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*The concentration of lipids, lipoproteins and apolipoproteins  
in cord blood serum of newborns in the course  
of intrauterine period*

The period of foetal life as the first stage in the individual development is very important for every man. This is a period in which the greatest dynamics of developmental changes and particularly great susceptibility to the influence of negative factors are observed. The health condition of a newborn results from the course of foetal life and decides about the child's further development and the quality of life in adult life (9).

The exponent of the correct prenatal life of the foetus is the birth weight of a newborn, which defines the degree of biological maturity of the child and its ability to live in the course of the subsequent stages of individual life. If there are unfavourable conditions during the foetal life, the newborn is born with dysfunctions of its physical development, the indication of which is the low birth weight (LBW). Such newborns, described as LBW newborns, are the ones with body weight below 2500 g, the premature babies, or the ones with the symptoms of intrauterine development retardation (11). Physiological labour is between 38–42 week of pregnancy. Premature babies are those born before the 37<sup>th</sup> week of pregnancy counted from the first day of the last menstruation (7). The gestational age is important information used for the evaluation of the foetal development and it indirectly defines its postnatal adaptation abilities.

The results of the performed studies confirm that metabolism of the body is programmed still in the foetal life and depends on the mother's genetic material and to great extent on the external factors influencing mother's organism, such as: nutrition, health condition, taken drugs and stimulants as well as the woman's life style during pregnancy.

At present, it is thought that there is a close relationship between nutrition during the foetal life and the health of an adult individual. It has been confirmed that low birth weight and malnutrition during foetal life are risk factors for the development of lipid disorder, cardiac ischaemia, hypertension, obesity, and diabetes during adult life (1,2). It is proved by longitudinal studies carried out in the adults who were born with low birth weight (3,4,6). The disorders of lipids metabolism are the factors which can be detected early enough, i.e. at birth. Therefore the aim of the present study was to check the influence of foetal life on some of the parameters of lipids metabolism in the cord blood serum in healthy newborns as well as evaluation of the concentration of lipids, lipoproteins and apolipoproteins with relation to the birth weight and also the gestational age of the studied newborns.

MATERIAL AND METHODS

The study was carried out on 137 healthy newborns (63 boys and 74 girls). The study included newborns coming from normal, physiological pregnancies, spontaneously born, with

good general condition. The evaluation of health condition of the newborns after birth was evaluated as 8–10 points according to Apgar scale. The gestational age of the studied newborns was evaluated on the basis of the date of the last menstruation of the mother and was given in weeks of pregnancy.

Physical development of the newborns after birth was defined on the basis of body weight and length. In all of the studied newborns tests on the concentration of triglycerides, total cholesterol, LDL-cholesterol, VLDL-cholesterol and HDL-cholesterol as well as of apolipoproteins (apo-AI, apo-B) in the cord blood serum sampled soon after birth were performed. The concentration of triglycerides, total cholesterol and HDL-cholesterol was assayed with the analyser Cobas-Mira S. The concentration of LDL-cholesterol (LDL-cho) and VLDL-cholesterol (VLDL-cho) was determined using the formula given by Friedewald. Apolipoproteins: apo-AI and apo-B were assayed with immunoturbidimetric method with the reagents by "Roche". The assays were performed with the Cobas-Mira S apparatus basing on the known concentrations of T-Standard apolipoproteins. For the analysis of the relationship between the concentration of triglycerides, total cholesterol and its concentrations in HDL, LDL and VLDL fractions and apolipoproteins (apo-AI and apo-B) and the birth weight and the gestational age of the newborns, the values of body weight was divided into five categories: I. 2000g –2500g, II. 2501g –3000g, III. 3001g –3500g, IV. 3500g –4000g, V. 4001g –5200g; the gestational age was divided into two groups: I. 36–37 weeks, II. 38–42 weeks. The concentration of triglycerides, total cholesterol and its concentrations in the fractions LDL, VLDL and HDL as well as of apolipoproteins apo-AI and apo-B were characterized by arithmetic mean (M), standard deviation (SD), mean error of arithmetic mean (SE) and variability coefficient (V).

Evaluation of the significance of the differences in the mean values of lipids, lipoproteins and apolipoproteins in cord blood serum of newborns with relation to birth weight and gestational age was tested with t-Student test for the values characterized by normal distribution. In the case of abnormal distribution of the variables the statistical analysis was performed with Mann-Whitney test.

All of the statistical calculations concerning the differences between the mean values were performed on the significance level  $\alpha=0.05$ . The differences with  $p<0.05$  were considered significant.

