International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 6, Issue 8, ISSN No. 2455-2143, Pages 122-128
Published Online December 2021 in IJEAST (http://www.ijeast.com)

TO STUDY THE CHANGES IN AUTONOMIC NERVOUS ACTIVITY IN DIFFERENT SLEEPING POSITIONS ADOPTED BY PREGNANT FEMALES IN LAST TRIMESTER BY CARDIAC AUTONOMIC NEUROPATHY ANALYZER

Jeewandeep Kaur [1],
Associate Professor
Physiology (C R L), BPS GMC for Women, Sonepat

Arvinder Pal Singh Batra[2]
Professor & Head
Anatomy BPS GMC for Women, Sonepat.

***Abstract*-Ba*ckground*-** Pregnancy is associated with substantial changes in cardiovascular system. The action of the autonomic nervous system is thought to be essential for the circulatory adaptation seen in pregnancy and nourishing growing fetus.

Aims and objective- The study was conducted to assess the changes in autonomic nervous activity in different sleeping positions adopted by pregnant females in last trimester and compare it with non pregnant females.

Material and methods: A Comparative study was carried out amongst pregnant and non pregnant women in Department of Physiology. A total of 60 women (30 pregnant as study group and 30 non pregnant healthy women as control group) aged between 18- 30 years were included in study.

Results: The present study showed the role of parasympathetic activity in controlling hemodynamic in late pregnancy and left lateral position is found to be better recumbent position for uteroplacental circulation.

Conclusions: it was concluded that the supine position should be avoided and the left lateral decubitus position encouraged in late pregnancy, since the suppression of cardiac vagal activity and enhancement of cardiac sympathetic activity were greatest in the supine position and are least in the left lateral position.

Keywords: Pregnancy, autonomic nervous system, hypertension, sleeping position.

I. INTRODUCTION

Maternal hemodynamic undergoes profound changes during pregnancy, including increase in blood volume, cardiac size and cardiac output.[1, 2] The action of the autonomic nervous system is thought to be essential for the circulatory adaptation seen in pregnancy, but its actual role is poorly understood.[3] When the posture is changed from supine to upright in normal subjects, gravitational stress can activate sympathetic activity and suppress the vagal activity.[4] In late pregnancy, however, assumption of the supine position might induce a hypotensive response.[5, 6]

Aortocaval compression was suggested to be main factor responsible for this change; this theory was supported by the observation that moving to upright position could lead to lessening of sympathetic activation.[7] In some previous study, it was found that autonomic nervous activity was shifted to lower vagal and higher sympathetic modulation in late pregnancy.[8]

During pregnancy there is increase in blood volume , heart rate and cardiac output while peripheral resistance and resting blood pressure decreases.[9]The baroreflex function would be decreased in pregnancy because the physiological hypervolemia of pregnancy would be expected to dampen large changes in blood pressure.[10]In pregnancy the vascular tone decreases which leads to systemic vasodilatation and rise in arterial compliance; there is possible role of vasopressin which causes haemodilution and reduction in viscosity potentiates fall in vascular resistance and contributes in fall in afterload.[11] The increased nitric oxide activity during pregnancy plays a important role for pregnancy associated drop in systemic resistance.[12]The circulating estrogens during pregnancy stimulate vascular function directly or indirectly via increased NO availability.[13]Other factors like increased concentration of prostaglandins, increased heat production by developing fetus and development of low resistance circulation in pregnant uterus.[14] leads to decrease in blood pressure during pregnancy.

Many research reports have been extensively shown in maternal pregnancy position but very few studies are present in Indian population. This study is being conducted for the Indian women in context with positional effect on autonomic nervous activity in third trimester of pregnancy and comparing it with that of non-pregnant females to know the changes during late pregnancy.

