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Analysis of Myocardial Left Ventricular Deformation During the Third Trimester of Healthy Pregnancy

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Abstract **Background:** Pregnancy, a distinctive physiologic state, that associated with multiple changes in the several body systems. One of the affected systems is cardiovascular system , with volume overload being one of the typical adaptation encountered during pregnancy, with chronic volume overload being one of the characteristic changes experienced during pregnancy. However, the effect of these changes on left ventricular myocardial contractile function has not been fully illustrated. **Aim:** To assess the maternal cardiac function during the third trimester of healthy pregnancy using Speckle Tracking echocardiography. **Patient and Methods:** This cross sectional study was carried out in Al-Furat teaching hospital in the time period from 1st of April 2022 to 30 of May 2023. A total of 150 women were studied, they were classified into two groups; 75 pregnant women with normal singleton pregnancy at their third trimester served as study group and 75 non pregnant women served as control group. Clinical evaluation, anthropometric assessments, and two-dimensional M-mode and Doppler echocardiography as well as Speckle Tracking echocardiographic study had been done for each one of them to assess the left ventricular systolic function. **Results:** The two groups showed significant difference in accordance with weight , height & BMI. Global longitudinal strain (GLS) was significantly different between the study groups ($p = 0.001$). Its Average value was decrease to -20.3 compared with -25.3 in control group. Besides, apical long-axis, three, and four-chamber strain showed significant changes as well. With lowest strain value was the apical long-axes -18.96 in comparison with the control. **Conclusion:** Left ventricular global longitudinal strain (GLS) shows significant reduction during the third trimester of healthy pregnancy ,this reduction in LV thickening is one of the cardiac adaptation throughout the pregnancy.

Key Words Cardiac deformation, Speckle-Tracking echocardiography, GLS, Left ventricular function, Third trimester pregnancy

1. Introduction

During latest years, thanks to the advances in clinical research, technologies and, new preventive and therapeutic strategies have been advanced for cardiovascular diseases, as coronary artery disease, heart failure, and cardiomyopathies. To prevent the onset of overt cardiac dysfunction, researchers have focused their attention particularly, on finding early indices of myocardial damage.

Echocardiography is the first-level technique for diagnosis and monitoring in cardiovascular disease, due to its many advantages such as availability, feasibility and repeatability, in acute and chronic settings besides, its low costs for the national health system. However, disease at early stages may minimally affect cardiac performance with subtle changes of myocardial structure and, consequently, function, which chronically end in overt myocardial impairment and symptom onset. Basic echocardiographic indices often fail to detect these ultrastructural damages; therefore, more than 12 years ago, an advanced echocardiographic technique was announced; speckle tracking echocardiography (STE) [1].

STE is a semi-automatic technique, that quantifies myocardial deformation, known as 'strain', of all cardiac chambers, on a segmental or a global basis. It has the advantage of overpowering basic echocardiography, such as angle and load-dependence, and low reproducibility and providing more sensitive information with a quick and easy evaluation [2].

Normal or healthy pregnancy that is uncomplicated with any chronic condition known to have cardiovascular effects such as diabetes, human immunodeficiency virus (HIV), sickle cell disease, asthma, or systemic lupus erythematosus (SLE) [3]. Some maternal cardiovascular adaptations that go along with a normal pregnancy include increased cardiac output, increased stroke volume, increased left ventricular wall thickness, decreased blood pressure, and decreased systemic vascular resistance [3], [4].

Pregnancy as a natural physiological state, it offers a challenge to the cardiovascular system on its own, resulting in usually reversible changes in a woman's cardiovascular system with structural remodeling and increased functional performance [5], [6]. Cardiac changes that occur during pregnancy can mimic cardiovascular diseases [7] which may also present for the first time during pregnancy [8].

Maternal cardiovascular disease (present in 2% of all pregnancies) is the leading cause of non-obstetric death during pregnancy worldwide [6].

2. Materials and Methods

A cross sectional study with samples collected from Gynecological consultation unit in Al-Furat Teaching Hospital at Al-Najaf Governorate from the beginning of April 2022 till end of march 2023. The Study groups included 75 healthy pregnant woman at third trimester of age (18-40 years old) and 75 healthy non pregnant young women of the same age as control group. All subjects were subjected to thorough medical history and physical examination to exclude other conditions as clinical evidence or previous history of any organic cardiac disease, renal disease, thyroid disease, severe anemia, diabetes, hypertension, and on any chronic medication or smoking. The height (cm) and weight (kg) are obtained, by means of measuring tape and digital weight scale respectively. Calculation of body mass index is carried out as: Weight (kg) / Height (m2) for each one [9]. ECG, Abdominal ultrasound U/S :to calculate gestational age, have been recorded. All individual participants in the study gave their informed consent.

