Lipid Metabolism and Functions of Pituitary-Thyroid Axis in Children with Arterial Hypotension

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Abstract—The aim of this study was to investigate the features of lipid metabolism and the functions of pituitary-thyroid axis in primary school children with arterial hypotension. A total of 416 primary school children were involved in the study. Of these, 113 children had primary arterial hypotension (PAH); 111 children had symptomatic arterial hypotension (SAH), which developed on the background of chronic gastroduodenal pathology; 104 children had chronic pathology of gastroduodenal zone without arterial hypotension (conditional control); 88 were healthy children of comparable age and sex. The determination of lipidogram indices was carried out on a biochemical analyzer "RANDOX kits" and computation of atherogenic indices. The level of hormones of the pituitary and thyroid glands was determined by the method of immunoradiometric analysis. Children with SAH, which arose on the background of chronic pathology of the gastroduodenal zone, compared with healthy children, had dysfunction of the thyroid gland with a decrease in the levels of free and bound thyroxine in blood and dyslipidemia with predominance of atherogenic over antisclerotic factors. Children with SAH also had more pronounced disorder of thyroid function and lipid metabolism than children of the conditional control who had isolated form of chronic gastroduodenal pathology. In conclusion, the results of this study indicate that children with any form of arterial hypotension (PAH or SAH) have the similar disorders of lipid metabolism and thyroid function, which predispose them to early atherosclerotic process.

Keywords—children; primary arterial hypotension; symptomatic arterial hypotension; lipid metabolism; hormones; pituitary; thyroid gland

I. Introduction

Lipids play an important role in many functions of the human body and constitute about 70% of the dry mass of the blood plasma.

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Any disorders of the lipid transport system or deviation in the concentration of its individual components can lead to the development of dyslipidemia [1–3]. The most common manifestations of dyslipidemic disorders in clinical practice are characterized by increased indices of total cholesterol (TC), triglycerides (TG), low density lipoprotein (LDL), very low density lipoprotein (VLDL) and a reduction of high density lipoprotein (HDL), which indirectly indicates the predominance of transport of cholesterol in the cell over its excretion in the liver [4, 5]. Lipid transport in biological fluids is carried out by lipoproteins (LP), which participate in the dissolution of cholesterol esters, regulate the interaction with certain enzymes and bind to receptors on the cell surface [6–8]. Major LP are LDL, VLDL and HDL. In addition to the transport function, HDL inhibit the production of certain pro-inflammatory cytokines, hydrolyze oxidized lipids, exhibit antioxidant, cardioprotective, anti-apoptotic properties, regulate vascular tone and anticoagulant activity, act as antimicrobial and antiviral agents [9– 12]. According to Panina et al. [12], the cardiotonic actions of HDL are manifested by an increase in the amplitude and frequency of heart rate without a significant increase in oxygen consumption.

Each lipoprotein complex is composed of one or more apolipoproteins (ApoLP), which determine its functional properties. The main protein component of HDL is ApoLP group A. the increase in levels of this apolipoprotein is considered a predictor of reduction in the risk of cardiovascular disease [5]. The highest anti-atherogenic properties are due to ApoLPA1, which constitute more than 70% of the HDL protein. ApoLPA1 provides reverse transport of cholesterol from peripheral tissues to the liver for induction and steroidogenesis, has antioxidant, anti-inflammatory, anti-apoptotic, vasodilating, antithrombotic and anti-infectious properties [10]. ApolPA1 stimulates the production of insulin, inhibits the synthesis of thyroxine and weakens the stimulating effect of thyroid stimulating hormone (TSH) on the accumulation of cAMP in thyroid tissue. Some fractions of HDL have the greatest binding ability to thyroxine [13].

Apolipoprotein B100 (ApoLPB100) is a structural component of LDL, VLDL and intermediate-density lipoproteins (LDL). Many authors [1, 14] report that the ratio ApoLPB100 / ApoLPA1 (IAApolP) characterizes the balance between atherogenic and antiatherogenic lipoproteins in the

blood and serves as an early potential marker of the risk of developing cardiovascular diseases.