International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 6, Issue 8, ISSN No. 2455-2143, Pages 122-128
Published Online December 2021 in IJEAST (http://www.ijeast.com)

II. AIMS AND OBJECTIVES

The current study was planned to learn the significance of autonomic function tests in different sleeping positions adopted by pregnant females in last trimester and compare it with non pregnant females

III. MATERIALS AND METHODS

Autonomic nervous control can be non-invasively studied with the cardiovascular reflex test, such as the Valsalva maneuver, the orthostatic test, the isometric test and by measuring heart rate variability.[15] We assessed autonomic activity in three different sleeping positions that is supine, left lateral decubitus and right lateral decubitus.

Study setting and study design:

A comparative study was carried out at Department of Physiology of BPS GMC (W), Khanpur Kalan, Haryana after taking approval of institutional ethical committee during study period of 2 months.

Study population: 30 healthy pregnant females were taken as subjects and 30 non pregnant females were taken as control.

Inclusion criteria for both groups:

1) 18-30 years age limit
2) Healthy pregnant and non pregnant females
3) No history of complicated pregnancy

Exclusion criteria for both groups:

1) Twin gestation
2) History of preeclampsia
3) Gestational diabetes
4) Placenta previa
5) Bad obstetric history
6) Chronic hypertension
7) Chronic renal disease
8) Diabetes
9) Cardiopulmonary disease
10) Chronic respiratory illness
11) On any medication like anti hypertensive's
12) The females who refused to give consent for study

Data collection:

All subjects were explained the procedure to be undertaken and a written consent were obtained (Annexure-1). All 30 pregnant women attending antenatal clinic along with healthy controls were assessed for variation in sympathetic and parasympathetic system associated with the position during last trimester pregnancy (28-38 weeks). Cardiac autonomic function test for assessing sympathetic and parasympathetic control was doneby CANWIN-504(Cardiac Autonomic Neuropathy Analyser-504).

CANWIN-504 (Cardiac Autonomic Neuropathy Analyser):

Canwin is the state of the art window based computer having cardiac autonomic neuropathy (CAN) analysis system with interpretation. It has an extensive data base to keep track of subject's history and for archive test retrieval and comparisons. Being fully automatic, the need of manual recordings, readings and calculation is eliminated. Inbuilt time domain waveform analysis and blood pressure measurements make the task of conducting all the autonomic nervous system tests very easy. Cardiac Autonomic Neuropathy Analyzer model CANS 504 is an important tool to measure and diagnose autonomic dysfunctions using ECG of R-R intervals and autonomic BP measurement.

CANWIN-504

A) **Test for assessing Parasympathetic activity** :

1. **Resting Heart Rate** was calculated from ECG by usingstandard limb leads.
2. **Heart rate response to standing (30:15)** was calculatedas ratio between R- R interval at beats 30 and 15 of the ECG recorded immediately upon standing. This test evaluates the cardiovascular response elicited by change from horizontal to vertical position. The typical heart rate response to standing is largely attenuated by parasympathetic blockade.
3. **Heart rate response to deep breathing:** Heart rate was recorded first during normal breathing at rest and then during deep breathing (6/ min). ECG 3rd and 6th respiration, minimum R- R interval and corresponding heart rate were calculated.

B) **Test for assessing Sympathetic activity:**

1. Isometric hand grip exercise test: Before the exercise, subjects were allowed to rest for 10 minutes in a quiet room. Resting blood pressure of all subjects was measured by auscultatory method with help of mercury sphygmomanometer (DIAMOND). First kortk of sound indicated systolic blood pressure (SBP) and fifth kortk of sound indicate diastolic blood pressure (DBP). Isometric handgrip test was done in both study and control group. After recording basal blood pressure, subjects were asked to perform isometric handgrip exercise. Subjects were told to hold the handgrip spring dynamometer in dominant hand to have full grip. Handles of dynamometer were compressed by subject with maximum effort for few seconds. Then subject were told to perform 30% of maximum handgrip for 3 min. During the test blood pressure was recorded from non exercising arm and again recorded after 5 min after exercise.