3. Echocardiography

A complete two dimensional echocardiography is achieved in all patients, using a commercially available ultrasound transducer and equipment (M5sc probe, GE, Vivid E9, 2015, USA). All acquisitions were performed by the same operator with the patients in the left lateral position speckle tracking analysis.

Three apical views were used for the purpose of speckle tracking analysis (long-axis ,two chamber and four-chamber). Three points on each view (the apex and two on each mitral annuli) are identified by the examiner. Peak systolic longitudinal strain in corresponding segments of every view along with defining an aortic valve closure is then identified by the software. Global longitudinal strain (GLS) was obtained by taking the average strain for these three views (seventeen segments with six basal, six mid, four apical, and the one true apex). The frame rate was reserved between 70 Hz and 100 Hz. The strain curve is extracted, the peak negative wave of strain during the whole cardiac cycle is referred as peak strain [10].

The analysis of speckle tracking was held offline using EchoPAC PC version 108.1.4 software ,GE Healthcare) with

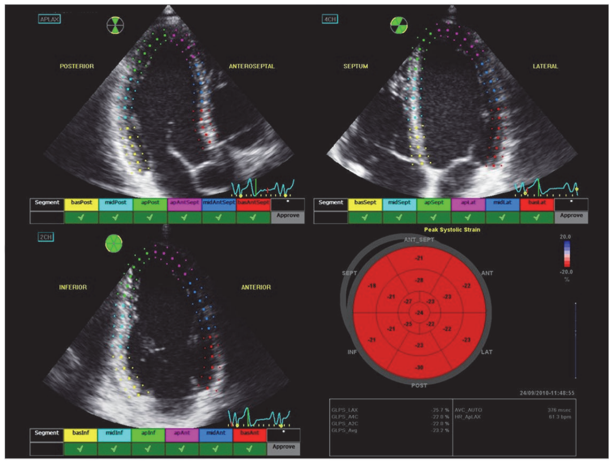

Figure 1: Regions of interest (dotted lines) have been traced on apical long axis, 4- and 2-chamber views. Each region of interest is divided into 6 segments for each view. The operator may accept/reject segments in case of suboptimal tracking of speckles

protocol for Bull's eye projection. Endocardial tracing was manually made (8-10 points) over one frame, while endocardial borders were automatically delineated by the software throughout the cardiac cycle as in Figure 1. The next step was the manual verification of the accuracy of tracking adjusting the region of interest in order to achieve optimal tracking [11].

4. Statistical Analysis

In this cross-sectional study, statistical analysis was performed using the statistical package SPSS for windows (version 23, SPSS Inc., Chicago, IL, USA). Data analyzed as per group I (total: n=75) compared with a control group (total: n=75) were shown as mean $\pm$ SD. Continuous variables were compared using independent sample t tests. A P value <0.05 was adopted to indicate statistical significance [12].

5. Results

This study included 150 women, 75 of them represented the study group and the other 75 were control group, as shown in (Table 1). The results show significant difference in weight which was higher at pregnant women than the control with (p value of 0.0001), while the age and the height show no difference between the two groups. However, BMI have been increased in the pregnant women group in comparison to the non-pregnant women with (p value 0.0001) as shown in Table 1.

On other hand, Table 2 shows that the global longitudinal strain (Average GLS) has significant decrease in the pregnant women in comparison to control non pregnant women (p= 0.001).

The Long-axis strain (LAX) in pregnant cases had significantly lower values compared to controls cases ($p < 0.001$) and it's the lowest among all views. Besides, four chamber

Groups/Parameters	Study group N:(75)	Control group N:(75)	P- value
Age (years)	26.5 ± 5.95	25.1 ± 4.4	0.1 (NS)
Weight (Kg)	75.9 ± 8.9	63.7 ± 9.3	0.0001
Height (centemeters)	158.6 ± 5.1	160.12 ± 4.1	0.4(NS)
BMI (Kg/m^2)	30.4 ± 2.9	25.03 ± 3.5	0.0001
NS: nonsignificant; BMI: body mass index			

Table 1: Demographic characteristic of women involved in study

longitudinal strain (A4C) also was significantly different between the study groups ($p < 0.001$). Pregnant cases had significantly lower values compared to controls cases.

Moreover, two-chamber longitudinal strain (A2C) was statistically different between the study groups ($p < 0.001$). Pregnant cases had significant lower values compared to control.

6. Discussion

Pregnancy triggers significant cardiovascular adaptation mechanisms; the most notable adjustments are: increased cardiac output and blood volume expansion related to a decrease in systemic vascular resistance and blood pressure leading to left ventricular remodeling [13]. In the current study, we find significant increase in the body weight and BMI of pregnant women, the increased weight gain during pregnancy is considered among the risk factors for maternal and fetal complications, including the risk of future cardiovascular diseases [14]. Similar results were found by [15].