A definite contribution to the development of dyslipidemia is due to disorders of the pituitary-thyroid function [15, 16]. Thyroid hormones take a direct part in the processes of synthesis and catabolism of atherogenic LDL, affect peripheral utilization of glucose, and increase the uptake of LDL by hepatocytes [17]. Triiodothyronine (T3) increases the activity of the cholesterol-ester transport protein, which transfers cholesterol esters from HDL cholesterol to VLDL, exchanges them for TG, stimulates lipoprotein lipase, converts VLDL to LDL, and transport phospholipids and free cholesterol in HDL, regulates the synthesis of some ApoLPA, increases capture of LDL by hepatocytes [18]. Thyroid hormones stimulate hepatic lipase, inhibit the formation of oxidized CL-LDL, and activate LDL receptors [16].

Dyslipidemia is a risk factor for hypertension, ischemic heart disease, metabolic and coronary syndromes, and cerebral stroke [19]. In the available literature, the peculiarities of lipid metabolism in patients with primary arterial hypotension (PAH) remain poorly understood, and there is no analogous information in children with chronic gastroduodenal pathology and symptomatic arterial hypotension (SAH) in general.

In the last decade, many studies have investigated the involvement of Helicobacter pylori (Hp) infection in the onset and development of metabolic disorders of lipids [20]. In the opinion of some authors [21], this microbe activates the inflammatory process with the production of cytokines and eicosanoids, and due to the molecular mimicry of Hp antigens and components of human cellular structures leads to the development of autoimmune damage of the organs and tissues. One of the components of the autoimmune mechanism is the heat shock protein 60-kD, which is synthesized by the CagA-positive Helicobacter strain, and has the same antigenic structure with human vascular wall proteins. Thus, this microbe creates favorable conditions for an active atherosclerotic process in infected patients [17]. Studies by Japanese scientists [22] have shown that Helicobacter pylori infection increases the level of total cholesterol (TC), CL-LDL, and reduces the CL-HDL, thus creating the basis for transport disorders of cholesterol and the development of dyslipidemia. Kucukazman et al. [23] found positive correlations between LDL, TC, and the degree of inflammatory changes in the gastric mucosa in persons infected with Hp. Successfully performed eradication not only sanitize the gastric mucosa, but contribute to a decrease in the concentration of CL-LDL and the increase in of CL-HDL [24]. All these results of the independent laboratories point to the need for in-depth studies in this category of patients.

The aim of this study was to investigate the peculiarities of lipid metabolism and pituitary-thyroid function in primary school children with arterial hypotension.

II. Methods

A. Ethics and Research Committee

The medical ethics and research committee of the Belarusian State Medical University (Minsk, Belarus) approved the study protocol before parents and children were contacted.

B. Inclusion Criteria

1. Only children that met the criteria for arterial hypotension (PAH, SAH) were included in the study.
2. Children who participated in the study freely gave assent in addition to their parents' consent.

C. Exclusion Criteria

1. Children and/or parents who did not show willingness or refused participation were not involved in the study.
2. Patients with heart failure, hypotensive shock, electrolyte imbalance, severe kidney injury, and coma were not involved in the study.

D. Patients

The children that met the inclusion criteria were treated in designated children hospitals of the Belarusian State Medical University in Minsk (Belarus). After ethical approval, parents of the children were approached and explained the purpose of the study, as well as risks and benefits of participation in the study. Consent was obtained from parents before the children were informed, in a developmentally acceptable way, regarding the aims/objectives, risks and benefits of the study. To minimize discomfort and fear, all children were told that participation was voluntary, and that they are allowed to withdraw from participation at any point of the study. The dignity and confidentiality of all involved children were maintained at all times. Only children who gave their assent were involved in the study. The study involved 416 primary school children aged 7–11 years. Of these, 113 children had PAH and 111 children had SAH, which developed on a background of chronic gastroduodenal pathology. The comparison group included 104 patients with chronic gastroduodenal pathology without hypotension (conventional control) and 88 healthy children matched by age and sex.

E. Sample Collection

4 ml of overnight fasting venous blood was collected from all participants. Of the collected blood, 2ml each was transferred into a fluoride containing tube and a plain bottle. The serum was separated by centrifugation at 3000rpm for 10 minutes and stored at -80^{O}C.