International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 6, Issue 8, ISSN No. 2455-2143, Pages 122-128
Published Online December 2021 in IJEAST (http://www.ijeast.com)

IV. OBSERVATION AND RESULTS

Mean and standard deviation of sympathetic and parasympathetic tests were carried out for study as well as control group. Statistical analysis was done by calculation of "p" value and "t" test. The collected data was entered in excel spreadsheet. Mean ± SD calculated for quantitative data, percentage. Student t–test was used for normally distributed variables to find the mean difference using SPSS software. P-value < 0.05 considered as statistically significant.

Table No. 1: Distribution of Mean and Standard deviation amongst Pregnant and control group for Sympathetic test in different positions.

	SympatheticTest	Control(30) Mean±Sd	Pregnant(30) Mean±Sd
SHG(Change in diastolicBP)	Supine	4.53± 7.505	4.53±7.519
	Right Lateral	1.53± 9.142	3.637±0.453
	Left Lateral	8.83±8.301)	8.83±11.576

(SHG= Sustained hand grip)

Table 2(A): Resting heart rate (RHR): Distribution of Mean and Standard deviation amongst Pregnant and control group for Parasympathetic tests in different positions

		Control (30)Mean±SD	Pregnant(30)Mean±SD
Resting heart rate(beats perminute)	Supine	72.67± 19.139	87.43± 25.488
	Right lateral	75.60± 15.869	81.63± 15.677
	Left lateral	75.37± 14.447	85.80± 14.180

Table 2(B): Deep breathing: **Distribution of Mean and Standard deviation amongst Pregnant and control group for Parasympathetic tests in different positions**

		Control(30) Mean±Sd	Pregnant(30) Mean±Sd
Deep breathing	Supine	31.67±16.251	43.77±38.056
	Right Lateral	42.17±17.475	42.17±17.475
	Left Lateral	37.40±16.487	34.40±15.797

Table 2(C): Heart rate response to standing (30:15)

		Control(30) Mean±Sd	Pregnant(30) Mean±Sd
Standing	Supine	1.10±0.481	1.20±1.095
	Right Lateral	1.00±0.00	1.00±0.525
	Left Lateral	1.00±0.00	0.97±0.183

Table 3: Comparison of Mean values of sympathetic test between pregnant and control group indifferent positions

	SympatheticTest	Control(30) Mean±Sd	Pregnant(30) Mean±Sd	t- value	P value
SHG (Change in diastolicBP)	Supine	4.53±7.505	4.53±7.519	0.00	1.00
	Right Lateral	1.53±9.142	3.63±7.453	0.975	0.334
	Left Lateral	8.83±8.301	8.83±11.576	0.00	1.00

International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 6, Issue 8, ISSN No. 2455-2143, Pages 122-128
Published Online December 2021 in IJEAST (http://www.ijeast.com)

Table 4(A): Resting heart rate:- Comparison of Mean values of Parasympathetic test between pregnant and control groupin different positions

		Control (30) Mean±Sd	Pregnant(30) Mean±Sd	t- value	P value
Resting heart rate(beats per minute)	Supine	72.67±19.139	87.43±25.488	2.538	0.014*
	Right lateral	75.60±15.869	81.63±18.314	1.481	0.144
	Left lateral	75.37±14.447	85.80±14.180	2.823	0.007*

Table 4(B): Heart rate response to deep breathing:

		Control(30) Mean ±Sd	Pregnant(30) Mean±Sd	t- value	P value
Deep breathing	Supine	31.67±16.251	43.77±38.056	1.602	0.115
	Right Lateral	42.17±17.475	46.93±26.322	0.826	0.412
	Left Lateral	37.40±16.487	34.40±15.797	0.720	0.475

Table 4(C): Heart rate response to standing (30:15)

		Control(30) Mean±Sd	Pregnant(30) Mean±Sd	t- value	P value
Standing	Supine	1.10±0.481	1.20±1.095	0.458	0.649
	Right Lateral	1.00±0.00	1.00±0.525	0.000	1.000
	Left Lateral	1.00±0.00	0.97±0.183	1.000	0.321

