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PECULIARITIES OF THE MORPHOFUNCTIONAL STATE OF THE PANCREAS AMONG CHILDREN WITH METABOLIC SYNDROME

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Key words: children, metabolic syndrome, the pancreas, structural changes of the pancreas, pancreatic adaptability

Introduction

In many countries around the world the problem of obesity and closely associated with it the metabolic syndrome (MS) acquires more threatening scale. The number of sick children has doubled in the past two decades and each year continues to increase [5]. According to the data of the epidemiological researches, conducted in six federal districts of our country, about 12% of adolescents aged from 12 to 17 have excess weight, 2.3% of them obesity, and the symptoms of MS are detected every one in three adolescents with obesity [1].

MS is not a disease and not a diagnosis, but the complex of metabolic, hormonal and clinical disorders, which are closely associated with diabetes mellitus type 2. These disorders are the risk factors of the cardiovascular diseases development, which are based on insulin resistance (IR) and compensatory hyperinsulinemia (GI).

Currently, it is convincingly confirmed the point of view, according to which the digestive organs play the direct role in the pathogenesis of endocrine-metabolic disorders, while they become themselves the target organs [2, 3, 7]. Many authors assign the leading role in the development of the MS components, as well as the digestive organs diseases, to chronic stress. By the prolonged and excessive exposure of the internal and external stress factors, the forming dysfunction of the hypothalamus, the vegetative segment of the central nervous system contributes to the peristalsis and the tone of the digestive tract smooth muscles malfunction, the hyperproduction of gastrin and hydrochloric acid. The hypersecretion of

catecholamines, glucagon, cortisol leads to the progression of these disorders, which result in the reduced resistance of the mucous membrane of the stomach and bowels, the damage of the parenchyma of the pancreas (PG) and the liver. At the same time, the emotional personality and psycho-vegetative disorders contribute to the development of different forms of eating behavior malfunctions. The change of the dietary habits, intake of the large amount of food violate the biological rhythm of the digestive tract functioning. This leads to the formation and maintenance of motor-evacuation disorders and, as a consequence, the development of inflammatory changes of the digestive organs. Another reason for the dysfunction of the digestive organs, the chronic inflammation may be, in its genesis the adipocytokines of adipose tissue and the activation of lipid peroxidation play the important role.

One of the digestive organs, having the exocrine and endocrine activity and directly involved in the process of formation of IR and GI, is the pancreas. The contemporary literature presents evidence that the adults, with excess body weight, are frequently diagnosed to have the pancreas affection similar to the non-alcoholic fatty disease of liver– the pancreas steatosis, which attracts recently the increasing interest of the scientists from the position of the MS development [2].

It should be emphasized, that there is the intercommunication of the endocrine and exocrine parts of the pancreas through the insuloacinar portal system, which can have a direct impact both on the pathogenesis, and the clinical symptoms of MS. The information about the correlation of the morphofunctional state of the pancreaticacinar tissue with nutrition type and trophological status is presented in the few researches [4, 6, 8].

Aim of research is to study the morphofunctional state of the pancreas on the basis of the ultrasonic parameters and to estimate its postprandial response in children with MS.

Materials and methods of research

The study involved 48 children with various forms and levels of obesity aged from 6 to 15 (23 boys and 25 girls). For the convenience of data interpretation, two groups of children were allocated. The main group consisted of 31 children (an

average age 12.91 ± 1.78), the control group consisted of 17 children, having obesity without MS symptoms (an average age 11.45 ± 2.72).

In the course of the survey, the complex of clinical, laboratory and instrumental methods of examination, according to standard methodology, was performed.

The ultrasonic scanning of the pancreas before and after the food stimulation, allowing to estimate its adaptive resources, was conducted to all children according to the worked in clinic methodology. In this case, the ultrasonic scanning of the pancreas was performed twice: in the interdigestive period the standard examination on the empty stomach, then in 1.5–2.0h after breakfast, which contained not less than 20g fat (eg.: 100g of 20% cream; 150–200g 10% cream of wheat or scrambled eggs, white bread and butter, coffee or tea with milk). After the emptying of the stomach and re-visualization of the pancreas, the repeated measuring of transversal dimensions and the calculation of the percentage increase of sum of the pancreas head, body and tail dimensions before and after breakfast were done. The increase of the pancreas size after a meal within 15–40% was considered physiological. The lack of the postprandial response, when the pancreas size did not change or increased insignificantly (less than 5%), was considered a characteristic feature of chronic pancreatitis (CP) [6].

