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SONOGRAPHIC COMPARISON OF FETAL HEART RATE IN GESTATIONAL HYPERTENSIVE AND NORMOTENSIVE MOTHERS IN THE SECOND AND THIRD TRIMESTER

Original Research

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ABSTRACT

Background: Hypertensive disorders during pregnancy are among the leading causes of maternal and fetal morbidity and mortality worldwide. These conditions can significantly alter maternal cardiovascular dynamics, which in turn may impact fetal heart rate (FHR)—a key indicator of fetal well-being. Monitoring FHR through sonographic techniques provides critical insights into fetal health, particularly in pregnancies complicated by gestational hypertension.

Objective: To evaluate and compare fetal heart rate patterns between gestational hypertensive and normotensive mothers during the second and third trimesters using ultrasound imaging.

Methods: A comparative analytical study was conducted at the Radiology Department of Services Hospital Lahore, Pakistan, over six months from February 2019 to July 2019. After obtaining ethical approval from the Institutional Review Committee of the University of Lahore, a total of 130 pregnant women in their second and third trimesters were enrolled through convenience sampling. Among them, 21 women (16.1%) were diagnosed with gestational hypertension and 109 (83.8%) were normotensive. All participants underwent standardized obstetric ultrasound using a MINDRAY-DP-22 machine with a 3.5 MHz convex transducer. Gestational age and FHR were assessed using a four-chamber cardiac view, and FHR was recorded using M-mode ultrasound. Descriptive statistics were reported using mean, standard deviation, and percentage, while group comparisons were analyzed using the independent samples t-test.

Results: The mean fetal heart rate in gestational hypertensive mothers was significantly higher (173.71 ± 9.93 bpm) compared to normotensive mothers (150.23 ± 5.82 bpm) with a p-value of 0.000. The mean gestational age was 24.48 ± 3.20 weeks in the hypertensive group and 26.37 ± 4.16 weeks in the normotensive group. Most hypertensive cases occurred in the second trimester (n = 13, 16.4%) and among women aged 26–31 years.

Conclusion: Fetal heart rate was markedly elevated in pregnancies complicated by gestational hypertension, particularly during the second trimester. These findings underscore the influence of maternal blood pressure on fetal autonomic regulation and reinforce the value of early and regular sonographic monitoring in hypertensive pregnancies.

Keywords: Blood Pressure, Fetal Heart Rate, Gestational Age, Gestational Hypertension, Maternal Age, M-mode Ultrasound, Pregnancy Trimester, Second.

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INTRODUCTION

Ultrasonography has become an indispensable component of routine antepartum and intrapartum care, particularly for the non-invasive monitoring of fetal heart rate (FHR), a critical parameter in assessing fetal well-being. The FHR is not a static entity but evolves throughout gestation, reflecting the maturation of the autonomic nervous system and the developing fetal cardiovascular system. Typically, FHR is first detectable via ultrasound around the sixth week of gestation, beginning at approximately 100–120 beats per minute (bpm) and peaking near 150 bpm by the fourteenth week. It then gradually declines to about 140 bpm at 20 weeks and stabilizes around 130 bpm by term (1,2). The beat-to-beat variability in FHR, particularly noticeable in early gestation, becomes more regulated in the third trimester and is considered an essential indicator of fetal neurologic integrity (3,4). Despite some variation in guidelines, the International Federation of Gynecology and Obstetrics (FIGO) recommends a normal baseline FHR between 110 and 150 bpm, or alternatively between 120 and 160 bpm (4). Deviations such as tachycardia (>150 bpm) or bradycardia (<110 bpm) may be indicative of fetal compromise and warrant prompt evaluation (5). Among the various maternal conditions influencing FHR, hypertensive disorders of pregnancy (HDP) have received considerable attention. These disorders, affecting up to 10% of all pregnancies, have a profound impact on both maternal and fetal outcomes (6). Gestational hypertension, in particular, is the most prevalent and is diagnosed when systolic blood pressure reaches or exceeds 140 mmHg and/or diastolic pressure reaches or exceeds 90 mmHg after the 20th week of pregnancy in previously normotensive women, with confirmation on at least two occasions spaced six hours apart (7,8). Severe cases are characterized by systolic readings ≥160 mmHg or diastolic readings ≥110 mmHg sustained over a six-hour period (9).

