Journal of Cardiovascular Disease Research

ISSN: 0975-3583,0976-2833 VOL11, ISSUE 04, 2020

Echocardiographic Assessment of Left Ventricle Diastolic Function in Normal Pregnancy Before and After Delivery

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Abstract

Background: Assessment of diastolic function during late pregnancy and early delivery is not addressed well in literature. However, it is important as it could predict heart failure in cases of preserved ejection fraction.

Aim of the work: the current study aimed to assess the diastolic cardiac function in the late normal pregnancy (third trimester) and early after delivery (within one week).

Methodology: 221 women with normal singleton pregnancy were included. The study carriedout from January 2018 to January 2020 in a tertiary care hospital. All women received standard antenatal care, and their age, body mass index, parity, past history of chronic medical diseases, duration of pregnancy, mode of delivery, fetal weight, blood loss during delivery need for blood transfusion and maternal mortality were recorded. All had an echocardiography examination during the third trimester and within one week after delivery.

Results: the women age ranged between 24 and 36 years. The majority of them had normal body mass index and para 2 were prevalent (54.3%). Past history of hypothyroidism was recorded for 4.5%, asthma for 1.8%, renal disease for 1.4% and connective tissue disease for 0.9%. The history of gestational hypertension was reported among 3.2%, chronic hypertension 1.8%, preeclampsia 1.4%, gestational diabetes 4.1% and abnormal placentation 3.6%. Preterm labor was reported among 3.6%. The fetal birth weight ranged between 2.50 to 3.52 kg. The normal vaginal mode of delivery was the prevalent(73.3%). No woman need blood transfusion and maternal mortality was absent. There was significant increase of left ventricle dimensions and mitral valve velocities after delivery than during gestation, while E/A ratio, EDT, and E' were significantly decreased after delivery. Blood pressure was significantly increased after delivery whileheart rate and left ventricle ejection fractions showed non-significant difference. **No**

ISSN: 0975-3583,0976-2833 VOL11, ISSUE 04, 2020

woman had diastolic dysfunction. Changes in left ventricle diastolic functions remains in normal levels during gestation and after delivery.

Conclusion: Normal pregnancy is associated with normal cardiac diastolic function during late pregnancy and early after delivery. This is valuable for prediction of heart failure during this critical period. The routine echocardiographic evaluation of cardiac function during the peripartum period is advocated.

Keywords:
Echocardiography; Pregnancy; Delivery; Diastolic Function; Left Ventricle

Introduction

The Maternal cardiovascular system undergoes marked changes in functions gestation to cope with the fluctuating hemodynamics. All changes function to aid the fetal development and protecting the mothers against the risks associated with delivery **(1).** One of the major physiologic changes is the enlargement of left ventricle (LV) chamber size and mass with preserved contraction **(2).** These physiological changes start early and reach the peak during the second and third trimesters of pregnancy **(3).** However, the changes in diastolic function during gestation is not studied sufficiently **(4-6).**

In women with past history of preeclampsia, the diastolic function of the heart was reported to be worsened **(7,8).**

In addition, high parity was reported to be a risk factor for diastolic dysfunction of the left ventricle with or without a past history of preeclampsia **(9,10).** The previously mentioned changes suggested that, diastolic function of the heart could be impaired during normal peripartum period. However, the heart function was not studied well during peripartum period.

The aim of the work

The current study aimed to investigate the changes in the diastolic function of the heart during late pregnancy (the third trimester) and early after delivery.

Methodology

We prospectively included 300 pregnant women during their third trimester of normal gestation. They were followed up till the time of delivery and shortly after that. Women who did have echocardiographic examination during the third trimester or who lost the follow up visit were excluded from the study and finally we included 221 women in the final analysis. All were selected from the Department of Obstetrics and Gynecology, Al-Azhar University Hospital (New Damietta), from January 2018 to January 2020.

All women received standard antenatal care, and at the first visit, the followed data were collected: woman age, pre-pregnancy weight, height and body mass index, exposure to smoking or other environmental toxins, parity, past history of chronic medical diseases, duration of pregnancy (calculated by last menstrual period and confirmed by ultrasound examination) and

ISSN: 0975-3583,0976-2833 VOL11, ISSUE 04, 2020

mode of delivery. In addition, the birth weight and amount of blood loss during delivery, needfor blood transfusion or any maternal mortality were documented.

Echo cardiographic examination

Cardiac function was evaluated by cardiac sonographer who had three-years' experience of echocardiography. The examination had been carried out during the third trimester (after 28 weeks of gestation) and within the first week after delivery. The procedure was performed in a standard manner described by the American Society of Echocardiography **(11).** The Teichholz method was used to measure the left ventricle ejection fraction. The tissue doppler indices of early diastolic mitral annulus velocity (e') were measure at the septal basal region, and e' < 7 cm/s or E/e' ratio >15.11 was recognized as left ventricle diastolic dysfunction **(12).**

Ethical considerations: The study protocol was introduced to, investigated and approved by the Institutional Review Board of Damietta Faculty of Medicine, Al-Azhar University (An internationally, registered board) (IRB no.#IRB00012367-20-01-016). In addition, each woman and her husband signed an informed consent to participate in the study. Their confidentiality and withdrawal rights were guaranteed. The study had been completed according to Helsinki declaration codes for research conduct and reporting.

