

A Comparative Study of Cardiovascular Changes during Three Trimesters of Pregnancy with Nonpregnant Controls

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Abstract

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Introduction: 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 fetus. The present study was designed to compare the cardiovascular changes at different trimesters of pregnancy with the nonpregnant women. *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 subgroups comprising 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 anthropometric, Blood pressure and ECG were recorded during morning hours. *Statistical Analysis:* The data were expressed as Mean±SD. Z test was used for comparison between control and study groups and within the study group. 'p' value of 0.05 or less was considered as statistically significant. *Result:* There was a significant increase in the pulse rate of the subjects in the 1st, 2nd and 3rd trimesters of pregnancy when compared to the control group (p=0.0001) and a significant decrease in SBP in the 1st and 2nd trimester of pregnancy compared to control group (p=0.0146 and 0.0001 respectively). The MAP was significantly decreased in the 2nd trimester of pregnancy compared to control group (p=0.0003) whereas, the decline was insignificant in the 1st and 3rd trimesters of pregnancy (p=0.596 and 0.638 respectively). *Discussion:* The pregnancy induced changes in the cardiovascular system develop primarily to meet the increased metabolic demands of mother & fetus. The overall decrease in vascular tone in response to an unknown endocrine stimulus represents the very first adaptive change in cardiovascular system giving rise to both an increased vascular capacity and a decreased filling state.

Keywords: Pregnancy; BP Responses; ECG Changes; Trimesters.

Introduction

Pregnancy is considered to be the most beautiful and enriching experience in the life of a woman. It is characterized by profound changes in the function of virtually every regulatory system in the human body. In pregnant women, large number of local and systemic changes are known to occur. These changes will continue throughout pregnancy [1] especially cardiovascular changes such as increase in heart rate, cardiac output and intravascular volume. 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 fetus [2]. In the absence of these adaptations, incidence of gestational complications such as fetal growth restriction and pregnancy induced hypertension are known to increase.

In normal pregnancy, functional systolic murmurs are quite common. They are heard over the precordium. It is of great importance to document the presence or absence of the systolic murmur and to identify it as innocent or pathologic [3]. Heart diseases contribute significantly to

maternal mortality throughout the world. Although heart diseases rarely occur during pregnancy, it is a fact that greater number of women with known or potential heart diseases are becoming pregnant [7]. Hemodynamic changes during pregnancy play a major role in the induction of arrhythmias. The increased incidence of arrhythmias during pregnancy is also reported [4].

The anatomical, physiological and biochemical adaptations to pregnancy are profound. Many of these changes begin soon after fertilization and continue throughout gestation. During pregnancy and puerperium, there are remarkable changes in the heart and circulation. The most important changes in cardiac function occur in the first eight weeks of pregnancy [5].

During pregnancy, a great deal of new maternal tissue is synthesized, especially in the uterus and the breasts. These areas show an increase in the size of the vascular bed. The blood volume increases during pregnancy to fill the enlarged vascular bed. There is also redistribution of blood. Both plasma volume and red cell mass increase in proportion to the duration of gestation to about 1000ml and 250ml respectively above non-pregnant values. The total increase in blood volume is about 25-30%. But, the percentage increase of plasma is almost 50% while that of red cells is only 18%. This shows that there is a much greater increase in plasma than in cells, which is a fundamental feature of pregnancy [6].

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 liter per minute. At the eighth month of pregnancy, this rises to about 5.5L. 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 [7]. 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 [5].

In normal pregnancy, the blood pressure in first few months is similar to that of non-pregnant woman. In the middle three months, however, the blood pressure tends to fall on an average by about 3-5 mm Hg. But sometimes the blood pressure drop may be of the order of 20-30 mm Hg, though the patients seem not to suffer at all from this. In the last three months of pregnancy, the blood pressure

slowly rises again until it comes back to the normal non-pregnant level [8]. With this background, the present study was designed to compare the cardiovascular changes at different trimesters of pregnancy with the nonpregnant women.

