RESEARCH
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CARDIAC DYNAMICS IN HYPERTENSIVE DISORDERS OF PREGNANCY AN IN-DEPTH ECHOCARDIOGRAPHIC EXAMINATION AND COMPARATIVE ANALYSIS WITH NORMOTENSIVE PREGNANT WOMEN

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Abstract
Introduction: This analytical study explores the hemodynamic alterations linked to hypertensive diseases during pregnancy, highlighting the substantial influence these illnesses have on maternal health, especially in areas such as India where 7.8% of pregnant mothers experience problems connected to hypertension.
Aim and Objective: The purpose of the study is to evaluate echocardiographic changes in pregnant hypertensive women by contrasting them with their normotensive counterparts. The research methodology uses statistical analysis, ethical issues, and careful participant selection.
Methods and Material: End-diastolic volume of the left ventricle in pregnant women with and without hypertension conditions. The study used statistical analysis, specific exclusion criteria, and ethical considerations to shed light on complex cardiac dynamics with a sample size of 102. Methodological rigour was ensured by the step-by-step approach.
Result: According to the results, hypertensive cases had a higher BMI and significant variations in cardiac parameters, which highlight the cardiovascular burden of hypertensive illnesses during pregnancy.
Discussion: The debate highlights the value of echocardiography in detecting high-risk cases by placing findings within the perspective of previous research. The necessity of echocardiography in comprehending long-term clinical ramifications is emphasised in the investigation's conclusion.
Conclusion: Serious problems can be avoided with prompt echocardiography-guided management, but extra caution should be used when extrapolating results from single instances of congestive heart failure or left ventricular hypertrophy.
Keywords: Hypertension Disorder, Echocardiographic, normotensive pregnant women, Examination.

I. INTRODUCTION

Hypertensive disorders associated with pregnancy are a major danger to maternal health, accounting for a large portion of maternal morbidity and mortality worldwide. The impact is most noticeable in India, where 7.8% of expectant mothers have difficulties from hypertension diseases. The situation in developing countries is even more concerning because hypertension illnesses cause 10–15% of maternal deaths. Unfortunately, these disorders are the second most common cause of maternal death worldwide. Preeclampsia, eclampsia, chronic hypertension, and preeclampsia on top of chronic hypertension are all included in the spectrum of hypertensive disorders. These conditions vary in the difficulties they offer according to gestational age and the presence of proteinuria. Preeclampsia stands out among these as a serious issue, impacting the heart more severely than gestational hypertension [1]. Early detection and intervention are crucial due to the complex link between gestational age and the onset of hypertension diseases. Early-trimester studies that concentrate on the anatomy and function of the heart become crucial, offering better outcomes for expectant women and foetuses both.

The fact that hypertension related to pregnancy is the most common medical condition and the second largest cause of death for mothers highlights the need for thorough knowledge and efficient treatment [2]. Echocardiography becomes an indispensable diagnostic instrument, able to spot minute modifications in cardiovascular function prior to the development of serious clinical implications or the worsening of hypertension. Although [3] operator-dependent, this non-invasive technique shows little variability in terms of timing and offers important insights into the remodelling of the heart

linked to hypertension diseases. Preeclamptic women are more likely to have echocardiographic abnormalities such as concentric hypertrophy, increased left ventricular mass, and chamber enlargement [4]. Different hypertension illnesses show different patterns in systolic and diastolic functions; preeclampsia is frequently linked to more significant dysfunction, particularly in early onset cases. It is essential to comprehend these changes in the heart in order to create strategies that effectively manage hypertension diseases during pregnancy.

II. AIM AND OBJECTIVE

AIM:

The main goal of this study was to examine and evaluate the changes in echocardiography that occur in pregnant women with hypertensive diseases and then compare the results with those of pregnant women with normal blood pressure.

OBJECTIVES:

The research aimed to achieve the following particular goals:

- **Evaluation of Heart Dysfunction and Function:**

To conduct a thorough assessment of the functional and dysfunctional heart dynamics in pregnant women diagnosed with hypertension diseases.

- **Comparative Evaluation Using Pregnant Normotensive Women:**

To perform a comparative analysis by comparing and contrasting the echocardiographic alterations seen in normotensive pregnant women with those seen in women with hypertensive diseases.

