Carbohydrate Metabolism in the Myocardium During Experimental Diabetes

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Abstract

Background: Metabolic syndrome is a consequence of metabolic disorders and this syndrome plays a leading role in the pathogenesis of cardiovascular diseases. According to modem statistics, according to researchers from many countries, the relationship between insulin content in the blood and ischemic heart disease is very common. According to some well-known researchers, this fact is reflected in the morfological changes that occur with age, and in particular, in a gradual decrease in the number of islets of langerhans and a simultaneous degreasein the body's ability to convert proinsulin into insulin.
Aim: our task was to study the age-related changes in carbohydrate metabolism in the myocardium of animal with alloxan-induced diabetes mellitus.
Methods: Glicogen in the material taken the heart as a result of decapitation for quantitative determitation, we used the Seifert and Anton methods, as wellas histomorphological, histochemical and histoenzimochemical research methods. The pieces taken from the heart were placed in the following fixatives: 1. Neutral fixing fluid (provided by Shabadash), 2. 10% neutral formalin, 3. Beker s in fixative solution .
Results: Our studies have shown that under stressful conditions, glycogenolysis is enhanced by the effect of adrenaline on the corresponding enzymes and at the same time the bodys need for carbohydrates increases. The heart muscle is able to quickly restore polysaccharide reserves. The lack of glycogen content in the myocardiocytes of young rats may indicate the strennngth of oxidative processes. As is known, the myocardium belongs to insulin-sensitive tissues, due to which glucose consumption decreases and the myocardium preferentially switches to the consumption of fatty acids, as evidenced by the increase in lipolytic activity in myocardiocytes.
Conclusions: Thus, all these possible factors and the incrfease in glycogen content in alloxan-induced diabetes, in the age-related aspect, may be the cause of the decrease in myocardial contractility and the basis for the subsequent development of ischemic disease . **(TCM-GMJ May 2026; 11 (1): P13-P16)**

Keywords: : Carbohydrate, Myocardium, Alloxan, Diabetes, Metabolism.

Introduction

Metabolic syndrome is a consequence of metabolic disorders and plays a leading role in the pathogenesis of cardiovascular diseases. According to modem statistics, according to studies in many countries, the relationship between insulin levels in the blood and ischemic heart disease is very common (1). According to prominent researchers, this fact is reflected in the morfological changes that occur with age, and in particular, in thegradual decrease in the number of islets of langerhans. At the same time, the body's ability to convert proinsulin into insulin decreases.

Diabetes mellitus is observed in 12–13% of patients, with myocardial infarction, and it is among them that a high probability of mortality is observed (2). Hyperglycemia, as an importantsymptom of diabetes mellitus, is not only a characteristic of this disease, but also occurs in cases of infarctions that are not accompaniedby diabetes mellitus. The role of insulin resistance in the pathogenesisof these diseases is associated not only with endotelial damage, smooth muscle cell proliferation, but also with other metabolic changes (especially dyslipidemia (3)). Subsequently, with increasedaggregation of blood formed elements, with leads to vascular thrombosis (4). Hyperglycemia is the primary factor that promotes functional affects the morphological and fuctional properties and negatively rndothelial cells in the ischemic area of the myocardium (5,6). Disrupts endothelial function, promotes erythrocyte aggregation on damaged cells and the formation of atherosclerotic plagues.

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Methods

The experiment was conducted on intact malechinchillas weighing 2.4–4.0 kg. The animals are divided into three age groups according to the accompanying periodization (7) based on the exact date of birth:

- **Group I:** Sexually immature kittens from (3,5 months

to 8 months)

- **Group II:** Reproductively immature from rabbits (8 months to 3 years)
- **Group III:** Older children from (3years to 7 years old)

A total of 127 rats were included in the experiment, including 52 controls of 3 bgroups of appropriate age. 75. Alloxan, diabetes was induced in rats by injecting a freshly prepared 5% aqueous solution of alloxan into the ear vein at a dose of 150 mg. per kg. of body weight. Of these, 11 rats did not develop diabetes, 14 died during the experiment after stable hyperglycemia (10-12 days) and were euthanized by decapitation.

