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Haemorheological, plasma lipids and blood pressure changes during normal pregnancy in Nigerians

L.A.Olatunji*[1], A.O. Soladoye[1], A.A. Fawole[2] J.F.A. Owoeye[3] O.R. Balogun[2] and B. Mustapha[1]

Departments of [1]Physiology and Biochemistry, [2]Obstetrics and Gynaecology, and [3]Ophthalmology, College of Medicine, University of Ilorin, Ilorin, Nigeria.

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ABSTRACT: Some haemorheological markers (haematocrit, total plasma protein and relative plasma viscosity), plasma lipids, lipoproteins, and blood pressure were evaluated in thirty-three healthy pregnant and twenty age-matched non-pregnant women. Systolic blood pressure ($p < 0.01$), diastolic blood pressure ($p < 0.001$), mean arterial pressure ($p<0.001$), and haematocrit ($p < 0.001$) were significantly lower in pregnant women compared with those in non-pregnant women. On the other hand, pregnant women had significantly higher plasma viscosity and triglyceride ($p < 0.001$) than non-pregnant women. However, there were no significant differences in the pulse pressure, total plasma protein, plasma total cholesterol, LDL- cholesterol and HDL-cholesterol between the two groups of women. These data confirm that normal pregnancy is associated with decreased blood pressure, which in part, may be due to decrease in haematocrit. The observed elevated plasma viscosity during normal pregnancy may be triglyceride- mediated but not plasma protein mediated. In addition, these results indicate significant of haemodilution on blood pressure changes during pregnancy.

Keywords: Pregnancy; Blood pressure; Haemodilution; Plasma viscosity; Triglycerides.

Introduction

Normal pregnancy is associated with marked alterations in the maternal circulation, including a 50-70% increase in plasma volume (1,2) accompanied by increases in heart rate, cardiac output and decrease in peripheral resistance, leading to a progressive fall in blood pressure (3). These changes are associated with increased maternal blood flow (4). Altered levels of rheological parameters which affect blood flow in both micro- and macro-vessels have been found to be associated with conditions that increased perinatal morbidity and mortality, such as hypertension (5,6), smoking (5,6), diabetes mellitus (7,8), and pre-eclampsia (9).

*To whom correspondence should be addressed.
E-mail: ayotunji03@yahoo.co.in (Tel: +234(0)803- 5755360).

However, the management and measurement of plasma viscosity is becoming a central issue affecting blood replacement with plasma expanders and the development of artificial blood (10). Despite increasing interest in blood rheology, little attention has been paid to the changes in haematocrit (the main determinant of whole blood viscosity) (5, 6, 11) and plasma viscosity whose determinants are plasma proteins, triglycerides and lipoproteins (5, 11-13) during normal pregnancy, especially in Africans.

Steroid hormones, such as oestrogens and progesterone that are known to be high during pregnancy, have been shown to cause significant alterations in plasma lipid and lipoprotein metabolism (14). Moreover, plasma triglycerides levels were also found to be positively correlated with oestrogen and insulin concentrations (14, 15). However, triglycerides-rich lipoproteins (chylomicrons, very low density lipoproteins [VLDL]) have been shown to cause an exponential increase in plasma viscosity (5, 11-13). In contrast, HDL-cholesterol showed inverse associations with haemorheological markers (5, 13). Elevated plasma viscosity may lead to atherothrombosis through impaired blood flow, shear stress damage at the blood -endothelial interface and facilitation of plasma protein interactions with the endothelium (16). Therefore, the purpose of this study was to evaluate the influence of normal pregnancy on arterial pressure, some haemorheological markers, plasma lipids and lipoproteins.

Materials and Methods

Thirty-three (33) non-smoking healthy pregnant women aged between 20 and 38 (27.8 0 ± 1.0)years, and regularly attending the antenatal Clinic of the University of Ilorin Teaching Hospital, Ilorin, Nigeria were recruited for the study. Pregnant women with family history of diabetes mellitus, obesity, glycosuria, proteinuria, and hypertension were excluded from the study. Twenty healthy non-pregnant women aged between 20 and 40 (27.0 ± 2.5) years who were mainly staff of the University of Ilorin were also admitted into the study provided they were non-smokers, not on any medication including contraceptive steroids. The subjects had regular menstrual cycles and were not in the menstrual phase of the menstrual cycle. The anthropometric measurements were determined as well as relevant obstetric history (Table1). The informed written consent of each pregnant or non-pregnant woman was obtained before participating in the study. Fasting venous blood was collected in heparinized sample bottles for estimations of haemorhelogical and plasma lipid variables.

