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A Comparative Study of Electrocardiographic Changes during Different Trimesters of Pregnancy with Nonpregnant Controls

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Abstract

Introduction: During normal gestation, a variety of hemodynamic changes are going to occur. They will influence the condition of heart, which in turn results in changes in electrocardiography. Hence, the present study was designed to study the electrocardiographic changes during different trimesters of pregnancy was compared with nonpregnant controls. *Materials and Methods:* It is a cross sectional study conducted in the Department of Physiology after institutional clearance and consent from all the participants,150 pregnant women in the age group of 20-35yrs who were attending the OPD of OBG were recruited and divided into 3 subgroupscomprising 50 women in first, second and third trimesters of pregnancy. The control group was comprising of another apparently healthy age matched 50 non-pregnant women.ECG was recorded in all 12 leads and was evaluated for different parameters such as heart rate, P wave, PR interval, QRScomplex, Q wave, T wave, QTc interval, axis deviation, R and S amplitudes and ST segment. *Statistical Analysis:* The data were expressed as Mean±SD. Z test was used for comparison between control and study groups andwithin the study group. 'p' value of 0.05 or less was considered as statistically significant. *Result:* There was statistically significant decrease in PR interval ($p<0.001$) in all trimesters of pregnancy when compared to control group. QT intervals did not show significant difference between the control and the study groups or within in the subgroup of study group ($p> 0.05$). But, QTc interval showed a statistically significant increase 1st, 2nd and 3rd trimester of pregnancy when compared to control group ($p< 0.001$). Similarly, a statistically significant increase in QTc interval was observed in 2nd and 3rd trimester ($p< 0.001$, Table-6) of pregnancy when compared to 1st trimester and also in 3rd trimester ($p< 0.001$) of pregnancy when compared to 2nd trimester. *Discussion:* Heart rate was increased in 1st, 2nd and 3rd trimesters of pregnancy, a decrease in PR interval was seen all the trimesters of pregnancy, Occurrence of Q wave in leads II and III showed an increase in 2nd and 3rd trimesters of pregnancy, ST segment depression was noticed in 4 subjects in 2nd trimester and 6 in 3rd trimester of pregnancy, QTc interval showed an increase in pregnant women in 1st, 2nd and 3rd trimesters of pregnancy. *Conclusion:* This knowledge may be helpful in the prevention of gestational complications associated with an inadequate maternal hemodynamic adaptation.

Keywords: Pregnancy; Hemodynamic Changes; ECG Changes; Trimesters.

Introduction

In pregnant women, large number of local and systemic changes are known to occur. These changes will continue throughout pregnancy especially cardiovascular changes such as increase in heart rate, cardiac output and intravascular volume [1]. The physiological changes during pregnancy facilitate the adaptation of the cardiovascular system to the increased metabolic needs of the mother enabling adequate delivery of oxygenated blood to the peripheral tissues and to the foetus.

The demands for an increased flow of blood during pregnancy are met mainly by increasing the cardiac output. In an average non-pregnant woman, cardiac output is about 4.5 litre per minute. At the eighth month of pregnancy, this rises to about 5.5 L. The cardiac output rises to a peak in the middle of pregnancy and thereafter slowly declines thereafter though it still remains 1 L/min above the non-pregnant values. The decline in cardiac output in late pregnancy might be due to postural changes. In the supine position, the large uterus often impedes cardiac venous return. It can decrease to about 20% less in supine position as compared to the lateral recumbent position [2,3].

Cardiac output depends on the heart rate and stroke volume. The heart rate increases by 10-15 beats per minute more than the pre - pregnant state. There

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is an increase in both stroke volume and heart rate. The stroke volume increases to 10% more than the non-pregnant value, whereas the heart rate increases to 20% more than the non-pregnant value. In the early months of pregnancy, the stroke volume rises rapidly to a peak and then declines, while the pulse rate slowly increases. The mechanisms of increasing the cardiac output have varying importance at the extremes of pregnancy [4].

Heart diseases during pregnancy remain a serious problem. One of the important tools for the diagnosis of heart diseases is recording electrocardiogram. Electrocardiography is one of the simplest techniques used to detect ischemic heart diseases, hypertensive heart diseases & asymptomatic arrhythmias [5]. The effect of pregnancy on the electrocardiogram has been a subject of great interest since the early days of electrocardiography [6]. A major purpose of recording ECG in clinical practice is to help the clinician in the diagnosis and prognosis of heart diseases.

