

Electrocardiographic QRS Axis, Q Wave and T-wave Changes in 2nd and 3rd Trimester of Normal Pregnancy

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ABSTRACT

Background: Pregnancy although a physiological phenomena affects all the functions of the maternal body and brings about remarkable changes in the cardiovascular system. The cardiovascular changes and many of the physiological adaptations of normal pregnancy alter the physical findings thus, sometimes misleading the diagnosis of heart disease. Pregnancy also brings about various changes in the electrocardiogram, further confusing with that of heart disease. This study is undertaken to highlight the effect of normal pregnancy on the QRS axis, Q wave and T-wave of the Electrocardiogram and thereby helps us to distinguish it from that of pathological changes.

Objectives: To study the effect of normal pregnancy on the QRS axis, Q wave and T-wave in the electrocardiogram and to compare with that of normal non pregnant women.

Materials and Methods: Fifty normal pregnant women in 2nd and 3rd trimester each between 20– 35 y of age and 50 normal

non pregnant women of the same age group were selected for the study. A 12 lead ECG was recorded by using ECG machine with special emphasis on QRS axis, Q wave and T-wave changes and all the parameters were analysed.

Results: The ECG changes observed in our study include, deviation of QRS axis towards left as pregnancy advanced, significant increased incidence of occurrence of prominent Q waves in lead II, III and avF in pregnant group ($p < 0.05$) and, T-wave abnormalities like flat and inverted T-waves in lead III, V1 – V3 were more frequent in pregnant group ($p < 0.05$) than in non pregnant group.

Conclusion: Normal pregnancy brings about various changes in ECG. These changes during pregnancy should be interpreted with caution by the physicians. It is necessary to understand the normal physiological changes which in turn help us in better management of those with cardiac disease.

Keywords: Electrocardiogram, Pregnancy, QRS axis, T-wave changes

INTRODUCTION

Pregnancy is the process by which the life of a baby begins in the mother's womb and progresses up to the stage when it is safe to expose the baby to the external world [1]. Pregnancy although, a physiological phenomena affects all the functions of the maternal body [2]. Various physiological changes, especially changes in the cardiovascular system do occur during normal pregnancy [3].

The cardiovascular changes which occur normally during pregnancy sometimes simulates heart disease [2]. In addition, many of the physiological adaptations of normal pregnancy alter the physical findings thus misleading the diagnosis of heartdisease [4].

Pregnancy also brings about various changes in ECG. Probably, the most common reason for referral of the pregnant patient from the obstetrician to the cardiologist is evaluation of a systolic murmur heard over the precordium [5]. To have diagnostic specificity of cardiovascular disease the ECG changes must exceed normal variations encountered during pregnancy [6]. It is important not to diagnose heart disease when none exists and at the same time not to fail to detect and appropriately treat heart disease when it does exist [4].

The effect of normal pregnancy on the electrocardiogram has been a subject of great interest since the early days of electrocardiography [7].

The present study was set out to determine electrocardiographic changes in normal pregnancy as the electrocardiogram reflects the condition of the heart which in turn is regulated by hemodynamic alterations during normal pregnancy [2].

MATERIALS AND METHODS

Fifty apparently healthy pregnant women in 2nd and 3rd trimester each, between 20- 35 y were selected consecutively as and when they presented to the obstetric outpatient department of Bapuji Hospital and Chigateri Hospital, Davangere. Fifty healthy nonpregnant women of the same age group were selected randomly from the general population. The study was conducted in the Physiology Department, J.J.M Medical College, Davangere, India.

Each participant was given an explanation of the study protocol. Those subjects who were willing to participate in the study were included after obtaining informed consent.

A detailed assessment was done and a pretested structured proforma was used to record the relevant information from each individual case selected. Data acquisition was performed in the morning.

A detailed physical and systemic examination was done in the subjects who were selected. Physical examination of all the subjects included measuring height in centimeters, weight in kilograms. Subjects were matched for age, height, and weight. Subjects were allowed to take rest for ten minutes. Recording of resting pulse rate done by palpating the radial artery and blood pressure was recorded with a mercury sphygmomanometer using the appropriate sized cuff. Clinical examination of the cardiovascular system and respiratory system was done in detail.

