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Comparison of Biventricular Function between Pregnant and Non-Pregnant Women by Conventional and Newer Echocardiographic Indices

Abdul Razak [1,*], Antony Priyanka [1], R Padmakumar [1], Krishnananda Nayak [1]

[1] Department of Cardiology Kasturba Medical College Manipal, India

**Corresponding author: Abdul Razak UK, MD, DM, Department of Cardiology Kasturba Medical College Manipal, India. E-mail: razakkaup@gmail.com*

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Abstract

Introduction: Pregnancy is a physiological process associated with increased cardiac output, blood volume, decreased systemic vascular resistance and other metabolic changes. The purpose of this study was to evaluate biventricular function between pregnant and non-pregnant women by conventional and newer echocardiographic indices.

Methods: Echocardiography was done at the beginning of the second and third trimester for 51 (18-24 GW) pregnant women and age-matched 50 non-pregnant women were included in this study. Patients were assesses based on their sex, age, detailed history, and anthropometric values. Moreover, cardiac investigations including echocardiography and tissue Doppler imaging were performed.

Results: The mean age of pregnant women was 27 ± 3, and the non-pregnant woman was 24 ± 4 years. When compared with control during pregnancy left ventricular (LV) end-diastolic volume was increased, and LV ejection fraction was decreased for women in second to third trimester. Right ventricular (RV) function increased significantly ($P < 0.05$) in the third trimester when compared with control. RV tissue Doppler early diastolic filling wave E' gradually decreased during pregnancy.

Conclusions: During pregnancy, left ventricular ejection fraction & contractility is reduced. The myocardial peak velocity changes occurred throughout pregnancy. Echocardiographic indices of ventricular function were used to detect the changes in cardiac function during both normal and high-risk pregnancy.

INTRODUCTION

Cardiovascular disease is the leading non-obstetric cause of indirect maternal mortality in developed countries [1]. Many maternal complications occur throughout pregnancy, including increased cardiac output, blood volume, decreased systemic vascular resistance and other metabolic changes [2]. These changes may increase cardiac decompensation and lead to maternal as well as perinatal adverse outcomes during delivery [3-5]. Therefore, precise assessment of cardiac function is important during pregnancy [6]. Various physiological changes that occur are essential to protect the growing embryo or fetus during pregnancy [7]. These changes begin in the first trimester, reach their peak by mid-gestation (second trimester) and then remain relatively constant at the time of delivery [8]. In pregnancy, the number of women with heart disease is increasing because more pregnancies are occurring with congenital heart failure (CHF) [9]. Previous studies suggested diastolic dysfunction and left ventricular (LV) systolic function is a major cause of CHF in pregnant women [10, 11]. There is evidence that pregnant women with heart disease can have a long-term adverse effect on the right and left the ventricular function [12]. In the previous technique, LV diastolic function was evaluated by pulsed-wave Doppler echocardiography but it is load dependent. This method does not assess LV relaxation. Tissue Doppler imaging (TDI) is an echocardiographic technique for determining the LV diastolic function and relatively independent of preload. Therefore, TDI will be a more precise technique for evaluating LV diastolic function during pregnancy [6]. Additionally, studies have mainly focused on cardiac function in pregnant women non-invasively by echocardiography. This method to examine physiological preload, afterload, contractility & related hemodynamic parameters influence the heart and biventricular functions. Therefore, the present study was to investigate biventricular function between pregnant and non-pregnant women by conventional and newer echocardiographic indices.

METHODS

This was an observational study conducted in accordance with the Helsinki Declaration. The study was undertaken at a tertiary care hospital in the department of cardiology from June 2013 to June 2014. Age-matched non-pregnant, pregnant women in second and third trimester were also included in the study. Subjects with diabetes mellitus, hypertension, and any structural heart disease were excluded from the study. Before the initiation of the study, the protocol was approved by the institutional ethical committee. Detailed history and anthropometric values were assessed. Echocardiography (ECG) and TDI were also performed. The LV strain was obtained by automated function imaging. Cardiac output was calculated from stroke volume (determined by pulsed-wave Doppler recordings) multiplied by heart rate.

