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Influence of Maternal Anthropometric Measurements and Serum Biochemical Nutritional Indicators on Fetal Growth

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This study aims to assess mother weight, height and body mass index (BMI = weight in kg/height in m^2) as well as maternal and cord blood prealbumin, albumin, retinol binding protein, transferrin and fibronectin and their impaction on fetal growth. The study included 54 pregnant women at delivery with their corresponding full term newborns. They were chosen to be free of any medical or obstetric problems that may interfere with intrauterine growth and development. Newborn body weight, length, head circumference, arm circumference, chest circumference and Ponderal Index (PI = weight in grams/length in cm^3) were recorded. Serum albumin, prealbumin, retinol binding protein, transferrin and fibronectin in maternal and cord blood were evaluated using radial immunodiffusion kits. Cases were put into two groups: low birth weight equal to or less than 2.5 kg (n = 24) and control above 2.5 kg (n = 30). In low birth weight group, the correlation between maternal weight and neonatal birth-weight, PI and cord fibronectin was significantly positive. It was negative between maternal body weight and neonatal length, head and chest and arm circumferences. Correlation between maternal BMI and neonatal weight, cord blood albumin and fibronectin was significantly positive. It was negative between BMI and neonatal length, PI, head and chest and arm circumferences. In both studied groups, maternal height positively correlated with neonatal weight. While maternal albumin and fibronectin were significantly lower in low birth weight group, prealbumin, retinol binding protein and transferrin were not. Maternal albumin positively correlated with each of the neonatal length, head and chest and arm circumferences in low birth weight group. Maternal fibronectin positively correlated with each of the neonatal length, PI and cord blood fibronectin and negatively correlated with each of the neonatal head and chest and arm circumferences in low birth weight group. In conclusion, mother underweight and low BMI reduce newborn weight. Newborn length and head, chest and arm circumferences are negatively affected with maternal hypoalbuminemia. While low fibronectin reduces newborn body length and PI, low prealbumin, retinol binding protein and transferrin have no influence on fetal growth.

Key words: Anthropometric measurements, low birth weight, albumin retinol binding protein, transferrin, fibronectin

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INTRODUCTION

Nutrition is the major intrauterine environmental factor that alters expression of the fetal genome and may have lifelong consequences. Alternations in fetal nutrition and endocrine status may result in developmental adaptations that permanently change the structure, physiology and metabolism of the offspring, thereby predisposing individuals to metabolic, endocrine and cardiovascular diseases in adult life (Wu *et al*., 2004a). Maternal nutrition influences the availability of nutrients for transfer to the fetus. Substrate supply to the fetus is a major regulator of prenatal growth. Animal experiments demonstrate that restriction of maternal protein or energy intake can retard fetal growth. Recent studies suggest that in Western settings the balance of macronutrients in a woman's diet can influence newborn size (Moore and Davies, 2005; Kind *et al*., 2006).

This study aimed to evaluate the role of the maternal anthropometric measurements including weight, height and Body Mass Index (BMI = weight in kg/height in m^2) and biochemical nutritional indicators including prealbumin, albumin, retinol binding protein, transferrin and fibronectin in maternal and cord blood as measures of maternal nutritional status and their impact on fetal growth.

MATERIALS AND METHODS

Fifty four pregnant women at delivery and their corresponding full term (gestational age ranging between 37 and 42 weeks) newborns were selected from Al-Mataria Teaching Hospital during the year 2004-2006 constituted the material of this study. They were chosen to be free of hypertension, diabetes and toxemia of pregnancy, ante-partum hemorrhage or any medical or obstetric problems that may interfere with intrauterine growth and development. They had normal vaginal delivery. Anthropometric measurements of the mother including weight, height and BMI were recorded. Measurements of the newborn including weight, length, head circumference, arm circumference, chest circumference and Ponderal Index (PI = weight in grams/length in cm^3) were recorded too. Cases were put into two groups: low birth weight equal to or less than 2.5 kg (n = 24) and control above 2.5 kg (n = 30).