Halphen C et al., conducted electrocardiographic study of left ventricular performance in normal pregnancy and reported that the heart rate raised significantly from third to ninth month and then fell during the postpartum period [7]. 50% of the maximum increase in heart rate had already occurred by 8 weeks. The initial abrupt increase was followed by a more gradual progressive rise as pregnancy continued which plateaued after 32 weeks. The abrupt increase in heart rate in early pregnancy suggests a hormonal mechanism. This is linked to the production of chorionic gonadotropin with the later gradual increase being related to the vascular changes which accompany placental and foetal growth.

Lechmanova M and Parizet A et al., compared the measured parameters of the electrical field with hemodynamic parameters before & after delivery in the group of non-obese women with physiological pregnancy & in a group of healthy non-obese& non-pregnant women [8]. They observed several significant changes of the electrical field in the pregnant women such as, increase in the heart rate, shortening of AV conductance, prolongation of QT interval normalized for the heart rate (QTc), change in the ventricular depolarization & repolarisation pattern.

Philip J Podrid observed ECG changes during normal pregnancy and observed shortening of PR & QT interval, may accompany the increase in the heart rate, frontal lead axis changes were rare despite significant elevation of diaphragm when seen, slight right ward shift were more common than leftward deviation, nonspecific abnormalities of ST segment & T wave appeared in 4 to 14% of the pregnancy [9]. These changes predominated in left precordial leads & resolved in the majority of subjects after delivery.

During normal gestation, a variety of hemodynamic changes are going to occur. They will influence the condition of heart, which in turn results in changes in electrocardiography. Hence, the present study was designed to study the electrocardiographic changes during different trimesters of pregnancy was compared with nonpregnant controls.

Materials and Methods

It is a cross sectional study conducted in the Department of Physiology, Shimoga institute of Medical Sciences. Sagar Road, Shivamogga. 150 pregnant women in the age group of 20-35yrs who were attending the OPD of OBG were included in the study group. The study group was in turn divided into 3 subgroups. Each sub group was comprising of 50 women in first, second and third trimesters of pregnancy. The control group was comprising of another apparently healthy age matched 50 non-pregnant women.

The nature and purpose of the study were explained to the subjects who had volunteered for the study. From each participant an informed consent was obtained. A thorough physical & systemic examination of each subject was done (in particular, cardiovascular and respiratory system). Recordings were taken during morning hours between 9 am to 12 Noon.

Apparently healthy subjects of Indian origin were included in the study. The apparent health status of the subject was determined through thorough clinical examination and history taking. Subjects with history or clinical signs of cardiovascular diseases, acute respiratory infection in the previous three months, history of diabetes mellitus, hypertension, history of tobacco consumption in any form, history of alcohol intake, any endocrine disorders, obesity and with moderate to severe anaemia were excluded.

ECG was recorded after giving 5 minutes of rest to the subject to allay anxiety. ECG was recorded in all 12 leads such as 3 Standard Bipolar Limb Leads I, II & III, 3 Unipolar augmented limb leads: aVR, aVL, aVF and 6 Precordial leads: VI to V6, by connecting electrodes to left arm, right arm, left leg and right leg in supine position. Date of recording, name and age of the subject were written on ECG strip.

ECG recorded was evaluated for different

parameters such as heart rate, P wave, PR interval, QRScomplex, Q wave, T wave, QTc interval, axis deviation, R and S amplitudes and ST segment.

Statistical Analysis

The results were expressed as Mean±SD. Z test was used for comparison between control and study groups and within the group.A 'p' value of 0.05 or less was considered as statistically significant.

Result

The heart rate showed a statistically significant increase in 1st, 2nd and 3rd trimesters of pregnant women when compared to non-pregnant women ($p < 0.001$) (Table 1). Similarly, there was a statistically significant increase in heart rate in 2nd and 3rd trimesters ($p < 0.001$) when compared to 1st trimester of pregnant women. There was a statistically significant increase in heart rate in 3rd trimester ($p < 0.001$) when compared to 1st trimester of pregnant women (Table 2).

The P wave duration among control and study group and within the subgroups of study group were not statistically significant ($p>0.05$).The P wave amplitude among control and study group and within the subgroup of study group were not statistically significant ($p>0.05$, Table 3).