Materials and Methods

It is a cross sectional study conducted in the Department of Physiology, Shimoga institute of Medical Sciences, Sagar Road, Shivamogga. The study was undertaken to determine the ECG and blood pressure changes in 1st, 2nd & 3rd trimesters of pregnancy. The observations were compared with age matched healthy non-pregnant women.

One hundred fifty 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 proforma was used to record the relevant information from each selected individual who had fulfilled inclusion criteria. The subjects who had exclusion criteria were dropped from the study. 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 anemia were excluded.

Statistical Analysis

The results were expressed as Mean \pm SD for continuous data and number and percentages for

categorical data. Z test was used for comparison between control and study groups and Z test was used for comparison within the study group. Categorical data was analyzed by Chi-square test. A 'p' value of 0.05 or less was considered as statistically significant.

Results

In the present study, we have recorded the anthropometric, physiological & ECG parameters in control and study groups. The mean values of age, height, weight, body mass index and body surface area were shown in Table 1. In our study, there was no much change in all the anthropometric parameters of the subjects between study and control groups.

There was a significant increase in the pulse rate of the subjects in the 1st, 2nd and 3rd trimesters of pregnancy when compared to the control group

(p=0.0001, Table 2, 3, & 4). Our study revealed a significant decrease in SBP in the 1st and 2nd trimester of pregnancy compared to control group (p=0.0146 and 0.0001 respectively, Table 2, 3, & 4) but there was no significant difference in SBP at 3rd trimesters of pregnancy as compared to controls (p=0.17, Table-2,3, & 4). DBP was shown to be significantly decreased in the 2nd trimester of pregnancy compared to control group (p=0.0001) whereas, the decline was insignificant 1st and 3rd trimesters of pregnancy (p=0.378 and 0.441 respectively, Table 2, 3, & 4). The pulse pressure did not show any significant variation at any trimester of pregnancy as compared to controls.

The mean arterial blood pressure (MAP) was shown to be significantly decreased in the 2nd trimester of pregnancy compared to control group (p=0.0003) whereas, the decline was insignificant 1st and 3rd trimesters of pregnancy (p=0.596 and 0.638 respectively, Table 2, 3, & 4).

Table 1: Mean±SD and Range of Age and Anthropometric Parameters of subjects in Control and Study Groups

Parameters	Control Mean ± SD	1 st Trimester Mean ± SD	2 nd Trimester Mean ± SD	3 rd Trimester Mean± SD
Age (yrs)	26 + 3.43	25.12 ± 3.37	24.12±4.02	24.58 ± 3.47
Height (cms)	152.2 ± 0.06	154.4 ± 0.05	153.2±0.06	153.6± 0.06
Weight (kg)	52.38 ± 3.71	52.2 ± 7.00	55.22±6.53	59.60 ± 9.19
BMI (kg/m ²)	21.63 ± 2.12	21.75 ± 3.00	23.81±2.46	25.96 ± 3.42
BSA (Sq m)	1.48 ± 0.06	1.48 ± 0.10	1.53±0.45	1.53 ± 0.14

Table 2: Mean ± SD and Range of Physiological Parameters of subjects in Control and Study groups

Parameters	Control Mean± SD	1 st trimester Mean ± SD	2 nd trimester Mean ± SD	3 rd trimester Mean ± SD
PR (beats/min)	76.32 ± 4.12	82.28 ± 7.84	87.82 ± 8.70	95.12 ± 6.88
SBP (mm Hg)	118.66±4.40	115.60 ± 7.67	109.56 ± 5.68	117.56±7.94
DBP (mm Hg)	74.32 ± 4.75	73.36 ± 5.97	66.52± 5.68	75.60 ± 7.41
PP (mm Hg)	44.34 ± 5.47	42.44 ± 7.81	43.20 ± 5.33	42.44 ± 8.33
MAP (mm Hg)	88.94 ± 5.72	88.32 ± 5.80	80.90 ± 4.19	89.45 ± 7.26

Table 3: Test of Significance for Physiological Parameters Using Z Statistics between Control and Study groups