Venous blood samples, 5 mL each, were collected from each woman before delivery and similar amounts of mixed arterio-venous cord blood were collected from each corresponding newborn infants at birth. Serum was separated and stored at -20°C until further assayed. Serum albumin was determined using spectrophotometric technique (Doumas *et al*., 1971). Serum prealbumin, retinol binding protein, transferrin and fibronectin were determined using radial immunodiffusion kit (Mancini *et al*., 1965).

Statistical analysis using the SPSS program of personal computer version 10 employed the student's t-test for comparison of the mean values and the simple correlations. Pearson Correlations were calculated to evaluate the relationship between the variables. p-values were two-tailed and values <0.05 were considered statistically significant.

RESULTS

Maternal mean weight, height and BMI were 54.33±11.73 kg, 153.50±5.40 cm and 22.99±4.50 kg m^{-2}, respectively in low birth weight infants group. The mothers of control group had means of 67.25±16.45 kg, 162.79±8.92 cm and 25.65±5.31 kg m^{-2}, respectively. Weight and height differences were statistically significant. The low birth weight infants group had a mean newborn weight of 2200±117.95 g, mean length of 48.50±0.78 cm, mean PI of 1.930±0.147 g cm^{-3}, mean head circumference of 32.33±1.63 cm, mean chest circumference of 31.67±1.74 cm and mean arm circumference of 10±1.32 cm. The mean values of the control group were 3295.83±371.56 g, 50.33±2.28 cm, 2.599±0.357 g cm^{-3}, 33.25±1.39, 33.23±1.12 and 11.13±0.95 cm, respectively. Differences in neonate weight, length, PI, head circumference, chest circumference and arm circumference were statistically significant (Table 1).

In low birth weight infants group, the mean values of maternal serum prealbumin, albumin, retinol binding protein, transferrin and fibronectin were 18.400±4.169, 3.417±0.447, 2.750±1.478, 4.717±0.937 and 9.5167±11.029 mg dL^{-1}, respectively. These figures were 18.763±5.580, 3.737±0.422, 2.833±1.050, 4.571±1.985 and 19.892±11.311 mg dL^{-1}, respectively in the control group. Only the maternal albumin and fibronectin in low birth weight group were significantly lower than in the control group. The mean values of the tested nutritional biochemical parameters in cord blood of low birth weight neonates' were 14.883±2.389 mg dL^{-1}, 3.867±0.281 g dL^{-1}, 1.65±1.04 mg dL^{-1}, 2.317±0.314 g L^{-1} and 1.800±1.463 mg dL^{-1}, respectively, while values in the cord blood of control group were 14.425±4.585 mg dL^{-1}, 4.075±0.415 g dL^{-1}, 1.55±0.87 mg dL^{-1}, 2.275±1.325 g L^{-1} and 6.888±5.055 mg dL^{-1}. Only cord blood fibronectin was significantly lower in low birth weight neonates than in control group (Table 2).

In low birth weight group, the maternal weight was positively correlated with each of the neonatal weight, PI

Table 1: The maternal and the neonatal anthropometric measurements

Parameters	Low birth weight group (n = 24)	Control group (n = 30)	p-value
Maternal weight (kg)	54.33±11.73	67.250±16.45	0.003
Maternal height (cm)	153.50±5.400	162.790±8.920	0.000
Maternal BMI (kg cm^{-2})	22.99±4.500	25.650±5.310	NS
Neonatal weight (g)	2200.00±117.95	3295.830±371.56	0.000
Neonatal length (cm)	48.50±0.780	50.330±2.280	0.001
Neonatal PI (g cm^{-3})	1.93±0.147	2.599±0.357	0.000
Neonatal head circumference (cm)	32.33±1.630	33.250±1.390	0.023
Neonatal chest circumference (cm)	31.67±1.740	33.230±1.120	0.003
Neonatal arm circumference (cm)	10.00±1.320	11.130±0.950	0.007