There was statistically significant decrease in PR interval ($p<0.001$) in all trimesters of pregnancy when compared to control group. Similarly, a statistically significant decrease in PR interval was observed in 2nd ($p<0.05$) and 3rd trimesters ($p<0.001$) when compared to 1st trimester of pregnancy. Duration of QRS Complex (seconds) did not show significant difference among the control and study groups or within the subgroups of study group ($p>0.05$, Table 3).

Occurrence of Q wave in lead I showed a slight increase in 2nd and 3rd trimesters of pregnancy when compared to 1st trimester of pregnancy and control group. But, there was no significant statistical difference between the groups ($p>0.05$, Table 4).

QT intervals (sec) also did not show significant difference between the control and the study groups or within in the subgroup of study group ($p> 0.05$, Table 5). But, QTc interval showed a statistically significant increase 1st, 2nd and 3rd trimester of pregnancy when compared to control group ($p< 0.001$). Similarly, a statistically significant increase in QTc interval was observed in 2nd and 3rd trimester ($p< 0.001$, Table 6) of pregnancy when compared to 1st trimester and also in 3rd trimester ($p< 0.001$) of pregnancy when compared to 2nd trimester (Table 7).

The T wave duration among control and study groups and within groups was not statistically significant ($p>0.05$, Table 8). The T wave amplitude among control and study groups and within the groups was not statistically significant ($p>0.05$, Table 9).

Table 1: Mean ± SD of Heart rate, P wave and PR Interval of subjects in Control and Study groups

Parameters	Control Mean ± SD	1ST Trimester Mean ± SD	2ND Trimester Mean ± SD	3RD Trimester Mean ± SD
HR (beats/min)	75.68 ± 3.99	82.28 ± 7.84	88.24 ± 9.10	95.52 ± 7.04
P wave				
Duration (sec)	0.08 ± 0.01	0.08 ± 0.01	0.08 ± 0.01	0.07 ± 0.01
Amplitude (mv)	1.00 ± 0.17	1.00 ± 0.23	1.02 ± 0.27	1.02 ± 0.28
PR Interval(sec)	0.15 ± 0.01	0.14 ± 0.02	0.14 ± 0.02	0.13 ± 0.02

Table 2: Test of Significance of Heart rate, P wave and PR Interval using Z Statistics b/n Control and Study groups

Parameters	Control & 1ST Trimester P-Value	Control & 2ND Trimester P-Value	Control & 3RD Trimester P-Value
HR (beats/min)	0.0001***	0.0001***	0.0001***
P wave			
Duration (sec)	0.667	0.696	0.711
Amplitude(mv)	1	1	1
PR Interval (sec)	0.0003**	0.0003**	0.0003**

p>0.05: Not Significant, *p<0.05: Significant, **p<0.01: Highly significant, ***p<0.001: Very highly significant

Table 3: Test of Significance for Heart rate, P wave and PR Interval using Z Statistics within the subgroups of Study group

Parameters		1ST& 2ND Trimesters P-Value	1ST& 3RD Trimesters P-Value	2ND& 3RD Trimesters P-Value
	HR (beats/min)	0.0001***	0.0001***	0.0001***
P wave	Duration (sec)	0.696	0.218	0.624
	Amplitude(mv)	1	0.689	1
	PR Interval (sec)	0.012*	0.0001***	0.0034**

p>0.05: Not Significant, *p<0.05: Significant, **p <0.01: Highly significant, ***p<0.001: Very highly significant.

Table 4: Chi Square Test for association of occurrence of Q wave in Std Limb Leads between the study and the control groups

Limb Leads	Occurrence of Q Wave		
	Control&1stTrimester	Control & 2nd Trimester	Control & 3rd Trimester
I	NS	NS	NS
II	p>0.05	P<0.05	P<0.001
III	p>0.05	P<0.05	P<0.001

p>0.05: Not Significant, *p<0.05: Significant, **p<0.01: Highly significant, ***p<0.001: Very highly significant.

