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RESEARCH ARTICLE

A comparative study of heart rate variability in pregnant and nonpregnant women in a tertiary care hospital of East India

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ABSTRACT

Background: Pregnancy is associated with dramatic cardiovascular adaptations, including increases in heart rate and blood volume, resulting in increased cardiac output throughout pregnancy and in decreased systemic vascular resistance in the first half of pregnancy with subsequent attenuation in the last trimester. The evidence of association between these cardiovascular parameters is well established but the evidence on extent of association needs to be strengthened with more research. **Objectives:** The study aims to evaluate changes in heart rate during deep breathing and to compare the changes in heart rate variability at various phases of pregnancy in different age groups. **Materials and methods:** Hospital based observational and prospective study was done from January 2018 to June 2019. Heart rate variability was determined by the method given by Wheeler and Watkins in which heart rate maximum and minimum was determined during deep inspiration and expiration. Heart rate variability was considered as the difference between maximum and minimum heart rate. The difference in data between two groups was analysed by using unpaired t test and the difference in interphase data within same group was analysed using repeated measure one way ANOVA. **Results:** There was higher heart rate but lower heart rate variability in pregnant women as compared to nonpregnant women. Heart rate variability was significantly lower in pregnant women of above 30 years ($p<0.05$). In the present study the mean of heart rate variability of pregnant women in second trimester was 5.96 and the mean of heart rate variability of non pregnant women was 11.52. Our study shows that the heart rate variability in pregnant women is significantly lower as compared to non pregnant women ($p<0.05$). **Conclusion:** We have found significant association of high heart rate and low heart rate variability with pregnancy and this association was stronger in second trimester of pregnancy. Moreover, the feasibility of predicting clinical outcomes in pregnancy by measuring heart rate variability bears further investigation.

Keywords: Heart rate, pregnancy, autonomic nervous system, cardiovascular outcome, gestation.

Pregnancy is associated with dramatic cardiovascular adaptations, including increases in heart rate and blood volume, resulting in increased cardiac output throughout pregnancy and in decreased systemic vascular resistance in the first half of pregnancy with subsequent attenuation in the last trimester [1]. All of these adaptations are associated with changes in the autonomic nervous system that produce alterations in cardiac autonomic modulation [1].

Heart rate is modulated by a combination of sympathetic and parasympathetic inputs, resulting in short and longterm changes in heart rate. This heart rate variability provides an accurate and noninvasive window through which to study the autonomic outflow to the cardiovascular system [2]. As a result, heart rate variability determined from electrocardiographic recordings has permitted the study of cardiac autonomic modulation in outpatients. As the strongest component of vagal modulation of the heart rate is related to respiration (respiratory sinus arrhythmia), mathematical analysis of shortterm changes in heart rate allows you to determine simultaneous respiratory rates.

Heart rate variability refers to the magnitude of the fluctuation in the number of beats per minute in conjunction

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with respiration. Assessment of heart rate variability in health and disease has now attained widespread use in a diverse group of discipline that include neurology, cardiology, psychophysiology, obstetrics, anaesthesiology and psychiatry [3]. In population studies, reduced heart rate variability was a predictor of mortality in healthy adults. The last two decades have witnessed the recognition of a significant relationship between the autonomic nervous system and cardiovascular mortality, including sudden cardiac death [4].

The women's health initiative research group showed that resting heart rate, a low-tech and inexpensive measure of autonomic tone, independently predicted myocardial infarction or coronary death. It was reported that all conventional risk factors for coronary heart disease were associated with the sympathetic nervous system which was implicated in all the mechanism of coronary heart disease [5].

The autonomic nervous system and changes in ANS during different pathophysiological conditions could be evaluated with heart rate variability analysis test. The apparently easy derivation of this measure has popularized it's use. The variation in the duration of R-R interval depends on the activity of sympathetic and parasympathetic nervous systems. The variations constitute what is commonly called heart rate variability. Although the exact pathophysiology of preeclampsia is not well understood, ANS imbalance is suggested as one of the main factors.

Autonomic balance involves complex interactions with several physiologic mechanisms that act to maintain heart rate and blood pressure with in normal limit. Recent investigations have suggested that autonomic dysfunction (heightened activity of the sympathetic nervous system and suppressed activity of parasympathetic nervous system) decreases the capability of the autonomic nervous system in regulating the cardiovascular system. This leads to cause various cardiac conditions. In earlier research, it was found that neural control of the heart rate and blood pressure are disturbed in pregnancy induced hypertension, as shown by increased blood pressure and heart rate variability [6].

