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Research Paper

Electrocardiographic Changes During Normal Pregnancy In Southern Nigeria

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ABSTRACT
BACKGROUND: There are major hemodynamic changes that occur during normal pregnancy, and this may produce clinical manifestations which can mimic cardiac disorders. These hemodynamic adaptations can result in several electrocardiographic (ECG) changes reported during normal pregnancy. Data on ECG changes in the three trimesters of normal pregnancy are few in Southern Nigeria
OBJECTIVE: The aim of this study was to describe the resting electrocardiogram (ECG) changes in healthy pregnant women and to compare them with non-pregnant women of same age group in Southern Nigeria
METHODOLOGY: This is a cross-sectional descriptive study comprising one hundred and fiftyhealthy pregnant women (50 each in their first, second and third trimesters) and 50 age matched non-pregnant controls. A 12-lead resting electrocardiogram (ECG) was recorded in all the participants and control.
RESULTS: The mean age of the study participants was 30.81 ± 4.7 years. The mean weight, body mass index (BMI) and heart rate were higher in the pregnant subjects than the controls (79.70±13.38 kg vs 73.84±15.12 kg, p=0.002, 30.16±5.28 vs 28.32±5.64kg/m^2,p = 0.0 82.43±10.99 vs 77.96±10.99 beats/min respectively, p = 0.001). The mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) were lower in the pregnant subjects compared to the controls (114.72±9.8 vs 115.64±9.8 mmHg, 72.77±9.1 vs 73.12±7.3 mmHg) with a significant drop in DBP in the third trimester.SignificantECG changes in the pregnant subjects in comparison with the controlswerereduced QTc duration in 2nd and 3rd trimesters, left axis deviation (LAD), increased QRS duration andleft ventricular hypertrophy (LVH) in the third trimester.
CONCLUSION: Electrocardiographic changes that results from hemodynamic adaptations were found in healthy women with normal pregnancy. The understanding of these physiologic changes is important to be able to distinguish between pathological changes during evaluation and interpretation of ECG in pregnant women.

Keywords: *Electrocardiographic changes, normal pregnancy, hemodynamic changes, left ventricular hypertrophy, left axis deviation, Nigeria*

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I. INTRODUCTION

Pregnancy is a physiologic condition that is characterized by major hemodynamic changes which may produce symptoms and signs that may mimic cardiovascular disorders. These hemodynamic adaptations usually begin in the first trimester and increases to 50% and above in the second and third trimesters. The hemodynamic changes include increase in blood volume, cardiac output and decreased systemic vascular resistance (SVR) and vascular reactivity.[1]The heart rate (HR) also increases by 25% due to increased adrenergic activity. There is increase in preload that is due to increased circulating volume and afterload decreases due to decreased SVR and all these factors increases the cardiac output.[2]

The size of the cardiac silhouette increases during pregnancy as a result of upward displacement by the enlarging uterus and together with the hemodynamic adaptations that occurs during pregnancy can lead to different changes on the ECG, which must be considered during ECG interpretation to avoid errors[3,4]. Electrocardiogram is a graphical record of summated action potentials generated in cardiac muscle by means of metal electrodes placed on the surface of the body on a moving strip of paper[5]. Interpretation of the ECG is an important component in the evaluation of heart disease.

Data on ECG changes in the three trimesters during normal pregnancy in Nigeria and other African countries are few. This study was carried out to identify the electrocardiographic changes among healthy

pregnant women compared with age matched control group of non-pregnant women in Southern Nigeria, a developing West African country.

II. METHODS

The data was derived from a cross-sectional comparative study design involving 150 healthy women (50 each in their first, second, and third trimesters) and 50 age-matched non-pregnant controls carried out at two private hospitals in Port Harcourt, Rivers State between November and December 2022.

Inclusion criteria:
Normal healthy pregnant women
Exclusion criteria: Women with valvular heart disease, coronary artery disease, systemic hypertension, diabetes mellitus, renal disease, thyroid disorder, severe anemia, and on any chronic medication. Informed consent was taken from all participants in the study.A detailed history was obtained, a thorough physical examination was carried out and anthropometric measurements which includedweight, height, and BMI were taken. The HR, SBP and DBP were also recorded. A 12 lead ECG and a rhythm strip were recorded for all participants at rest using a 12 -channel BTL-08-MT plus electrocardiograph. All the ECG indices were measured manually according to standard recommendations[6].