F. Indices of Lipid Metabolism

Determination of indicators lipid metabolism was carried out on biochemical analyzer BS200 (China) using RANDOX commercial kits (United Kingdom). The indices analyzed include TC, TG, CL-LDL, CL-VLDL, CL-HDL, ApoLPA1, and ApoLPB100. The atherogenic index of plasma (AIP) and atherogenic coefficient (AC) are two main atherogenic indices that represent measure of cholesterol in LDL, VLDL, IDL fractions with respect to CL-HDL. AC and AIP were calculated according to earlier studies [25–27] and computed as AC = non-CL-HDL/CL-HDL and AIP = log (TG/CL-HDL). AC is a measure of cholesterol in LDL, VLDL, IDL (Intermediate-density lipoprotein) fractions with respect to

CL-HDL [28]. The sub-fractionation of lipoproteins cannot be analyzed in all clinical laboratories. To this end, AIP is used as an indirect measure of the size and composition of LDL and HDL subpopulations s [25, 28].

G. Analysis of Hormones in Blood Plasma

The content of the hormones of the pituitary and thyroid gland was determined by the method of immunoradiometric analysis using the equipment sets (RANDOX kits, United Kingdom) of the Institute of Bioorganic Chemistry of the National Academy of Sciences of Belarus in the laboratory of biochemical methods of research of the Belarusian National Medical University, Minsk, Belarus. The analyzed hormones are TSH (thyroid-stimulating hormone), T3 (triiodothyronine), T4 (thyroxine) and fT4 (free thyroxine). The ratio of T3/T4 was also computed.

H. Statistics

Statistical processing of data was carried out using the program Statistica 10.0 for Windows. Continuous variables were expressed as mean ± standard error of mean (M ± m) and discrete variables were expressed as a percentage (%). Comparison of data was done by nonparametric Mann–Whitney U-test (for data that are not normally distributed) and parametric *t*-test (for data that have normal distribution). The statistical value for significance was set at $p < .05$.

III. Results And Discussion

Analysis of the results of the study of lipids and blood proteins of patients with PAH allowed us to establish differences in the values of both the lipid fractions and the indices of the apolipoproteins A1 and B100 (Table 1).

TABLE I. Indicators of Lipid Metabolism and Thyroid Status in Children with Primary Arterial Hypotension (PAH)

Indicators of apolipoproteins, lipids, blood hormones	Patients (children) with PAH n=113	Control (healthy children) n=88
TC, mmol/L	4.22±0.08**	3.89±0.11
TG, mmol/L	1.08±0.06	1.11±0.09
CL-VLDL, mmol / L	0.49±0.03	0.50±0.05
CL-LDL, mmol / L	2.28±0.09****	1.38±0.09
CL-HDL, mmol / L	1.43±0.04****	2.04±0.05
AC	1.95±0.09****	0.94±0.08
%CL-LDL	54.22±1.38****	35.37±2.42
%CL-HDL	33.97±1.24****	51.94±2.14
ApoLPA1, mg / dL	107.05±5.09****	134.72±5.07
ApoLPB100, mg / dL	57.73±2.26**	49.83±2.35
AIP	0.53±0.02****	0.37±0.01
Thyroid-stimulating hormone, mIU / L	2.12±0.11	2.08±0.18
T3, nmol / L	2.24±0.05	2.23±0.06
T4, nmol / L	86.2±2.71***	99.8±1.87
fT4, pmol / L	17.0±0.56*	18.8±0.63
T3/T4	0.026±0.002	0.022±0.001

* - p <0.05; ** - p <0.02; *** - p <0.01; **** - p <0.001; TC – total cholesterol, TG – triglycerides, CL-VLDL – very low-density lipoprotein cholesterol, CL-LDL – low-density lipoprotein cholesterol, CL-HDL – high-density lipoprotein cholesterol, AC – atherogenicity coefficient, % CL-LDL – , % CL-HDL – , ApoLPA1 – apolipoprotein A1, ApoLPB100 – apolipoprotein-B100, AIP – atherogenic index of plasma, TSH – thyroid-stimulating hormone, T3 – triiodothyronine, T4 – thyroxine, fT4 – free thyroxine, T3/T4 – ratio of T3 to T4.

