Electrolytes concentrations in mothers' and their newborns' hair

Paweł Krajewski[1], Anita Chudzik[1], Jarosław Kalinka[2], Maria Kwiatkowska[1], Małgorzata Pokrzywnicka[1]

Abstract

The aim of this study was to estimate the sodium, potassium, magnesium, calcium and phosphorus concentrations in mothers' and their newborns' hair. Twenty women and their term newborns were approached. Samples of the mother's and baby's hair were taken and these minerals concentrations were estimated using an absorption atomic spectrometry. Statistical analysis was performed by Student's paired *t*-tests and Wilcoxon test. Pearson's Correlation Coefficient for mothers' and their newborns' hair levels of electrolytes and the demographic data was estimated. The levels of electrolytes such as sodium, potassium, calcium in newborns' hair were statistically higher than in their mothers' hair and reference ranges. Magnesium levels in mothers' and their newborns' hair were statistically significantly lower than reference ranges. Concentrations of searched minerals in mothers' and their newborns' hair are the good indication of their status in the later periods of pregnancy and the health status of the newborns.

Key words: newborn hair analysis, electrolytes in hair, newborn

Introduction

The growing fetus is entirely dependent on its mother for the supply of nutrients and oxygen and removal of waste products across the placenta. The placenta and transplacental transfer plays very important role in this process. Transition from fetal to neonatal period is associated with major changes in water and electrolyte homeostatic control. The fetus body composition changes during gestation [3]. During pregnancy serum sodium, potassium levels remain stable, while calcium, phosphorus levels decrease progressively after the first trimester [9]. Magnesium levels decrease progressively during pregnancy too but from early pregnancy to term [6].

Sodium is the main extracellular ion and its transfer through placenta exhibits great interspecies differences. Sodium is present in large quantities in diet. The recommended daily allowance for sodium is 1.5 mg during non pregnancy state, pregnancy and lactation [6]. Well-balanced diets provides adequate sodium requirement and there is not any need for its supplementation [2, 3].

The intracellular minerals or minerals sequestered in bones like potassium, magnesium, calcium, and phosphorus are in low concentrations in plasma. They are mainly transported through placenta to the fetus actively [2, 3]. Because of the maternal adaptations, mothers' serum calcium and inorganic phosphorus levels remain constant during pregnancy. Hormonal adaptation and increased intestinal absorption protect maternal bones during pregnancy and cover the fetal calcium requirements. Calcium and phosphorus are major components required for fetal bone formation. Calcium also acts as a regulator of many intracellular functions. Therefore, large quantities of calcium and phosphorus are required in pregnancy for metabolic regulation and construction of fetal tissues, especially in the third trimester. Term newborn contains of about 20-30 g of calcium (98% is in skeleton), 16 g of phosphorus (80% is in skeleton), 750 mg of magnesium – 60% is in skeleton. Midgestation and the third trimester are the periods of the greatest mineral absorption. In pregnant women calcium absorption and its urinary excretion are approximately double in comparison to non pregnant women. The changes in absorption of the other bone-forming minerals and their excretion largely correspond to those of calcium [1, 7]. Concentrations of calcium and phosphorus in hair seem to be not affected by dietary intake of these minerals. Biological variability of calcium levels was higher in the maternal sera than in the cord sera [1, 7]. Fetal homeostasis of calcium and phosphorus

[1] Division of Neonatology, Department of Perinatology, I[st] Chair of Obstetrics and Gynecology, Medical University of Łódź, Poland

[2] Medical and Environmental Pregnancy Health Hazards Unit, Department of Perinatology, I[st] Chair of Obstetrics and Gynecology, Medical University of Łódź, Poland

seems to be partly independent of maternal factors [3]. The recommended daily allowance for non pregnant, pregnant, and lactating women is 1000 mg of calcium and 700 mg of phosphorus [7]. A well-balanced diet provides adequate value of calcium and phosphorus for all fetal needs, so supplementation of them is not recommended. But we should remember that pregnant women younger than 25 years also still require calcium for their bone mass. For calcium absorption vitamin D is required [2, 3]. Concentration of electrolytes in the blood often does not provide a complete picture of the content of these elements in the organism. This is caused by the fact, final concentration of components is a result of balancing of their concentrations by various homeostatic factors. Growing hair as a metabolically active and a recording filament reflects to metabolic effects occurred when the hair was formed. During hair growing many macroelements and microelements enter the newly formed hair cells and that is why evaluating of electrolytes concentration in hair is the best method of determining the quantity of them in human body while the hair was growing [12, 13].

In this study, it is intended to investigate the relationship between maternal and newborns' hair minerals concentrations (sodium, potassium, magnesium, calcium, phosphorus).