Although significant adaptation of maternal cardiovascular system is known to occur during normal pregnancy, our specific knowledge of maternal heart rate and blood pressure is poor. To use heart rate and blood pressure variability as markers for hypertensive pregnancy disorder, it is first necessary to describe these parameters in normal pregnancy.

We hypothesized that heart rate variability could be readily measured during pregnancy and would provide a sensitive, non-invasive, and unobtrusive means of measuring the serial changes in cardiac autonomic modulation that occur during gestation. And comparison of these parameters with nonpregnant control group would generate even more scientifically and statistically significant data.

The purpose of this study was to evaluate changes in heart rate during deep breathing and to compare the gestational variation in pregnant women. An attempt was made to record the changes in heart rate variability at various phases of pregnancy in different age groups.

Materials and methods

It was observational and prospective, open label, parallel arm study carried out at department of physiology of a tertiary care institute of northern India from January 2018 to June 2019 after getting approval from institutional ethics committee. Study participants were recruited after matching them with inclusion and exclusion criteria of the protocol and after taking informed consent.

Inclusion criteria:

For test group: Pregnant women of age group 20 to 40 years.

For control group: Healthy nonpregnant women of age group 20 to 40 years.

Exclusion criteria:

- Women with diabetes, cardiovascular and renal disease.
- History of hypertensive disorders in earlier pregnancy.
- Women taking drug which is likely to have any cardiovascular effect.

Assuming heart rate in pregnant women as 72 ± 5 in nonpregnant women and 80 in pregnant women as predicted from earlier evidences with 0.05 alpha value and 80% power and 1:1 allocation, minimum sample size with 20% maximum possible rate was found to be 8. So, in each group, 50 women were enrolled in our study. Each group was then divided into two subgroups, one with subjects aged 30 or younger and the other with subjects over 30 years old. Among nonpregnant controls 28 were up to 30 years of age and 22 were above 30 years. In pregnant cases 24 were up to 30 years and 26 above 30 years of age.

Electrocardiogram was used to determine heart rate and heart rate variability. Heart rate variability was determined by the method given by Wheeler and Watkins in which heart rate maximum and minimum was determined during deep

inspiration and expiration. Heart rate variability was considered as the difference between maximum and minimum heart rate [7].

Electrocardiogram was done after the subject rested in lying posture on the couch. The electrocardiogram was obtained from two electrodes placed on the chest. It was recorded continuously at a speed of 25mm/sec. observation of heart rate was made for five minutes with subject breathing quietly, and then for one minute during a series of deep inspiration and expiration at a rate of six to eight breaths a minute. The heart rate was determined by counting the number of small squares in horizontal direction between two successive R waves. The maximum and minimum heart rate rates were calculated. The heart rate was calculated as 1500/number of small squares.

Statistical analysis: Data collected from each study participants were entered into Microsoft Excel 365. Mean heart rate and mean variability in heart rate of each group and subgroup was calculated and compared. The difference in data between two groups was analysed by using unpaired t test and the difference in interphase data within same group was analysed using repeated measure one way ANOVA. Significance level for tests was determined as 95 % ($p< 0.05$).

Results

Table 1 shows that there is higher heart rate in pregnant women but lower heart rate variability in pregnant women as compared to non-pregnant women. The result is also highly statistically significant ($p < 0.001$).

Table 1: Heart rate parameters of pregnant women and nonpregnant women

Subject	Heart rate in beats/ min (Mean ± SD)	Heart rate variability in beats/min (Mean ± SD)
Non pregnant (N=50)	74.0400 ± 2.1567	11.3600 ± 2.5052
Pregnant (N=50)	82.8400 ± 3.3828	6.1600 ± 1.3303
't'	15.51	12.98
'p'	<0.001	<0.001

Table 2: Influence of age on the heart rate and heart rate variability of pregnant women

Age group (in years)	Heart rate in beats/ min (Mean ± SD)	Heart rate variability in beats/min (Mean ± SD)
Up to 30 (N=24)	83.5833 ± 3.4881	6.5833 ± 1.3805
Above 30 (N=26)	82.1538 ± 3.1962	5.7692 ± 1.1767
't'	1.51	2.24
'p'	>0.05	<0.05

Table 2 shows that there was not any significant difference ($p >0.05$) in mean heart rate of pregnant women up to 30 years and above 30 years of age but heart rate variability was significantly lower in pregnant women of above 30 years ($p <0.05$).

Table 3 shows that unlike pregnant women, age had no significant effect on heart rate variability of non-pregnant women ($p >0.05$).