- **Prognostic Assessment Using Echocardiographic Modifications:**

In order to forecast the anticipated course of events and prognosis for pregnant women afflicted with hypertensive illnesses, it is necessary to investigate the potential of echocardiographic alterations as prognostic markers.

III. METHODS AND MATERIAL

Subha Sivagami Sengoden et al.'s study sought to investigate the left ventricular end-diastolic volume (LVEDV) in two different populations: pregnant women with hypertensive diseases and pregnant women without hypertension. The investigators used a methodical approach, applying a formula that took into account the two groups' averages, standard deviations, power of the investigation, and significance level [5], [6]. By establishing a minimum sample size of 55 for every group, this technique made sure that their comparison analysis was statistically sound. The study's qualifying requirements for primigravida patients with hypertensive disorders of pregnancy were broad, highlighting the significance of this particular group in comprehending the cardiac [7] consequences associated with these conditions. Furthermore, a critical inclusion criterion that enabled a thorough investigation of cardiac dynamics in the latter stages of pregnancy was gestational age greater than 20 weeks till term. A crucial component of ethical research, informed consent, was taken into account to make sure that subjects gave their consent voluntarily [8].

This [9], [10] rigorous selection procedure was designed to separate the effects of hypertensive illnesses from other potential influences on cardiac parameters, such as pre-existing ailments. Additionally, patients who were in labour were eliminated since the dynamic physiological changes that occur during labour could bring unfavourable factors into the echocardiographic evaluation. The study's methodological rigor which includes determining the sample size and imposing strict eligibility criteria reflects a methodical approach to deciphering the intricate cardiac dynamics linked to hypertensive disorders of pregnancy. As a result, the study adds significant knowledge to the body of existing research on maternal-fetal medicine.

A. Procedure:

The stepwise approach contributes to the methodological rigour and validity of the echocardiographic evaluation in the setting of hypertensive disorders of pregnancy by ensuring clarity in patient selection, research design, diagnostic criteria, measurement procedures, and parameters investigated.

a. Patient Selection and Consent that is Informed:

After receiving signed informed consent from both patients and their families, patients who fit the requirements for inclusion in the Obstetrics and Gynaecology department were chosen as cases. Ensuring that participants voluntarily participate in the study and are aware of the nature and implications of their involvement is a vital ethical step.

b. Study Plan and Number of Samples:

102 women participated in the prospective observational study over a two-year period. With an emphasis on statistical robustness, the sample size of 51 patients with hypertension disorders of pregnancy and 51 normotensive patients as controls was established using a computed formula.

c. Pre-eclampsia and gestational hypertension definitions:

For uniformity, precise definitions of gestational hypertension and pre-eclampsia were given. New-onset hypertension (≥140/90 mmHg) that develops after 20 weeks of gestation combined with 24-hour proteinuria of 0.3 grammes or more was considered pre-eclampsia. After 20 weeks of gestation, increased blood pressure (≥140/90 mmHg) without proteinuria or other preeclamptic clinical signs was considered as gestational hypertension. These episodes had to occur at least 4 hours apart.

d. Measurement of Blood Pressure with Echocardiography Procedure:

A mercury sphygmomanometer with the proper cuff size was used to measure blood pressure accurately. Patients were placed in the left lateral position for echocardiography. A thorough evaluation was aided by the up to two echocardiograms performed at various gestational stages.

e. Cardiologist Assessment and Preliminary 2D Imaging:

A cardiologist examined each patient using an echo machine equipped with a 2.5 MHz transducer. Early 2D research made it possible to visually examine left ventricular contractile performance and evaluate heart anatomy.

f. Examined Systolic Parameters:

The systolic parameters that were measured were the left ventricular outflow tract (LVOT), left ventricular mass (LVM), cardiac output (CO), ejection fraction (EF), stroke volume (SV), left ventricle end systolic volume (LVESV), and aortic root diameter (ARD).

$$EF = \frac{(EDV - ESV)}{EDV \times 100}$$

The formula used to compute the Ejection Fraction (EF), with normal values falling between 50 and 75 percent.

g. Diastolic Measurements Examined:

Diastolic parameters included E and A waves, E/A ratio, E wave velocity time integral (E VTI), E wave deceleration time (DtE), isovolumetric relaxation time (IVRT), and A wave velocity time integral (A VTI). Particular criteria were given, such as the threshold for prolonged IVRT (>110 ms), which indicates diastolic dysfunction, and the E/A ratio (0.8 to 2).