The data obtained were entered into Microsoft excel and exported to IBM SPSS version 25 for analysis. Descriptive tables were represented as Mean and standard deviation as well charts indicating frequencies and proportions. Inferential statistics was conducted using independent sample t test for numerical variables and chi square for categorical variables. P value of ≤ 0.05 was considered statistically significant.

III. Results

Sociodemographic characteristics of participants of the study

The pregnant participants were matched for age with non-pregnant participants. The mean age of the participants was 30.81±4.7yrsvs 30.76 ± 5.98yrs in the pregnant and non-pregnant participants respectively. The age range was between 18 and 43 years.The mean weight of the participants was significantly higher, 79.7± 13.38kgcompared to 73.84± 15.12kg in the non -pregnant group (p = 0.002) as seen in table 1.There was also a significant increase in mean body mass index(BMI) and pulse rate in pregnant participants compared to the non-pregnant control group(Table 1.)

Table 1.Anthropometric and cardiovascular characteristics among pregnant and non-pregnant participants of the study

Variables	Study groups				T	P value
	Pregnant		Non-pregnant			
	(Mean±SD)	Range	(Mean±SD)	Range		
Age	30.81±4.70	18-42	30.76±5.98	21-43	0.066	0.948
Weight	79.7±13.38	48-108	73.84±15.12	47-105	3.142	0.002*
Height	162.63±5.9	140-185	161.44±5.34	149-174	1.642	0.102
BMI	30.16±5.28	19.47-42.19	28.32±5.64	17.91-41.91	2.593	0.010*
PR	82.43±10.9	60-115	77.96±10.99	60-98	3.303	0.001*
SBP	114.72±9.7	90-140	115.64±9.79	98-137	-0.581	0.562
DBP	72.77±9.15	50-94	73.12±7.27	60-84	-0.333	0.740

*p – value statistically significant, BMI- Body mass index, PR- Pulse rate, SBP- Systolic blood pressure(mmHg), DBP- Diastolic blood pressure(mmHg), weight (kg), Height (cm).

The weight, BMI and pulse rate increased significantly from the first to the third trimester(p values 0.019, 0.046, and 0.001 respectively) in table 2. The mean systolic and diastolic blood pressures were reduced in the pregnant women compared to the non-pregnant women but did not show any statistical significance. When the DBP was compared in the 3 trimesters there was a significant decrease from74.54 ± 7.79 mmHgin the first trimester to 68.93 ± 8.92mmHg in the third trimester (p 0.048) in Table 2

Table 2.Comparison of variables among the three trimesters of pregnancy

Variables	Trimesters (N=150) (Mean±SD)			F	P value
	1st Trimester n=50	2nd Trimester n=50	3rd Trimester n=50		
Age	30.38±5.06	31.38±4.62	30.66±4.40	0.599	0.551
Weight	77.84±13.79	77.24±12.79	84.02±12.72	4.098	0.019*
Height	161.36±5.22	162.94±5.36	163.58±7.02	1.860	0.159
BMI	30.06±5.78	28.91±4.49	31.52±5.27	3.142	0.046*
Pulse Rate	79.54±8.14	79.74±9.97	88.00±12.42	10.928	0.001*
SBP	115.12±11.04	115.46±9.04	113.20±8.92	0.902	0.408
DBP	74.54±7.79	73.12±8.93	68.93±8.92	2.294	0.048*

*p – value statistically significant, BMI- Body mass index, SBP- Systolic blood pressure(mmHg), DBP-Diastolic blood pressure(mmHg), Weight kg, Height (cm).

When the ECG parameters were compared in the 3 trimesters, the heart rate significantly increased from the first to the third trimesters. The PR interval, P-wave duration, and P wave amplitude did not show any significant differencein the three trimesters compared to the non-pregnant controls. The QRS duration was significantly prolonged in the third trimester of pregnancy compared to the non-pregnant control (87.96 ± 16.95 vs 83.40± 10.88, p value =0.0192). Left ventricular hypertrophy assessed using the mean SV1+RV5 (Sokolow-Lyon criteria)was significantly increased in the third trimestercompared to that in the non-pregnant group (Table 5).The mean corrected QT interval by Framingham's formulawas significantly reduced in the second and third trimesters of pregnancy compared to the mean QTc in non-pregnant controls (p= 0.001 and 0.008 respectively) as seen in Table 4.