Echocardiography

Echocardiographic examinations were executed using Vivid 7 echo machine with 2.5 MHz transducers. Participants were studied in the left lateral decubitus position during the test. Echocardiographic images were obtained by standard apical four chambers (4C), three chambers (3C), two chambers (2C), and parasternal long axis. Conventional echocardiographic measurements by M-mode echocardiographic technique included LV end-diastolic dimension, end systolic dimension, ejection fraction (EF), fractional shortening, tricuspid annular plane systolic excursion (TAPSE), left atrial dimension, and aortic root dimension. Transvalvular velocities were obtained at mitral, tricuspid, aortic and pulmonary valve sites using pulse wave Doppler. Isovolumic relaxation time, isovolumic contraction time and deceleration time were also measured [13].

Tissue Doppler Imaging

Tissue annular velocity and color tissue Doppler images were obtained using three orthogonal standard apical views. Tissue annular velocities were measured using pulse wave interrogation method. Peak systolic (S), early diastolic (E') and late diastolic (A') velocities were measured by keeping the sample volume at lateral mitral annulus, septal mitral annulus, and right ventricular annulus. The E/E', E'/A' were also calculated to assess LV diastolic function [6].

LV Strain

LV global strain was obtained by automated function imaging technique. We recorded 2D cine loop of 4C, 3C and 2C consisting at least >2 cardiac cycles. These acquired cine loops were transferred to a workstation for offline analysis. Hence, the bull's eye image containing 17 segments were derived.

Statistical analysis

Statistical analysis was carried out using Microsoft Excel spreadsheet (version 2007, Microsoft Corp, Seattle, Washington). Values were expressed as a mean ± standard deviation or percentages. The analysis was performed by using the paired "sample t-test" using SPSS software. A p value of less than 0.05 was considered statistically significant.

RESULTS

Second trimester (18-24 GW) for 51 pregnant women was recruited for the study. During the study period, sixteen of them defaulted for follow-up in the third trimester (28-36 GW). The mean age was 27 ± 3 years. All of them had an uneventful antenatal course, with normal systolic and diastolic blood pressure (BP) throughout pregnancy. Mother's weight gain during pregnancy was 13 ± 6 kg. These women remained in sinus rhythm during pregnancy. There was no occurrence of gestational hypertension, preeclampsia or fetal growth restriction among the subjects. Age-matched 50 non-pregnant healthy women were also included in the control group with mean age 24 ± 4 years. Systolic and diastolic BP was reduced during the pregnancy. Cardiac output was increased by around 25%, throughout pregnancy as compared to the control group.

As shown in Table 1, it was observed that during pregnancy LV end-diastolic volume increased by 10% and LV ejection fraction (LVEF) decreased by 6% second to the third trimester by 11% ($P < 0.001$) when compared with the control group. The LV wall thickness was noted to be increased slightly during pregnancy. The LV myocardial longitudinal global strain (myocardial contraction- parameter) reduced non-significantly in the third trimester compared with the control group. Basal myocardial peak systolic longitudinal velocity S' remained unaltered. During pregnancy, there were only minor alterations in parameters of the diastolic function and filling pressures (Table 2).

Trans mitral rapid filling E wave velocity decreased by 22% ($P < 0.001$) when compared with the control group, and decreased by 12.5% from second to the third trimester. There was 20% increase in left atrium (inferior-superior) dimension during pregnancy compared to control group. LV lateral wall early diastolic lengthening velocity E', a marker of diastolic function, significantly reduced at third trimester in pregnant women ($P < 0.001$). However, E/E' as a marker of LV filling pressure remained essentially unaltered. No subjects showed evidence of increased LV filling pressure (E/E' ratio >15) during pregnancy. TAPSE, a measure of RV function increased significantly ($P < 0.02$) in the third trimester. Furthermore, RV tissue Doppler early diastolic filling wave E' decreased non-significantly during pregnancy. Late diastolic filling wave A' increased non-significantly during pregnancy compared to control but remained the same in a second and third trimester. Furthermore, E/E' ratio decreased non-significantly as compared to control throughout pregnancy.