Statistical analysis: For quantitative and qualitative data, statistical measures were mean ±SD, frequency and percentages, respectively were used to represent data. Value before and after delivery were compared by paired samples "*t*" test, and p value < 0.05 was considered significant. All measures and test were carried out by the statistical package for social sciences (SPSS) version 16 (SPSS Inc., USA).

Results

The included women age ranged between 24 and 36 years. The majority of them had normal body mass index (BMI) and para 2 was reported among 54.3% of them. Past history revealed that, hypothyroidism was reported among 4.5%, asthma in 1.8%, renal disease in 1.4% and connective tissue disease in 0.9%. The gestational hypertension was reported among 3.2%, which chronic hypertension was reported among 1.8%, preeclampsia developed among 1.4%, gestational diabetes in 4.1% and abnormal placentation among 3.6%. All these cormobid conditions were of mild nature and treated by standard protocols with no more complications. Premature delivery was reported among 3.6%. The gestational age at delivery ranged between 35and 40 weeks and fetal birth weight ranged between 2.50 to 3.52 kg. The normal vaginal mode ofdelivery was the prevalent (73.3%). The blood loss during delivery was 314.43±74.91 ml. No female need blood transfusion and maternal mortality was absent (Table 1).

Echocardiographic changes after delivery when compared to values at the third trimester of pregnancy, showed non-significant difference regarding left ventricle ejection fraction. However, LVDd, LVDs, IVST, PWT, LAD, LAVI, mitral peak (E), mitral peak A-wave velocity, E/e' were significantly increased, while E/A ratio, EDT, and E' were significantly

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decreased after delivery. Finally, blood pressure was significantly increased after delivery while heart rate showed non-significant difference (Table 2). No woman had diastolic dysfunction.

Table (1): Peripartum data of studied populations

Variables			**Measures (n=221)**
Prenatal characteristics	Age (years)	Mean±SD	29.82±3.56
		Min. – Max.	24-36
	BMI (kg/m^2)	Mean±SD	24.88±1.12
		Min. – Max.	22.59- 30.04
	Parity	Primipara	28(12.7%)
		Para 1	52(23.5%)
		Para 2	120(54.3%)
		Para 3 or more	21 (9.5%)
		Mean±SD	1.61±0.83
Past history Of comorbid diseases	Hypothyroidism		10(4.5%)
	Asthma		4(1.8%)
	Renal disease		3 (1.4%)
	CTD		2 (0.9%)
Perinatal comorbid conditions	Gestational hypertension		7(3.2%)
	Chronic hypertension		4(1.8%)
	Preeclampsia		3 (1.4%)
	Gestational diabetes		9(4.1%)
	Abnormal placentation		5(2.3%)
	Premature delivery		8(3.6%)
Fetal data	Gestational duration (weeks)	Mean±SD	38.04±0.93
		Min. – Max.	35- 40
	Birth weight (kg)	Mean±SD	3.07±0.19
		Min. – Max.	2.50 – 3.52
Delivery	Mode of delivery	NVD	162(73.3%)
		CS	59(26.7%)
	Blood loss (ml)	Mean ±SD	314.43±74.91

BMI: Body mass index; CTD: connective tissue disease; NVD: Normal vaginal delivery; CS: cesarean section; SD: standard deviation

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Table (2): Echocardiographic data during pregnancy compared to values after delivery

Variables	During pregnancy	After delivery	Paired test	P value
LFEF%	62.09±3.94	62.17±3.89	1.27	0.20
LVDd (mm)	48.25±3.77	48.73±3.71	6.67	***<0.001****
LVDs (mm)	30.39±1.12	31.80±1.02	30.45	***<0.001****
IVST (mm)	6.55±0.25	6.78±0.32	15.71	***<0.001****
PWT (mm)	6.47±0.25	6.55±0.28	6.19	***<0.001****
LAD (mm)	30.67±1.60	31.01±1.70	5.05	***<0.001****
LAVI (mL/m^2)	17.31±1.42	19.78±1.30	29.67	***<0.001****
E [cm/s]	0.78±0.04	0.85±0.03	28.56	***<0.001****
A [cm/s]	0.52±0.04	0.65±0.04	30.38	***<0.001****
E/A ratio	1.53±0.14	1.33±0.10	19.38	***<0.001****
E DT [ms]	182.45±4.01	173.01±4.57	27.31	***<0.001****
E' (cm/s)	12.95±1.21	11.32±0.81	17.21	***<0.001****
E/e'	6.21±0.65	7.58±0.62	26.34	***<0.001****
SBP (mmHg)	111.60±9.02	117.89±8.21	14.45	***<0.001****
DBP (mmHg)	67.89±7.36	71.92±7.49	13.00	***<0.001****
HR (beats/min)	74.39±2.36	74.29±2.39	1.73	0.08

LVEF: left ventricle ejection fraction; LVDd, left ventricular diastolic dimension; LVDs, left ventricular systolic dimension; IVST, interventricular septal thickness;PWT, posterior wall thickness; LAD, left atrial dimension; E, mitral peak E-wave velocity; A, mitral peak A-wave velocity;e', velocity of mitral annulus early diastolic motion; SBP: Systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate.