The statistical analysis of the results was performed using the statistical package Statistika 6.0. The differences of average indexes were considered significant at $p < 0.05$. During the correlation and regression analyses, we calculated the corresponding coefficients, the reliability of which was considered at $p < 0.05$.

Results and discussion

The overwhelming majority of children had the family history of obesity, diabetes mellitus type 2 and arterial hypertension. Every third child had the relatives, suffering from diseases of the liver and gall bladder, pancreas, gastro-intestinal tract organs. The primary, exogenous-constitutional obesity was diagnosed in 41.7% of the patients, the hypothalamic one in 58.3%, within the third of children the hypothalamic syndrome developed on the background of the primary obesity. I–II degrees of obesity were revealed in 52.1% of children, III–IV degrees in 47.9% of

children. In most cases (75.0%), the fatty tissue was distributed according to the abdominal and mixed type, rarely according to the gynoid type. The duration of the disease in 16.7% of children was less than 2 years, and in 45.8% 5 years and more. 31 patients (64.5%) had the symptoms of MS (WHO, 1999).

In all children by the ultrasonic scanning, the various changes of the pancreas were diagnosed: in 39 children (81.3%) –the increase of acoustic density, in 32 children (66.7%) the presence of hyperechoic inclusions of both small and large sizes, in 5 children (10.4%) the dilatation of the pancreatic duct more than 2.5 mm, and in the third of children the visualization of the duct was difficult.

It was tested, that the pancreas size on the empty stomach in children of the main group exceeded the normative indexes and were statistically significantly higher ($p < 0.05$), than in the control group, and were 59.1 ± 6.80 and 54.2 ± 7.22 mm respectively, at the rate for children with normal body weight 46–56 mm [6]. After the food stimulation the sum of the pancreas head, body and tail dimensions was 64.9 ± 7.98 mm in the main group, and in the control group 60.5 ± 4.41 mm. As you know, to ensure the intensive secretory process in the digestive period, the increased blood flow, called “working hyperemia”, takes place under the influence of the complex of intestinal hormones. In healthy children the increase of the pancreas size after eating is 15–40%. The postprandial response in the main group was lower (9.9 ± 11.54 and $13.8 \pm 6.98\%$ respectively), which shows the reduction of the adaptive resources of the pancreas and the higher risk of developing the chronic pancreatitis in children with MS.

It is known, that the size of the pancreas is determined by the dimensions of head and tail, while the pancreas body width is independent of the child’s weight and height. It was determined the correlation between the size of the pancreas head and the degree of obesity ($r = 0.28$ at $p < 0.05$), as well as the disease duration ($r = 0.21$ at $p < 0.05$).

The determination of the dimensions of the pancreas head, body and tail before and after eating allowed revealing the statistically significant differences between groups (Table 1).

It is known, that in healthy children with the normal trophological status, the dimensions of the pancreas head are to the dimensions of the pancreas tail as 1:1, which is an average of 0.98. The increase of the pancreas head is considered an unfavorable factor, as the pancreatitis with damaged head, in the opinion of many authors, runs more severe [6, 8].

The correlation of the pancreas head and tail on the empty stomach in the main group was on average 0.95, and in the control group 1.01. In the postprandial period it was observed the uneven increase of the pancreas, the correlation head/tail was respectively 0.91 and 0.95, which confirmed the earlier obtained data of the higher risk of developing CP in children with MS.

Table 1

The dimensions of the pancreas before and after food stimulation, mm

		Main group (1)	Control group (2)
Head	before	24,8±3,43*,**	21,7 ±3,55****
	after	27,8±3,93*	25,1±2,62
Body	before	10,7±1,61**	10,4±1,82
	after	11,8 ±2,50	11,5 ±2,80
Tail	before	24,7 ±3,39	23,8±3,46
	after	25,4±3,42	23,9±2,53

Note: ± ;* — $p < 0,001$; **** — before-after $p < 0,005$

Table 2

Biochemical and hormonal indexes of blood serum of observed children

	Main group (1)	Control group (2)	Norm
P. amylase (u/l)	25,8±12,59	21,7±15,27	13–53
Glucose (mmol/l)	5,6±0,77*	5,02±0,53	3,3–5,6
Lipase (u/l)	19,6±5,23	20,5±6,9	5,6–51,3
Insulin (pmol/l)	186,7±72,13*	92,0±58,25	20–160
HOMA (units)	7,0±2,81*	3,2 ±2,25	<3,2