Following detailed assessment of the subjects, they were screened for the presence of inclusion and exclusion criteria and dropped if any exclusion criteria that are likely to affect cardiovascular system were present.

| Variables | Particulars | Controls [A] | 2 nd TM [B] | 3 rd TM [C] | Difference between groups | | | |
|-----------------------|---------------|-----------------|------------------------|------------------------|---------------------------|------------|------------|-------------|
| | | | | | F value | A-B | A-C | B-C |
| QRS axis (in degrees) | Mean \pm SD | 64.10 \pm 6.8 | 53.0 \pm 16.7 | 45.9 \pm 22.1 | F - 15.31 | p < 0.01 S | p < 0.01 S | p < 0.09 NS |
| | Range | 48 - 82 | (-3) - 82 | (-3) - 80 | p < 0.001 HS | | | |

[Table/Fig-1]: Comparison of qrs axis (degrees) between three groups

| Lead | Control (A) | | 2 nd TM (B) | | 3 rd TM (C) | | Difference between groups | | | |
|------|-------------|-----|------------------------|-----|------------------------|-----|---------------------------|----------------------|---------------------|----------------------|
| | n | (%) | n | (%) | n | (%) | Chi square value X2 | A-B | A-C | B-C |
| I | 2 | 4% | 3 | 6 | 4 | 8 | 0.71 p>0.05 NS | NS | NS | NS |
| II | 13 | 26 | 25 | 50 | 34 | 68 | 17.8 p<0.001 S | 6.11 p<0.05 S | 17.7 p<0.01 S | 3.35 p>0.05 NS |
| III | 20 | 40 | 27 | 54 | 33 | 66 | 12.1 p<0.05 S | 1.97 p>0.05 NS | 6.78 p<0.01 S | 1.50 p>0.05 NS |
| avR | - | - | - | - | - | - | - | - | - | - |
| avL | 2 | 4 | - | - | 3 | 6 | 2.89 p>0.05 NS | NS | NS | NS |
| avF | 19 | 38 | 25 | 50 | 32 | 64 | 6.78 p<0.05 S | 1.46 p>0.05 NS | 6.76 p<0.01 S | 1.99 p>0.05 NS |

[Table/Fig-2]: Comparison of incidence of occurrence of prominent q wave in limb leads between three groups

| Lead | Control (A) | | 2 nd TM (B) | | 3 rd TM (C) | | Difference between groups | | | |
|------|-------------|-----|------------------------|-----|------------------------|-----|---------------------------|-----|-----|-----|
| | n | (%) | n | (%) | n | (%) | Chi square value X2 | A-B | A-C | B-C |
| V1 | - | - | - | - | - | - | - | - | - | - |
| V2 | - | - | - | - | - | - | - | - | - | - |
| V3 | - | - | - | - | - | - | - | - | - | - |
| V4 | 4 | 8 | 6 | 12 | 8 | 16 | 1.52 p>0.05 NS | NS | NS | NS |
| V5 | 25 | 50 | 29 | 58 | 32 | 64 | 2.02 p>0.05 NS | NS | NS | NS |
| V6 | 27 | 54 | 30 | 60 | 32 | 64 | 1.05 p>0.05 NS | NS | NS | NS |

[Table/Fig-3]: Comparison of incidence of occurrence of prominent q wave in chest leads between three groups

Inclusion Criteria

1. Normal healthy pregnant women in 2nd and 3rd trimester between 20-35 y of age.
2. Normal healthy non pregnant women between 20-35 y of age.

Exclusion Criteria

1. Women aged less than 20 and more than 35 y.
2. Women with any organic cardiac disease.
3. Women with renal disease.
4. Women with severe anaemia.
5. Women with thyroid disease.
6. Women with diabetes, hypertension, chronic medication and surgery.

Electrocardiographic Recording

A 12 lead electrocardiogram was recorded in the subjects during the resting state.

The instrument used to record electrocardiogram is the twelve channel electrocardiograph HEWLETT PACKARD page writer manufactured by Philips electronic Ltd.

This high-quality cardiograph captures accurate 12-lead ECGs on full-size paper with no cutting or pasting. It records 3 or 6 channels at speeds ranging from 5mm to 50mm per second, so we can capture multiple levels of detail. We can activate an ECG at the press of a single button.