## RESULTS

The birth weight of newborns ranged from 2000g to 5200g, and the mean value was  $3268.0g \pm 529.4 g$ . The mean birth weight of male newborns was  $3302.0 g \pm 538.0 g$ ; however, of female newborns it was  $3240.0 g \pm 520.3 g$ . The body length ranged from 37.0 to 62.0 cm, the mean value was  $54.4 cm \pm 3.1 cm$ , for male newborns  $54.3 cm \pm 2.0 cm$ , and for female newborns  $54.4 \pm 3.3 cm$ .

The mean gestational age of the newborns was  $39.1 \pm 1.5$  weeks and it ranged from 36 to 42 weeks. The mean gestational age of boys was  $39.0 \pm 1.5$  weeks, and of girls  $39.1 \pm 1.5$  weeks. Statistical characteristics of the concentration of triglycerides, total cholesterol and cholesterol of fractions LDL, VLDL and HDL as well as of apo-AI and apo-B in the cord blood serum in newborns and the range of mean values are presented in Table 1. The mean values of the concentration of triglycerides, total cholesterol and cholesterol of fractions LDL, VLDL and HDL in the cord blood serum in newborn with relation to the birth weight are presented in the Table 2. The concentration of triglycerides in the cord blood serum in the group of newborns with the lowest birth weight (from 2000 to 2500 g) was  $91.833 \pm 75.001 mg/dl$  and was higher in comparison to the levels in newborns with higher birth weight. In the group of newborns with birth weight ranging from 2501 to 3000 g the concentration of triglycerides was  $44.972 \pm 22.700 mg/dl$ , in the group from 3001 to 3500 g – it was  $62.386 \pm 94.383 mg/dl$ , and in the group of newborns with birth weight over 4001 g the level of  $38.444 \pm 6.483 mg/dl$  was confirmed and the differences were statistically significant ( $p<0.05$ ).

Table 1. Concentration of lipids, lipoproteins and apolipoproteins in cord blood serum of newborns (mg/dl)

	Min	Max	M ± SD	SE	V
Triglyceride	20.000	399.000	58.752 ± 66.721	5.700	4451.673
Total chol	32.000	194.000	65.051 ± 21.393	1.827	457.666
HDL – chol	1.000	57.000	19.628 ± 8.395	0.717	70.484
LDL – chol	5.600	107.600	34.124 ± 14.080	1.203	198.226
VLDL – chol	4.000	67.400	11.457 ± 9.926	0.848	98.533
Apo-AI	26.00	186.00	89.50 ± 18.60	1.60	3.50
Apo-B	25.00	130.00	37.90 ± 17.70	1.50	3.20

M – arithmetic mean, SD – standard deviation, SE – mean error of mean arithmetic, V – variability coefficient

Table 2. Concentration of lipids and lipoproteins in cord blood serum of newborns depending on the birth weight

Parameters (mg/dl)	Birth weight (g)		N	M	±SD	p
Triglyceride	1	2000- 2500	12	91.833	75.001	p<0.05 1:2 1:3 1:5 4:5
	2	2501-3000	36	44.972	22.700	
	3	3001-3500	44	62.386	94.383	
	4	3501-4000	36	62.139	53.325	
	5	4001-4500	9	38.444	6.483	
Total chol	1	2000- 2500	12	70.667	13.437	p>0.05
	2	2501-3000	36	63.361	27.265	
	3	3001-3500	44	66.295	18.944	
	4	3501-4000	36	63.139	18.978	
	5	4001-4500	9	65.889	20.733	
LDL – chol	1	2000-2500	12	34.408	10.299	p>0.05
	2	2501-3000	36	33.449	17.936	
	3	3001-3500	44	35.842	13.190	
	4	3501-4000	36	32.395	11.609	
	5	4001-4500	9	34.962	12.191	
VLDL – chol	1	2000- 2500	12	18.367	15.000	p<0.05 1:5 3:5 4:5
	2	2501-3000	36	8.997	4.584	
	3	3001-3500	44	11.296	10.571	
	4	3501-4000	36	12.750	10.583	
	5	4001-4500	9	7.689	1.297	
HDL – chol	1	2000- 2500	12	17.892	8.901	p>0.05
	2	2501-3000	36	21.163	7.958	
	3	3001-3500	44	19.444	7.187	
	4	3501-4000	36	17.993	9.048	
	5	4001-4500	9	23.238	9.424	

In the group of newborns born with body weight ranging from 3501 to 4000 g the triglyceride level was  $62.139 \pm 53.325$  mg/dl and as compared to the levels of newborns with the highest body weight the difference was significant statistically ( $p < 0.05$ ).

