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A Comparative Study of Echocardiographic Parameters between Pregnant Women with New Onset Hypertension and Normotensive Pregnant Women after 28 Weeks of Gestational Age

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Abstract

Background

Cardiac disease is being the leading non obstetric cause of death in pregnancy and puerperium. Hypertensive disorders constitute 5-10% of all pregnancies, being one of the components of deadly triad with hemorrhage and infection. Preeclampsia is a pregnancy complication of placental etiology with acute onset of predominantly cardiovascular manifestations and constitutes 2-7% of medical disorders in pregnancies. In India, preeclampsia accounts for approximately 8-14% of maternal deaths. There is limited knowledge with respect to parameters of cardiac function in pregnancy and even less in the presence of pregnancy complications such as preeclampsia. In preeclampsia mean arterial pressure and total vascular resistance are increased resulting in increased afterload on heart. Transthoracic echocardiography is frequently considered the reference standard for cardiovascular system monitoring. It is a non-invasive, precise device and is validated in pregnancy.

Aim & Objective:- *To compare the echocardiography parameters in pregnant women with new onset hypertension and normotensive pregnant women after 28 weeks of gestational age.*

Methods:- *This is a hospital based observational case control study carried out in the departments of obstetrics and gynecology and cardiology at Gandhi hospital during the study period. Patients were enrolled in the study after applying the inclusion and exclusion criteria. On admission subjects are assessed clinically, appropriate biochemical tests done.*

• The subjects were studied by standard 2 – dimensional and Doppler transthoracic echocardiography in the left lateral decubitus position and data acquired at end expiration from standard parasternal/apical views.

Results*:- In the present study, it is observed mean heart rate is 82.9bpm in cases and 84 bpm in controls. It is observed that mean stroke volume index in cases is 39.05 and in controls is 39.06. Cardiac work index (CWI) is increased in cases compared to controls. Mean CWI in cases is 385 and in controls are 288.89.Mean E wave velocity in cases is 0.79 m/s and in controls are 0.82 m/s. A wave is increased in cases which is statistically significant. Mean A wave velocity in cases is 0.65 m/s and in controls is 0.60 m/s. E/A ratio is reduced in cases which is statistically significant. Mean E/A ratio in cases is 1.22 and in controls is 1.35.In the present study it is observed Left ventricular mass index (LVMI) is increased in cases compared to controls. Mean LVMI in cases is 75.26 gm/m² and in controls is 70.48 gm/m².*

Conclusion*:- Preeclampsia is a multisystem disease complicating 5-10% of pregnancies and remains in the top three causes of maternal morbidity and mortality globally. In women with preeclampsia cardiac work index ,left ventricular mass index,left ventricular posterior wall diameter and interventricular septal thickness are increased as a result of increased workload on heart to maintain cardiac output against increased after load.Systolic function is well preserved.*

Diastolic function is reduced and those with global diastolic dysfunction are at increased risk of developing pulmonary edema.

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I. Introduction:-

Cardiac disease is being the leading non obstetric cause of death in pregnancy and puerperium[1]. Hypertensive disorders constitute 5-10% of all pregnancies, being one of the components of deadly triad with hemorrhage and infection[2]. These hypertensive disorders are classified based on gestation at which elevated blood pressure identified (gestational hypertension, preeclampsia, eclampsia) presence and absence of multisystem involvement or significant proteinuria and blood pressure normalizing in post natal period.

Preeclampsia is a pregnancy complication of placental etiology with acute onset of predominantly cardiovascular manifestations and constitutes 2-7% of medical disorders in pregnancies. Pathological changes in this disorder are primarily ischemic in nature and known to effect placenta, kidney, liver and brain, where as there is scanty and conflicting information about the impact on heart [3-10]. Deaths are due to intracranial hemorrhage and cerebral infarction, acute pulmonary edema, respiratory failure, hepatic failure or rupture, and bleeding such as may occur with disseminated intravascular coagulation or placental abruption. It is the leading cause of fetal growth restriction, intrauterine fetal demise and planned preterm birth [11, 12].