Table 5: Mean ± SD of QRS Complex, QT Interval, QTc Interval and QRS frontal axis in subjects of Control and Study groups

Parameters	Control Mean ± SD	1ST Trimester Mean ± SD	2ND Trimester Mean ± SD	3RD Trimester Mean ± SD
QRS Complex (sec	0.08 ± 0.01	0.08 ± 0.01	0.08 ± 0.01	0.08 ± 0.01
QT Interval (sec)	0.35 ± 0.02	0.35 ± 0.02	0.35 ± 0.02	0.36 ± 0.01
QTc Interval (sec)	0.38 ± 0.01	0.39 ± 0.01	0.40 ± 0.01	0.41 ± 0.01
QRS frontal axis (degree)	64.56 ± 7.66	60.48 ± 11.05	55.70 ± 12.61	45.4 ± 22.54

Table 6: Test of Significance for QRS Complex, QT Interval, QTc Interval and QRS frontal axis using Z Statistics between Control and Study groups

Parameters	Control & 1ST trimester P-Value	Control & 2ND trimester P-Value	Control & 3RD trimester P-Value
QRS Complex (sec)	0.067	0.105	0.091
QT Interval (sec)	0.401	0.384	0.293
QTc Interval (sec)	< 0.0001***	< 0.0001***	< 0.0001***
QRS frontal axis (degree)	0.032*	<0.0001***	<0.0001***

p>0.05: Not Significant, *p<0.05: Significant, **p<0.01: Highly significant, ***p<0.001: Very highly significant

Table 7: Test of Significance for QRS Complex, QT Interval, QTc Interval and QRS frontal axis using Z Statistics within the subgroups of Study group

Parameters	1ST& 2ND Trimesters P-Value	1ST& 3RD Trimesters P-Value	2ND& 3RD Trimesters P-Value
QRS Complex (sec)	0.105	0.833	0.849
QT Interval (sec)	0.384	0.027	0.030
QTc Interval (sec)	0.0001***	0.0001***	0.0001***
QRS frontal axis (degree)	0.051	0.0001***	0.0001***

p>0.05: Not Significant, *p<0.05: Significant, **p<0.01: Highly significant, ***p<0.001: Very highly significant

Table 8: Mean±SD of T wave in subjects of Control and Study groups

Parameters		Control Mean ± SD	1ST Trimester Mean ± SD	2ND Trimester Mean ± SD	3RD Trimester Mean ± SD
T wave	Duration(sec)	0.19 ± 0.04	0.19 ± 0.04	0.18 ± 0.03	0.19 ± 0.04
	Amplitude (mv)	2.72 ± 1.01	2.70 ± 1.11	2.78 ± 0.89	2.45 ± 0.93

Table 9: Test of significance for T wave using Z Statistics between Control and Study groups

Parameters		Control & 1ST trimester P-Value	Control & 2ND trimester P-Value	Control & 3RD trimester P-Value
T wave	Duration (sec)	0.275	0.833	0.275
	Amplitude (mv)	0.928	0.920	0.920

p>0.05: Not Significant, *p<0.05: Significant, **p<0.01: Highly significant, ***p<0.001: Very highly significant

Discussion

In our study there was a statistically significant increase in the heart rate in 1st, 2nd and 3rd trimesters of pregnancy as compared to non-pregnant women.

A progressive increase in heart rate is observed as age of pregnancy advances. Heart rate increased by approximately 15% in the 5th week. It increased after 8th week to a maximum of approximately 85-90 beats per minute. In the last trimester of pregnancy, there is a chance of an increase of 10-20 beats per min. The heart rate of a pregnant woman steadily increased throughout pregnancy [10]. The increase in the heart rate is linked to autonomic nervous system changes that produce alterations in cardiac autonomic modulation [11]. Failure of these adaptations may result in pregnancy related complications.

The increase in heart rate may have been triggered to maintain the cardiac output in a state of relative hypovolemia [12]. The increase in heart rate was due to a decrease in vagal baroreflex as well as a decrease in parasympathetic tone. The increase in heart rate mainly during third trimester of pregnancy compensates for the fall in the stroke volume resulting from caval compression [13]. The observations made in our study are in agreement with the findings of other studies [14].

In our study, there was no statistically significant difference in measurements of P wave amplitude and duration when compared between the control and the study groups.PR interval was shown to be statistically significantly decreased in 1st, 2nd and 3rd trimesters of pregnancy as compared to control group. There was also a statistically significant decrease in 2nd& 3rd trimesters of pregnancy compared to 1st trimester of pregnancy and in 3rd trimester of pregnancy when compared to 2nd trimester of pregnancy.