A significant increase in TC was accompanied by changes in CL-LDL and CL-HDL. If in healthy children the TC values were 3.89 ± 0.11 mmol / L, LDL-LDL – 1.38 ± 0.09 mmol / L, CL-HDL – 2.04 ± 0.05 mmol / L, then children with PAH had – 4.22 ± 0.08 mmol / L ($p < 0.02$), 2.28 ± 0.09 mmol / L ($p < 0.001$) and 1.43 ± 0.04 mmol / L ($p < 0.001$), respectively. Quantitative changes in cholesterol fractions increased the coefficient of atherogenicity in patients with PAH by more than two times and changed the percentage ratio of CL-LDL and % CL-HDL. In the control group, % CL-HDL was 51.94 ± 2.14% compared to 33.97 ± 1.24% of children with PAH ($p < 0.001$), and % CL-LDL was 35.37 ± 2.42% and 54.22 ± 1.38% ($p < 0.001$). The quantitative indices of TG and CL-VLDL of blood in PAH children did not differ from the control values ($p > 0.1$; $p > 0.1$). The observed deviations, in our opinion, were due to disorders of protein synthesis of the carriers Apo1 and ApoB100 in children with PAH. Thus, in the children of the control group, Apo1 prevailed, which was 134.72 ± 5.07 mg / dL. At the same time, in patients with PAH, ApoB100 value ($p < 0.02$) was decreased, while ApoA1 value ($p < 0.001$) was elevated. This dysfunction in the formation of apolipoproteins formed a high index of atherogenicity in PAH children. If in healthy children the value of AIP was 0.37 ± 0.01, in children with PAH it was 0.53 ± 0.02 ($p < 0.001$).

Thus, in children with PAH, there are observed disorders of the synthesis of apolipoproteins with increasing blood concentration of ApoB100, and deficiency of ApoA1 (Table 1), which in turn lead to disruption of the function of the transport system of cholesterol, and the predominance of its delivery to organs and tissues over excretion in the liver, increase in CL-LDL and a decrease in CL-HDL values (Table 1). This consequently creates a favorable condition for the formation of early atherosclerotic process in this category of patients. The cause of such changes, according to many authors [1, 4, 15, 19], can be hereditary. Moreover, environmental factors and changes in the pituitary-thyroid function can also contribute to such changes. Determination of the concentration of hormones did not reveal a significant difference in the indices of TSH. Thus, in the patients, TSH 2.12 mIU / l versus 2.08 mIU / L ($p > 0.1$) in the healthy children. The concentration of triiodothyronine remained normal in children with PAH (Table 1). At the same time, the indices of free and bound thyroxine remained significantly low and was 86.2 nmol / L ($p < 0.001$) and 17.0 pmol / L ($p < 0.05$), respectively (Table 1).

Decrease in T4, fT4 blood concentration in children with PAH without an increase in TSH, in our opinion, may be due to the stable vagotonia that was described by our research group in an earlier study [1]. The predominance of the parasympathetic division of the autonomic nervous system, according to some researchers, inhibits the functional activity of thyroid cells, disrupts the normal blood supply of the thyroid itself and reduces the sensitivity of the receptors to a decrease in thyroxine [11]. Such thyroid dysfunction in patients with PAH can further increase vagotonia, promote

dyslipidemia, worsen chrono- and ino-tropic functions of the heart, and support clinical manifestations of arterial hypotension in children.