In India, preeclampsia accounts for approximately 8-14% of maternal deaths[13]. It is estimated that approximately 50,000 women die each year of preeclampsia worldwide and approximately 300,000 babies die predominantly due to premature birth in women with preeclampsia[14]. There is limited knowledge with respect to parameters of cardiac function in pregnancy and even less in the presence of pregnancy complications such as preeclampsia. In the latter condition, there is at present no consensus on the systolic and diastolic parameters of cardiac function and the literature are contradictory about whether there is increased, decreased or any change in cardiac output. Normal pregnancy is characterized by decreased vascular resistance and mean arterial pressure with increased cardiac output. In preeclampsia mean arterial pressure and total vascular resistance are increased resulting in increased afterload on heart[14]. Echocardiography is a safe, noninvasive technique to assess cardiac structure and function in pregnancy[15-18]. Modern ultrasound technologies can demonstrate subtle changes in cardiac geometry and performance, and has important potential for longitudinal assessment in view of its non invasive nature[19-22]. Transthoracic echocardiography is frequently considered the reference standard for cardiovascular system monitoring. It is a non-invasive, precise device and is validated in pregnancy.

Transthoracic echocardiography is becoming increasingly widespread and has the potential to provide far greater diagnostic insight into the cardiovascular abnormality associated with preeclampsia, thereby offering improved patient care[14].

Several long term studies confirm that hypertension during pregnancy is a marker for increased events of later cardiovascular related morbidity and mortality. In the present study we assess cardiovascular hemodynamics in hypertensive disorders of pregnancy using transthoracic echocardiography in comparison with appropriately matched controls.

AIM AND OBJECTIVES

To compare the echocardiography parameters in pregnant women with new onset hypertension and normotensive pregnant women after 28 weeks of gestational age.

II. Materials And Methods

This is a hospital based observational case control study carried out in150 cases and 150 controls in the departments of obstetrics and gynecology and cardiology at Gandhi hospital during the study period [October 2016 – September 2018]. Approval was taken from the Institutional Ethical Committee before commencing the study. The participants were informed regarding the purpose, procedures, risks and benefits of the study. Written and Informed Consent was obtained from all participants.

INCLUSION CRITERIA:

• Singleton pregnancy
• Gestational age>28 weeks
• Gestational hypertension, preeclamptic pregnant women
.

EXCLUSION CRITERIA:

Gestational age<28 weeks
Heart disease
Twin gestation
Severe anemia
Alcohol and tobacco abuse
Chronic hypertension
Angina pectoris, previous Myocardial infarction
Diabetes mellitus.

METHODS OF COLLECTION OF DATA:

Approval from institutional ethics committee was obtained prior to commencement of the study. Patients were enrolled in the study after applying the inclusion and exclusion criteria.

• 150 pregnant woman admitted with the diagnosis of gestational hypertension and preeclampsia were recruited as cases by simple random sampling

• An equal number of age [± 2yrs] and gestation[± 1wk] matched healthy normotensive pregnant woman attending the antenatal OP during the study period constituted control group

Blood pressure is measured in right arm in sitting position with arm at the level of heart. Appearance of sound [phase I korotkoff] and disappearance of sound [phase v korotkoff] is recorded as systolic and diastolic BP respectively.

On admission cases are assessed clinically, appropriate biochemical tests done, Controls are assessed clinically.

• The subjects were studied by standard 2-dimensional and Doppler transthoracic echocardiography in the left lateral decubitus position and data acquired at end expiration from standard parasternal/apical views.

• Cardiac indices were normalised for body surface area.

• Heart remodelling

Chamber quantification and left ventricular geometric pattern were estimated using M-mode

M-mode study is performed at the level of aorta, left atrium, left ventricle at a midposition between the tips of mitral valve and papillary muscles. Pulsed doppler flow across the mitral valve is recorded to obtain the left ventricular diastolic filling pattern.