The decrease in PR interval during pregnancy could be due to shortening of A-V conductance with respect to tachycardia that accompanies during pregnancy. Similar report was made by Joseph E Carruth et al. In their study, they found that mean PR interval was shorter at 3rd trimester when compared to 1st and 2nd trimesters of normal pregnancy & it was statistically significant [15].

In the present study, there was a statistically significant increase in occurrence of Q wave in the 2nd and 3rd trimesters when compared to 1st trimester of pregnancy and the control group.These changes may be either due to an increase in the circulating vasopressor agents or may reflect diaphragmatic changes that have been associated with pregnancy [16]. The frequent occurring of Q wave during pregnancy when compared to normal non-pregnant women may be due to altered position of the heart [17].

QRS Complex measurement had no statistically significant difference in duration either when compared between the study and the control groups, nor between the subgroups within study groups.In the present study, ST segment depression was noticed in 4 subjects in 2nd trimester and 6 subjects in the 3rd trimester of pregnancy. There was no change in ST segment in the subjects of control group and 1st trimester of pregnancy. There was no statistically significant difference between the control and the study groups or between subgroups within study group.One of the causes for ST segment depression during pregnancy may be due to electrolyte imbalance such as hypokalaemia as a result of persistent vomiting, but the prevalence of hypokalemia and hyperemesis was less. It has been suggested that transient ST segment depression is associated with anxiety which may be a provoking stimulus and that can be attributed to an endogenous hypersensitivity. One of the mechanisms by which adrenaline induces hypersensitivity is by increasing oxygen demand by the increased muscular action and coronary dilation.Our findings are in accordance with the observations made by others [18-20].

In our study, there was no statistically significant increase or decrease in the QT interval when compared between the control and study groups or within the study group. QTc Interval in electrocardiogram reflects the time taken for depolarization and repolarization in the ventricular myocardium. The QT interval when corrected for heart rate is QTc. It must be emphasized that the surface

electrocardiographic QTc interval reflects complex and interrelated aspects of cardiac electrophysiology, cardiac geometry, torso shape, tissue impedance and biological signal processing.

In the present study, it was found that there was a statistically significant increase in QTc interval in 1st, 2nd and 3rd trimesters of pregnancy when compared to control group. There was also a statistically significant increase in QTc interval in 2nd and 3rd trimesters when compared to 1st trimester of pregnancy and also in the 3rd when compared to 2nd trimester of pregnancy.It is first necessary to determine the normal range of QTc interval in healthy pregnant women. It seemed possible that the altered circulatory dynamics during pregnancy might have some effect on its duration. It appears that the physical and emotional stress during 9 months of pregnancy may be a factor in triggering heart rhythm disorders in some vulnerable women.An increase in the QTc interval may be due to tachycardia. They must be considered as a complex consequence with changes in regulatory mechanisms during normal pregnancy [21].

In the present study, there was no statistically significant change in the T wave amplitude and duration when compared between the control and the study group, or between the subgroup within the study group. During pregnancy, there is an increase in blood volume, which inturn results in a temporary increase in workload on heart. Eventually temporary ischemia develops which is represented by T wave inversion.

It has been suggested that in normal pregnant women, flat or negative T waves may be observed during pregnancy and this fact should be kept in mind while interpreting electrocardiograms of pregnant women. With increase in gestational age, position of heart changes from vertical to intermediate indicating that heart shifted to left as gestation proceeds. The change in the electrical axis may be due to raise in the diaphragm during pregnancy. The changes in the left ventricular size and mass and associated increased volume may cause the apical impulse to be displaced to the left. Elevation and rotation of the heart resulting from the enlarging uterus and left axis shift in early pregnancy can be explained from the fact that there is an increased blood volume which in turn causes left ventricular load.

Conclusion

Heart rate was increased in 1st, 2nd and 3rd trimesters of pregnancy, a decrease in PR interval was seen all the trimesters of pregnancy, Occurrence of Q wave in leads II and III showed an increase in 2nd and 3rd trimesters of pregnancy, ST segment depression was noticed in 4 subjects in 2nd trimester and 6 in 3rd trimester of pregnancy, QTc interval showed an increase in pregnant women in 1st, 2nd and 3rd trimesters of pregnancy. This knowledge may be helpful in the prevention of gestational complications associated with an inadequate maternal hemodynamic adaptation.

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