Analysis of lipidogram data in patients with SAH (Table 2) compared to the control group showed the absence of a reliable difference in the indices of TG, CL-VLDL, and differences in other lipid fractions of the blood. Although the level of TC did not exceed the normal range for this age of children, it was 0.35 mmol / L higher than the healthy children ($p < 0.05$). The values of CL-LDL, AC, % CL-LDL were increased and CL-HDL, % CL-HDL remained significantly decreased. So, if in the control group the concentration of CL-LDL was 1.38 mmol / L, CL-HDL – 2.04 mmol / L, AC – 0.94, % CL-LDL – 35.37%, % CL-HDL – 51.94%, in children with SAH the values were – 2.39 mmol / L ($p <0.001$); 1.32 mmol / L ($p <0.001$); 2.22 ($p <0.001$); 56.34% ($p <0.001$) and 31.15% ($p <0.001$), respectively. Changes in blood lipid fractions in patients with SAH were similar to the modification of apolipoproteins involved in the transfer of low-density and high-density lipoprotein cholesterol. Blood ApoA1 of the children of the control group remained within the limits of 134.72 ± 5.07 mg / dL, ApoB100 – 49.83 ± 2.35 mg / dl, AIP – 0.37 ± 0.01 versus 102.96 ± 3.88 mg / dL ($p <0.001$); 57.86 ± 2.16 mg / dL ($p <0.001$); 0.57 ± 0.01 ($p <0.001$) in the children with SAH.

The data given in Table 2 indicate the development of dyslipidemia in patients with pathology of the gastroduodenal zone and SAH. In this category of patients, according to the data in Table 2, there is an increase in atherogenic blood factors (ApoB100, CL-LDL) over the antisclerotic factors (ApoA1, CL-HDL), which underlie the basis for early atherosclerosis in this category of children.

As for the pituitary-thyroid function in patients with SAH, at normal TSH and T3, we found a decrease in the values of T4, fT4 (Table 2). If in the SAH patients, the concentration of T4 was 87.4 ± 1.63 nmol / L, fT4 – 16.7 ± 0.51 pmol / L, then in control it was 99.8 ± 1.87 nmol / L ($p <0.05$) and 18.8 ± 0.63 pmol / L ($p <0.05$), respectively. Such dysfunction of the thyroid gland may be related to the prevalence of parasympathetic activity established in an earlier study [29]. The latter assumption is confirmed by a previous report, in which the author found that acetylcholine inhibits the functional activity of thyroid cells [30]. The observed dysfunction of thyroid functions in children with SAH (Table 2) can aggravate the course of the underlying disease, leading to development of SAH, and constitute one of the numerous factors contributing to the development of dyslipidemia.

There was significant difference in some lipid fractions in children with SAH and patients of the conditional control (Table 2). Thus, with the same values of TC ($p > 0.1$) and TG ($p > 0.1$), we have established an increase of 0.36 mmol / L of CL-LDL ($p < 0.02$), AC – 0.53 ($p < 0.001$), % CL-LDL ($p <0.02$), ApoB100 ($p <0.05$), AIP ($p <0.001$) and decrease of CL-HDL ($p <0.05$), % CL-HDL ($P <0.01$), ApoA1 ($p <0.001$) in patients with chronic gastroduodenal pathology and SAH. The predominance of cholesterol transport in cellular structures over excretion in the liver indicates a disorder of lipid metabolism in this category of patients.

TABLE II. INDICATORS OF LIPID METABOLISM AND THYROID STATUS IN CHILDREN WITH SYMPTOMATIC ARTERIAL HYPOTENSION (SAH)

