±0.16	0.671±0.24 a	0.60±0.2	0.70±0.13 a	F=4.49 P=0.009*
E/A ratio	1.90±0.63	1.29±0.86 a	1.20±0.84 a	0.74±0.11 a	F=5.42 P=0.003*
E wave dec time	182.08±24.44	223.57±43.46 a	241.0±26.5 a	244.0±28.81 a	F=11.47 P≤0.001*
e'	8.75±2.68	6.43±2.21 a	4.50±1.32 a	4.20±0.75 a	F=8.64 P≤0.001*
E/e'	9.79±1.86	12.14±3.67 a	13.40±2.61 a	12.60±1.67 a	F=5.31 P=0.004*
Diastolic dysfunction Normal Grade I Grade II	21 (87.5%) 3 (12.5%) 0 (0%)	2 (28.6%) a 4 (57.1%) 1 (14.3%)	0 (0%) a 6 (60%) 4 (40%)	0 (0%) a 10 (100%) 0 (0%)	≤0.001*

a: significant difference with Gestational HTN, **b:** significant difference with Preeclampsia, **c:** significant difference with Chronic HTN with superimposed preeclampsia by post hoc LSD test.

DT; deceleration time, **EF;** ejection fraction, **FS;** fractional shortening, **IVSd;** interventricular septum thickness in diastole, **LVIDd;** left ventricular internal dimension in diastole, **LVIDs;** left ventricular internal dimension in systole, **PWTd;** posterior wall thickness in diastole.

As in **Table (7)** and **Figure (3)** showed in addition to statistically significant difference in GLS between control group and patient group as a whole, average GLS was found to be a significant parameter in distinguishing between the different categories of HPDs in our study cases P≤0.001. GLS was significantly affected in chronic HTN (-16.02±0.48), chronic HTN with superimposed preeclampsia (-16.26±1.28) and preeclampsia (-17.37±1.81), when compared to gestational HTN (-20.03±1.50).

Table (7): Comparison of Global Longitudinal Strain among categories of hypertensive pregnant disorders:

GLS	Gestational HTN (n=24)	Preeclampsia (n=7)	Chronic HTN with superimposed preeclampsia (n=10)	Chronic HTN (n=10)	Test of significance (p value)
A4C view	-20.42±2.18	-17.27±2.47 a	-16.16±0.78 a	-16.42±0.41 a	F=11.78 P≤0.001*
APLAX view	-17.95±8.76	-17.43±2.04	-16.50±1.80	-16.04±1.37	F=0.14 P=0.936
AP2C view	-20.25±1.68	-17.44± 1.81 a	-16.20±1.76 a	-15.68±0.64 a	F=18.18 P≤0.001*
Average GLS	-20.03±1.50	-17.37±1.81 a	-16.26±1.28 a	-16.02±0.48 a	F=18.74 P≤0.001*

a: significant difference with Gestational HTN. **AP2C view;** apical 2 chamber view, **A4C view;** apical 4 chamber view, **APLAX view;** apical long axis view, **GLS;** global longitudinal strain, **HTN;** hypertension.

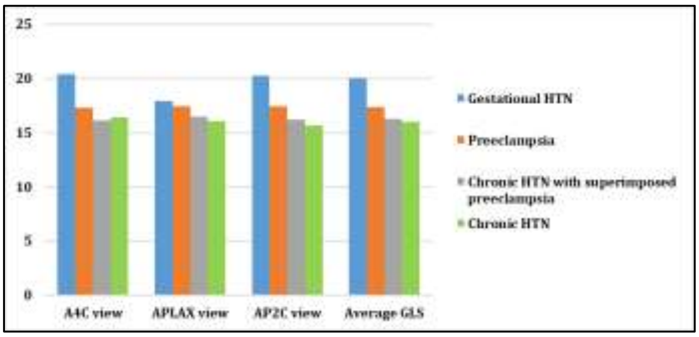

Figure (3): comparison of Global Longitudinal Strain among categories of hypertensive pregnant disorders.

AP2C view; apical 2 chamber view, **A4C view;** apical 4 chamber view, **APLAX view;** apical long axis view, **GLS;** global longitudinal strain, **HTN;** hypertension.

Discussion

Hypertension is seen in 4% to 8% of pregnancies and the incidence is increasing as the obstetric population becomes older and more obese. Hypertensive pregnancy disorders (HPD), categorized into: gestational hypertension (GH), chronic hypertension (CH), preeclampsia (PE), or chronic hypertension with superimposed PE. Failure of the maternal cardiovascular system to adapt to pregnancy is hypothesized to be the primary mechanism leading to HPD. Due to this inability to adapt, the maternal myocardium changes subtly in shape, size, and function. (6).