Table 3.Comparison of Quantitative ECG features in the different trimesters of pregnancy

Variables	Trimesters (N=150)			F	P value
	1st Trimester Mean±SD	2nd Trimester Mean±SD	3rd Trimester Mean±SD		
Heart rate	80.88±11.25	80.28±13.49	87.36±11.00	5.381	0.006*
P Wave Duration	90.96±15.15	93.32±18.60	91.28±15.15	2.672	0.072
P wave amplitude	1.20±0.40	1.22±0.42	1.26±0.44	1.628	0.200
PR Interval	173.40±16.61	171.40±19.79	170.00±17.96	1.119	0.226
QRS Duration	83.40±10.99	86.53±8.79	87.96±16.95	1.669	0.192
SVI+RV5Sokolow-Lyon criteria	24.32±6.01	24.37±6.26	25.80±6.29	0.905	0.407
QTC Bazzet	422.92±20.34	413.82±17.25	420.46±22.56	1.891	0.132
QTC Framingham	403.66±13.91	395.28±12.64	396.80±17.18	5.817	0.001*

*p – value statistically significant

Table 4. Comparison of continuous ECG findings of each trimester with non-pregnant women

Variables	Study groups (N=200)			
	Non-Pregnant (Group I)	1st Trimester (n=50) (Group II)	2nd Trimester (n=50) (Group III)	3rd Trimester (n=50) (Group IV)
Heart rate	74.56 ± 9.38	80.88 ± 11.25 **I vs II =0.006***	80.28 ± 13.49 **I vs III=0.016***	87.36 ± 11.00 **I vs IV=0.001***
PR Interval	177.20±27.56	173.40±16.61 **I vs II=0.943**	171.40±19.79 **I vs III=0.942**	170.00±17.96 **I vs IV=0.242**
P Wave Duration	97.40±15.41	90.96±15.15 **I vs II=0.098**	93.32±18.60 **I vs III= 0.236**	91.28±15.15 **I vs IV=0.126**
P wave amplitude	1.30±0.46	1.20±0.40 **I vs II=0.253**	1.22±0.42 **I vs III=0.367**	1.26±0.44 **I vs IV=0.660**

QRS Duration	81.60±7.52	83.40±10.99 **I vs II= 0.776**	86.53±8.79 **I vs III=0.212**	87.96±16.95 **I vs IV= 0.045***
SVI+RV5	23.12 ± 5.31	24.32±6.08 **I vs II=0.637**	24.37 ± 6.26 **I vs III=0.612**	25.80 ± 6.28 **I vs IV=0.045***
QTC Bazzet	417.78±19.64	422.92±20.34 **I vs II=0.202**	413.82±17.25 **I vs III=0.287**	420.46±22.56 **I vs IV=0.528**
QTC Framingham	405.70±15.63	403.66±13.91 **I vs II=0.492**	395.28±12.64 **I vs III=0.001***	396.80±17.18 **I vs IV=0.008***

*p – value statistically significant,SVI+RV5(Sokolow-Lyon criteria)