B. Statistical Method:

- The study's data were subjected to a thorough statistical analysis using a variety of techniques in order to extract significant findings. The findings of continuous measures were summarised using descriptive statistics, which included frequency, percentage, mean, and standard deviation (SD) [11]. The results were presented in the form of Mean ± SD (Min-Max). Numbers and percentages were used to express categorical metrics. A rigorous 95% level of significance was strictly adhered to in the investigation, guaranteeing a solid assessment of the results.
- The study's assumptions were described in the context of inferential statistical analysis. It was assumed that samples were taken at random, cases within samples were independent, and dependent variables had a normal distribution [12]. The validity and dependability of the ensuing statistical analyses are predicated on these assumptions.
- To analyse the continuous scale parameters between groups, an independent Student t-test with two tails was utilised. The relevance of the study parameters between the two groups under inquiry was determined in large part thanks to this strategy. Being a flexible statistical tool, the t-test sheds light on mean differences and clarifies how hypertensive disorders affect different metrics.

C. Ethical Issues:

- The study's ethical considerations were carefully taken into account to protect the participants' rights and welfare. Prospective participants were given a comprehensive explanation of the study's nature and goal at the start of the procedure to ensure their comprehension in a language that was appropriate for them. The goal of this tailored strategy was to encourage prospective participants to make well-informed decisions.
- As soon as they understood the specifics of the study, participants had to give their free and informed consent by signing an informed consent form. The ethical commitment to respecting participants' autonomy was emphasised by the explicit act of signing the Informed Consent Form (ICF) and the emphasis on voluntariness.
- Giving participants the clear-cut option to withdraw from the study at any time, without having to give a reason, was part of the ethical guidelines. This clause reaffirmed the commitment to respecting participants' autonomy and made sure that their choice to withdraw would not affect their ability to get the care and treatment they need.
- Crucially, participants paid no additional expenses that were solely for the study's objectives. The investigator took up responsibility for any additional costs incurred for the study so as to save the participants from financial hardship.

IV. RESULT

A detailed summary of the distribution of Body Mass Index (BMI) between participants in the normotensive and hypertensive groups is given in Table 1. With a standard deviation of 3.24 and a mean BMI of 23.2 kg/m², the normotensive group had a lower BMI than the hypertensive group, which was 26.7 kg/m².

Table 1: The BMI of the participants in both research groups

Body mass index (kg/ m2)	Hypertensive (n = 55)		Normotensive (n = 55)		P Value
	Mean Value	Percentage	Mean Value	Percentage	
less than 18.5	3	5.45	7	12.73	0.0013
Between 18.5 - 25	11	2	16	29.09	
Between 25.1 - 30	31	56.36	24	43.64	
Greater than 30	10	18.18	8	14.55	
Total	55	100	55	100	
Mean BMI (kg/m2)	26.7	SD 7.11	23.2	SD 3.24	

There were significant variations (p = 0.0013) between the two groups in the distribution across BMI categories. Compared to the normotensive group, the hypertensive group notably had a greater percentage of subjects with a BMI over 30, indicating obesity.

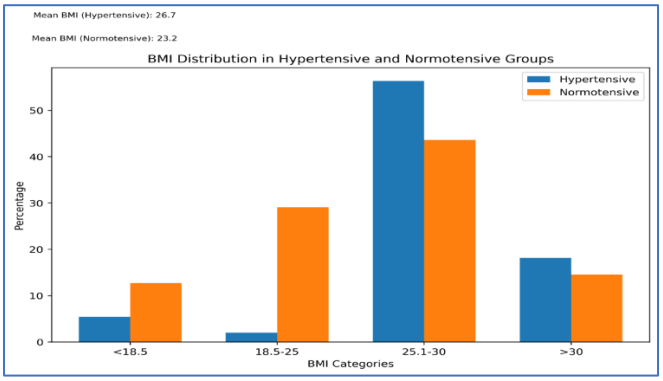

Figure 1: Representation of BMI of the participants in both research groups

The significance of taking BMI into account as a potential factor in the context of hypertensive problems during pregnancy is highlighted by this table. The cardiac parameters of the patients in the normotensive and hypertensive groups are examined in Table 2. The systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and heart rate are displayed together with their respective means and standard deviations. The considerable difference ($p < 0.001$) between the two groups suggests that hypertension diseases have a major effect on cardiac parameters. All measures showed higher values in the hypertension group, highlighting the burden that hypertensive disorders during pregnancy place on the cardiovascular system. Important information on the hemodynamic changes in pregnant hypertensive women is provided by this table.