Note: ± ;* $p < 0,05$

It should be noted, that only in 3 (9.7%) children from the main group and in 4 (23.5%) children from the control group ($p < 0.05$) the postprandial increase of the pancreas dimensions was more than 15%, which indicated the adequate response of

the pancreas to the food stimulation. The majority of children from the main and control groups had that index ranged from 5 to 15% (22.0–71.0% and 13.0–76.5% children respectively), and 5 (16.1%) children from the main group less than 5%, which might be the symptom of the formation of the latent or chronic pancreatitis in them.

It was analyzed the changes of the biochemical and hormonal profile of blood serum. The pancreatic amylase level was elevated in 3 (9.7%) children from the main group and in 2 (11.8%) children from the control group. The indexes of lipase were within normal limits in all children. The levels of glucose, insulin and IR index (HOMA) were significantly higher in children from the main group (Table 2).

As you know, the increase of the glucose level in the blood has a toxic effect and promotes narrowing of the arteriolar lumen due to proliferation of their smooth muscle cells and the malfunction of the pancreas tissue blood supply. The stellate cells, which exist not only in the liver, but also in the pancreas, are activated, that naturally is accompanied by the development of fibrosis, similar to the process in the liver. All this has the negative impact on the state of both the excretory and endocrine functions of the pancreas.

The toxic effect on the pancreatic β -cells provokes the chronic increase of free fatty acids level due to visceral obesity. Thus, the increase of the FFA in the β -cells leads to the acceleration of apoptosis, the rise in them the synthesis of ceramide and the malfunction of their secretory activity. Besides, the early stage of stimulated secretion falls and the impulse secretion of insulin is violated: the 1st (fast) phase of insulin secretion, by which the vesicles with accumulated insulin are emptied, is absent, and the 2nd phase of the basal secretion is carried out in a monotone mode.

It was determined, that the disorders of the carbohydrate metabolism in children from the main group were detected three times more frequently, than in the control group (24.0–77.4% and 4.0–23.5% children respectively, $p < 0.05$). Besides, the malfunction of glucose tolerance was diagnosed only in the patients from the main group (7.0–22.6%), and fasting hyperglycemia in 14 (45.2%) children from the main group and in 3 (17.6%) children from the control group ($p < 0.05$). It was

revealed the correlation between the pancreas total and head dimensions on the empty stomach and the presence of the carbohydrate metabolism disorders ($r=0.14$ and $r=0.16$ at $p<0.05$).

Conclusion

1. Thus, the absolute majority of obese children as with MS, and without it have the various changes of the pancreas structure: a rise of dimensions, an increase of echogenicity of acinar tissue and the availability of hyperechoic inclusions.
2. There is the correlation between the pancreas head and tail dimensions on the empty stomach and both the degree of obesity and the disease duration.
3. The most evident changes of the morphofunctional state of the pancreas are diagnosed in children with MS, which results in the lower postprandial response and uneven increase of the pancreas due to the head in the postprandial period. All this indicates the reduction of the adaptive resources of the organ and the high risk of developing CP in children with MS.
4. It was determined the correlation between the pancreas total and head dimensions on the empty stomach and the disorders of carbohydrate metabolism.

These findings point out the need of profound examination of children with various forms and degrees of obesity for the purpose of timely diagnostics of chronic pancreatitis in them. These data enable to develop methods of the targeted prevention of MS and closely associated with it diabetes mellitus type 2, and thereby reduce the risk of early disability and premature death.

Peculiarities of the morphofunctional state of the pancreas among children with metabolic syndrome

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The paper presents the results of a study of the morphofunctional state of the pancreas among children with metabolic syndrome. It is shown that the absolute majority of children have various changes in the structure of the pancreas. Decrease of a postprandial response and uneven increase of the gland due to a head in a postprandial period are identified, which means a decrease in the adaptive abilities of the organ and a high risk of pancreatitis among children with metabolic syndrome. The interrelation between a total size and size of the head of the pancreas on an empty stomach with disorders of carbohydrate metabolism is set. Obtained data indicate the need for in-depth examination of children with metabolic syndrome in order to diagnose chronic pancreatitis.