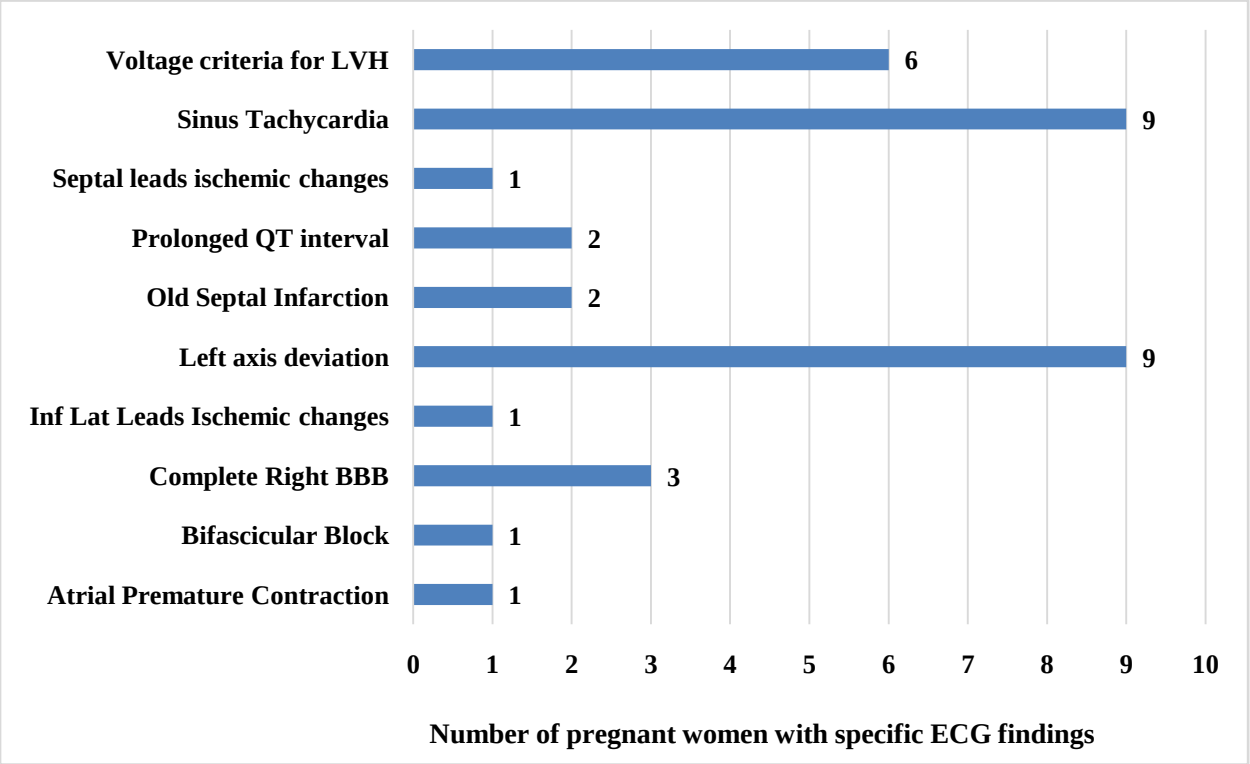

Fig. 1 Specific ECG abnormalities among participants of the study

Table 5. Comparison of categorical ECG findings of each trimester with non-pregnant women

Variables	**Trimesters (N=200)**			
	Non-Pregnant (n=50) (Group I)	**1st Trimester (n=50) (Group II)**	**2nd Trimester (n=50) (Group III)**	**3rd Trimester (n=50) (Group IV)**
APC				
Absent	50 (100.0)	50 (100.0)	49 (98.0)	50 (100.0)
Present	0 (0.0)	0 (0.0)	1 (2.0)	0 (0.0)
		I vs II=1.000	**I vs III=0.315**	**I vs IV=1.000**
QRS Axis				
Abnormal	1 (2.0)	0 (0.0)	3 (6.0)	6 (12.0)
Normal	49 (98.0)	50 (100.0)	47 (94.0)	44 (88.0)
		I vs II =0.617	**I vs III=0.315**	**I vs IV=0.05***
LVH voltage criteria				
Abnormal	1 (2.0)	1 (2.0)	2 (4.0)	3 (6.0)
Normal	49 (98.0)	49 (98.0)	48 (96.0)	47 (94.0)
		I vs II =1.000	**I vs III=0.558**	**I vs IV=0.307**
RSR				
Normal	50 (100.0)	46 (92.0)	49 (98.0)	49 (98.0)
V1	0 (0.0)	0 (0.0)	1 (2.0)	0 (0.0)
V2	0 (0.0)	1 (2.0)	0 (0.0)	0 (0.0)
V1-V3	0 (0.0)	3 (6.0)	0 (0.0)	1 (2.0)
		I vs II =0.117	**I vs III=0.315**	**I vs IV=0.315**
Sinus Tachycardia				
Yes	0 (0.0)	2 (4.0)	3 (6.0)	4 (8.0)
No	50 (100.0)	48 (96.0)	47 (94.0)	46 (92.0)
		I vs II =0.495	**I vs III=0.079**	**I vs IV=0.041***
T wave Inversion				
Normal	50(100.0)	47 (94.0)	49 (98.0)	46 (92.0)

Lead III	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.0)
V1-V3	0 (0.0)	2 (4.0)	0 (0.0)	1 (2.0)
V2-V3	0 (0.0)	1 (2.0)	1 (2.0)	0 (0.0)
V3-V6	0 (0.0)	0 (0.0)	0 (0.0)	2 (4.0)
		I vs II =0.242	**I vs III=0.315**	**I vs IV=0.117**
Tall Broad T waves				
Absent	50 (100.0)	50 (100.0)	48 (96.0)	49 (98.0)
Present	0 (0.0)	0 (0.0)	2 (4.0)	1 (2.0)
		I vs II =1.000	**I vs III=0.495**	**I vs IV=0.315**
Path Q Waves				
Absent	50 (100.0)	48 (96.0)	50 (100.0)	49 (98.0)
Present	0 (0.0)	2 (4.0)	0 (0.0)	1 (2.0)
		I vs II =0.495	**I vs III=1.000**	**I vs IV=0.315**