Indices	SAH n=111	Conditional control n=104	Control n=88	Significance level
1	*2*	*3*	*4*	*5*
TC, mmol / L	4.24±0.10	3.98±0.11	3.89±0.11	$p_{2-4}<0.05$;
TG, mmol / L	1.14±0.07	1.02±0.09	1.11±0.09	-
CL-VLDL, mmol / L	0.52±0.03	0.46±0.05	0.50±0.05	-
CL-LDL, mmol / L	2.39±0.10	2.03±0.11	1.38±0.09	$p_{2-3}<0.02$; $p_{2-4}<0.001$; $p_{3-4}<0.001$;
CL-HDL, mmol / L	1.32±0.06	1.49±0.06	2.04±0.05	$p_{2-3}<0.05$; $p_{2-4}<0.001$; $p_{3-4}<0.001$;
AC	2.22±0.11	1.67±0.07	0.94±0.08	$p_{2-3}<0.001$; $p_{2-4}<0.001$; $p_{3-4}<0.001$;
% CL-LDL	56.34±1.79	50.47±1.49	35.37±2.42	$p_{2-3}<0.02$; $p_{2-4}<0.001$; $p_{3-4}<0.001$;
% CL-HDL	31.15±1.76	38.07±1.38	51.94±2.14	$p_{2-3}<0.01$; $p_{2-4}<0.001$; $p_{3-4}<0.001$;
ApolPA1, mg / dL	102.96±3.88	122.17±4.07	134.72±5.07	$p_{2-3}<0.001$; $p_{2-4}<0.001$;
A. ***ApoLP B100, mg / dL***	57.86±2.16	50.59±2.37	49.83±2.35	$p_{2-3}<0.05$; $p_{2-4}<0.02$;
AIP	0.57±0.01	0.42±0.01	0.37±0.01	$p_{2-3}<0.001$; $p_{2-4}<0.001$; $p_{3-4}<0.001$;
TTG, mIU / L	2.09±0.13	2.42±0.17	2.08±0.18	-
T3, nmol / L	2.13±0.04	2.19±0.05	2.23±0.06	-
T4, nmol / L	87.4±1.63	105.8±2.51	99.8±1.87	$p_{2-3}<0.001$; $p_{2-4}<0.05$;
Free T4, pmol / L	16.7±0.51	18.2±0.50	18.8±0.63	$p_{2-3}<0.05$; $p_{2-4}<0.05$;
T3/T4	0.024±0.002	0.021±0.001	0.022±0.001	-

All abbreviations are similar to those in Table 1 footnotes.

The data obtained (Table 2) suggest that SAH promotes the development of atherosclerotic dyslipidemia in children, and the disease itself can be a risk of early development of atherosclerosis.

Comparative analysis of the pituitary-thyroid function in patients with SAH and conditioned control group did not show any significant difference in the concentration of blood TSH, T3, T3/T4 (Table 2). However there was decrease in T4 ($p < 0.001$) and fT4 ($p < 0.05$), which indicates the involvement of thyroid dysfunction in the development of dyslipidemia in children with chronic pathology of the gastroduodenal zone and SAH.

Thus, development of symptomatic hypotension in children with gastroduodenal pathology is accompanied by the formation of a vicious circle of disorders of lipid metabolism. At the first stage, dyslipidemia seems to develop due to genetic and extrinsic factors, leading to an increase in the synthesis of ApoB100 and, thereby, increase in the activity of cholesterol transfer into cellular structures, increasing the concentration of CL-LDL, AC, decreasing ApoA1 formation and reverse excretion of cholesterol, which consequently decreases the concentration of blood CL-HDL without involvement of the thyroid gland in this process. There is also active formation of autonomic and hemodynamic disorders in patients with SAH, which leads to thyroid dysfunction with a decrease in the formation of thyroxin, its stimulating effect on dyslipidemia and even greater disruption of lipid metabolism.

Our assumption was confirmed not only by the difference in lipidogram fractions in children with SAH and conditioned control, but also in patients with an isolated form of gastroduodenal pathology and children of the control group (Table 2). Thus, under normal TC ($p > 0.1$), TG ($p > 0.1$), CL-VLDL ($p > 0.1$) in the conditioned control children, the values of CL-LDL ($p < 0.001$) % CL-LDL ($p < 0.001$) were significantly higher, but CL-HDL ($p < 0.001$), % CL-HDL ($p < 0.001$) values were low compared to similar indices of children in the control group (Table 2). The coefficient of atherogenicity was 1.8 times higher than the control group and was 1.67 versus 0.94 in healthy children ($p < 0.001$). AIP predominance in the conditional control patients (0.42 ± 0.01) over indicators of the control group (0.37 ± 0.01) ($p < 0.001$) under normal ApoB100 ($p > 0.1$) and ApoA1 ($p > 0.1$) values indicates a latent disorder of apolipoprotein synthesis and the formation of the initial stage of atherosclerotic process in children with gastroduodenal pathology without symptomatic hypotension. These metabolic changes may not only be caused by inflammation of the stomach or duodenum (change in cytokine homeostasis in gastroduodenal pathology) [31], but also an active change in biocenosis of the colon in majority of patients, which many authors [9, 19] recognized as a risk factor for the development of atherosclerosis. The data obtained necessitate inclusion in the diagnostic protocols for patients with chronic gastroduodenal pathology, not only determination of lipid profile fractions, but also apolipoproteins with computation of AIP.