Parameters	Control & 1 st trimester		Control & 2 nd trimester		Control & 3 rd trimester	
	Z-Value	P-Value	Z-Value	P-Value	Z-Value	P-Value
PR (beats/min)	4.75	0.0001***	4.37	0.0001***	5.25	0.0001***
SBP (mm Hg)	2.44	0.0146*	3.01	0.0001***	1.38	0.17
DBP (mm Hg)	0.88	0.378	3.09	0.0001***	0.77	0.441
PP (mm Hg)	1.40	0.161	1.75	0.080	1.34	0.180
MAP (mmHg)	0.53	0.596	2.59	0.0003*	0.47	0.638

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

Table 4: Test of Significance for Physiological Parameters Using Z Statistics within the subgroups of Study group

Parameters	1 st & 2 nd trimesters		1 st & 3 rd trimesters		2 nd & 3 rd trimesters	
	Z-Value	P-Value	Z-Value	P-Value	Z-Value	P-Value
PR (beats/min)	3.34	0.0001***	7.75	0.0001***	4.1	0.0001***
SBP (mm Hg)	4.47	0.0001***	1.45	0.147	7.04	0.0001***
DBP (mm Hg)	6.47	0.0001***	2.11	0.034*	10.09	0.0001***
PP (mm Hg)	0.56	0.575	0.0	1	0.71	0.477
MAP (mm Hg)	7.33	0.0001***	1.12	0.262	10.21	0.0001***

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

Discussion

Pregnancy is a normal physiological process. It induces widespread circulatory adaptations in the mothers. The pregnancy induced changes in the cardiovascular system develop primarily to meet the increased metabolic demands of mother & fetus.

Both structural and functional changes are known to occur in the heart and vessels due to pregnancy. Ventricular dimensions, heart rate, cardiac output, vascular compliance and capacitance will increase whereas peripheral resistance and blood pressure decrease during pregnancy. Many of these changes are induced by gestational hormonal milieu which influences vessel structure, basal tone and reactivity via receptors for chorionic gonadotropin, estradiol and progesterone located in vascular endothelium and smooth muscle [9].

Despite the increased work load on the heart during gestation, the healthy pregnant women have no impairment of cardiac reserve. An understanding of these changes and the mechanism involved would be helpful in deciding on the optimal management of pregnant women with preexisting cardiovascular diseases as well as potentially useful in the prevention of gestational complications associated with inadequate maternal hemodynamic adaptation [10].

Electrocardiography is one of basic tools in the investigation of cardiovascular diseases. The electrocardiogram during normal pregnancy may show wide variation from the normal accepted. These variations may be due to the changed spatial arrangement of the chest organs as well as changed electrical properties of the myocardium. These changes are in turn due to sympathetic and hormonal modulation of cardiac electrical activity during pregnancy [11,12].

There was a significant increase in the pulse rate of the subjects in the 1st, 2nd and 3rd trimesters of

pregnancy when compared to the control group. Our study revealed a significant decrease in SBP in the 2nd trimester of pregnancy compared to control group and also when compared to 1st and 3rd trimesters of pregnancy. DBP was shown to be significantly decreased in the 2nd trimester of pregnancy compared to control group and also when compared to 1st and 3rd trimesters of pregnancy.

In the normal course of pregnancy, the blood pressure during the first few months is similar to that of pre-pregnant women. During the middle 3 months of gestation, the blood pressure tends to fall by an average of 3-5mm Hg. Sometimes, the drop may be up to 20-30 mm Hg [11]. The blood pressure both SBP and DBP tend to fall in early pregnancy reach nadir in the second trimester of pregnancy and return towards pre-pregnant level at term. Fall in blood pressure is due to fall in systemic vascular resistance. The overall decrease in vascular tone in response to a yet unknown endocrine stimulus represents the very first adaptive change in cardiovascular system giving rise to both an increased vascular capacity and a decreased filling state. In early pregnancy, an overall decrease in vascular tone leading to a systemic vasodilatation and rise in arterial compliance. The arterial blood pressure and vascular resistance tend to normalize during the 3rd trimester of pregnancy [12]. The present study is in agreement with the findings of studies [13,14].

Conclusion

The increase in heart rate may have been triggered to maintain the cardiac output in a state of relative hypovolemia. 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.

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