The subjects were made to rest for 15min before blood pressure was determined in the sitting position using a standard mercury sphygmomanometer. The first and fifth korotkoffs phases were taken as the systolic and diastolic blood pressure respectively. Pulse pressure was determined by subtracting the diastolic blood pressure from the systolic blood pressure. Mean arterial pressure was determined as one third of pulse pressure plus the diastolic blood pressure. Haematocrit was analyzed using standard micro-haematocrit technique and total plasma proteins was by the biuret-micro method using assay kit supplied by Randox Laboratory Inc. (U.K.) as in the past studies (17). Relative plasma viscosity was determined by capillary viscometry as previously described (8, 17, 18). Measurements of plasma concentrations of total cholesterol, HDL cholesterol and triglycerides were determined by coupled enzymatic assay using spectrophotometry by kits supplied by Randox Laboratory Inc. (U.K.). LDL-cholesterol levels were computed by the Friedewald formula (19). Determination of plasma lipids was done on the same day.

Statistical Analysis

All data were reported as means ± SEM. Statistical comparison was made using the unpaired student t-test. The level of significance was set as $p < 0.05$.

Results

Table1. Shows the anthropometric measurements in pregnant and non-pregnant women. The mean ages, heights, and body weights were similar in both groups of women. Haematocrit value among pregnant

women was 34.5 ± 0.6%, which was significantly reduced ($p < 0.001$) compared with that of non-pregnant women, while relative plasma viscosity and mean plasma triglyceride level in pregnant women were significantly higher ($p < 0.001$) than those in non-pregnant women (Table 2). However, the mean values for plasma total protein, total cholesterol, LDL-cholesterol and HDL- cholesterol levels were not significantly different between the two groups (Table 2). Pregnant women had significantly lower systolic blood pressure ($p < 0.01$), diastolic blood pressure ($P < 0.001$) and mean arterial pressure ($P < 0.001$) than those observed in non-pregnant women (Table 3), while the mean value for pulse pressure in pregnant women was similar to that of the non-pregnant women (Table 3).

Table 1: Age, height, weight, body mass index and parity for pregnant and non-pregnant women.

Variable	Non-Pregnant	Pregnant
Age (Years)	27.0 ± 3.4 (20 – 40)	27.8 ± 10 (20 – 38) n.s.
Height (m)	1.56 ± 0.01 (1.50 – 1.60)	1.63 ± 0.01 (1.52 – 1.73) n.s.
Weight (kg)	61.2 ± 3.3 (46 – 79)	65.3 ± 2.3 (50.7 – 93.0) n.s.
Parity (n)	2 (0 – 3)	2 (1 – 3)
n	20	33

Values are given as mean ± SEM with the ranges in parentheses. n = number of subjects per group.
n.s. = Not significant.

Table 2: Haemorheological variables and plasma lipids in pregnant and non-pregnant women.

Variables	Non-Pregnant	Pregnant
Hct (%)	37.5 ± 0.8 (32.0 – 40.0)	34.5 ± 0.6 (30.0 – 40.5)**
TPP (g/L)	57.7 ± 2.2 (42.0 – 63.0)	53.7 ± 2.9 (42.0 – 63.0) n.s.
RPV	1.72 ± 0.03 (1.60 – 1.95)	1.84 ± 0.02 (1.70 – 2.00)***
TG (mmol/L)	0.85 ± 0.08 (0.50 – 1.00)	1.15 ± 0.09 (0.80 – 1.40)*
TC (mmol/L)	3.56 ± 0.17 (2.80 – 4.40)	3.50 ± 0.13 (2.50 – 4.80) n.s.
LDL-C (mmol/L)	1.79 ± 0.24 (1.00 – 2.96)	2.00 ± 0.16 (1.10 – 3.50) n.s.
HDL-C (mmol/L)	1.51 ± 0.09 (1.08 – 1.73)	1.40 ± 0.08 (0.96 – 2.60) n.s.