Table 5: Intra group comparison of pregnant females for supine, right lateral decubitus and leftlateral decubitus

Sympathetic Activity		**t- value**	**P value**
Sustained Hand grip(Change in BP)	Supine-Right lateral	0.461	0.648
	Supine-Left lateral	2.268	0.031*
Parasympathetic Activity			
Resting HeartRate	Supine-Right lateral	1.120	0.272
	Supine-Left lateral	0.294	0.771
	Right lateral-left lateral	0.980	0.335
Heart rate response to deep breathing	Supine-Right lateral	0.375	0.711
	Supine-Left lateral	1.685	0.103
	Right lateral-left lateral	2.455	0.020*
Heart rate response tostanding	Supine-Right lateral	1.361	0.184
	Supine-Left lateral	1.000	0.326
	Right lateral-left lateral	0.273	0.787

*= significant ($p < 0.05$)

Table 1:- showed mean score of change in diastolic BP is higher in left lateral position (8.83±8.301) in both control and pregnant group and lower in right lateral position in both control (1.53±9.142) and pregnant (3.637±0.453) group.

Table 2(A):-showed that mean score of RHR in supine position in pregnant (87.43±25.488) is higher than that of control group (72.67±19.139), right lateral in pregnant (81.63±15.677) is higher than control group (75.60±15.869), left lateral in pregnant (85.80±14.180) is higher than control (75.37±14.447).

Table 2(B):- showed that mean score of heart rate response deep breathing is higher
in supine position in pregnant to females **(**43.77±38.056).

Table 2(C):-showed mean score of heart rate response to standing is higher in pregnant females (1.20±1.095) in

International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 6, Issue 8, ISSN No. 2455-2143, Pages 122-128
Published Online December 2021 in IJEAST (http://www.ijeast.com)

supine position.

Table 3:-showed that the mean difference in diastolic BP in Supine, RL, LL between study and control group was statistically not significant (P>0.05).

Table 4(A):-showed that the mean difference of RHR in supine and left lateral positions between pregnant and control group was statistically significant (p value <0.05).

Table 4(B):-showed the mean difference in heart rate response to deep breathing in all threepositions between pregnant and non pregnant women was statistically not significant (p>0.05).

Table 4(C):- showed that the mean difference in heart rate response to standing in all three positions between control and study group was statistically not significant (P>0.05).

Table5:- showed that mean of sympathetic activity in leftlateral positionwas higher thansupine and right lateral position which was statistically significant. The parasympathetic activity in terms of resting heart rate and heart rate response to standing don't show any statistically significant in allthree positions. While the mean of heart rate response to deep breathing was higher in right lateral on comparison with left lateral position and was statistically significant (P=0.020).

V. DISCUSSION

In our study the response of autonomic activity (sympathetic and parasympathetic) during different positions adopted by pregnant female in third trimester was studied and compared with control group i.e. non pregnant women. Diastolic BP following isometric handgrip strength didn't show any statistically significant (P>0.05) change in pregnant women when compared with control group. These results were consistent with the study done by Barron et al.[16]

In thelate pregnancy, the mechanism of pressor response to isometric handgrip test is similar to post partum: there is an increase in cardiac output and reduction in forearm vascular resistance.[17] In contrast to this maximal isometric exercise near to fatigue has been reported to raise the total peripheral resistance without a change in cardiac output during second half of pregnancy.[18]

The heart rate and pressor response to maximal isometric exercise of short duration is unaffected by pregnancy. The vagal withdrawl induced by somatic pressor reflex is unchanged in pregnancy.[19]

The primary role of arterial baroreflex is immediate and short term adjustment of BP following perturbations around an existing mean pressure.[20]The mean diastolic BP in pregnant women in left lateral position was significantly higher (P<0.05) than supine and right lateral position. In late pregnancy, assumption of supine position might induce a supine hypotensiveresponse.[5]

