Electrocardiographic Changes during Normal Pregnancy

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Abstract

Background   Pregnancy is a physiologic condition which is unique in that it alters the physiology of each organ in the body. Cardiovascular changes during pregnancy are significant and start at 6 to 8 weeks of gestation. Physiologic cardiovascular changes during pregnancy suggest the chance of altered electrocardiographic (ECG) parameters during pregnancy. Study of variations in ECG in normal pregnant women serves as a basis to detect pathologic changes in pregnant women.

Material and Methods   This is a cross-sectional data of case series of pregnant women across all stages of gestation who attended antenatal clinic of our teaching hospital, on Women's Day (March 8, 2017). A 12-lead ECG was recorded in all the participants in supine position. The parameters noted from the ECG include heart rate, PR interval, QRS duration, QRS axis, corrected QT (QTc) interval, and ST-T changes.

Results   Total 151 pregnant women were studied. The average age was 23.38 ± 3.49 years. With respect to gestational age, 12 (7.94%), 48 (31.78%), and 91 (60.26%) women were in the first, second, and third trimesters of pregnancy, respectively. With respect to parity, 60 (39.7%) were primigravidae and 91 (60.26%) were multigravidae. The mean ECG heart rate was increased (100.15 ± 12.48 beats/min). The mean systolic blood pressure (109.67 ± 9.34 mm Hg) and the mean diastolic blood pressure (71.32 ± 6.89 mm Hg) were decreased. The mean of ECG intervals and durations (PR, QRS, QTc) were in normal range (0.14 ± 0.01, 0.08 ± 0.008, and 407.83 ± 11.98, respectively). There was no abnormal P-wave dispersion. Even though the QTc was in normal range in 63.56% of pregnant women, this parameter was in upper quadrant of the normal range. General linear regression demonstrated that systolic blood pressure and palpitations were the only variables to independently predict QTc in upper quadrant of normal range ($p = 0.05, 0.03$, respectively).

Conclusion   The cardiovascular hemodynamic adaptation to pregnancy is a well-established fact that is also seen in our study. There is shortening of PR interval and QRS duration. Even though QTc is with in normal range, in more than half (63.56%) of pregnant women, it is in the upper quadrant of the normal range.

Keywords
► pregnancy
► electrocardiograph
► PR interval
► QRS duration
► QRS axis
► corrected QT interval

Introduction

Pregnancy is a physiologic condition that is unique in that it alters the physiology of each organ in the body.[1] The importance of these physiologic changes is that we should know normal range of acceptability; otherwise, they may land in pathologic disorder. Cardiovascular changes during pregnancy are significant and start at 6 to 8 weeks of gestation.[2] The cardiovascular changes during pregnancy mimic as those of heart disease.[1] The most common reason for referral of a pregnant woman to the cardiologist is the evaluation of systolic

murmur heard over the precordium.[3] The present study of cardiac evaluation was done on the eve of Women's Day (March 8, 2017) for all the pregnant women attending antenatal clinic on that day. Electrocardiogram (ECG) 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.[4] Physiologic cardiovascular changes during pregnancy suggest the chance of altered ECG parameters during pregnancy.

ECG changes during pregnancy (already reported) include sinus tachycardia, left axis deviation, ectopic beats, inverted or flattened T waves, Q wave in lead III, and augmented voltage unipolar left foot lead.[5]

Material and Methods

This is a cross-sectional data of case series of pregnant women across all stages of gestation who attended antenatal clinic at our institute on Women's Day (March 8, 2017). The study was carried after obtaining permission by the institutional ethics committee. Informed consent was taken from each participant after explaining the procedure. Their medical and obstetric history was taken in detail and further clinical examination was done.

Inclusion criteria: Normal healthy pregnant women with singleton pregnancy.

Exclusion criteria: Women with any organic cardiac disease, renal disease, thyroid disease, severe anemia, diabetes, hypertension, and on any chronic medication.