The highest concentration of total cholesterol was found in the group of newborns with the lowest birth weight and it was  $70.667 \pm 13.437$  mg/dl, but as compared to the values of the newborns with higher birth weight, no statistically significant differences between the mean values were confirmed ( $p > 0.05$ ).

No statistically significant differences between the mean levels of cholesterol in fraction LDL in the cord blood serum in the newborns depending on the body weight at birth were confirmed, either. The mean level of LDL-cholesterol in the newborns with the lowest birth weight was  $34.408 \pm 10.299$  mg/dl, however in the newborns with body weight at birth of over 4001 g it was  $34.963 \pm 12.191$  mg/dl. The highest mean LDL-cholesterol level was confirmed in the newborns with body weight ranging from 3001 to 3500 g and it was  $35.842 \pm 13.190$  mg/dl, but the differences in comparison to other groups were also random.

The concentration of cholesterol in VLDL fraction was higher in the group of the lightest newborns ( $18.367 \pm 15.000$  mg/dl) as compared to the concentrations in the heaviest newborns and it was  $7.689 \pm 1.297$  mg/dl, the difference being statistically significant ( $p < 0.05$ ). A statistically significant difference in the level of mean values of VLDL-cholesterol was also confirmed between the group of newborns with body weight ranging from 3001 to 3500g ( $11.296 \pm 10.571$  mg/dl) and the newborns with body weight of over 4001g ( $7.689 \pm 1.297$  mg/dl) as well as between the newborns with body weight from 3501 to 4000 g ( $12.750 \pm 10.583$  mg/dl) and the newborns with body weight over 4001 g ( $p < 0.05$ ).

The concentration of cholesterol in HDL fraction had the lowest value and it was  $17.892 \pm 8.901$  mg/dl in the blood serum of the newborns with the lowest birth weight, however the lowest ( $23.238 \pm 9.424$  mg/dl) in the blood serum of the newborns with the highest birth weight. However, the differences in the mean values of HDL-cholesterol between the individual/specific group of the newborns depending on the birth weight were not statistically significant ( $p > 0.05$ ).

Table 2a. Concentration of apolipoproteins in cord blood serum of newborns depending on the birth weight

Parameters (mg/dl)	Birth weight (g)		N	M	±SD	p
Apo AI	1	2000- 2500	12	89.17	10.02	p>0.05
	2	2501-3000	36	90.14	20.41	
	3	3001-3500	44	90.25	18.80	
	4	3501-4000	36	89.11	14.35	
	5	4001-4500	9	85.89	29.25	
Apo B	1	2000-2500	12	47.25	18.01	p<0.05 1:2
	2	2501-3000	36	33.97	14.88	
	3	3001-3500	44	35.48	12.82	
	4	3501-4000	36	41.47	22.27	
	5	4001-4500	9	39.33	20.24	

N – number, M – mean, SD – standard deviation, p- significance level

In Table 2a the values of apolipoproteins in the cord blood serum in the newborns with relation to the birth weight are presented. The concentration apo-AI had the lowest value and was  $85.89 \pm 29.25$  mg/dl in the cord blood serum of the newborns with the highest body weight as compared to the levels of the newborns with the lower body weight, but the differences were

random. However the highest concentration of apo-B ( $47.25 \pm 18.00$  mg/dl) was confirmed in the newborns with the lowest birth weight and in comparison to the concentration in the newborns with birth weight ranging from 2501 to 3000g this difference was statistically significant ( $p < 0.05$ ).

The values of the concentration of lipids, lipoproteins and apolipoproteins in the cord blood serum of the newborns with relation to the gestational age are presented in Table 3.