STATISTICAL ANALYSIS

Data was entered and analyzed using MS Excel and SPSS (Statistical Package for the Social Sciences) version 23.0 and the data was analyzed and statistical test as applicable was used to test the significance of differences between proportions. A p value of less than 0.05($p<0.05$) was considered statistically significant.

III. Observation And Results

TABLE – 1 – DISTRIBUTION OF CARDIAC PARAMETERS IN CASES AND CONTROLS (n=300)

	CASES	CONTROLS	P VALUE
HEART RATE	82.9 (74 – 90)	84 (73 – 93)	>0.05
STROKE VOLUME INDEX	39.05 (33 – 45)	39.06 (28 – 48)	>0.05
AORTIC ROOT DIAMETER	2.46 cms(2.3 – 2.8)	2.09 cms (2 – 2.3)	<0.05
INTER VENTRICULAR SEPTUM THICKNESS (cms)	0.958 (0.8 – 1.1)	0.8 (0.7 – 0.9)	<0.05
LEFT VENTRICULAR POSTERIOR WALL THICKNESS (cms)	0.98 (0.8 – 1.3)	0.79 (0.7 – 0.9)	<0.05
CARDIAC INDEX l/min/m^2	3.23 (2.6 – 3.8)	3.3 (2.4 – 3.8)	>0.05
EJECTION FRACTION	67.12 (53 – 79)	68.05 (55 – 80)	>0.05
FRACTIONAL SHORTENING	37.78 (27 – 48)	26.03 (28 – 45)	>0.05
E WAVE (m/s)	0.79 (0.72 – 0.95)	0.82 (0.72 – 0.94)	>0.05
A WAVE (m/s)	0.65 (0.55 – 0.72)	0.60 (0.55 – 0.67)	<0.05
E/A RATIO	1.22 (1 – 1.43)	1.35 (1.25 – 1.64)	<0.05

In the present study as shown in table 1, it is observed mean heart rate is 82.9bpm in cases and 84bpm in controls. It is observed that mean stroke volume index in cases is 39.05 and in controls is 39.06.It is observed that mean aortic root diameter in cases is 2.46cm and in controls is 2.09 cm. The mean Inter ventricular septum thickness in cases is 0.958 and in controls is 0.8. Mean Left ventricular posterior wall thickness in cases is 0.98 and in controls is 0.79. Both are increased in cases compared to controls.

Systolic function is preserved in cases. Mean cardiac index in cases is 3.23 and controls is 3.3. Mean Ejection fraction in cases is 67.12 and in controls is 68.05. Mean Fractional shortening in cases is 37.78 and in controls is 36.03.

It is observed that E wave is reduced in cases which is statistically not significant. Mean E wave velocity in cases is 0.79 m/s and in controls are 0.82 m/s. A wave is increased in cases which is statistically significant. Mean A wave velocity in cases is 0.65 m/s and in controls is 0.60 m/s. E/A ratio is reduced in cases which is statistically significant. Mean E/A ratio in cases is 1.22 and in controls is 1.35.

Table – 2 – DISTRIBUTION OF CARDIAC WORK INDEX IN CASES AND CONTROLS (p<0.05)(n=300)

CARDIAC WORK INDEX(CWI) (mm of hg X lit/min/m²)	**191-290**	**291-390**	**391-490**
CASES 385 (311-455)	-	**83(55.34%)**	**67(44.66%)**
CONTROLS 288.89(197-344)	**70(46%)**	**80(54%)**	

In the present study it is observed CWI is increased in cases compared to controls. Mean CWI in cases is 385 and in controls are 288.89. In 70(46%) of controls CWI is in the range of 191-290. In 83(55.34%) of cases and 80 (54%) of controls CWI is in the range of 291-390. In 67 (44.66%) of cases CWI is in the above normal range of more than 390 as shown in table 2.