The instrument used to record 12-lead ECGs was Page-Writer TC30 cardiograph (Philips, Amsterdam, the Netherlands). ECG was recorded in supine position in all 12 leads: 3 standard bipolar limb leads I, II, and III; 3 unipolar augmented limb leads aVR, aVL, and aVF; and 6 precordial leads V_1 to V_6 by connecting electrodes to the left arm, right arm, and right leg in supine position.

The parameters noted from the ECG include heart rate, PR interval, QRS duration, QRS axis, corrected QT interval (QTc), ST-T changes, and P-wave dispersion. PR interval 0.12 to 0.20 second, QRS duration 0.06 to 0.10 second, P-wave dispersion 0.272 +/−0.053, and QRS axis of +90 to −30 degrees are considered as normal. Corrected QT interval was calculated using Bazett's formula. The QT interval is defined from the beginning of the QRS complex to the end of the T wave. The maximum slope intercept method defines the end of the T wave as the intercept between the isoelectric line with the tangent drawn through the maximum down slope of the T wave (left). When notched T waves are present (right), the QT interval is measured from the beginning of the QRS complex extending to the intersection point between the isoelectric line and the tangent drawn from the maximum down slope of the second notch, T2. We have taken QTc is prolonged if > 460 milliseconds in women and short if < 350 milliseconds. We divided QTc intervals into four quadrants: first quadrant (FQ) 350 to 375 milliseconds, second quadrant (SQ) 375 to 400 milliseconds, third quadrant (TQ) 400 to 425 milliseconds, and fourth quadrant (four Q) 425 to 450 milliseconds.

Statistical Analysis

The results were expressed as mean ± standard deviation (SD) for continuous data and number and percentages for categorical data. The assumption of normality was sustained in all the data. Data were analyzed by analysis of variance (ANOVA) for repeated measures, and contingency tables were used to compare findings of results. A p value of < 0.05 was considered significant.

Results

Total 151 pregnant women were studied. The average age was 23.38 ± 3.49 years. Parity details are given in ►**Table 1**. The mean ECG heart rate was increased (100.15 ± 12.48 beats/min) as expected. The mean systolic blood pressure (109.67 ± 9.34 mm Hg) and the mean diastolic blood pressure (71.32 ± 6.89 mm Hg) were decreased. With respect to gestational age, 12 (7.94%), 48 (31.78%), and 91 (60.26%) women were in the first, second, and third trimesters of pregnancy, respectively. With respect to parity, 60 (39.7%) were primigravidae and 91 (60.26%) were multigravidae.

Details of ECG parameters, that is, PR interval, QRS duration and axis, P-wave dispersion, and QTc, in all trimesters in pregnant women are given in ►**Table 2**.

Even though mean of ECG intervals and durations were in normal range, few of the parameters were in the upper quadrant of normal range such as QTc. Usually certain degree of tachycardia in pregnancy is expected, so relative shortening of all intervals like PR, QRS, and QT are expected. This is true for PR and QRS duration. However, QTc was different. P-wave dispersion is also within normal range. QRS axis is normal in 139 (92.05%) cases, leftward in 11 (7.28%) cases, and rightward in 1 (0.66%) case (►**Fig. 1**).

In ►**Table 3**, QTc distribution in normal pregnant women is mentioned. There are no patients in first quadrant (FQ) of QTc, 55 (36.42%) in second quadrant (SQ), 92 (60.92%) in third quadrant (TQ), and 4 (2.64%) in fourth quadrant (FQ). According to the trimester, there is not much change of QTc, and testing by ANOVA demonstrated that there is no significance for QT interval trimesterwise (►**Fig. 2**).

As there is tendency of QTc to be in upper half of normal in more than half of the patients, we did multivariate analysis to find out the determinants for this. General linear regression demonstrated that systolic blood pressure and palpitations were the only variables to independently predict QTc ($p = 0.05$, 0.03 respectively).