Table 3. Concentration of lipids, lipoproteins and apolipoproteins in cord blood serum of newborns depending on the gestational age

Parameters (mg/dl)	GA (weeks)	N	M	$\pm$ SD	P
Triglyceride	36-37	22	51.364	39.638	$p > 0.05$
	38-42	115	60.165	70.367	
Total chol	36-37	22	67.773	16.498	$p > 0.05$
	38-42	115	64.530	22.079	
LDL – chol	36-37	22	36.510	14.086	$p > 0.05$
	38-42	115	33.668	13.970	
VLDL – chol	36-37	22	11.027	8.451	$p > 0.05$
	38-42	115	11.539	10.140	
HDL – chol	36-37	22	20.235	7.585	$p > 0.05$
	38-42	115	19.518	8.501	
Apo – AI	36-37	22	88.09	15.47	$p > 0.05$
	38-42	115	89.82	19.04	
Apo- B	36-37	22	35.77	11.48	$p > 0.05$
	38-42	115	38.36	18.64	

GA – gestational age, N – number, M – mean, SD – standard deviation, p – significance level

The concentration of triglycerides in the cord blood serum of the newborns born in the 36<sup>th</sup> and 37<sup>th</sup> weeks of pregnancy was  $51.364 \pm 39.638$  mg/dl and it was lower than in the newborns born from 38<sup>th</sup> to 42<sup>nd</sup> weeks of pregnancy ( $60.1165 \pm 70.367$  mg/dl), but the difference was not statistically significant.

The mean concentration of total cholesterol in the newborns whose gestational age was 36–37 weeks was  $67.773 \pm 16.498$  mg/dl, however in the newborns from 38–42 weeks of pregnancy it was lower ( $64.530 \pm 22.079$  mg/dl), but the difference was random.

No significant differences in the mean values of cholesterol in LDL, VLDL and HDL fractions and apolipoproteins: apo-AI and apo-B in the cord blood serum in the newborns born at 36<sup>th</sup> – 37<sup>th</sup> weeks and 38<sup>th</sup> – 42<sup>nd</sup> weeks of pregnancy.

## DISCUSSION

The studies of Barker's team allow us to think that the tendency for the occurrence of some risk factors of atherosclerosis may be conditioned by the course of foetal life. They think that metabolism is programmable still during the gestation (3,6). Many ailments occurring at the later stage of life, such as: arteriosclerosis, hypertension or diabetes type 2, originate during the foetal life. These ailments may result from faulty development and disorders of the structure, physiology

and metabolism of the developing organism. The evidence that myocardial ischaemia, hypertension and diabetes are "programmed" during the foetal life originate in the longitudinal studies. In the patients with the above listed ailments the body weight at birth was evaluated and it was confirmed that the patients with low birth weight had a higher index of cardiac ischaemia, higher blood pressure, higher cholesterol level in the blood serum, more frequent diabetes and a syndrome of resistance to insulin as well as stroke (3,4,10).

In spite of the fact that the results of studies performed recently more and more often point to the relationship between the course of gestational life and health during the adult life, there are very few investigations evaluating the influence of foetal life on the lipids metabolism parameters at birth. As it is known, the clinical symptoms of arteriosclerosis occur at a later stage of life, but the very process of atherogenesis may originate still in early childhood. One of the important risk factors for arteriosclerosis are the disorders of lipids metabolism, particularly hyperlipoproteinemia. The evaluation of the concentration of triglycerides, total cholesterol and its fractions and apolipoproteins was performed in the cord blood serum in the newborns with relation to the birth weight and the duration of pregnancy to check if then disorders of lipids metabolism may be present. On the basis of the results higher concentrations of triglyceride, VLDL-cholesterol and apolipoprotein B in the group of newborns with low birth weight (from 2000g to 2500g) as compared to the values obtained from the newborns with higher birth weight were confirmed. In the group of newborns with lower birth weight a tendency towards higher levels of total cholesterol and lower values of HDL-cholesterol was also confirmed in comparison to the newborns with higher birth weight. When analyzing the lipids metabolism parameters in the cord blood serum in the newborns with relation to the gestational age, no significant relationships were confirmed.

Other authors studying the concentrations of total lipids and phosphate lipids in the cord blood serum of the newborns with intrauterine inhibition of growth of the foetus also confirmed higher values of the studied parameters as compared with the eutrophic newborns. However, they did not indicate the relationship between the degree of inhibition of the foetal growth and the concentration of lipids in the cord blood serum (8).

The results of our study suggest that disorders of lipids metabolism in the cord blood serum of full term newborns depend on their birth weigh; however, no significant differences of the influence of the duration of pregnancy are observed, and it complies with the assumptions of the other authors (6). Longitudinal studies carried out by various researchers confirm that the cardiac ischaemia results from malnutrition of the foetus. The authors suggest that the most susceptible group to suffer from circulatory diseases at the adult age are those women who were born with small body length and those men who were born with low birth weight (5).

On the basis of our study and the results obtained by other authors we can suggest that predisposition to cardio-vascular diseases in adults may depend on the disordered intrauterine development.