Gestational hypertension is more commonly observed in nulliparous women, with reported prevalence ranging between 6% and 17%, whereas in multiparous women, the rate is lower, between 2% and 4% (10). The condition is a leading contributor to maternal and fetal morbidity and mortality, implicated in up to 15% of maternal deaths worldwide (11). One of its most concerning pathophysiological effects is the compromise of placental blood flow, resulting in increased vascular impedance and oxidative stress that disrupt fetal hemodynamic and endocrine development (12). Furthermore, approximately 50% of women diagnosed with gestational hypertension may progress to preeclampsia, exacerbating the risk to both mother and fetus (13). Evidence also suggests a strong association between maternal hypertension and altered fetal heart rate patterns, mediated by maternal autonomic dysregulation. In such pregnancies, a shift towards increased sympathetic and reduced parasympathetic modulation in the maternal cardiovascular system can impair placental perfusion, thereby influencing fetal cardiac function (6). Given that the offspring of hypertensive mothers are at an increased lifetime risk of developing hypertension themselves, early diagnosis and careful monitoring become paramount (14). Normotensive maternal blood pressure typically hovers around 120/80 mmHg, and a prior history of hypertension should be a critical component of prenatal assessment (15). However, clinical practice often places greater emphasis on fetal complications than maternal risks, leading to potential gaps in holistic perinatal care (8,10). Recognizing this, the present study was undertaken to determine the prevalence, risk factors, and maternal-fetal outcomes of gestational hypertension, with particular attention to differences between primigravid and multigravid women. Moreover, it aimed to explore the correlation between maternal cardiac autonomic regulation and fetal heart rate variability, thereby offering new insights into the maternal-fetal cardiovascular interplay in hypertensive pregnancies. Through the use of ultrasound—an accessible, affordable, and safe diagnostic modality—the study seeks to identify early indicators of risk, improve outcomes, and contribute to the reduction of maternal and neonatal morbidity and mortality in the regional context.

METHODS

This observational study was conducted at Services Hospital Lahore over a six-month period from September 2020 to February 2021, following approval by the Institutional Review Committee of the University of Lahore. A total of 130 pregnant women in their second and third trimesters were enrolled after providing written informed consent. Ethical guidelines were strictly adhered to, and all participants were informed about the purpose, procedures, and voluntary nature of the study. The sample comprised 21 women diagnosed with gestational hypertension and 109 normotensive controls. Only women with singleton pregnancies beyond the 19th week of gestation were eligible. The inclusion criteria for the hypertensive group involved women of reproductive age with a systolic blood pressure of ≥140 mmHg after 20 weeks of gestation, without proteinuria, and not diagnosed with preeclampsia. Normotensive participants were selected from the same population cohort, ensuring comparable baseline characteristics. Exclusion criteria applied to both groups

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included women with gestational diabetes, pre-existing diabetes mellitus, intrauterine growth restriction (IUGR), structural fetal anomalies, obesity, eclampsia, or superimposed preeclampsia. This exclusion was implemented to eliminate confounding factors that could influence fetal heart rate variability.

Maternal blood pressure was measured using a standard mercury sphygmomanometer under controlled conditions. Participants were seated with their feet flat on the floor, legs uncrossed, and backs fully supported. Measurements were taken after five minutes of rest, and participants were instructed to avoid speaking or engaging in distracting activities such as using a mobile phone or reading. The arm was supported at heart level using a pillow, and an appropriately sized cuff—covering two-thirds the length between the shoulder and elbow—was used. The cuff's lower edge was placed 1–2 cm above the antecubital fossa. Incorrect cuff size or positioning was carefully avoided, as these factors can lead to errors of up to 13 mmHg in systolic and 10 mmHg in diastolic readings (16). Initial readings were discarded, and the average of two subsequent measurements, taken one minute apart, was used for analysis, in accordance with best-practice guidelines (17,18). Fetal heart rate (FHR) assessment was performed using an ultrasound system (MINDRAY-DP-22) equipped with a 3.5 MHz convex transducer suitable for obstetric use. Cross-sectional grey-scale sonographic imaging was employed to visualize fetal heart activity. Scans were conducted with the patient in a supine position, employing longitudinal, transverse, and oblique planes to localize the fetal heart and obtain a four-chamber view. Once the heart was clearly visualized, M-mode (motion mode) ultrasound was activated to record fetal cardiac cycles and calculate the FHR. This technique projects a single scan line over time to detect cardiac motion and interval timing, making it suitable for evaluating atrioventricular synchrony, heart rate, and arrhythmias such as bradycardia and tachycardia (19). The sonographic evaluations were carried out by two experienced obstetricians and sonographers to ensure consistency and reduce inter-observer variability.