LVEF has been the most frequently utilized measure of the systolic function of LV in clinical practice, for this reason, most of previous research have used global indices of the ejection phase such LVEF or fractional shortening, which shows certain restrictions [16]. Better knowledge of cardiac deformation is provided by speckle tracking echocardiography (STE), which provides a greater understanding of the mechanics of the myocardium [17].

In the current study, the global longitudinal strain (GLS) was significantly different between the study groups. Pregnant cases had significantly lower Average GLS values compared to control, this is similar to the previous study of [18]. Besides, long-axes and four-chamber strain showed the highest changes.

In another study, GLS showed significant decrease in pregnant women throughout the 1st trimester and continued decreased all over the pregnancy and labor with lowest value in the 3rd trimester. Accordingly, global radial strain (GCS) also significantly decreased throughout the pregnancy compared to the subjects in the control group, and it continued to decline over the course of the next trimesters [19].

Although some studies have evaluated the LV systolic performance throughout pregnancy, the results have been inconsistent [20], [21]. Pregnant females were measured with LV segmental LS Doppler by [20]. Furthermore, RS and CS were measured, but utilizing STE only from 1 short-axis view. It was documented that LS decreased throughout pregnancy.

Cong and his coworkers [22] employed 3D STE to evaluate the contractile function of the myocardium throughout pregnancy. They documented that all strain components and the overall LEVF decreased throughout pregnancy but increased to normal levels after labor. GLS decreased down from -21.32 in the first trimester down to -20.30 and -18.85 in the second and third trimesters respectively.

Nofal and his colleagues [23] utilized 2D STE to evaluate the contractile function of the myocardium throughout pregnancy, 15 non pregnant women with another 45 pregnant women, 15 at each pregnant trimester, they found that Global longitudinal strain was significantly different between the study groups. It decreases from -20.73 in the first trimester down to -18.33 and -16.67 in the second and third trimesters respectively.

Longitudinal strain (LS) is mainly determined by the vertical sub-endocardial fibers that are more susceptible to pathological changes of myocardium. In the majority of the disease states' impairments are first seen in GLS. Contrarily, sub-epicardial and mid-myocardial fibers, which are organized in a radial pattern and become active in late circumstances, are primarily responsible for determining GRS and GCS [24], [25].

A certain direction's impaired contractile function is linked to compensatory changes in the other directions. In light of these findings, the GRS augmentation in a prior study [19] suggests that there was a significant cardiac adaptation that helped maintain the LV's typical ejection performance and meet the high hemodynamic requirements of pregnancy. This explains why, despite decreased longitudinal shortening in studies with pregnant women, the overall LV function was remained normal [22].

The reduction of GLS during pregnancy explained by Sengupta and his colleagues to be the result of changed loading condition and geometric changes in the left ventricular shape such as increasing sphericity [19], in his study measure all three STE parameters; GLS, GCS and GRS, and he find that GRS increased during pregnancy so he suggest that this GRS augmentation is an adaptation strategy based on the assumption that the myocardium is essentially normal and that impairment of contractile function in one direction is accompanied with counterbalancing changes in the other directions that helps maintain normal LV ejection performance and meet the increased circulatory needs of pregnancy [19].

7. Conclusion

Changes are noticed in the cardiac deformation, left ventricular global longitudinal strain (GLS) shows significant reduction during the third trimester of healthy pregnancy. Screening of seemingly healthy pregnant women who later experienced complaints is indicated for early detection and treatment of cardiovascular problems in pregnancy, as cardiac changes might be significant throughout pregnancy.

GLS	Pregnant (n=75) Mean ± SD	Control (n=75) Mean ± SD	P value
LAX View	-18.96 ± 2.6	-25.3 ± 2.8	0.0001
A4C View	-19.4 ± 7.6	-25.1 ± 3.01	0.0001
A2C View	-21.2 ± 3.03	-24.7 ± 6.1	0.0001
Average	-20.3 ± 5.3	-25.3 ± 14.4	0.0001
GLS: global longitudinal strain; ALX: apical long-axis view; A4C apical 4-chamber view, A2C: apical 2-chamber view			

Table 2: Comparison of Global Longitudinal Strain (GLS) parameters within the study groups

Ethics Approval and Consent to Participate

All patients had given informed consent, and the study design was approved by the Department of Physiology, Faculty of Medicine ,University of Kufa (Department of Echocardiography) Al-Furat Teaching Hospital, Najaf, Iraq.

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Conflict of Interest

The authors declare no conflict of interests. All authors read and approved final version of the paper.

Authors Contribution

All authors contributed equally in this paper.

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