NS = Not Significant

Table 2: Maternal and Cord biochemical parameters

Parameters	Low birth weight group (n = 24)	Control group (n = 30)	p-value
Maternal serum prealbumin (mg dL^{-1})	18.4000±4.1690	18.763±5.5800	NS
Maternal serum albumin (g dL^{-1})	3.4170±0.4470	3.737±0.4220	0.016
Maternal serum retinol binding protein (mg dL^{-1})	2.7500±1.4780	2.833±1.0500	NS
Maternal serum transferrin (g L^{-1})	4.7170±0.9370	4.571±1.9850	NS
Maternal serum fibronectin (mg dL^{-1})	9.5167±11.029	19.892±11.311	0.004
Cord blood prealbumin (mg dL^{-1})	14.8830±2.3890	14.425±4.5850	NS
Cord blood albumin (mg dL^{-1})	3.8670±0.2810	4.075±0.4150	NS
Cord blood retinol binding protein (mg dL^{-1})	1.6500±1.0400	1.600±0.8300	NS
Cord blood transferrin (g L^{-1})	2.3170±0.3140	2.275±1.3250	NS
Cord blood fibronectin (mg dL^{-1})	1.8000±1.4630	6.888±5.0550	0.000

NS = Not Significant

Table 3: Correlation between significant maternal and neonatal variables in the low birth weight group

Parameters	Maternal weight	Maternal height	Maternal BMI	Maternal albumin	Maternal fibronectin
Neonatal weight	0.716**	0.683**	0.566**	0.000	0.274
Neonatal length	-0.627**	0.351	-0.787**	0.524**	-0.617**
Neonatal PI	0.959**	0.268	-0.956**	-0.387	0.650**
Neonatal head circumference	-0.741**	0.158	-0.852**	0.564**	-0.764**
Neonatal chest circumference	-0.780**	-0.056	-0.826**	0.747**	-0.882**
Neonatal arm circumference	-0.304	0.342	-0.433*	0.679**	-0.485*
Neonatal albumin	0.320	-0.230	0.424*	0.018	0.014
Neonatal fibronectin	0.677**	-0.359	0.847**	-0.109	0.422*

**: Correlation is significant at the 0.01 level (2-tailed), *: Correlation is significant at the 0.05 level (2-tailed)

Table 4: Correlation between significant maternal and neonatal variables in the control group

Parameters	Maternal weight	Maternal height	Maternal BMI	Maternal albumin	Maternal fibronectin
Neonatal weight	0.194	0.393*	0.056	0.109	-0.355
Neonatal length	-0.068	0.028	-0.120	-0.101	-0.122
Neonatal PI	0.238	0.337	0.159	0.233	-0.168
Neonatal head circumference	0.203	0.159	0.235	0.203	0.042
Neonatal chest circumference	0.205	0.164	0.235	0.027	0.099
Neonatal arm circumference	0.260	0.090	0.284	0.291	0.087
Neonatal albumin	-0.123	0.134	-0.246	0.294	-0.179
Neonatal fibronectin	0.278	0.240	0.294	0.161	0.342

*: Correlation is significant at the 0.05 level (2-tailed)

and cord blood fibronectin and negatively correlated with each of neonatal length, head and chest and arm circumferences. BMI positively correlated with each of the neonatal weight and cord blood albumin and fibronectin. It was negatively correlated with each of the neonatal length, PI, head and chest and arm circumferences. The maternal albumin positively correlated with each of the neonatal length, head and chest and arm circumferences. The maternal fibronectin positively correlated with each of the neonatal length, PI and cord blood fibronectin. It was negatively correlated with each of the neonatal head and chest and arm circumferences (Table 3).

The maternal height positively correlated with the neonatal weight of both the low birth weight group and the control group (Table 3, 4).