The aortocaval compression by gravid uterus has been postulated as the cause for this change in hemodynamic in late pregnancy.[8] Avoidance of supine was recommended during blood pressure measurement in pregnant women by British Hypertensive Society in order to minimize aortocaval compression.[21]Lateral slit was suggested as a means of relieving compression of inferior vena cava and improving cardiac output.[6]

The parasympathetic activity in terms of RHR was significantly higher in supine (P=0.014) and left lateral (P=0.007) in pregnant women when compared with control group. There was no significant difference in right lateral position between study and control group (P=0.144) These findings coincide with results of C.D. Kuo et al.[22]

As gestational age increases, aortocavalcompression caused by the enlarging gravid uterus further compromises venous return and cardiac output, leading to a shift in autonomic nervous activity towards an even higher sympathetic and lower vagal modulation in third trimester of pregnancy. Due to increase in sympathetic activity there is rise in heart rate in last trimester when comparedwith non-pregnant women. There was no significant difference in mean RHR (P>0.05) between three different recumbent positions in pregnant women. These finding were different from study done by Chen G-Y.[22]

Insufficient numbers of patients might be the cause of these discrepancies. There was no significant difference in heart rate in response to deep breathing in all three positions between control and study group. Our findings were similar with the findings of K E Juhani Airaksinen et al. longitudinal studies begun before pregnancy have shown that maximal heart rate response to deep breathing diminishes progressively throughout pregnancy.[23]Several factors may be involved in these changes: the decrease in functional residual capacity of lungs in pregnancy may reduce the difference in the breathing volume during spontaneous and deep breathing in pregnant women.[24]

During deep breathing , the oscillations of venous return to heart and thorax may be enhanced inpregnant subjects due to changes in thoraco-abdominal pressure .these factor would change the afferent neural inflow differently in pregnant and non pregnant subjects and diminish the difference in heart rate variability in pregnant and non pregnant subjects during deep breathing .Heart response to deep breathing is significantly higher (P=0.022) in left lateral position when compared with right lateral in pregnant women. In pregnancy, the tidal volume is increased in subjects lying in left lateral position.[25]

In our study the result indicated that the heart rate response to standing 30:15 was statistically non significant in pregnant and non pregnant women. There was no significant difference in heart rate in all three positions among study group. These results coincide with the study done by Easterling et al.[26]

Doppler sonography, on the other hand has found that the decrease in both cardiac output and stroke volume caused by standing up are unaffected by pregnancy.[26]The

vasoconstriction induced by orthostatic stress is diminished in pregnancy.[27] The forearm vasoconstrictor response is abolished during the last trimester of pregnancy compared with post partum.[17] The central venous pressure remains practically unchanged after standing up both in late pregnancy and post partum.[27]In a study done by Daniela Lucini et al prevailing sympathetic modulation of sino-atrial node and reduction in BP in last stage of pregnancy was found to be accompanied by diminished responsiveness to standing.[28]

VI. SUMMARY

The present study was aimed to assess the changes in autonomic nervous activity in different sleeping positions adopted by pregnant females in last trimester and compare it with non pregnant females. This study was conducted in 30 pregnant women and 30 controls (non-pregnant women) in supine, right lateral and left lateral position. Isometric handgrip exercise test was used for assessment of sympathetic activity. To assess parasympathetic activity; resting heart rate, heart rate response to deep breathing and standing 30:15 was recorded. In our study it was found that there was significant change to resting heart rate in supine and left lateral positionamong the study group as compared to control group reflecting higher parasympathetic activity in last trimester while test for sympathetic system has not shown significant difference among both groups.

On intra group comparison of pregnant women we found that decrease in BP was more in supine and right lateral position than left lateral position and the resting heart rate was significantly lower in left lateral position when compared with supine and right lateral position. The present study showed the role of parasympathetic activity in controlling hemodynamic in late pregnancy and left lateral position is found to be better recumbent position for uteroplacentalcirculation.