Table – 3 – DISTRIBUTION OF LEFT VENTRICULAR MASS INDEX IN CASES AND CONTROLS (p<0.05)

LVMI(gm/m²)	**56-65**	**66-75**	**76-85**	**86-95**
CASES 75.26(60-94)	**3 (2%)**	**93(62%)**	**33(22%)**	**21(14%)**
CONTROLS 70.48(57-83)	**39(26%)**	**82(55%)**	**29(19%)**	

In the present study it is observed LVMI is increased in cases compared to controls. Mean LVMI in cases is 75.26 gm/m² and in controls is 70.48 gm/m². In 3(2%) of cases and 39(26%) of controls LVMI is in the range of 56-65. In 93(62%) of cases and 82(55%) of controls LVMI is in the range of 66-75. In 33(22%) of cases and 29(19%) of controls LVMI is in the range of 76-85. In 21(14%) of cases LVMI is in the range of 86-95 as shown in table 3.

IV. Discussion

Pregnancy induces a major stress on the maternal cardiovascular system. In pregnancy complicated by hypertension, abnormal pressure overloading would lead to different cardiac remodelling compared to that of normal pregnancy

In present study mean pulse rate for cases is 82.9bpm and ranges from 74-90bpm and 84bpm in controls which ranges from 73-93bpm. In Karen Melchiorre et al[23] it is 80bpm in cases with normal diastolic function an 83 in cases with global diastolic dysunction and 82bpm in controls. In Dennis et al [14] it is 81bpm in cases and 78bpm in controls. There is no statistical significant variation in pulse rate between cases and controls.

In present study mean stroke volume index is 39.05 ml/m2 in cases and 39.06 ml/m2 in controls, this function is preserved in cases and comparable (P>0.05) to Karen Melchiorre et al[23] study (2011) in which mean stroke volume index in cases with normal diastolic function is 36 ml/m2, in cases with global diastolic dysfunction is 38 ml/m2 and in controls is 39 ml/m2 with 50 cases and 50 controls.

•Regarding cardiac work indexnormal value in non pregnant women 157-307 mm of hg X lit/min/m² andnormal value in pregnant women 208-380 mm of hg X lit/min/m².

In present study cardiac work index is increased in cases compared to controls, it is 385 in cases an 288.89 in controls which is statistically significant(p<0.05) which is comparable to Narasinga rao et al [24] (2015)study where it is 386.7 in cases and 287.5 in controls and Karen Melchiorre et al[23] (2011) study where it is 312 in cases with normal diastolic function ; 360 in cases with global diastolic dysfunction and 262 in controls. In the entire studies cardiac work index is increased in cases compared to controls. This represents increased work load on heart due to increased after load.

Normal value of left ventricular mass index in non pregnant woman is43-95 gm/m² and in pregnant women is 66-100 gm/m² . In Karen Melchiorre et al[23] (2011) it is 73 in cases with normal diastolic function;80 in cases with global diastolic dysfunction and 70 in controls. In Narasinga Rao et al study[24](2015) it is 74.5 in cases and 70 in controls. In the present study it is 75.26 in cases and 70.48 in controls which is statistically significant (p<0.05). In all the studies left ventricular mass index is increased in cases compared to controls. This is likely to reduce the wall stress associated with increased afterload, thereby maintaining the balance between myocardial oxygen demand and supply.

Aortic root diameter is found to be higher in cases when compared to controls. In present study aortic root diameter is 2.46cm and in controls is 2.09 cm which is statistically significant (p<0.05) and comparable to study observed by Solanki et al[25] study where aortic root diameter is 2.48cm in cases and 2.02cm in controls and in Kyoung –Im Cho et al[26] (2011) it is 2.96 in cases and 2.81 in controls.