DISCUSSION

Literature confirms the traditional state that anthropometric measurements of pregnant mothers assess their nutritional status (Bissenden *et al.*, 1981). The BMI is an age dependent index for nutritional status evaluation (Guthrie, 1989). Recent studies showed that intrauterine malnutrition have more serious consequences for children

than postnatal malnutrition. Low pre-pregnancy BMI is considered a risk factor for preterm birth and intra-uterine growth retardation (Kruger, 2005). Hulsey *et al.* (2005) reported that appropriate maternal BMI at conception followed by adequate weight gain during pregnancy may have a substantial influence on reducing the number of low birth weight deliveries. Women with less than adequate weight gain were 1.4 times more liable to deliver a very low birth weight baby and 1.9 times more likely to deliver moderately low birth weight baby as compared with women with adequate weight gain. Kulkarni *et al.* (2006) reported that maternal lean body mass was found to be the most important determinant of birth weight. Thame *et al.* (2004) found that maternal weight and weight gain was directly related to fetal anthropometry through influencing the placental volume and the rate of placental growth. Neonatal nutritional status is measurable using weight and length versus gestational age (Graitcer *et al.*, 1981). The PI is used to calculate the relative amount of soft tissue present in an infant (Miller and Hassanein, 1971). Hendricks (1990) stated that PI is the accurate indicator of body built and nutritional status. The neonate mid-arm and chest circumference measures are simple, quick, easy and cheap indicator for birth weight. Arm circumference reflects skeletal muscle protein and fat stores (Raubenstine *et al.*, 1990). A mid-arm circumference usually measures less than 9.0 cm when birth weight is less than 2500 g. Neonatal mortality was shown to have an inverse relation with mid-arm circumference (Ahmed *et al.*, 2000). Naik *et al.* (2003) reported that chest circumference had the maximum sensitivity of detecting low birth weight in newborns. While the current study proves a positive correlation between mother weight and BMI on one side and newborn weight and PI on the other, the correlation between mother weight and BMI on one side and neonatal mid-arm and chest circumference on the other side was negative.

Literature shows contradictory relations between birth weight and maternal prealbumin, transferrin and retinol binding protein. While some workers (Bhatia and Ziegler, 1983; Xu Shi-Xia, 1993; Jain *et al.*, 1995) proved these relations, the current work, similar to others (Raubenstine *et al.*, 1990; Wong and Saha, 1991; Maher *et al.*, 1993; Maier *et al.*, 1999; Wu *et al.*, 2004b), has not. Physiologic changes associated with pregnancy including plasma volume expansion and pregnancy related effects on protein biosynthesis in the liver were theoretically attributed as factors behind negative relations. Dissanayake and Desilva (1984) could detect a significant correlation between birth weight and cord blood transferrin in the very low birth weight infants only. The risk of being born with 2500 g and below did not appear to depend on the newborn albumin level. This current results match (Raubenstine *et al.*, 1990; Vudhiviai *et al.*, 1990) with two papers and contradict other two (Lao *et al.*, 1990; Hasin *et al.*, 1996). The maternal and cord blood fibronectin was found not correlated with the birth weight. Literature shows similar (Valletta *et al.*, 1988) and contradictory (Taylor *et al.*, 1991; Tamas *et al.*, 1992; Wang *et al.*, 2001) results. Maternal hypo-albuminemia was found to have negative impaction on the anthropometric measurements of the newborn. Bar-Or *et al.* (2005) reported elevated maternal plasma levels of cysteinylated albumin and decrease in levels of total albumin in intrauterine growth restriction pregnancies.

CONCLUSION

Mother underweight and low BMI reduce newborn weight. Hypo-albuminemia has a negative impaction on newborn length and head, chest and arm circumferences. Low fibronectin reduces newborn body length and PI while low prealbumin, retinol binding protein and transferrin have no influence on fetal growth.

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