VII. CONCLUSION

From this study it was concluded that the supine position should be avoided and the left lateral decubitus position encouraged in late pregnancy, since the suppression of cardiac vagal activity and enhancement of cardiac sympathetic activity were greatest in the supine position and are least in the left lateral position. Due to low vagal activity in pregnancy, heart rate increased whencompared to control group. Aortocaval compression might be mechanism underlying suppression of cardiac vagal activity. Supine or right lateral position in late pregnancy results in decrease venous return thereby decreasing cardiac output and blood pressure. Supine hypotensive syndrome in late pregnancy compromises utero placental circulation and might be the cause of maternal and fetal complications. So, to prevent utero placental insufficiency left lateral position should be advised to pregnant women in last trimester. However further studies in this regards are required to establish effect of recumbent position in last trimester.

VIII. REFERENCE

[1]. Duvekot JJ, Cheriex EC, Pieters FA, Menheere PP, Peeters LL. Early pregnancy changes in hemodynamics and volume homeostasis are consecutive adjustments triggered by a primary fall in systemic vascular tone. American journal of obstetrics and gynecology. 1993 Dec 1; 169(6):1382-92.

[2]. Slangen BF, Out IC, Verkeste CM, Peeters LL. Hemodynamic changes in early pregnancy in chronically instrumented, conscious rats. American Journal of Physiology-Heart and Circulatory Physiology. 1996 May 1; 270(5):H1779-84.Kinsella SM, Lohmann G. Supine hypotensive syndrome. Obstetrics and gynecology. 1994 May; 83(5 Pt 1):774-88.

[3]. Ekholm EM, Piha SJ, Erkkola RU, Antila KJ. Autonomic cardiovascular reflexes in pregnancy. A longitudinal study. Clinical Autonomic Research. 1994 Aug 1; 4(4):161-5.

[4]. Smith JJ, Hughes CV, Ptacin MJ, Barney JA, Tristani FE, Ebert TJ. The effect of age on hemodynamic response to graded postural stress in normal men. Journal of Gerontology. 1987 Jul 1; 42(4):406-11.

[5]. Holmes F. Incidence of the supine hypotensive syndrome in late pregnancy. BJOG: An International Journal of Obstetrics & Gynaecology. 1960 Apr 1; 67(2):254-8.

[6]. Holmes F. The supine hypotensive syndrome. Anaesthesia. 1995 Nov; 50(11):972-7.

[7]. Kuo CD, Chen GY, Yang MJ, Tsai YS. The effect of position on autonomic nervous activity in late pregnancy. Anaesthesia. 1997 Dec; 52(12):1161-5.

[8]. Chen GY, Kuo CD, Yang MJ, Lo HM, Tsai YS. Comparison of supine and upright positions on autonomic nervous activity in late pregnancy: the role of aortocaval compression. Anaesthesia. 1999 Mar; 54(3):215-9.

[9]. Hytten FE, Leitch I. The physiology of human pregnancy. The physiology of human pregnancy. 1964.

[10]. Thompson CA, Tatro DL, Ludwig DA, Convertino VA. Baroreflex responses to acute changes in blood volume in humans. American Journal of Physiology-Regulatory, Integrative and Comparative Physiology. 1990 Oct 1; 259 (4):R792-8.

[11]. Valdés G, Salas SP, Foradori AC, Gormaz G, Croxatto HR. the neurogenic response to 55-degree head-up tilt in normal pregnant-women. Hypertension. 1986 Apr 1;8(4):1

[12]. Morris NH, Eaton BM, Dekker G. Nitric oxide, the

endothelium, pregnancy and pre- eclampsia. BJOG: An International Journal of Obstetrics & Gynaecology. 1996 Jan;103(1):4-15.

[13]. Gerber JG, Payne NA, Murphy RC, Nies AS. Prostacyclin produced by the pregnant uterus in the dog may act as a circulating vasodepressor substance. The Journal of clinical investigation. 1981 Mar 1; 67 (3):632-6.