Table 2: Cases' cardiac parameters in both research groups

Attribute	Hypertensive (n = 55)		Normotensive (n = 55)		P Value
	Mean Value	Standard Deviation	Mean Value	Standard Deviation	
SBP	155	13.45%	110.1	22.75%	leass than 0.001
DBP	98.4	93.60%	68.4	59.40%	leass than 0.001
MAP	116.8	98.70%	84.7	58.30%	leass than 0.001
Heart Beat Rate (beats/min)	91.4	13.31%	78.1	12.21%	leass than 0.001

The cardiac output (CO) and stroke volume (SV) in the normotensive and hypertensive groups are the main topics of Table 3.

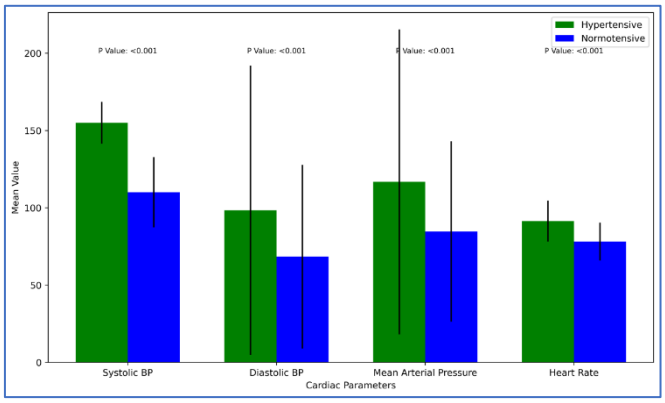

Figure 2: Cardiac Parameters in Hypertensive and Normotensive Groups

There is no discernible difference in stroke volume between the two groups, according to the mean values and standard deviations ($p = 0.84$). Nonetheless, there is a substantial difference in cardiac output ($p < 0.001$), highlighting the impaired heart function in hypertensive pregnancies. The group with hypertension exhibited increased cardiac output, confirming the complex connection between hypertensive conditions and the mechanics of the heart during pregnancy. Understanding the hemodynamic adjustments in the setting of hypertension disorders is made easier with the help of this table.

Table 3: Cases' cardiac output and stroke volume in both research groups

Attribute	Hypertensive (n =55)		Normotensive (n = 55)		P Value
	Mean Value	Standard Deviation	Mean Value	Standard Deviation	
SV (ml)	71.83	13.91%	72.22	3.28%	0.84
CO (ml/min)	68.19	4.65%	54.98	1.73%	Less than 0.001

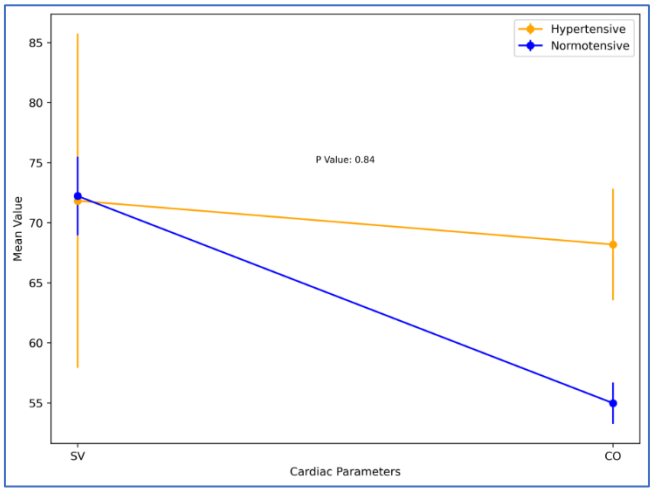

Figure 3: Stroke Volume and Cardiac Output in Hypertensive and Normotensive Groups

Table 4 classifies cardiac issues according to the type and severity of hypertension associated with pregnancy. The comprehensive results for various hypertension disorders include congestive heart failure (CCF), pulmonary edoema, and cardiomyopathy.