*p – value statistically significant, APC- atrial premature complexes

Table 6.Comparison of Sinus tachycardia and left axis deviation in study population

Variables	**Study groups**		**X^2**	**p- value**
	Pregnant n (%)	**Non-Pregnant n (%)**		
Sinus Tachycardia			5.318	0.021*
No	141 (94.0)	50 (100.0)		
Yes	9 (6.0)	0 (0.0)		
Left axis deviation				
No	141 (94.0)	49 (98.0)	1.512	0.261
Yes	9 (6.0)	1 (2.0)		
LVH				
No	143 (95.3)	49 (98.0)	0.694	0.405
Yes	7 (4.7)	1 (2.0)		

*p – value statistically significant, LVH- Left ventricular hypertrophy

IV. Discussion

ECG is a non-invasive procedure that may be performed in pregnant women who present with symptoms like chest pain, palpitation and dizziness. Adaptive ECG changes may occur especially in the second and third trimester of pregnancy that may mimic pathologic findings of ECG. Pregnancy may also unmask cardiac conditions.It is necessary to distinguish adaptive ECG changes that occur in normal pregnancy from pathologic changes.

In this study, there was a significant increase in heart rate during pregnancy particularly during the third trimester which was similar to some other studies.[7,8,9,10] Heart rate may increase due to sympathetic and hormonal variations in normal pregnancy. A compensatory rise inHR may be due to adecrease in stroke volume fromcaval compression.We found a slight non-significant reduction in systolic blood pressure in the third trimester while diastolic blood pressure reduced significantly from the first trimester to the third trimester. Areduction in SBP and DBP was also noticed by Salisu et al in their study on rural pregnant women and Akinwusi et al who also had significant reduction in DBP[9,11].Uterine blood flow is known to increase in pregnancy and is associated with a fall in peripheral resistance and slight fall in blood pressure that begins in the first trimester.[12]

Our study did not show any significant change in Pwave duration or amplitude which was also noted by Parthasarathy et al in their study in 150 pregnant women[13].The mean PR interval in this study wasreduced to 170±17.96ms in the third trimester and did not show any statistical significance compared to lower values byVenkatachalam et al[7]and Kole et al[14] who had PR intervals of124ms and 120ms respectively. This study also had older females than the studies with lower PR interval, so despite the significant tachycardiathat is usually associated with a reduced PR interval, our study did not show a significant reduction. Several studies have associated increased PR interval to result from with increased age.[15,16,17.]

QTC interval in the study was measured using Bazzet and Framingham. The QTC interval in this study based onBazzet's estimation did not vary significantly amongst the three trimestersor when compared tothe control group. With Framingham, a significantly reduced QTC interval was noted in this study during the second and third trimester of pregnancy and this report was in contrast with values obtained from a previous study.[9] QTC interval changes is usually related to alteration in properties of the cardiac muscles by pregnancy hormones. Comparison of the QRS axis among patients within the various trimester revealed a significant Abnormal QRS axis in the third trimester ($p < 0.05$) and this was similar to other studies.[11,15,18-23]Left axis

deviation(LAD) is due to the enlarging uterus raising the diaphragm as the pregnancy progresses resulting in elevation and rotation of the heart. LAD is alsoconsidered to be due to increased blood volume leading to increased left ventricular load, axis shift and a more horizontal heart.[21-23]Arrhythmias like atrial fibrillation, atrial flutter, ventricular tachycardia was not seen in this study showing that normal pregnancy is not usually associated with these arrhythmias.

V. Conclusion

In this study significantECG changes in the pregnant subjects when compared with the non- pregnant women were increased heart rate in all trimesters,reduced QTc duration in 2nd and 3rd trimesters, left axis deviation (LAD), increased QRS duration and left ventricular hypertrophy (LVH) in the third trimester. Hemodynamic adaptations of pregnancy are associated with ECG changes especially in the third trimester of pregnancy and should be distinguished from pathologic changes of cardiac disease when evaluating pregnant women.

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