Table 1: Echocardiographic variable in the second and third trimester and age-matched controls

Parameter	Age matched controls (n = 50)	Second trimester (n = 51)	Third trimester (n = 36)	P value (second trimester vs. age matched control)	P value (third trimester vs. age matched controls)	P value (second vs. third trimester)
EDD (mm)	41.0 ± 6.00	43.00 ± 5.00	44.0 ± 4.00	NS	NS	NS
ESD(mm)	24.0 ± 3.00	27.00 ± 6.00	29.0 ± 6.00	0.002	0.0001	NS
SEPTUM(mm)	8.00 ± 1.00	9.00 ± 1.00	10.0 ± 1.00	0.0001	0.0001	0.0001
PW(mm)	8.00 ± 1.00	9.00 ± 1.00	9.00 ± 1.00	0.0001	0.0001	NS
EF (%)	71.0 ± 5.00	68.0 ± 6.00	64.0 ± 6.00	0.0076	0.0001	0.0029
FS (%)	40.0 ± 4.00	39.00 ± 8.00	37.00 ± 15.00	NS	NS	NS
GLS (%)	-21.0 ± 1.4	-20.00 ± 2.5	-20.0 ± 2.04	NS	NS	1.0000
TAPSE(mm)	21.0 ± 2.00	22.00 ± 3.00	23.0 ± 3.00	0.0520	0.0004	NS
EDV(ml)	76.0 ± 15.0	85.00 ± 20.0	84.0 ± 25.00	0.0122	NS	NS
ESV(ml)	22.0 ± 16.0	29.00 ± 15.0	33.0 ± 9.00	0.0255	0.0004	NS

Data are presented as Mean ± SD. EDD = end diastolic dimension, ESD = end systolic dimension, PW = posterior wall thickness, EF = ejection fraction, FS = fractional shortening, GLS = global strain, TAPSE = tricuspid annular plane systolic excursion, EDV = end diastolic volume, ESV = end systolic volume. NS- Not significant.

Table 2: Trans Mitral Inflow Parameters and Tissue Doppler Imaging of Lateral and RV Free Wall

Parameter	Age Matched Controls (n = 50)	Second Trimester (n = 51)	Third Trimester (n = 36)	P value (second trimester vs. age matched control)	P value (third trimester vs. age matched controls)	P value (second vs. third trimester)
E(m/s)	0.9 ± 0.16	0.8 ± 0.15	0.7 ± 0.14	0.0016	0.0001	0.0023
A(m/s)	0.4 ± 0.10	0.5 ± 0.13	0.5 ± 0.10	0.0001	0.0001	1.0000
E/A	1.9 ± 0.53	1.5 ± 0.46	1.4 ± 0.36	0.0001	0.0001	NS
DT [1]						
158 ± 25.00	140 ± 37.0	129 ± 34.0	0.0052	0.0001	NS	
Lateral wall E'(m/s)	0.18 ± 0.02	0.16 ± 0.04	0.14 ± 0.03	0.0020	0.0001	0.0130
A'(m/s)	0.06 ± 0.01	0.07 ± 0.03	0.07 ± 0.04	NS	NS	NS
E'/A'	3 ± 0.8	2.0 ± 0.9	2.00 ± 0.8	0.0001	0.0001	NS
E/E'	5 ± 10	5.0 ± 1.3	5.1 ± 2.00	NS	NS	NS
RV free wall E'(m/s)	0.17 ± 3.00	0.15 ± 4.0	0.14 ± 4.00	NS	NS	NS
A'(m/s)	0.10 ± 3.00	0.14 ± 5.0	0.14 ± 0.01	NS	NS	NS
S(m/s)	0.13 ± 2.00	0.15 ± 0.01	0.14 ± 0.01	NS	NS	0.0001
E'/A'(m/s)	1.7 ± 4.00	1.2 ± 0.01	1.00 ± 0.01	NS	NS	0.0001
E/E'(m/s)	5.3 ± 8.00	5.5 ± 3.00	5.3 ± 2.00	NS	NS	NS
LA AP (mm)	29 ± 3.00	30.0 ± 3.00	31.0 ± 4.00	NS	NS	NS
LA IS(mm)	35 ± 4.00	40.0 ± 4.00	42.0 ± 5.00	0.0001	0.0001	NS

Data are presented as Mean ± SD. E= peak early Trans mitral flow velocity, A = peak late trans mitral flow velocity, DT = E wave deceleration time, E' = Early diastolic tissue velocity of lateral & RV free wall, A' = late diastolic filling velocity of lateral & RV annulus. LA (AP/IS) = left atrium anterio-posterior/inferio-superior. NS = Not significant.