Table 4: Cardiac problems based on the kind and intensity of pregnancy-related hypertension

Attribute	Total Cases		Outcome		
	Cases	Percentage	CCF	Pulmonary Edema	Cardiomyopathy
Gestational Hypertension	12	21.82	0	0	0
Non severe Preeclampsia	16	29.09	0	0	0
Severe Preeclampsia	21	38.18	1	1	0
Ante partum eclampsia	6	10.91	0	0	0
Total	55	100	1	1	0

Significantly, CCF incidence was higher in severe preeclampsia, suggesting that more severe hypertension conditions involve a greater degree of cardiac involvement. This table aids doctors in comprehending the variety of cardiovascular difficulties that patients with pregnancy-related hypertension may encounter by offering a thorough overview of the cardiac issues linked to various forms of the condition.

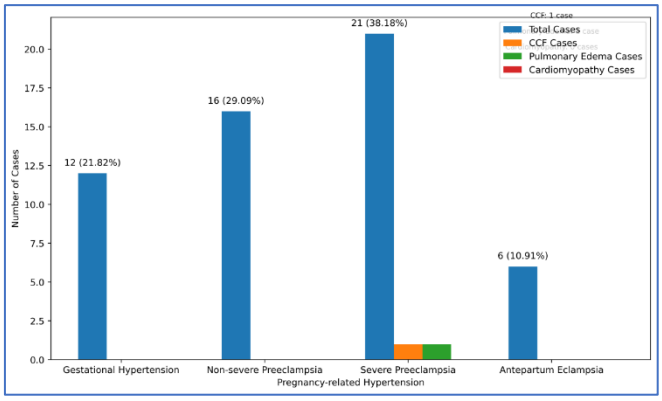

Figure 4: Cardiac Problems Based on Pregnancy-related Hypertension

V. DISCUSSION

Antenatal and foetal health are negatively impacted by preeclampsia, which is characterised by an angiogenic imbalance. After delivery, elevated antiangiogenic proteins such as soluble endoglin and soluble tyrosine kinase-1 (sFlt-1) remain elevated and are associated with long-lasting cardiac changes that can last up to a year. As preeclampsia progresses, peripheral vascular resistance increases, decreasing cardiac output and causing left ventricular hypertrophy and regional longitudinal systolic dysfunction. Preeclampsia, gestational hypertension, and chronic hypertension are all associated with pregnancy-related hypertension, which is the second greatest cause of maternal death. Increased peripheral vascular resistance, elevated afterload, cardiac remodelling, and perhaps decreased left ventricular ejection fraction are all caused by generalised vasospasm in hypertension. Echocardiograms were performed in the 110 pregnant women who were part of the conducted study, and the results were relevant. Compared to their normotensive counterparts, the subjects with hypertension disorders showed greater mean arterial pressure, heart rate, left ventricular end-systolic volume, and cardiac output. Echocardiographic metrics such as left ventricular mass, stroke volume, and ejection fraction also showed significant variations between the groups. Consistent with earlier research, the mean age and BMI comparisons produced non-significant findings. Interestingly, the differences in echocardiograms showed how hypertension diseases affected heart function. Diastolic dysfunction in hypertensive pregnancies was further highlighted by elevated E/A ratios, longer E wave deceleration time, and aberrant Tei index. The study also emphasised the necessity of early management and long-term surveillance due to the persistence of heart abnormalities after pregnancy.

VI. CONCLUSION

Investigating the hemodynamic changes associated with hypertension diseases during pregnancy, this analytical investigation found significant differences in circulatory dynamics, particularly systolic and diastolic dysfunction, between pregnant hypertensive and normotensive patients. According to the research, blood pressure monitoring alone may not be enough to detect cardiovascular risk in hypertensive pregnancies. Including maternal echocardiography in routine care guidelines may improve the identification of women who are at risk for cardiovascular events. Prompt detection and efficient treatment, guided by echocardiographic evaluations, can prevent serious outcomes such as heart failure and pulmonary edoema. The research emphasises how important echocardiography is to understanding the long-term clinical effects of hypertension problems during pregnancy. Even though echocardiography revealed two occurrences of left ventricular hypertrophy, it is important to proceed with caution when extrapolating findings from one case of congestive heart failure (CCF), since this problem can arise in people who are not hypertensive. There is a growing consensus to conduct a prospective cohort research with a large sample size in order to draw more reliable findings about the complex link between cardiovascular outcomes and hypertension problems during pregnancy.

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