Analysis of TSH and thyroid hormone levels in patients with an isolated form of gastroduodenal pathology and control group did not reveal a significant difference in their values (Table 2). Dyslipidemia in children of conditional control, in our opinion, is due to other causes, but not thyroid function.

TABLE III. INDICATORS OF APOLIPOPROTEINS AND BLOOD LIPIDS IN CHILDREN WITH ARTERIAL HYPOTENSION

Indices	PAH n=113	SAH n=111	Conditional control n=104	Significance level
1	*2*	*3*	*4*	*5*
TC, mmol / L	4.22±0.08	4.24±0.10	3.98±0.11	-
TG, mmol / L	1.08±0.06	1.14±0.07	1.02±0.09	-
CL-VLDL, mmol/L	0.49±0.03	0.52±0.03	0.46±0.05	-
CL-LDL, mmol / L	2.28±0.09	2.39±0.10	2.03±0.11	$p_{3-4}<0.02$;
CL-HDL, mmol / L	1.43±0.04	1.32±0.06	1.49±0.06	$p_{3-4}<0.05$;
CA	1.95±0.09	2.22±0.11	1.67±0.07	$p_{2-4}<0.02$; $p_{3-4}<0.001$
% CL-LDL	54.22±1.38	56.34±1.79	50.47±1.49	$p_{3-4}<0.02$;
% CL-HDL	33.97±1.24	31.15±1.76	38.07±1.38	$p_{2-4}<0.05$; $p_{3-4}<0.01$;
ApolPA1, mg / dL	107.05±5.09	102.96±3.88	122.17±4.07	$p_{2-4}<0.05$; $p_{3-4}<0.001$;
B. ***ApoLPB100, mg / dL***	57.73±2.26	57.86±2.16	50.59±2.37	$p_{2-4}<0.05$; $p_{3-4}<0.05$;
AIP	0.53±0.02	0.57±0.01	0.42±0.01	$p_{2-4}<0.001$; $p_{3-4}<0.001$;
TTG, mIU / L	2.12±0.11	2.09±0.13	2.42±0.17	-
T3, nmol / L	2.24±0.05	2.13±0.04	2.19±0.05	-
T4, nmol / L	86.2±2.71	87.4±1.63	105.8±2.51	$p_{2-4}<0.001$; $p_{3-4}<0.001$;
Free T4, pmol / L	17.0±0.56	16.7±0.51	18.2±0.50	$p_{3-4}<0.05$;
T3/T4	0.026±0.002	0.024±0.002	0.021±0.001	-

All abbreviations are similar to those in Table 1 footnotes.

To determine the severity of lipid disorders in each of the groups, analysis of lipidogram indices in children with PAH, SAH and conditional control patients was performed (Table 3). Similar values of TC ($p > 0.1$), TG ($p > 0.1$), CL-VLDL ($p > 0.1$) were accompanied by a significant difference in some lipid fractions of blood in children with PAH and patients with an isolated form of gastroduodenal pathology (Table 3). Although the concentration of CL-LDL, HDL-HDL was the same ($p > 0.1$; $p > 0.1$), AC of patients with PAH was 0.25 times higher than the value of children of conditional control ($p < 0.02$), which indicate a latent and more intense disorder of lipid metabolism in the PAH children than in children with chronic gastroduodenal pathology without SAH (Table 3). This assumption was confirmed by the difference in the % CL-HDL and apolipoprotein (Table 3). Thus, the value of % CL-HDL in patients with PAH was $33.97 \pm 1.24\%$ compared to $38.07 \pm 1.38\%$ in children of conditional control ($p > 0.05$), ApoLPA1 – 107.05 ± 5.09 mg / dL versus 122.17 ± 4.07 mg /

dL (p <0.05), ApoLPB100 – 57.73 ± 2.26 mg / dL versus 50.59 ± 2.37 mg / dL (p <0.05) and AIP – 0.53 ± 0.02 versus 0.42 ± 0.01 (p <0.001).