Materials and methods

This study was approved by the ethics and research committee of Medical University of Łódź. Twenty women who had delivery of a healthy infant at term (38–42 weeks of gestation) were approached. Samples of the mother's and baby's hair, only the first 3-4 cm of the hair counting from the scalp skin, were taken. Maternal hair samples were all taken with sharp scissors from the back of the women's heads in several places. Neonatal hair specimens were all taken in an identical manner by cutting the hair from the back of the babies' heads. The laboratory analysis of hair was performed. After weighing, the hair samples underwent digestion then were diluted to a standard volume. Analysis of hair concentrations of sodium, potassium, magnesium, calcium and phosphorus in mothers' and their babies' hair were performed using an absorption atomic spectrometry (ASA).

The data is presented as mean value and standard deviation. Statistical comparisons between mothers' hair electrolytes levels and newborns' hair electrolytes levels were carried out using STATISTICA 9 StatSoft with Student's t test to determine which means were different. If the data deviated from normality, Wilcoxon's test was used. Pearson's Correlation Coefficient for mothers' and their newborns' hair levels of electrolytes and the demographic dates were estimated. A value of $p < 0.05$ was considered statistically significant.

Results

In our study twenty mother/infant pairs had results for analysis. Demographic data for the mothers and their newborns are presented in Table 1.

From all newborns nine were born by cesarean section and eleven by vaginal delivery. The mean hair sodium, potassium, magnesium, calcium and phosphorus levels for maternal and neonatal samples are presented in Table 2.

As shown in Table 2 there were statistically significant differences between mothers' hair and their babies' hair levels of sodium 222.9 mg/kg ± 129,1 vs. 469.2 mg/kg ± 167.9 ($p < 0.001$), potassium 160.0 mg/kg ± 102.0 vs. 271.9 mg/kg ± 159.7 ($p < 0.01$) and calcium 688.6 mg/kg ± 448.9 vs. 937.5 mg/kg ± 302.0 ($p < 0.02$). No statistically significant difference between mothers' hair and their newborns' hair levels of phosphorus and magnesium were found in our researches.

There are significant differences between newborn's hair levels and normal hair levels of natrium 469.2 mg/kg ± 167.9 vs. 240.0 mg/kg ± 60.0 ($p < 0.001$), potassium 271.9 mg/kg ± 159.7 vs. 100.0 mg/kg ± 25.0 ($p < 0.001$), calcium 937.5 mg/kg ± 302.0 vs. 300.0 mg/kg ± 70.0 ($p < 0.001$). Newborn's hair levels of magnesium was statistically significantly lower than normal hair levels of magnesium 11.9 mg/kg ± 5.7 vs. 26.0 ± 5.4 ($p < 0.001$).

Table 1. Demographic data

	Gestation (weeks)	Birth weight (g)	Birth length (cm)	Apgar score (points)	Mothers' age (years)	Gravida
mean	39.0	3582.2	55.7	9.6	29.4	1.6
min	37.0	3000.0	50.0	9.0	20.0	1.0
max	40.0	4460.0	60.0	10.0	39.0	3.0

Table 2. Levels of sodium, potassium, calcium, phosphorus and magnesium in mothers' and babies' hair

	Sodium		Potassium		Calcium		Phosphorus		Magnesium	
	mean (mg/kg)	SD	mean (mg/kg)	SD	mean (mg/kg)	SD	mean (mg/kg)	SD	mean (mg/kg)	SD
Newborns	469.2	167.9	271.9	159.7	937.5	302.0	186.4	84.3	11.9	5.7
Mothers	222.9	129.1	160.0	102.0	688.6	448.9	151.8	54.8	13.5	5.5
Reference values	240.0	60.0	100.0	25.0	300.0	70.0	160.0	40.0	26.0	5.4

The concentration of phosphorus in hair of both groups was the same. Mother's hair levels of potassium, calcium were statistically significantly higher than the normal hair levels of them. For potassium 160.0 mg/kg ± 102.0 vs. 100.0 mg/kg ± 25.0 ($p < 0.05$) and for calcium 688.6 mg/kg ± 488.9 vs. 300.0 mg/kg ± 70.0 ($p < 0.001$). Magnesium level in mother's hair was statistically significant lower than normal hair levels of it 13.5 mg/kg ± 5.5 vs. 26.0 mg/kg ± 5.4 ($p < 0.001$). Other cations, including natrium, magnesium and phosphorus were present in hair of both groups in similar concentrations and no statistically signification was observed. Pearson's Correlation Coefficient (r) between mothers' and their newborns' hair levels of electrolytes and the demographic date was estimated. There is positive correlation between the mothers' hair level of sodium and the birth length of newborn $r = 0.657$ ($p < 0.01$) and the mothers' hair level of potassium and the birth length of newborn $r = 0.503$ ($p < 0.01$). In our study the negative correlation between the newborns' hair level of magnesium and the birth length of newborn $r = -0.468$ ($p < 0.05$) was observed. Our researches revealed positive correlation between the mothers' hair level of sodium and their hair level of potassium ($r = 0.645$; $p < 0.01$). The same observation was in newborns, neonates' hair level of sodium and newborns' hair level of potassium ($r = 0.757$; $p < 0.0001$).