Table 1 Distribution of cases according to gravidity and trimester wise

Group	First trimester	Second trimester	Third trimester	Total no. of patients
Primigravidae	8	16	36	60 (39.7%)
Multigravidae	4	32	55	91 (60.3%)
Total no. of patients	12 (7.94%)	48 (31.78%)	91 (60.26%)	151 (100%)

Table 2 ECG parameters in three trimesters

Trimester	Variable	Mean ± SD	Minimum	Maximum
First	PR interval (s)	0.14 ± 0.01	0.12	0.18
	QRS duration (s)	0.08 ± 0.008	0.06	0.09
	QTc (ms)	407.83 ± 11.98	396	440
	Axis	Normal		
	P-wave dispersion (s)	0.04 s in 1 patient only	No dispersion	0.04
Second	PR interval (s)	0.15 ± 0.02	0.1	0.2
	QRS duration (s)	0.07 ± 0.008	0.06	0.09
	QTc (ms)	403.65 ± 11.7	373	444
	axis	Left axis in 2 patients		
	P-wave dispersion (s)	0.04 s in 2 patients	No dispersion	0.04
Third	PR interval (s)	0.14 ± 0.02	0.1	0.2
	QRS duration (s)	0.07 ± 0.006	0.06	0.09
	QTc (ms)	403.87 ± 10.5	371	430
	axis	Left axis in 8 and right in 1 patient		
	P-wave dispersion (s)	0.04 s in 2 patients	No dispersion	0.04

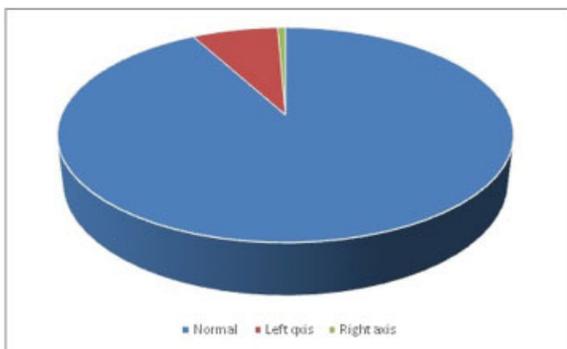Abbreviations: ECG, electrocardiogram; QTc, corrected QT; SD, standard deviation.

Fig. 1 Pie diagram showing the QRS axis distribution during pregnancy.

Discussion

In the current study, there is a significant increase in heart rate in pregnant women, due to decrease in vagal baroreflex as well as decrease in parasympathetic tone.[6] The increase in heart rate mainly during the third trimester of pregnancy compensates for fall in stroke volume resulting from caval compression.[7] This result correlates with many previous studies by Voss et al, Katz et al, Burwell, Stain et al, and Madras and Challa.[6,8–11]

In the present study, PR interval was shown to be decreased in all the three trimesters when compared with nonpregnant women. However, there was no statistically significant difference in PR interval when compared trimester wise in our study. In their studies, Carruth et al,[12] Kole et al,[13] and Madras and Challa[11] found that the mean PR interval was shorter in the third trimester when compared with the first and second trimesters of pregnancy, and it was statistically significant. Nandini et al observed statistically significantly decreased PR interval in the first, second, and third trimesters of pregnancy as compared with control group.[14] The decrease in PR interval during pregnancy could be due to shortening of A-V conductance and the resultant tachycardia that accompanies pregnancy.[13]

The QRS duration is a measure of the time for depolarization of the ventricles. In our study, there was no statistically significant difference in the QRS duration in all the three trimesters of pregnancy. QRS axis was normal in 139 (92.05%) cases, leftward in 11 (7.28%) cases, and rightward in 1 (0.66%) case in our study whereas QRS axis deviated to left side in studies by Madras and Challa, Carruth et al, Lechmanová et al, MS et al.[11,12,15,16] In this study, the incidence of left axis deviation is increased in eight patients in the third trimester from two patients in the second trimester. As the gestational age increased, there was an increased incidence of left axis deviation.