It has been demonstrated that conventional echocardiography, which assesses left ventricular ejection fraction and diastolic function, is unsuitable for the early detection of subclinical myocardial changes because these measurements give an indirect estimate of myocardial contractile function and change later in the cascade of myocardial dysfunction as a result of compensatory mechanisms. (7,8).

Left ventricular Global Longitudinal Strain (LV-GLS) is capable of early and accurate detection of cardiac alterations that may affect sub-endocardial longitudinal fibers. These fibers are involved in the first subclinical stages of several diseases such as ischemic injury and arterial hypertension, showing a reduced LV-GLS (9).

Given its noninvasive nature, echocardiography has significant promise for longitudinal strain measurement and evaluation of left ventricular function. Despite its widespread usage in clinical practice, literature is inconsistent regarding its definite role in HPDs and up till now, there is no clear recommendations regarding its routine or serial use in females with HPDs.

To our knowledge, no previous studies deeply assessed left ventricular function and its impairment in those with hypertension among Egyptian pregnant women. The discussion describes and analyze the results of conventional versus speckle tracking echocardiography (STE) parameters reflecting the LV structure and function in pregnant women with hypertensive disorders who participated in our study at Mansoura University, specialized medical Hospital (SMH). We hypothesized that "Global left systolic strain measurement would prove more sensitive than conventional left ventricular ejection fraction in detecting early changes in left ventricular function remaining as subclinical disease prior to overt progression."

The study was designed to be a descriptive cross-sectional comparative study, enrolling a control group that is; age, total body weight and body surface area matched to allow unbiased comparison of LV dimensions and function. Also, we didn't have statistically significant difference between patient and control group regarding gestational age to avoid variability of obtained measurements attributed to dynamic physiological changes during pregnancy.

The patient group involved the 4 categories of HPDs mentioned above. Moreover, it involved a wide variety of presentations; one of which is accidental discovery during routine pregnancy follow up visit. This hits our target of detecting subclinical LV dysfunction.

Regarding conventional echocardiography findings; we arrived at only two parameters with distinguishing ability between both patient and control groups as a whole and among four subcategories of HPDs.

The first significant parameter was left ventricular wall thickness. It has been demonstrated that, diastolic inter-ventricular septum thickness (IVSd) and diastolic posterior wall thickness (PWTd) were considerably significant parameters in distinguishing hypertensive pregnant patients from the normotensive pregnant patient group, with both IVSd and PWTd having higher values in hypertensive than normotensive cases, and with a statistically significant difference (P value ≤0.01).

The results of the current study were partially consistent with **Li Yu** and his colleagues who carried out a retrospective study to investigate whether pressure overload in patients with pregnancy-induced hypertension (PIH) affects (LV) function. Their results showed that, signs of LV remodeling in the patients with Preeclampsia (PE), with increased left atrial and ventricular dimensions and inter-ventricular septum thickness compared with the healthy control subjects. Furthermore, these parameters in their PE patients were still significantly larger 3 months after delivery. Also, The CO and EF of patients with PE were significantly lower compared with the control group in the third trimester of pregnancy (10).

The second significant parameter obtained by both conventional echocardiography and TDI was presence and grade of diastolic dysfunction. We found statistically significant differences among the different types of HPDs in our female cases as regard to diastolic dysfunction, P 0.001. Diastolic dysfunction grade I was seen in all cases associated with chronic HTN, as well as in 4 preeclampsia cases, 6 cases with chronic HTN with superimposed preeclampsia, and three gestational HTN cases. Almost 90% of our gestational HTN (GH) females were not found to have diastolic dysfunction according to our conventional echocardiography results.

Our study results were almost in line with (6) who performed a systematic review of all the literature pertaining to the use of echocardiography in pregnant women with a hypertensive disorder. They found that, A greater reduction in E/A has been shown in GH than in pregnancy unaffected by hypertension. Also, Diastolic function is also impaired in preeclampsia, where the usual reduction in E/A is exaggerated. And the ratio of early diastolic mitral inflow velocity: early diastolic mitral annular velocity (E/e′) was significantly higher in women with preeclampsia in 5 studies, suggesting higher LV filling pressures.

As regard HPDs subcategories, our study showed that E wave velocity, A wave velocity, E/A ratio, E wave dec time, e' and E/e' did differ significantly among the categories of hypertensive pregnant females ($p < 0.05$). The E/A ratio in preeclampsia (1.29±0.86) and chronic HTN pregnant cases (0.74±0.11) was significantly lower than in gestational HTN cases (1.90±0.63). In addition, preeclampsia had a higher E/e′ (12.14±3.67) than gestational HTN (9.79±1.86).

These finding are again in agreement with (6) stating that, if echocardiographic changes are seen in HPD, these changes are more severe in case of Preeclampsia (PE) compared with Gestational HTN (GH).