Discussion

The main results of the current study included slight reduction of diastolic function after delivery than values during pregnancy. The cardiac diastolic function is within normal during normal pregnancy and no one had diastolic dysfunction with pregnancy or after delivery. However, the diastolic dysfunction in the current work was assessed by e', E/e', peak velocity of tricuspid regurgitation (TR velocity), and LAVI **(13).** Although, LAVI is a reflection of cumulative effects of higher left ventricle filling pressure within time. Thus, it is difficult to reflect short-term alteration in the diastolic function during gestation. Interestingly, it is increased in the current work after delivery. Thus, the increased volume by affect the increase in LAVI, added to the cumulative effects of filling pressure. Alternatively, tissue doppler imaging is less dependent on the cardiac load than conventional Doppler and more accurate for evaluation of diastolic function during pregnancy **(14).** Thus, we used e' and E/e' for assessment of diastolic function. Previous studies showed that, during normal pregnancy, the heart had normal geometry **(15-18).** However, the changes in the third trimester and early after delivery is not well addressed.

In the current work, LVMI was significantly increased after delivery. This explained by LV wall thickness increase with enlarged dimensions of the left ventricle **(19)**. **Kim et al. (20)**

ISSN: 0975-3583,0976-2833 VOL11, ISSUE 04, 2020

reported eccentric hypertrophy of the left ventricle in the third trimester of normal pregnancy, with a spherical LV, as the best adaptation for efficient filling of the heart during diastole, with increased stroke volume to achieve increased needs of pregnancy **(20,21).** However, this eccentric hypertrophy usually reported with hypertensive diseases of pregnancy. This could be fully addressed in the current work due to few cases of gestational hypertension **(22, 23).**

In the current study, the systolic and diastolic blood pressure was significantly higher after delivery than before delivery (at the time of echocardiography). The value of e' is less affected by afterload, while transmitral flow is affected by the volume and after load of LV**(13).** However, in the current work changes in the blood pressure, irrespective of its significant changes, remain in the normal values. The elevated blood pressure could be linked to changes in the systemic vascular resistance (SVR) during pregnancy. SVR usually reduced with progressionof pregnancy, reaching the lowest values during the early third trimester. The SVR gradually returned to normal values after delivery (**1),** which could explain changes in blood pressure after delivery compared to values during late gestation.

Daimon et al. (24) reported comparable results to the current work regarding e' and E/e' in normal non-pregnant women. In addition, blood pressure was similar to the current reported values. Taking these results in considerations, it could be suggested that, blood pressure exerts minimal effects on the changes in diastolic functions **(12).**

Song et al. (25) reported reduction in cardiac diastolic function during the third trimester of pregnancy, that covered and returned to normal within 6 months after delivery of normal gestation. The current work confirmed these results and added that, there was significant reduction in the diastolic function shortly after delivery. However, it remains normal. No diastolic dysfunction was reported during gestation or after delivery. However, **Kimura et al. (12)** reported a diastolic function in 0.7% during third trimester of gestation that increased to 2% after delivery. Thus, minority of women with normal gestation could develop diastolic dysfunction, which may be accumulated pregnancy after the other (increased with increased parity). This reported by **Aggarwal et al. (10),** as they linked diastolic dysfunction to high parity (more than or equal five live births).

The significance of checking LV function during the peripartum period stands on the fact that diastolic dysfunction of the left ventricle could lead to heart failure despite preservation of LVEF **(26).** Thus, both systolic and diastolic cardiac functions must be evaluated to predict heart failure with LVEF preservation during late pregnancy and early after delivery.

In short, the current study showed that, normal pregnancy is associated with normal diastolic function of the left ventricle during late pregnancy and early after delivery. This is valuable for prediction of heart failure during this critical period. The routine echocardiographic evaluation of cardiac function during late gestation is recommended. However, the limitation of the current work included the absence of strain analysis during echocardiography and short follow up period after delivery. These shortages must be avoided in the future studies.

ISSN: 0975-3583,0976-2833 VOL11, ISSUE 04, 2020

Authors contributions

Alaa Eldin Mahmoud Megahed: All steps of the study from idea and protocol to the revision of the final version of manuscript and echocardiography.

Hamouda Abdelkhalek Elbahnasy: All steps of the study from idea and protocol to the revision of the final version of manuscript and echocardiography.

Mohamed Ibrahim Elraghy: All steps of the study from idea and protocol to the revision of the final version of manuscript and echocardiography.

Abdullah Almilaibary: protocol development, statistical analysis, manuscript drafting, revision and final approval.

NB: All authors held equal responsibility and are accountable for the research.

Conflict of interest: none

Financial disclosure: none

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