Ultrasound-based heart rate measurements involved identification of the region of interest (ROI) and positioning of M-mode lines through the fetal heart. Fetal heartbeats were detected by measuring the distance between two successive peaks corresponding to heart wall motion. Automated ranking of echo signals was applied to improve the reliability of heartbeat detection within the ROI (20). The use of ultrasound, a non-ionizing and non-invasive modality, made it an ideal choice for repeated fetal assessments throughout gestation. Data collected were analyzed using SPSS version 20 and Microsoft Excel 2016. Levene's test was used to assess the equality of variances. The independent samples t-test was applied to compare FHR values between hypertensive and normotensive groups. Quantitative variables such as maternal age were presented as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Bar charts and pie charts were used for graphical representation of categorical data. A p-value < 0.05 was considered statistically significant.

RESULTS

The study involved 130 pregnant women, with 16.1% (n=21) classified as gestational hypertensive and 83.8% (n=109) as normotensive. The mean maternal age among hypertensive participants was 26.52 ± 3.29 years, while in the normotensive group, it was 26.27 ± 3.64 years. The gestational age in weeks was slightly lower in the hypertensive group (mean: 24.48 ± 3.20) compared to the normotensive group (mean: 26.37 ± 4.16). Systolic and diastolic blood pressures were significantly elevated in the gestational hypertensive group. The mean systolic blood pressure among hypertensive mothers was 146.47 ± 5.86 mmHg compared to 108.35 ± 7.11 mmHg in normotensive mothers. Similarly, the mean diastolic blood pressure in hypertensive pregnancies was 91.95 ± 3.38 mmHg versus 72.22 ± 6.09 mmHg in the normotensive group. Fetal heart rate values were also considerably higher in the hypertensive group. The mean FHR in gestational hypertensive pregnancies was 173.71 ± 9.93 bpm, whereas in normotensive pregnancies it was 150.23 ± 5.82 bpm. The comparison of gestational ages revealed that gestational hypertension was more prevalent during the second trimester (20–26 weeks), accounting for 61.9% of hypertensive cases. Fewer cases were observed at the beginning of the third trimester, with no increase noted in later weeks. Regarding maternal age groups, the highest frequency of gestational hypertension was found in women aged 26–30 years (52.3% of hypertensive cases), followed by the 19–25 and 32–35 age brackets. Statistical analysis using an independent samples t-test showed a highly significant difference between the mean FHR values of the hypertensive and normotensive groups ($p = 0.000$), confirming that gestational hypertension significantly influences fetal heart rate. Levene's test confirmed the equality of variances, validating the use of the t-test.

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Table 1: Descriptive Statistics of frequency comparison of GHTN and Normotensive mothers

	Frequency	Percentage%
Gestational Hypertensive	21	16.1
Gestational Normotensive	109	83.8
Total	130	100.0

Table 2: Descriptive Statistics of Maternal Age, Gestational Age, and Blood Pressure in Gestational Hypertensive and Normotensive Pregnancies

Parameter	Maternal Hypertension	N	Minimum	Maximum	Mean	Std. Deviation
Maternal Age (in years)	Gestational Hypertensive	21	20.00	33.00	26.5238	3.29
	Gestational Normotensive	109	19.00	35.00	26.2661	3.64296
	Total	130	19.00	35.00	26.3077	3.58
Gestational Age (in weeks)	Gestational Hypertensive	21	20.00	30.00	24.4762	3.20
	Gestational Normotensive	109	20.00	37.00	26.3670	4.16
	Total	130	20.00	37.00	26.0615	4.07
Maternal Systolic BP (mmHg)	Gestational Hypertensive	21	135.00	157.00	146.4762	5.86190
	Gestational Normotensive	109	91.00	120.00	108.3486	7.11203
	Total	130	91.00	157.00	114.5077	15.68747
Maternal Diastolic BP (mmHg)	Gestational Hypertensive	21	82.00	98.00	91.9524	3.38343
	Gestational Normotensive	109	59.00	89.00	72.2202	6.08635
	Total	130	59.00	98.00	75.4077	9.27002

Table 3: Descriptive Statistics of Fetal Heart Rate of participant

Maternal Hypertension	N	Minimum	Maximum	Mean	Std. Deviation
Gestational Hypertensive	21	161.00	194.00	173.7143	9.92544
Gestational Normotensive	109	136.00	160.00	150.2294	5.81606
Total	130	136.00	194.00	154.0231	10.90300