[14]. Oakley CM. Cardiovascular disease in pregnancy. The Canadian journal of cardiology. 1990 May; 6:3 B-9B.

[15]. Wieling W. Non-invasive continuous recording of heart rate and blood pressure in the evaluation of neurocardiovascular control. Autonomic failue. 1992; 291.

[16]. Barron WM, Mujais SK, Zinaman M, Bravo EL, Lindheimer MD. Plasma catecholamine responses to physiologic stimuli in normal human pregnancy. American journal of obstetrics and gynecology. 1986 Jan 1;154(1):80-4.

[17]. NISELL H, HJEMDAHL P, LINDE B, LUNELL NO. Sympatho-adrenal and cardiovascular reactivity in pregnancy-induced hypertension. I. Responses to isometric exercise and a cold pressor test. BJOG: An International Journal of Obstetrics & Gynaecology. 1985 Jul; 92(7):722-31.

[18]. Van Hook JW, Gill P, Easterling TR, Schmucker B, Carlson K, Benedetti TJ. The hemodynamic effects of isometric exercise during late normal pregnancy. American journal of obstetrics and gynecology. 1993 Oct 1; 169(4):870-3.

[19]. Lotgering FK, van den Berg A, Struijk PC, Wallenburg HC. Arterial pressure response to maximal isometric exercise inpregnant women. American journal of obstetrics and gynecology. 1992 Feb 1; 166(2):538-42.

[20]. BLAKE MJ, MARTIN A, MANKTELOW BN, ARMSTRONG C, HALLIGAN AW, PANERAI RB, POTTER JF. Changes in baroreceptor sensitivity for heart rate during normotensive pregnancy and the puerperium. Clinical Science. 2000 Mar 1; 98(3):259-68.

[21]. Petrie JC, O'brien ET, Littler WA, De Swiet M. Recommendations on blood pressure measurement. British medical journal (Clinical research ed.). 1986 Sep 6; 293(6547):611.

[22]. Kuo CD, Chen GY, Yang MJ, Lo HM, Tsai YS. Biphasic changes in autonomic nervous activity during pregnancy. British journal of anaesthesia. 2000 Mar 1; 84(3):323-9.

[23]. Airaksinen KJ, Salmela PI, Ikäheimo MJ, Kirkinen P, Linnaluoto MK, Takkunen JT. Effect of pregnancy on autonomic nervous function and heart rate in diabetic and nondiabetic women. Diabetes care. 1987 Nov 1; 10(6):748-51.

[24]. Contreras G, GutiéRrez M, Beroíza T, Fantín A, Oddó H, Villarroel L, Cruz E, Lisboa C. Ventilatory drive and respiratory muscle function in pregnancy. American Review of Respiratory Disease. 1991 Oct; 144(4):837-41.

[25]. Rees GB, Pipkin FB, Symonds EM, Patrick JM. A longitudinal study of respiratory changes in normal human pregnancy with cross-sectional data on subjects with pregnancy- induced hypertension. American journal of obstetrics and gynecology. 1990 Mar 1; 162(3):826-30.

[26]. Easterling TR, Schmucker BC, Benedetti TJ. The hemodynamic effects of orthostatic stress during pregnancy. Obstetrics and gynecology. 1988 Oct; 72(4):550-2.

[27]. Clark SL, Cotton DB, Pivarnik JM, Lee W, Hankins GD, Benedetti TJ, Phelan JP. Position change and central hemodynamic profile during normal third-trimester pregnancy and post partum.American journal of obstetrics and gynecology.1991 Mar 1; 164(3):883- 7.

[28]. Lucini D, Strappazzon P, Dalla Vecchia L, Maggioni C, Pagani M. Cardiac autonomic adjustments to normal human pregnancy: insight from spectral analysis of RR interval and systolic arterial pressure variability. Journal of hypertension. 1999 Dec 1; 17(12):1899- 904.