The ECG was evaluated for axis deviation, Q wave and T-wave and results were drawn.

STATISTICAL ANALYSIS

Results were expressed as Mean \pm SD for continuous data, number and percentages for categorical data. One-way-ANOVA was used for multiple group comparisons followed by 'Post-hoc-Tukey' test for group - wise comparisons. Categorical data was analysed by Chi - square test. A p-value of 0.05 or less was considered for statistical significance i.e.

- p < 0.05, p < 0.01 : S - Significant.
 p < 0.001 : HS - Highly Significant.
 p > 0.05 : NS - Not Significant.

RESULTS

For the purpose of analysis of data, the results were tabulated. The statistical comparisons of the matching variables (age, height and weight) are inherently similar for all groups.

[Table/Fig-1] shows comparison of QRS axis measured in degrees among the three groups i.e. pregnant women in 2nd trimester, pregnant women in 3rd trimester and the normal nonpregnant women respectively.

There was significant decrease in the QRS axis (p < 0.01) in pregnant group when compared to controls. Decrease in QRS axis was found to be more in pregnant women in 3rd trimester compared to those in 2nd trimester. However, there was no significant difference in the finding in between the pregnant group (p < 0.09).

[Table/Fig-2] represents comparison of incidence of occurrence of prominent Q wave among the three groups in limb leads.

There was significant increase in the incidence of occurrence of prominent Q wave in lead II in pregnant women in 2nd trimester (p < 0.05) and in lead II, III, avF in pregnant women in 3rd trimester (p < 0.01) as compared to controls.

Pregnant women in 3rd trimester showed increased frequency of occurrence of definite Q wave in limb leads II, III and avF when compared to that of 2nd trimester, but this finding was not statistically significant (p > 0.05).

[Table/Fig-3] shows comparison of incidence of occurrence of prominent Q wave among the three groups in chest leads.

Frequency of occurrence of definite Q wave in chest leads V4, V5 and V6 increased in pregnant women when compared to controls, and also in 3rd trimester when compared to 2nd trimester. However, there was no significant difference in the finding among all the three groups (p > 0.05).

[Table/Fig-4] shows comparison of T-wave abnormalities in limb leads among the three groups.

In this study incidence of T-wave abnormalities like flat T-waves and inverted T-waves in lead III were significantly more frequent in the pregnant women than in the nonpregnant women. Also, similar finding was noticed in 3rd trimester when compared to 2nd trimester,

| Lead | Control (A) | | | 2 nd TM (B) | | | 3 rd TM (C) | | | Difference between groups | | | |
|------|-------------|-------------|----------|------------------------|-------------|----------|------------------------|-------------|----------|---------------------------------|---------------|---------------|----------------|
| | Flat n% | Inverted n% | Total n% | Flat n% | Inverted n% | Total n% | Flat n% | Inverted n% | Total n% | Chi square value X ² | A-B | A-C | B-C |
| I | - | - | - | - | - | - | - | - | - | - | - | - | - |
| II | - | - | - | - | - | - | - | - | - | - | - | - | - |
| III | 5 10 | 20 40 | 25 50 | 12 24 | 23 46 | 35 70 | 13 26 | 27 54 | 40 80 | X ² =10.5 p<0.01 S | 4.17 P<0.05 S | 9.89 p<0.01 S | 1.33 p>0.05 NS |
| avR | - | - | - | - | - | - | - | - | - | - | - | - | - |
| avL | - | - | - | - | - | - | - | - | - | - | - | - | - |
| avF | - | - | - | - | - | - | - | - | - | - | - | - | - |