It is observed that inter ventricular septum thickness is more in cases than controls. In present study it is 0.95cm in cases and 0.80cm in controls **i**t is comparable and is statistically significant (p<0.05). In Karen Melchiorre et al[23] the mean inter ventricular septum thickness in cases with normal diastolic function is 1cm; in cases with global diastolic dysfunction is 0.9cm and in controls is 0.8cm and in Narasinga et al[24] study where cases have 0.96cm and in controls is 0.8cm

In present study mean left ventricular posterior wall thickness (cm) is 0.98cm in cases and 0.79cm in controls which is statistically significant (p<0.05) and comparable to other studies like Karen Melchiorre et al [23] where mean left ventricular posterior wall thickness is 1cm in both cases with normal diastolic function and with global diastolic dysfunction and in controls is 0.8, in study observed by Narasinga Rao et al(2015) [24] it is 0.98 in2cases and 0.8 in controls .

Both interventricular septum thickness and left ventricular posterior wall thickness are increased in cases compared to controls as a part of hypertrophy associated with increased afterload in order to reduce wall stress in order to maintain the balance between myocardial oxygen demand and supply.

In Simmons,Gillin et al[27](2002) mean cardiac index is 4.1 in cases and 4.2 in controls. In Karen Melchiorre et al[23] (2011) it is 3.2 in cases with normal diastolic function; 2.9 in cases with global diastolic dysfunction and 3.2 in controls. In Narasinga Rao et al[24] (2015) study it is 3.3 in cases and controls. In present study it is 3.23 in cases and 3.3 in controls. In Simmons,Gillin et al[27](2002**),** Narasinga Rao et al[24](2015) and present study there is no significant difference in cardiac index between cases and controls while in Melchiorre et a[23](2011) it is reduced in cases with global diastolic dysfunction.

Ejection fraction is an indicator of systolic function. In present study mean ejection fraction is 67.12% in cases an 68.05 in controls which shows that systolic function is preserved in hypertensive's .Other studies with similar results were Narasing rao et al[24] with 66.6% in cases and 67.9% in controls and Tanuja Muthyala et al[10] with 57.55% in cases and 57.8 in controls

In present study parameters of systolic function are cardiac index, ejection fraction and fractional shortening. Variation in results of different studies might be possibly due to variation in parameters.

E wave is significantly more in cases than controls in Solanki Rizwana[25] study, Mi-jeong kim et al[28](2016) Padmaja Tangeda et al [29] (2017) Subha sivagami sengodan et al[30](2017) . It is significantly less in cases with global diastolic function in Karen Melchiorre et al[23] (2011) Narasinga rao et al(2015) [24] Zainab et al[31](2016) and same in Kyoung-im cho et al [26](2011) while there is no significant difference in present study.

In Simmons,Gillin et al[27](2002) mean A-wave velocity in cases and controls is 0.55. In Karen Melchiorre et al[23] (2011) it is 0.60 in cases with normal diastolic function(p more than 0.05); 0.82 in cases with global diastolic dysfunction(p <0.05) and 0.64 in controls. In Solanki Rizwana[25] study it is 0.77 in cases (p<0.05) and 0.50 in controls. Kyoung-im cho et al [26] (2011) observed 0.75 in cases and 0.64 in controls. Study conducted by Narasinga et al(2015) [24] observed 0.64 in cases and 0.60 in controls, while study by zainab et al[31] observed 0.91 in cases and 0.77 in controls, study by Mi-jeong kim et al[28](2016) shows 0.75 in cases and 0.62 in controls.

In present study it is 0.65 in cases and 0.60 in controls (p<0.05). A wave is significantly more in cases than controls in present study, Solanki Rizwana[25] study, Kyoung-im cho et al [26](2011), Narasinga et al(2015) [24] , Mi-jeong kim et al[28](2016), Zainab et al[31](2016) and in Melchiorre et al[23] (in cases with global diastolic dysfunction).

The higher peak A wave velocity in cases suggests more important role of atrial systole in filling of the hypertrophied ventricle in these women.