Table 4: Descriptive statistics of comparison of G.A among GHTN and normotensive pregnancies

Gestational Age			Gestational Hypertensive OR Normotensive		Total
			Hypertensive	Normotensive	
Gestational Age	2nd Trimester	Count	13	66	79
		% Within GAW	16.4%	83.5%	100.0%
	3rd Trimester	Count	8	43	51
		% Within GAW	15.6%	84.3%	100.0%
Total		Count	21	109	130
		% Within GAW	16.1%	83.8%	100.0%

Table 5: Descriptive statistics of comparison of maternal age among GHTN and normotensive pregnancies

			Gestational Normotensive OR Hypertensive		Total
			Hypertensive	Normotensive	
Age Group	19-25	Count	8	42	50
		% Within Age Group	16.0%	84.0%	100.0%
	26-31	Count	11	59	70
		% Within Age Group	15.7%	84.2%	100.0%
	32-35	Count	2	8	10
		% Within Age Group	20.0%	80.0%	100.0%
Total		Count	21	109	130
		% Within Age Group	16.1%	83.8%	100.0%

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Table 6: Descriptive statistics for Independent Sample Test

	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	14.884	128.000	.000	23.490	1.578
Equal variances not assumed	10.510	22.712	.000	23.490	2.235

Table 7: Descriptive statistics for Independent Sample Test

	t-test for Equality of Means	
	95% Confidence Interval of the Difference	
	Lower Limit	Upper Limit
Asymptotic (equal variance)	20.397	26.583
Asymptotic (unequal variance)	19.109	27.871
Exact (equal variance)	20.367	26.613
Exact (unequal variance)	18.863	28.117

Note: t, computed test statistic; df, degrees of freedom; Sig. (2-tailed), p-value corresponding to the given statistic and degrees of freedom.