As a resultsd of decapitation, we quickly obtained material from the heart for the quantitative determination of glycogen and used the Seifedrt and Anton methods for research, as well as histomorphological, histochemical, and histoenzymatic reseasrch methods. We placed the samples taken from the heart in fixatives:

- Neutral fixative Fluid (provided by Shabadash)
- 10% neutral formalin
- Baker's fixative

Histological sections were stained with hematoxylin and eosin. Phosphoaminoesterase activity was demonstrated using Gomori's method. Glycogen was identified by the Shabadash method with α-amylase control. Acid mucopolysaccharides were detected by metachromatic reaction using toluidine blue.

Results and discussion

Our findings indicate that glycogen in the myocardium plays an important role not only during muscular contraction but also in the resynthesis of ATF and creatine phosphate. This metabolic function enables sustained cardiac muscle activity throughout life. In control animals from the three different age groups, myocardial glycogen content and blood glucose levels were determined under normal (non-diabetic) conditions.

Blood Glucose Levels

The results (Table 1) demonstrate that blood glucose levels show a slight increase with advancing age. However, although glucose levels in Group III animals were 5.1% higher than in Group II, this difference was not statistically significant. Therefore, under physiological conditions, blood glucose concentration did not change significantly with age.

Thus, it is possible to assume that under normal conditions, blood sugar levels do not differ significantly with age.

Myocardial Glycogen Content

Quantitative analysis of glycogen in the myocardium showed (Table 2) that glycogen content progressively increased with age. In all age groups, glycogen levels were consistently higher in the right ventricle compared to the left ventricle. The increase in glycogen content was statistically higner in the myocardium of group I animals. Also, comparative analysis confirmed a furtherstatistically signi ficant increase in glycogen in group III animals compared to group I animals. The increase in the amount of glycogen (table 2) was determined in greater quantities in the myocardium of animals of group II than in animals of group I, which is statistically significant. Also statistically significant is the increase in glycogen in animals of group III compared to group I, as a results of the comparative analysis.

The resuilts in tables 1 and 2 show that the amount of glycogen increases with age and that this increase is particularly significant in the myocardium of the right ventricle compared to the left, which is characteristic of all cases studied.

It is noteworthy that the incidence of diabeters increases with age and is considered by many authors as a this is a gerontological problem. With increasing age, the possiblity of new changes in parallelwith the aging process, whih are caused by metabolic syndrome, whih develops in diabetes and deepens pathological processes, increases. Taking in to account the age-relatedrole of carbohydrate dysmetabolism in the pathogenesis of diabetes mellitus, experiments were conducted in alloxan-induced diabetic rats.

With increasing age, not only do involucional processes intensify, but also metabolic changes associated with metabolic syndrome become more pronounced. These disorders are especially relevant. In diabetes mellitus, where additional pathological syndromes further exacerbate metabolic imbalance. Experimental diabetes of to study carbohydrate dysmetabolism was carried out in rabbits of different age groups using alloxan.

Age-related trends: G**roup I (sexually immature),** had higner mortality of 22.2%, higher resistance of 18.5%, and 59.3% with the development of diabetes. **Group II (reproductive maturity) had** the development of Diabetes of 66.7%. **Group III (elderly) had the highest sensitivity to alloxan with the development of diabetes of 76,2**%, and a low resistance rate of 9.5%.

These findings suggest that older animals are more susceptible to alloxan-induced β-cell damage, whereas sexually immature rabbits demonstrate greater resistance. Notably, induction of diabetes in sexually immature rabbits required repeated (up to three) alloxan injections, whereas in mature and aged animals, a single injection was sufficient.

Sensitivity to Alloxan by Age Group

Analysis of the diabetogenic effect of alloxan revealed age-dependent differences in mortality, resistance, and diabetes induction rates.

Among the 75 rabbits:**14 animals (18.7%)** died after injection.**11 animals (14.7%)** were resistant to alloxan (diabetes did not develop). **50 animals (66.7%)** developed diabetes.

Severity of Hyperglycemia. Hyperglycemia levels also varied across age groups. Among diabetic animals (n =50). **64.0%** exhibited severe hyperglycemia (>381 mg%). **26%** had moderate hyperglycemia (281–380 mg%). **10%** showed mild hyperglycemia (≤280 mg%)

Severe hyperglycemia predominated in Group I (81.3%), whereas in Groups II and III, moderate hyperglycemia was more frequent relative to the youngest group.