In Karen Melchiorre et al[23] (2011) mean E/A ratio in cases with normal diastolic function 1.34(p more than 0.05) ; in cases with global diastolic dysfunction 0.81(p< 0.05) and in controls is 1.14. In Dennis study[14] (2012) it is 1.29 in cases(p<0.05) and 1.45 in controls. In Rafik.Hamad et al[7] (2010) study it is 1.29 in cases(p<0.05) and 1.54 in controls In Present study it is 1.22 in cases (p <0.05) and 1.35 in controls. E/A ratio is significantly reduced in cases compared to controls in present study , R.R.Hamad study[7] (2010) and in Melchiorre et al[23] (2011)(in cases with global diastolic dysfunction) while in Solanki Rizwana[25] study it is more in cases compared to controls but is statistically insignificant.

In present study parameters of diastolic function are E wave, A wave and E/A ratio and it is found that though the diastolic function in cases is within normal limits it is reduced compared to controls. This is a preliminary study undertaken to evaluate cardiovascular function in hypertensive disorders of pregnancy in comparison with normotensive controls. Variation in results of diastolic function in comparison with other studies who found diastolic dysfunction in significant proportion of cases might be due to inadequacy of conventional indices used in the present study to identify subtle changes in preeclampsia. Further studies can be carried out to evaluate cardiovascular function in hypertensive disorders of pregnancy, diastolic function in particular taking into consideration numerous other parameters and advanced techniques like speckle tracking echocardiography are extremely helpful. LV myocardial relaxation is paradoxically an energy-dependent

process that results in a rapid decrease in LV pressure after the end of contraction and during early diastole. Hence, the process of myocardial relaxation is more vulnerable than contraction and is apparently compromised in both early-stage cardiovascular disorders and in PE.

Evaluation of cardiovascular function can have significant clinical implications for peripartum intravascular volume management, because the women with global diastolic dysfunction are the ones most likely to sustain acute cardiopulmonary morbidity, most commonly from pulmonary edema[32,33]. The latter may be better predicted by the early diastolic mitral wave velocity/average lateral and septal diastolic myocardial velocities ratio in patients with global diastolic dysfunction, because it is a better indirect index of pulmonary capillary wedge pressure than central venous pressure[34,35]. The study findings also demonstrate that PE is associated with heart remodeling and significant changes in cardiac function. Many of the altered Tissue Doppler indices are known to be independently related to the long-term risk of cardiovascular morbidity in nonpregnantsubjects[36,37]. A better understanding of the relationship of these indices and subsequent morbidity in the context of pregnancy may provide an opportunity for early cardiovascular risk stratification and the introduction of prophylactic strategies.

V. Conclusion

- Preeclampsia is a multisystem disease complicating 5-10% of pregnancies and remains in the top three causes of maternal morbidity and mortality globally.
- During pregnancy mean arterial pressure and vascular resistance decrease, while blood volume and basal metabolic rate increase resulting in increased cardiac output
- In hypertensive disorders of pregnancy there is currently no consensus on the systolic and diastolic parameters of cardiac function and the literature is conflicting regarding whether there is increased, decreased or any change in cardiac output.
- Women with a history of preeclampsia/eclampsia have approximately double the risk of early cardiac, cerebrovascular, peripheral arterial disease,thromboembolic events and cardiovascular mortality.
- This study is undertaken to evaluate cardiovascular hemodynamic alterations in hypertensive disorders of pregnancy in comparision with appropriately matched age, parity, body surface area and gestational age control normotensive pregnancies.
- In women with preeclampsia cardiac work index ,left ventricular mass index,left ventricular posterior wall diameter and interventricular septal thickness are increased as a result of increased workload on heart to maintain cardiac output against increased after load.Systolic function is well preserved.
- Diastolic function is reduced and those with global diastolic dysfunction are at increased risk of developing pulmonary edema.
- Advanced techniques like speckle tracking echocardiography can better identify those with compromised cardiovascular function.

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