Our finding about significance of both LV wall thickness and diastolic dysfunction might explain the results by (11) who stated that, gestational hypertension suggests a 67% higher risk of subsequent CVD in women with gestational hypertension compared to women without. And Preeclampsia was associated with an approximately 75% higher risk of CVD-related mortality compared to woman with no history of preeclampsia (11).

Similar to conclusions by (12), in our study, although there were some differences in values of the other conventional echocardiography parameters in terms of left ventricular internal dimension in diastole (LVIDd), left ventricular internal dimension in systole (LVIDs), FS, EF, E wave velocity, A wave velocity, E/A ratio, E wave dec time, e', E/e', and diastolic dysfunction findings, these differences were not considered to be statistically significant ($P > 0.05$).

Regarding speckle tracking echocardiography, the present study reported that, the average GLS showed a significant decrease and less negative deformation in the left ventricle in the hypertensive pregnant female group (-18.63±2.23) compared to the normotensive pregnant female group (-20.06±3.01). This indicates that GLS is a significant STE parameter in assessing the early decrement of LV function in hypertensive pregnant females ($P = 0.041$).

Furthermore, our results demonstrated that average GLS was found to be a significant parameter in distinguishing between the different types of HPDs ($P \le 0.001$). GLS was significantly affected in chronic HTN (-16.02±0.48), chronic HTN with superimposed preeclampsia (-16.26±1.28) and preeclampsia (-17.37±1.81), when compared to gestational HTN (-20.03±1.50). These findings were partially consistent with **Moors** results, we indicated that, the Speckle Tracking Echocardiography (STE) parameters appear to be affected more in chronic HTN female cases than in gestational HTN or preeclampsia (PE) during pregnancy.

In agreement with our results, (13) conducted a Systematic Review to study whether Speckle Tracking Echocardiography (STE) is a suitable method to detect differences in cardiac function in pregnant women with HPD. Their findings demonstrated that, during pregnancy it was found a significantly decreased LV-GLS (left ventricular global longitudinal strain) in HPD compared with normotensive pregnant controls. Other deformation values show a significant decrease in women with severe or early-onset preeclampsia, with lasting myocardial changes after early-onset preeclampsia. In addition to that, they noticed that, When distinguishing between the 3 different HPD (i.e., Gestational HTN, Chronic HTN, and Preeclampsia), STE parameters seem to be altered more in PE than in GH or CH, both during pregnancy as postpartum.

As shown in two studies, which were, also in line with our study findings, **Clemmensen and his colleagues** concluded that, the LV global longitudinal strain was significantly lower in both early and delayed preeclampsia groups than in the normal group. Where, in early onset preeclampsia (EOPE) women (−18 ± 3% versus −21 ± 2%, $p < 0.001$) and late onset preeclampsia (LOPE) women (−18 ± 3% versus −21 ± 2%, $p < 0.01$). in another study of **Clemmensen**stated that, these preclinical changes in myocardial function last for almost 10 years after delivery; STE might be used as a sensitive method for early detection of women at high risk who can benefit from regular cardiovascular monitoring. (14,15).

To the contrary of our study findings, a case control study done by (16) reported that, the mean global longitudinal strain was -18.69 ± 2.8 in the group with preeclampsia and -19.39 ± 3.49 in the healthy group, with the difference not constituting statistical significance ($P = 0.164$). However, the mean global circumferential strain was significantly lower in the preeclampsia group ($P = 0.028$).

The current study produced similar results to **Ajmi's** study (17) findings and confirmed their hypothesis. It has been reported that GLS was significantly decreased in the hypertensive pregnant female group (-18.63±2.23) compared to control group (-20.06±3.01). GLS was significantly reduced in pregnant women with preeclampsia (-17.371.81). This means our GLS findings hit the threshold of the GLS (cut-off) that will have an acceptable sensitivity-specificity balance to predict the occurrence of complications, where the value >−18 appears to be the ideal point on the ROC curve, which corresponds to a sensitivity of 87% and a specificity of 42% according to **Ajimi's** results.

Therefore, we state that, in pregnant women with hypertension, GLS is more sensitive than other echocardiographic methods and markers in identifying subclinical myocardial dysfunction. It has a direct relationship with complications.

Similar results were seen in a study conducted by **Ashok Paudel**and his colleagues. It has been revealed that, the preeclamptic patients had significantly larger left atrium, thicker interventricular septum, higher systolic pulmonary artery pressure and mitral E/e′ ratio compared to controls during pregnancy while LV ejection fraction was similar. Preeclampsia patients had significantly lower LV global longitudinal strain (GLS) during pregnancy compared to controls (− 18.0 ± 2.6% vs. − 19.8 ± 2.1% p = 0.001). They suggested that preeclampsia might result in subclinical LV and RV dysfunction and STE as a more sensitive method in detecting preeclampsia associated subclinical myocardial dysfunction (12).

Conflict of interest

The authors confirmed that this article content has no conflict of interest.

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