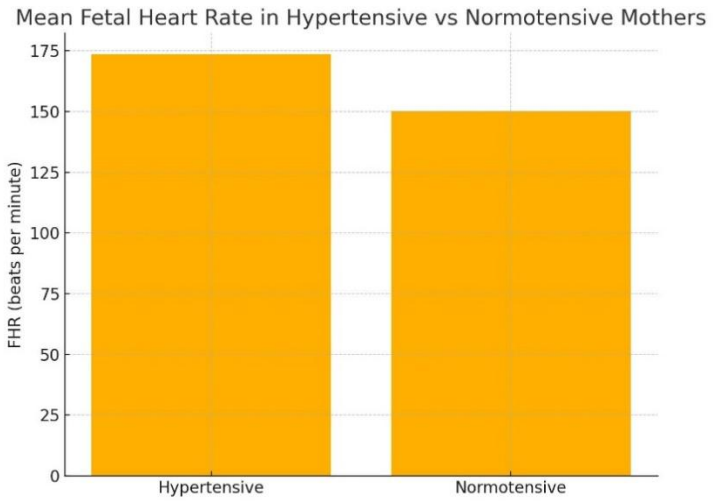

Figure 1 Mean Fetal Heart Rate in Hypertensive bs Normotensive Mothers

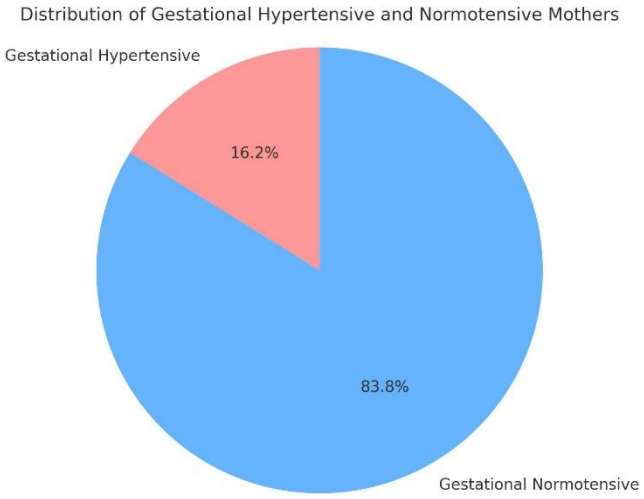

Figure 2 Distribution of Gestational Hypertensive and Normotensive Mothers

DISCUSSION

This study investigated the association between maternal heart rate variability and fetal heart rate (FHR) in pregnancies complicated by gestational hypertension, particularly during the second and third trimesters. The findings reaffirmed that fetal cardiac activity is strongly influenced by maternal hemodynamic status, particularly in the context of gestational hypertension. A significantly elevated FHR was observed in hypertensive mothers compared to normotensive counterparts, with the difference reaching high statistical significance ($p = 0.000$). This aligns with prior research indicating that elevated maternal blood pressure can alter fetal cardiovascular responses due to compromised placental perfusion and increased sympathetic activity mediated through maternal autonomic dysfunction (15). Fetal heart rate generally stabilizes within the range of 120–160 bpm after the 19th gestational week; however, this study found values exceeding 170 bpm in hypertensive cases, highlighting the potential for early cardiac stress in fetuses of hypertensive mothers. A particularly noteworthy case involved a maternal systolic blood pressure of 157 mmHg and diastolic pressure of 91 mmHg, where the FHR reached

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179 bpm, suggesting a possible relationship between the severity of maternal hypertension and fetal tachycardia (16,17). While most of the hypertensive cases in the study fell within mild to moderate categories, the lack of severe hypertension cases limited the spectrum of observations and reduced the ability to extrapolate findings to more severe forms of hypertensive disorders.

Epidemiologically, the findings were consistent with regional and global trends. The prevalence of gestational hypertension observed in this study (16.1%) fell within the commonly reported range of 6–17% in nulliparous women and 2–4% in multiparous women (17,18). Comparative data from other regions support these figures, with incidence rates reported at 37% in Karachi, 19.4% in Zimbabwe, and 20.8% in Nigeria (19,20). These variances underscore the role of population-specific risk factors, healthcare access, and diagnostic practices in shaping epidemiological trends. Maternal age was found to be a contributing factor in the distribution of gestational hypertension, with the highest frequencies recorded among women aged 26–31 years, followed closely by those aged 19–25 years. Women aged 32–35 years showed the lowest incidence. These findings support the need for targeted antenatal counseling and early screening, particularly in younger pregnant women who may not typically be considered high-risk but appear vulnerable to hypertensive complications in this cohort (21). One of the strengths of this study lies in its exclusive focus on gestational hypertension, distinct from more complex multisystem disorders such as preeclampsia. By isolating uncomplicated gestational hypertension, the study was able to more precisely explore the maternal cardiovascular influence on fetal parameters without the confounding systemic effects of proteinuria or organ dysfunction. Additionally, the use of standardized ultrasound-based M-mode imaging and validated blood pressure measurement techniques enhanced the reliability of the data collected.

However, the study was not without limitations. The sample size, particularly in the hypertensive subgroup, was relatively small, which may limit the generalizability of the findings. The absence of cases with severe hypertension restricted the ability to examine the full spectrum of hypertensive effects on fetal outcomes. Furthermore, the study did not incorporate longitudinal tracking of FHR changes over time or postpartum neonatal outcomes such as birth weight, Apgar scores, or neonatal intensive care unit (NICU) admissions, which could have provided a more comprehensive assessment of the clinical implications of maternal hypertension on fetal health. Future studies should include larger, more diverse populations and incorporate longitudinal follow-up to better understand the trajectory of fetal cardiac changes in relation to varying degrees of maternal hypertension. Additionally, integrating biochemical markers of placental function and maternal vascular resistance may yield deeper insights into the pathophysiological mechanisms underlying these associations. While this study offers valuable evidence linking gestational hypertension to altered fetal heart rate patterns, continued investigation is essential to inform early detection, risk stratification, and timely intervention strategies that could reduce maternal and neonatal morbidity.

Conclusion

The study concludes that gestational hypertension significantly influences fetal heart rate patterns, reflecting the close interplay between maternal cardiovascular status and fetal well-being. By highlighting the elevated FHR observed in hypertensive pregnancies compared to normotensive ones, the findings emphasize the importance of vigilant monitoring and early detection of maternal blood pressure changes during the second and third trimesters. The use of ultrasound as a non-invasive and reliable tool proved effective in identifying these variations, underscoring its value in routine antenatal care. These insights support the need for timely intervention strategies to minimize adverse maternal and fetal outcomes and contribute to improved perinatal health management.

AUTHOR CONTRIBUTION

Author	Contribution
Javeria Afzal*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Iqra Manzoor	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Syed Yousaf Gilani	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Kaynat Mustafa	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Tayyaba Zahid	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

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