DISCUSSIONS

The present study demonstrated structural and functional changes in the maternal cardiac function during normal pregnancy compared with non-pregnant women by echocardiography. The major finding of this study is the echocardiographic parameter (i.e. systolic and diastolic) during second and third trimester compared with the control group. In previous studies, cardiac adaptation, contractility and diastolic function have been reported in normal pregnancy [6, 10, 13-15]. In this study, 51 pregnant women showed a significant reduction in LVEF in the second and third trimester when compared with the control group. This was concordant with Enstensen et al. study [16]. Zentner et al. reported an evident increase in systolic and diastolic cardiac function during the gestational age [17]. This function decline has evidenced a reduction in both systolic myocardial velocities and EF. Also, a reduction in E' accompanied by changes in the MV inflow was observed. We could not record the first-trimester echocardiography parameter, as study included the subjects who referred for fetal echocardiography to cardiology usually consists more than 18 gestational weeks. The previous study by Ren et al. demonstrated that there was no significant change between non-pregnant women and early pregnant women (first trimester) [18].

Our finding shows that reduction in LVEF from the second trimester of gestation compared with the control group, is consistent with Estensen et al. study results [16]. These study results were the same as Estensen et al. and in contrast with Gilson et al., who observed no change in LVEF during pregnancy [16, 19]. Bmfo et al. found that axis shortening by M-mode decrease at the end of pregnancy [20]. There was a marginal reduction in a global strain compared with the control group in a second and third trimester. In similar findings by Estensen et al., the global strain was reduced at 36 weeks compared to 22-24 weeks [16]. In this study, there was increased in LVEDD and ESD during pregnancy. These finding in our study are similar to the obtained results from Estensen et al [16]. Diastolic function during pregnancy has been reported discrepantly. In similar results by Kametas et al., a reduction in E, E/A ratio and no changes in A wave during pregnancy was reported [21]. Our study results shown almost no changes in A velocity throughout pregnancy [16]. The decreased LV function is probably due to physical change during pregnancy. The changes LV function was probably due to moderate physical exercise in pregnancy [16]. Right ventricular myocardial excursion increased in the third trimester whereas the filing patterns (E) decreased but remained within the normal range as compared to control. Contractility, measured by global stain and EF has not been presented in studies on pre-eclampsia patients. Some studies reported that the second trimester of pregnancy with pre-eclampsia reduced systolic and diastolic function [20, 22, 23].

During pregnancy in healthy women, profound changes in LV systolic function, reduced LVEF, global myocardial strain, and increased end-diastolic as well as systolic volumes were observed. These findings underscore that pregnancy represents a significant load on the cardiovascular system. Therefore, present study has examined women in 30-33 weeks of gestation and could not include last 5-6 weeks of gestation which would reflect more pronounced changes likely to occur. It is due to the limitation of 2D echocardiographic imaging with foreshortened LV which results in late stages of gestation due to elevated hemidiaphragm and could interfere with measurements. Our comparison was with age-matched non-pregnant control subjects rather than with prejudice measurements in the study group.

CONCLUSION

This study demonstrates that left ventricular ejection fraction & contractility reduces during pregnancy. This suggests that pregnancy exerts a larger load on a cardiovascular system. However, the Ejection Fraction remains within the normal range. The early myocardial peak velocity (E') also reduced throughout pregnancy with its property of relatively loading independent index. This is a useful non-invasive technique for determining diastolic function both in normal and high-risk pregnancy. In the present study, tricuspid annular plane systolic excursion measurements and right ventricular function increased in pregnancy, which implies increased preload on the cardiovascular system. Echocardiographic assessment of ventricular function (both conventional & newer indices) was sensitive enough to detect the subtle changes in cardiac function during pregnancy. Further studies and follow-up may be required with a large number of subjects to obtain more data on recent indices of echocardiographic assessment of ventricular function in clinical scenario of pregnant women.

Conflicts of interest
The authors declare no conflicts of interest.

Author's Contributions
The first author prepared the first draft of the manuscript, which was then reviewed and edited by the coauthors. All authors actively contributed to the manuscript, and approved the final version.

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