Discussion

Physiological adaptive changes in mineral metabolism are observed during pregnancy. It seems to be independent of maternal mineral supply within the range of normal dietary intakes. During the first week of pregnancy, the future mothers usually increase their food intake. This may be due to a central action of progesterone since the levels of this hormone are elevated within the first period of pregnancy [1, 11]. The resulting increased intake of sodium and other electrolytes is accompanied by an increase in their urinary excretion. At the beginning of pregnancy no retention of sodium or higher blood osmolity are observed in pregnant women comparing with non pregnant women. But during the later periods of pregnancy elevated levels of sodium and potassium are observed. This is the result not only of an increase in electrolyte intake but also of a reduction in urinary output [1, 11]. Despite of sodium retention observed in the later stages of pregnancy, sodium levels in plasma of pregnant women remain depressed, probably because of about 60% of the retained sodium being sequestered by the fetuses. This observation is confirmed in our researches because the mothers' hair sodium concentration is similar to reference range but their babies' hair analysis showed statistically significant higher level of natrium than reference range [11]. These results show that newborns' hair was growing during later stages of pregnancy when the sodium retention is observed. In animal and human study, during the latest period of pregnancy, the increase in the potassium level of amniotic fluid and the decrease in urine flow rate in fetus were observed [13, 14]. This situation results in rapid increasing in the fetal potassium level. Increase in potassium secretion by the fetus is in the response to the pre-parturient increasing in corticosteroids (glucocorticoid and mineralocorticoid) activity in fetal plasma. This is the reason of statistically significantly higher newborns' hair potassium concentration comparing with reference range and mothers' hair potassium level what was improved in our study [13, 14]. Calcium, phosphorus and magnesium are the primary bone-forming minerals. The active transplacental mechanism of calcium transport results in the elevated levels of calcium in the fetus relatively to its mother. So placenta plays an important role in maintaining a high fetal-to-maternal calcium gradient. This situation stimulates calcitonin release and suppresses parathyroid hormone secretion by the fetus. This depressed secretion is still observed at birth of newborn. An unique extrarenal system for 1 alpha-hydroxylation of 25-hydroxyvitamin D3 exists in the placenta, providing a source of 1,25-dihydroxyvitamin D3 for the fetus [1, 8, 9]. These changes occurred in the mother and fetus during gestation in calcium homeostasis were confirmed in our studies too. Both mothers' hair levels of calcium and their newborns' hair levels of calcium were statistically significantly higher than reference ranges for calcium. More over the newborns' hair levels of calcium were in our studies statistically significantly higher than in their mothers' hair. This observation can be explained by active transplacental mechanism of calcium transports and 1 alpha-hydroxylation of 25-hydroxyvitamin D3 in placenta [8, 9]. Calcium and phosphorus levels are correlated with their intake under some circumstances and they intakes affect to other minerals in hair, which further complicates. Our results are in agreement with other researches suggesting that fetal homeostasis of calcium is partly independent of maternal factors [4, 5]. Magnesium deficiency is common in many population in all the continents. The main reason of it is lower dietary intakes than it is recommended. Magnesium deficiency during pregnancy can induce maternal, fetal, and newborn complications. It impairs parturitions, involution of uterine post deliver, fetal growth and development. Magnesium deficiency can cause teratogenic effects and higher morbidity of newborns [10]. Unfortunately our searches reviled statistically significantly lower hair magnesium levels in both groups: mothers and their newborns than reference ranges. This is the confirmation that during hair growing of fetus the magnesium level is low. Our study revealed negative correlation between the newborns' hair level of magnesium and the birth length of newborn. Our result can be a confirmation of the theory that magnesium deficiency in pregnant women can delay fetal growth and can be connected with intrauterine growth retardation (IUGR) [10]. Further studies evaluating the concentrations of selected electrolytes in newborns' and mothers' hair with main prenatal complications should be performed.

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✉ Paweł Krajewski
Departament of Perinatology
I Chair of Gynecology and Obstetrics
Medical University of Łódź
94-029 Łódź, ul. Wileńska 37, Poland
e-mail: pawel.krajewski@umed.lodz.pl