The study of hypophyseal-thyroid function in patients with PAH in comparison with the conditional control group made it possible to establish (as in the case of patients with SAH), the development of non-thyroid syndrome with decrease in T4 and the normal synthesis of TSH and T3 (Table 3). The concentration of blood T4 in children with PAH did not differ from those of the children with SAH (p > 0.1) and was 19.6 nmol / L lower than in patients with chronic pathology of the gastroduodenal zone without SAH (p <0.001). This is a confirmation of involvement of the thyroid gland dysfunction in the formation of lipid disorders in children with PAH and SAH.

A comparative analysis of lipidogram and apoprotein values in patients with arterial hypotension of both groups (PAH and SAH) did not reveal a significant difference in TC, TG, CL-VLDL, CL-LDL, CL-HDL, ApoA1, and ApoB100 (Table 3). The data indicate the development of dyslipidemia in children with arterial hypotension, regardless of its form. As for the hypophyseal-thyroid function in patients with PAH and SAH, the values did not differ from each other (Table 3) and were characterized by the same concentration of all blood parameters (TSH, T3, T4, fT4, T3 / T4).

IV. Conclusion

Disturbances in the synthesis of apolipoproteins in the form of an increase in the blood ApoB100 concentration (57.73 ± 2.26 mg / dL) (p <0.02), deficiency of ApoA1 (107.05 ± 5.09 mg / dL) (p <0.001) in combination with decrease of free (86.2 nmol / L) (p <0.001) and bound (17.0 pmol / L) (p <0.05) thyroxine in children with PAH leads to disruption of the function of the cholesterol transport system, predominance of its delivery to organs and tissues over excretion in the liver, increase of CL-LDL (2.28 ± 0.09 mmol / L) (p <0.001), % CL-LDL (54.22 ± 1.38%) (p <0.001), AC (1.95 ± 0.09) (p <0.001), AIP (0.53 ± 0.02) (p <0.001), and the incidence of CL-HDL (1.43 ± 0.04 mmol / L) (P <0.001),% CL-HDL (33.97 ± 1.24%) (p <0.001) of the blood, which encourages the development of early atherosclerosis in these patients. The development of SAH in children with chronic pathology of the gastroduodenal zone compared with healthy ones is accompanied by dysfunction of the thyroid gland with a drop in free (87.4 ± 1.63 nmol / L) (p <0.05), bound (16.7 ± 0, 51 nmol / L) (p <0,05) thyroxin and dyslipidemia with predominance of atherogenic blood factors [TC (4.24 ± 0.10 mmol / L) (p <0.05), CL-LDL (2.39 ± 0.10 mmol / L) (p <0.001), AC (2.22 ± 0.11) (p2-4 <0.001),% CL-LDL (56.34 ± 1.79%) (p <0.001), ApoLPB100 (57.86 ± 2.16 mg / dL) (p <0.02), AIP (0.57 ± 0.01) (p <0.001)] over the anti-sclerotic [CL-HDL (1.32 ± 0 (P <0.001), pL <0.001,% HDL-HDL (31.15 ± 1.76%) (p <0.001), ApolPA1 (102.96 ± 3.88 mg / dl) (p <0, 0 01)]. Symptomatic arterial hypotension is associated with pronounced disorders of thyroid function and lipid metabolism than an isolated form of chronic gastroduodenal pathology in primary school children. Dyslipidemia in children of conditional control group is formed against the background of a normal thyroid function and is caused by the increase in CL-LDL (2.03 ± 0.11 mmol / L) (p <0.001),% CL-LDL (50.47 ± 1.49%) (P <0.001), AC (1.67 ± 0.07) (p <0.001), and drop in CL-HDL (1.49 ± 0.06 mmol / L) (p <0.001),% CL-HDL 38.07 ± 1.38%) (p <0.001). The increase in AIP (0.42 ± 0.01) (p <0.001) in patients of this group with visible normal values of ApoB100 (p > 0.1) and ApoA1 (p > 0.1) indicate a latent disorder of synthesis of apolipoproteins and the formation of initial stage of the atherosclerotic process in children with gastroduodenal pathology without symptomatic arterial hypotension.Patients with arterial hypotension, regardless of its form (PAH or SAH) have the same disorders of lipid metabolism and thyroid function.

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