## CONCLUSIONS

1. In the cord blood serum of the LBW newborns higher values of triglycerides, total cholesterol, cholesterol in fraction VLDL and apolipoprotein B as well as a tendency towards lower values of HDL-cholesterol, were confirmed and it is an unfavourable phenomenon from the point of the risk of arteriosclerosis.

2. No statistically significant differences in the level of lipids, lipoproteins and apolipoproteins in cord blood serum of the studied newborns depending on their gestational age were confirmed.

3. The results may suggest that the risk factors of cardiovascular disease may to a great extent depend on the intrauterine development and low birth weight.

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#### SUMMARY

The period of foetal life as the first stage in the individual development is very important for every man. This is a period in which the greatest dynamics of developmental changes and particularly great susceptibility to the influence of negative factors are observed. The exponent of the correct prenatal life of the foetus is the birth weight of a newborn, which defines the degree of biological maturity of the child and its ability to live in the course of the subsequent stages of individual life. Therefore, the aim of the present study was to check the influence of foetal life on some of the parameters of lipids metabolism in the cord blood serum in healthy newborns as well as the evaluation of the concentration of lipids, lipoproteins and apolipoproteins with relation to the birth weight and also the gestational age of the studied newborns. The study was carried out on 137 healthy newborns (63 boys and 74 girls). In all of the studied newborns concentration of triglycerides, total cholesterol, LDL-cholesterol, VLDL-cholesterol and HDL-cholesterol as well as of apolipoproteins (apo-AI, apo-B) in the cord blood serum sampled soon after birth was studied. In the cord blood serum of the LBW newborns higher values of triglycerides, total cholesterol, cholesterol in fraction VLDL and apolipoprotein B were confirmed as well as the tendency towards lower values of HDL-cholesterol, which is an unfavourable phenomenon from the point of the risk of arteriosclerosis. No statistically significant differences in the level of lipids, lipoproteins and apolipoproteins in cord blood serum of the studied newborns depending on their

gestational age were confirmed. The results may suggest that the risk factors of cardiovascular disease may to great extent depend on the intrauterine development and low birth weight.

#### Stężenie lipidów, lipoprotein i apolipoprotein w surowicy krwi pępowinowej noworodków w zależności od przebiegu życia wewnątrzmacicznego

Okres życia wewnątrzmacicznego, jako pierwszy etap w rozwoju osobniczym, jest decydujący dla życia człowieka. Jest to okres, w którym obserwuje się największą dynamikę przemian rozwojowych i szczególnie dużą wrażliwość na działanie czynników negatywnych. Wykładnikiem prawidłowego rozwoju wewnątrzmacicznego płodu jest urodzeniowa masa ciała noworodka, która określa stopień dojrzałości biologicznej dziecka oraz zdolność do życia w następnych etapach rozwoju osobniczego. Celem niniejszej pracy było sprawdzenie, jaki jest wpływ życia wewnątrzmacicznego na zachowanie się wybranych parametrów gospodarki lipidowej w surowicy krwi pępowinowej u zdrowych noworodków oraz ocena stężeń lipidów, lipoprotein i apolipoprotein w zależności od urodzeniowej masy ciała oraz od wieku płodowego badanych noworodków. Badania przeprowadzono u 137 zdrowych noworodków (63 płci męskiej i 74 płci żeńskiej). U wszystkich badanych noworodków wykonano oznaczenia stężeń trójglicerydów, cholesterolu całkowitego, cholesterolu we frakcji LDL, VL $\dot{D}$ L, HDL oraz apolipoprotein (Apo-AI, Apo-B) w surowicy krwi pępowinowej, pobranej tuż po porodzie. W surowicy krwi pępowinowej u noworodków urodzonych z niższą masą ciała wykazano wyższe wartości trójglicerydów, cholesterolu całkowitego, cholesterolu we frakcji VLDL i apolipoproteiny B oraz tendencję do niższych wartości cholesterolu we frakcji HDL, co z punktu zagrożenia miażdżycą jest zjawiskiem niekorzystnym. Nie stwierdzono istotnych statystycznie różnic w poziomach lipidów, lipoprotein i apolipoprotein w surowicy krwi pępowinowej badanych noworodków w zależności od ich wieku płodowego. Uzyskane wyniki badań mogą sugerować, że predyspozycja do wystąpienia schorzeń układu sercowo-naczyniowego u osób dorosłych może zależeć od przebiegu rozwoju wewnątrzmacicznego, a szczególnie od urodzeniowej masy ciała.