[Table/Fig-4]: Comparison of T-wave abnormalities in limb leads between three groups

| Lead | Control | | | 2 nd Trimester | | | 3 rd Trimester | | | Difference between groups | | | |
|------|---------|-------------|----------|---------------------------|-------------|----------|---------------------------|-------------|----------|---------------------------|----------------|----------------|----------------|
| | Flat | Inverted n% | Total n% | Flat n% | Inverted n% | Total n% | Flat n% | Inverted n% | Total n% | X ² | A-B | A-C | B-C |
| V1 | 0 | 35 70 | 35 70 | 1 2 | 40 80 | 41 80 | 3 6 | 42 84 | 45 90 | 6.50 p<0.05 S | 1.97 p>0.05 NS | 6.25 p<0.05 S | 1.33 p>0.05 NS |
| V2 | 0 | - | - | 1 2 | 9 18 | 10 20 | 1 2 | 9 18 | 10 20 | 11.5 p<0.01 S | 11.1 p<0.01 S | 11.11 P<0.01 S | 0.0 p>0.05 NS |
| V3 | - | - | - | 2 4 | 8 16 | 10 20 | 1 2 | 3 6 | 4 8 | 11.9 p<0.01 S | 11.1 p<0.01 S | 4.19 p<0.05S | 2.99 p>0.05 NS |
| V4 | - | - | - | 1 2 | 1 2 | 2 4 | - | 2 4 | 2 4 | 2.06 p>0.05 NS | NS | NS | NS |
| V5 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| V6 | - | - | - | - | - | - | - | - | - | - | - | - | - |

[Table/Fig-5]: Comparison of t wave abnormalities in chest leads between three groups

but within the pregnant group the finding was not found to be significant.

[Table/Fig-5] shows comparison of T-wave abnormalities in chest leads among the three groups.

In this study significant increased incidence of T-Wave abnormalities in leads V2–V3 was observed in 2nd trimester and in leads V1–V3 in 3rd trimester pregnant women compared to the nonpregnant women ($p < 0.05$). Though this finding increased as pregnancy advanced, it was not significant within the pregnant group.

In spite of these findings, there was no difference in the overall impression regarding the normality of the ECG between either of the two stages of pregnancy and controls.

DISCUSSION

This study demonstrated that the electrocardiogram during normal pregnancy may show wide variation from the accepted normal in the absence of demonstrable heart disease. Most of the ECG changes that occur during pregnancy can be explained by the physiological adaptations in response to pregnancy. The electrocardiographic changes during pregnancy may be due to:

1. The changed spatial arrangement of the chest organs.
2. Changed electrical properties of the myocardium due to changes in both the sympathetic and hormonal modulation (epinephrine, progesterone) of the electrical heart activity during pregnancy.

Interestingly, pregnancy may be associated with a concentric enlargement of the left ventricle in response to the hemodynamic requirements, which in turn could explain these ECG changes [8].

The effect of normal pregnancy on electrocardiogram is analysed as follows.

QRS axis

The QRS axis is a measure of the overall direction of depolarisation of the ventricles. In our study the results showed that the QRS axis

significantly decreased i.e., left axis deviation, in both pregnant women in 2nd trimester and 3rd trimester when compared to controls. The magnitude of deviation apparently increased as pregnancy progressed. But there was no significant difference in QRS axis between pregnant women in 2nd trimester and pregnant women in 3rd trimester. In fact it was reassuring to find that no participant demonstrated a QRS axis which was outside of the normal range.

The change in the electrical axis can be attributable to:

1. The diaphragm raising as pregnancy advances [9].
2. Changes in the left ventricular size and mass with 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, also contribute to the displacement [10].
3. In early pregnancy the left axis shift can be explained from the fact that there is increased blood volume which causes left ventricular load [2].

Singh AD and his colleagues in their study found that, electrical axis of +60° corresponding to semivertical heart position was commonest in pregnant women except in two subjects who showed horizontal heart position. Left axis deviation has been found during pregnancy as early as first two trimesters. In their study the change in electrical axis was attributed to the diaphragm raising as pregnancy advances [9].

Furthermore Misra J and his co-workers in their study reported left axis shift in early pregnancy itself and here the left axis shift can be explained from the fact that there is increased blood volume which causes left ventricular load causing axis shift. And in late pregnancy the left axis shift making the heart more horizontal was attributed to elevation of diaphragm [2].

Lechmanova M et al., [11] in their study observed a change of the electrical heart field resulting from the changed spatial position of the heart during last trimester of pregnancy in healthy women. Carruth JE et al., in a study on Electrocardiographic changes in

normal pregnancy confirmed leftward axis deviation in the third trimester [6].