These data indicate that although younger animals show greater resistance to diabetes induction, once diabetes develops, hyperglycemia may be more pronounced.

Blood Glucose Levels in Diabetic Animals. Mean blood glucose levels were:

Group I: 524.4 ± 23.3 mg%.

Group II: 372.0 ± 18.5 mg%.

Group III: 357.9 ± 23.6 mg%. All values were statistically significant ($p < 0.001$).

The highest mean glucose concentration was observed in sexually immature animals, whereas middle-aged and aged groups demonstrated comparatively lower, though still markedly elevated, glucose levels.

As can be seen from tables 5 and 6, there is a tendency for hyperglicemia and glycogen content to increase in age groups I and II. In group III, similar data almost do not differ from the asge norm, which is why the comparative analysis with the age group under normal conditions turned out to be statistically rebiable.

Methodological Considerations

Biochemical quantification methods allow precise determination of total polysaccharide content. However, they do not provide information about functional redistribution of polysaccharides within different cellular and subcellular structures.

Therefore, combining biochemical assays with histological and histochemical analysis is essential for a comprehensive evaluation of structural and metabolic alterations in diabetic myocardium.

Conclusion

It is noteworthy that the incidence of diabetes increases with age and many authors considerit as a gerontological problem. With increasing age, the possibility of new changes, which are caused by metabolicsyndrome, impression parallelwith the aging processes. Taking in to account the age-related role of carbohydrate dysmetabolism in the pathogenesis of diabetes mellitus, experiments were conductedin alloxan-induced diabetic rats. As is clear from biochemical studies, the studies used allow us to accurately determine the amount of polysaccharide. Thus, histological examination, together with biochemical research, makes it possible to study the changes in more depth. Thus, the increase in glycogen content in alloxan-induced diabetes, in the age-related aspect, may be the reason for the development of ischemic disease with a decrease in myocardial contractility.

Table 1 . Blood sugar levels in animals of different age groups under normal conditions

The Object of investigation	Statistical indication	Animals group		
		I gr.	II gr.	III gr.
Blood	M+/-m N P	100,5+/-4,1 18 0,001	105,6=/-2,6 17 0,001	107,9+/- 4,8 17 0,001

Table 2. Glycogen content in the left and right ventricles of animals of different age group under normal conditions

Animal groups	Statistical indicator	The researching objects	
		Left ventricle	right ventricle
I	M+/-m N P	168,4+/-11,07 18 0,001	235,7+/-19,5 18 0,001
II	M+/-m N P	323,0+/-31,7 17 0,001	481,3+/-38,1 17 0,001
III	M+/-m N P	360,0+/-39,8 17 0,001	528,0+/-101,8 17 0,001

Table 3. Responseof rabbits of differentage groups to diabetogenic doses of alloxan.

study groups	rabbits quantity	died after injections		resistance to the alloxan		with diabetes	
		quantity	%	quantity	%	quantity	%
I	27	6	22,2	5	18,5	16	59,3
II	27	5	18,5	4	14,8	18	66,7
III	21	3	14,3	2	9,5	16	76,2
total	75	14	18,7	11	14,7	50	66,7

Table 4. Blood sugar levels in pacients with alloxan-induced diabetes mellitus age groups.

study groups	quantity of rabbits in alloxan diabetes	Blood sugar level mg %					
		280 to the mg%		281 _ 380 to the mg%		381 and more to the mg%	
		quantity	%	quantity	%	quantity	%
I	16	1	6,3	2	12,5	13	81,3
II	18	2	11,1	5	27,8	11	61,1
III	16	2	12,5	6	37,5	8	50.2
total	50	5	10,0	13	26	32	64,0

Table 5. Blood sugar levels in alloxan – induced diabetes mellitus in age groups.

Object	Statistics indicator	Animal groups		
		I group	II group	III group
Blood	M+m N P	524,4+/-23,3 16 0,001	372,0+/- 18,5 18 0,001	357,9+/-23,58 16 0,001

Table 6. Quantitative glycogen content in the left and right ventricles of the animal heartduring alloxan – induced diabetes in an experiment.

Object	Statistics indicator	Animal groups		
		I group	II group	III group
Blood	M+m N P	524,4+/-23,3 16 0,001	372,0+/- 18,5 18 0,001	357,9+/-23,58 16 0,001

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