Values are given as means ± SEM with the ranges in parentheses. Hct, haematocrit; TPP, total plasma protein; RPV, relative plasma viscosity; TG, triglycerides; TC, total cholesterol; LDL-C, low density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol.

n.s., not significant; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ when compared with non-pregnant.

Discussion

The results of the present study demonstrate that pregnant women have lower haematocrit value than non-pregnant women and that the decrease is accompanied by elevated plasma viscosity and triglyceride levels. In addition, decreased systolic blood pressure, diastolic blood pressure and mean arterial pressure were observed among pregnant women compared to non-pregnant women. The fall in arterial pressure in this study is in agreement with earlier observations in healthy pregnant women (3, 20) and animals (21).

The marked decrease in diastolic blood pressure in these pregnant women indicates a reduction in peripheral vascular resistance, which in turn may reduce initiation or progression of arterial disease. Reduced vascular resistance associated with pregnancy has been associated with increased venous compliance and stasis (22). This stasis has been shown to promote venous thromboembolism due to increased plasma viscosity (21).

Table 3: Blood pressure measurement in pregnant and non-pregnant women.

Variables	Non-Pregnant	Pregnant
SBP (mmHg)	122.8 ± 2.6 (110.0 – 135.0)	102.5 ± 5.4 (96.0 – 130.0)**
DBP (mmHg)	85.6 ± 2.6 (70.0 – 80.0)	65.6 ± 1.7 (60.0 – 85.0)***
PP (mmHg)	37.2 ± 2.6 (30.0 – 50.0)	40.8 ± 4.1 (20.0 – 70.0) n.s.
MAP (mmHg)	97.9 ± 2.3 (83.5 – 103.5)	78.6 ± 1.7 (70.0 – 96.6)***

Values are given as means ± SEM with the ranges in parentheses. SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; MAP, Mean Arterial Blood Pressure.

n.s., not significant; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ when compared with non-pregnant.

Whole blood viscosity is mainly determined by haematocrit (5, 6, 11). The decreased haematocrit observed among the pregnant women is suggestive of decreased whole blood viscosity during pregnancy. This finding is consistent with a previous study (4). The decrease in haematocirt in these pregnant women would also suggest haemodilution, which might be secondary to increase plasma volume, increased plasma volume has been consistently associated with pregnancy (1, 2, 20). Furthermore, most of epidemiological studies have demonstrated a strong positive correlation between arterial pressure and haematocrit (24, 25). Hence, the decrease in haematocrit in the pregnant women may by responsible for the observed reduction in arterial pressure.

The present study demonstrated an increase in plasma viscosity among the pregnant women and this finding is consistent with the report of Eastham (26), whereas other workers (4, 6) reported decreased plasma viscosity during pregnancy. Plasma viscosity has been shown to be determined by plasma proteins, triglycerides and/or lipoproteins (5,6,11,13). Despite the increase in plasma viscosity in the present study, total plasma protein levels remain unaltered but an increase in plasma triglycerides was observed among pregnant women. This finding corroborates the contention that triglyceride-containing lipoproteins may have some pathological significance by contributing to plasma viscosity. Hypertriglyceridaemia has been linked with pregnancy (27, 28). Steroid hormones, such as oestrogens that increase substantially during pregnancy have been found to cause increase triglyceride levels by stimulating hepatic synthesis of triglyceride -rich lipoproteins (VLDL) (15) and by inhibiting hepatic and adipose tissue lipoprotein lipase activity (29). It may be important to note that the increased plasma viscosity observed in the pregnant women may be triglyceride-induced rather than being plasma protein- induced. Thus, factors such as diuretic usage, severe dehydration, advanced age, smoking, arterial hypertension, coronary heart disease, diabetes mellitus or obesity which have been shown to cause increase in haematocrit and /or triglycerides (5,7,11) would tend to negate the haemodynamic advantage of the physiological haemodilution, which in turn, might lead to impaired blood flow, and elevated blood pressure.

In conclusion, triglyceride-mediated increased plasma viscosity may significantly contribute to impaired vasomotor tone, tissue ischaemia, fatigue, blurred vision and musculoskeletal pain during pregnancy. We therefore suggest that monitoring of plasma viscosity during pregnancy especially in patients with severe hypertriglyceraemia may be necessary. This study provides evidence that the reduction in blood pressure during pregnancy may be attributed to decrease haematocrit, arising from haemodilution which may exert beneficial effect on haemodynamic during normal pregnancy.

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