Table 3: Influence of age on the heart rate and heart rate variability of nonpregnant women

Age group (in years)	Heart rate in beats/ min (Mean ± SD)	Heart rate variability in beats/min (Mean ± SD)
Up to 30 yrs (N=28)	74.1429 ± 2.1032	11.5000 ± 2.7012
Above 30 yrs (N=22)	73.9091 ± 2.2659	11.1818± 2.2811
't'	0.37	0.44
'p'	>0.05	>0.05

Table 4 shows that there was highly significant effect of gestational age on heart rate and heart rate variability ($p <0.0001$). Heart rate variability was generally lower in first trimester.

Table 4: Influence of gestational age on heart rate

Gestational age (in trimester)	Heart rate in beats/ min (Mean ± SD)	Heart rate variability in beats/min (Mean ± SD)
I (N=50)	78.16± 2.96	5.16 ± 1.37
II (N=50)	86.10 ± 3.03	5.96 ± 1.39
III (N=50)	82.04± 2.93	6.69 ± 1.36
P value (ANOVA)	<0.0001	<0.0001

Discussion

Our study shows that the heart rate of pregnant women was higher than the nonpregnant women. D Chamchad et al also reported that compared to non pregnant volunteers the heart rate was higher in pregnant women [8]. Duvekot et al reported that the maternal cardiovascular adaptation to pregnancy involves enormous changes [9]. Cardiac output increases in early pregnancy, initially as a result of an increased heart rate, soon followed by an increased stroke volume. Thomas et al found that there was an increase in heart rate in pregnant women during the second half of pregnancy [10]. Robson et al found that heart rate synchronously increases by ten to fifteen beats per minute during pregnancy, so cardiac output begins to increase [11]. Maria L et al reported that the mean heart rate was higher in pregnancy compared to non pregnant controls [12].

It is reported that an increase in heart rate is evident as early as the fifth week of gestation. Since pregnancy is associate with a large increase in blood volume due to marked increase in plasma volume. Increased blood volume increases cardiac output. The marked augmentation of cardiac output in pregnancy results from asynchronous increase in both heart rate and stroke volume.

In our study we segregated the pregnant and non pregnant women in two groups, one with age up to 30 years and the other with age above 30 years. On comparison of heart rate of controls and cases in both the age group it was found that the heart rate in pregnant women both up to 30

years and above 30 years was higher as compared to non pregnant. According to Heiskanen Nonna et al parasympathetic deactivation is likely to contribute to increased heart rate and cardiac output in pregnancy. So, the increase in heart rate in our study is in line with reports of other workers [13].

In the present study the mean of heart rate variability of pregnant women in second trimester was 5.96 and the mean of heart rate variability of non pregnant women was 11.52. Our study shows that the heart rate variability in pregnant women is decreased compared to non pregnant women. There is probably a fall in baroreflex sensitivity as pregnancy progresses and heart rate variability falls.

Stein PK et al stated that maternal heart rate variability is declined during pregnancy [14]. He stated that the individual changes in heart rate, heart rate variability and respiration during pregnancy varied in both magnitude and direction. Thomas Walther et al stated that heart rate variability was reduced in normal pregnant women [10]. Ekholm et al reported that compared with nonpregnant women, those who were pregnant showed significantly lower heart rate variability during normal breathing [1]. In similar study, he reported that the overall heart rate variability was lower in pregnant subjects indicating a decreased parasympathetic tone at rest. The decreased parasympathetic tone probably counts for increased heart rate in pregnancy [15].

So, our present study on comparison of heart rate variability of pregnant and non pregnant women both up to and above 30 years of age it was found that the heart rate variability was decreased in pregnant women.

In the present study age did not have any significant effect on the heart rate and heart rate variability in non-pregnant women, but there was a significant reduction in heart rate variability in pregnant women with age. Andreas Voss et al reported no significant difference in heart rate in pregnant women with different maternal age [16]. Investigations on the influence of biological age on heart rate variability have shown that alternation in these parameters can occur as long-term effects over decades [17]. For this reason, significant changes due to ageing were not to be expected in our study mainly because of relatively short time frame observed with mean age difference of 8 years in pregnant women and 7 years in non pregnant controls.

There was highly significant effect of gestational age on heart rate and heart rate variability. Heart rate variability was generally lower in first trimester. Ramon C et al (2001) reported that in pregnancy heart rate increases until the end of the second trimester.

Conclusion

We have found significant association of high heart rate and low heart rate variability with pregnancyand this association was stronger in second trimester of pregnancy. Potentially, analysis of heart rate variability in pregnant women could determine which patients had elevated risk of preeclampsia and preterm birth and can shed light on underlying abnormal physiological states. Moreover, the feasibility of predicting clinical outcomes in pregnancy by measuring heart rate variability bears further investigation.

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