Q Wave

In the current study it was observed that, incidence of occurrence of definite Q Wave in leads II, III, aVF, V4, V5 and V6 which is within the normal limit increased in pregnant women when compared to controls and also as pregnancy advanced. These ECG changes may either be the result of an increase in the circulating vasopressor agents or may reflect diaphragmatic changes that have been associated with pregnancy [12]. The frequent occurring of definite Q wave during pregnancy when compared to normal non pregnant women may be due to altered position of the heart [9].

Misra J et al., reported a Q wave of less than one quarter of the length of R wave in lead III in 40% of the cases studied and prominent Q wave was noted in 6.66% of the cases. It was concluded that although the presence of Q wave in lead III has been widely accepted its aetiology remains still obscure. This finding could be due to left axis deviation of the heart [2].

Study by Veille JC and his colleagues found that the subjects "late" in pregnancy had significantly fewer Q waves in II, III, and aVF than the nonpregnant women [12]. Singh AD et al., noted Q wave of 1mm or more in 48% of the cases studied [10]. Carruth JE and his co-workers noticed that the development of Q wave was frequent in pregnant women [6].

T-wave

In this study T-wave abnormalities like flat T-waves and inverted T-waves in lead III and chest leads V1-V3 were more frequent in the pregnant women than in the nonpregnant women and also in 3rd trimester pregnant women as compared to 2nd trimester.

The above finding may be attributed to, the increased work load on heart due to temporary increased blood volume during pregnancy which may cause a temporary ischaemia, represented by T-wave inversion [2].

Misra J and his colleagues in their study six observed a negative T-wave in lead III in 70% subjects of normal pregnancy. The T-wave abnormalities in the normal pregnant women their study was detected in almost all the chest leads [2].

Oram S and co-workers in their study found that, out of the 100 normal pregnant women, 14% of the subjects showed S-T changes affecting both limb and chest leads. In another 28% of the subjects there were changes of similar character but limited to one or more of limb leads. The type of change noted was sagging of the ST segment, which was depressed to a depth of 0.5 to 1.0 mm, the T-wave in the same lead usually being of low voltage. The leads affected were mainly those from the left side of the precordium, V3 to V6 in most instances, the limb leads being involved according to cardiac position [13].

Veille JC et al., observed T-wave inversion in V2 which was more frequent in the pregnant than in the nonpregnant patients. Two cases in their study had marked T-wave peaking, and one had a biphasic T-wave in V2 out of the total cases studied [12]. Based on the observations in their study it was concluded that in normal pregnant women, ST depression and flat or negative T-waves may be observed during pregnancy and this fact should be kept in mind while interpreting electrocardiograms of pregnant women [3].

In view of these findings our study suggests that:-

1. A burden of great extent is put on the cardiovascular system by normal pregnancy.
2. This burden on cardiovascular system is compensated by the reserve capacity in normal woman.

3. The compensation for the increased burden is through mechanical and physiological processes.
4. The electrocardiographic changes observed during the course of pregnancy may be definitely interpreted on the basis of hemodynamic changes and mechanical shifting of the heart during pregnancy.
5. This shifting of the heart produces a left axis deviation, Q wave and T-wave changes in the electrocardiogram of the majority of the cases studied.

Although, we understand to some extent these changes and also since only very few studies have been done on this aspect, further studies are needed to study the effect of normal pregnancy on electrocardiogram.

Previous studies have suggested that, sex hormones (estrogen, progesterone) and serum electrolyte changes during pregnancy can affect the ECG. This study gives quantitatively and qualitatively more effective results, if hormonal assay as well as serum electrolytes assessment is included along with the study. Also, this study might give more accurate results if the same subjects were taken as controls before pregnancy and were followed during pregnancy. Hence, further studies are needed by considering these facts to evaluate the effect of normal pregnancy on electrocardiogram and to explore the supposed mechanisms.

CONCLUSION

We report that, ECG changes like leftward axis deviation, Prominent Q waves in lead II, III, aVF and T-wave abnormalities like flat and inverted T-waves in lead III chest leads V1 – V3 were more frequent in pregnant women than in non pregnant women. There is a need for systematic evaluation of hemodynamic and ECG changes during pregnancy in subsequent studies. The significance of a change in the electrical axes of the heart as well as Q wave and T-wave changes during pregnancy must be evaluated cautiously in view of the considerable variability of the electrocardiogram during normal pregnancy.

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