QT interval represents time from onset of ventricular depolarization to the completion of repolarization. Since it varies with heart rate, QTc interval is usually used.[17] In the

Table 3 QTc distribution in study population

Group	FQ (QTc 350–375 milliseconds)	SQ (QTc 376–400 ms)	TQ (QTc 401–425 ms)	Four Q (QTc 426–450 ms)	ANNOVA of QTc1, QTc2, QTc3, QTc4
No. of patients	0	55 (36.42%)	92 (60.92%)	4 (2.64%)	F = 0.75, p = 0.474

Abbreviation: FQ, fourth quadrant; QTc, corrected QT; TQ, third quadrant.
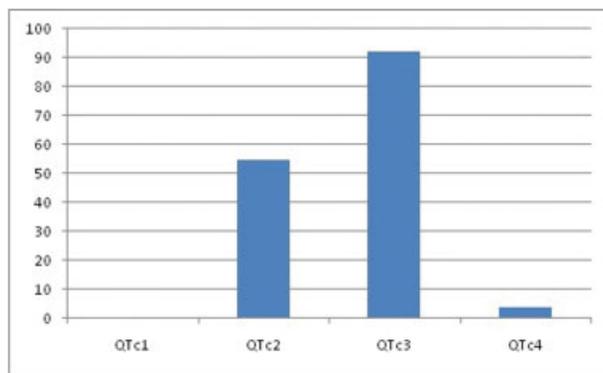
Fig. 2 Cluster chart of QTc in different quadrants. QTc, corrected QT.

present study, there was no statistically significant difference in QTc interval in three trimesters of pregnancy. As more than half of the pregnant women in this study had upper quadrant of normal range QTc, we were not certain whether this relative prolongation of QTc was responsible for any arrhythmias or precipitation of long QT syndrome during pregnancy. We have not done Holter monitoring in these patients to see the arrhythmic predisposition. Testing by ANOVA demonstrated that there was no significance for QT interval trimesterwise. Subsequent multivariate analysis using general linear models demonstrated that systolic blood pressure and palpitations were the only variables to independently predict QTc ($p = 0.05$, 0.03, respectively).

An increase in the QTc interval may be due to changes in ventricular depolarization and repolarization patterns during pregnancy. This must be considered as a complex consequence of changes in the various regulatory mechanisms occurring during normal pregnancy.[15] Prolongation of QTc interval was seen in previous studies by Madras and Challa, Carruth et al, and Lechmanova et al.[11,12,15] In their study, they found an increase in QT interval as well as prolongation of QTc interval during late pregnancy. These changes were attributed to changed spatial arrangement of chest organs during pregnancy and changed electrical properties of the myocardium due to changed sympathetic and hormonal modulation (epinephrine, progesterone) of the electrical heart activity during pregnancy. They also opined that this prolonged QT and QTc intervals should be interpreted simply as "an unspecific sign of changed course of repolarization."[13,15]

The major limitation of the study is that Holter monitoring was not done and there was lack of follow-up of patients. P and QT dispersions are better interpreted by Holter monitoring than a single-time ECG. Another Crucial point to be studied is when does the ECG changes in pregnancy normalize after delivery and whether the patients with ECG changes during pregnancy are prone for arrhythmias.

Conclusion

ECG changes such as increase in mean heart rate, decrease in PR interval, and relative increase in QT interval (upper quadrant of normal range) were more frequent in pregnant women in our study. There is alteration in circulatory dynamics during pregnancy, which leads to significant variations in ECG from the average normal. QRS axis is normal in most of the pregnant women in our study, but as the gestational age increases, there is an increased incidence of left axis deviation. QTc is in upper normal range in most of the pregnant women in our study. Systolic blood pressure and palpitations are the only variables to independently predict QTc ($p = 0.05$, 0.03, respectively).

As pregnancy itself is a pro-arrhythmogenic state, the incidence and evaluation of long QT syndrome in pregnancy need to be studied. There is need for systemic evaluation of hemodynamic and ECG changes during pregnancy, especially longitudinal studies to monitor the changes in ECG, whether they become normal after delivery, and if so, the time they take to become normal.

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