CLINOPTILOLYTE INFLUENCE ON THE RADIONUCLIDE ^{137}Cs REMOVAL FROM THE ANIMAL ORGANISM

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The possibility of zeolite use for the radionuclide ^{137}Cs removal from the animal organism under internal irradiation is investigated. The dependence of the dynamics of ^{137}Cs removal from the animal organism on such factors as clinoptilolyte introduction time and dose is established.

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1. INTRODUCTION

The history of radio protectors counts about 60 years. The advance in the study of these substances was connected with intensive development of radio biological investigations after the USA has used nuclear weapons for bombardments in Hiroshima and Nagasaki. During the period from the end of 50^{th} to the middle of 70^{th} years of the past century the extensive search of radio protectors was observed [1-2].

The most purposeful search of radio protecting substances took place in the USA in connection with solving the defense problems, as well as, due to developing the nuclear power engineering. In 1969 in the USA more than 4000 compounds were developed, prepared and tested for men. However, later it has been found that these substances do not meet completely the requirements to radio protectors [1-2].

The Chornobyl disaster has raised an acute problem of urgent search of radioprotectors. As a result of the Chornobyl NPP accident the environment was contaminated with long-lived radionuclides, such as ^{137}Cs. The radiation damaged areas, remained in the economics(93% of the total contaminated areas) continue to be populated by people. There exists a danger of radionuclide accumulation in the foods (vegetables, fruits, meat) and in the water. Therefore a menace of radionuclide penetration into the human organism with subsequent internal radioactive irradiation takes place.

During the recent years the criteria, to which radioprotecting substances should correspond, are well defined:

1. Radioprotector should be enough effective and should not cause side effects.

2. Radioprotector should act rapidly (in the first 30s) and during long time.

3. Radioprotector should not make a patient temporarily disabled.

4. Radioprotector should be prepared in the convenient pharmaceutical dosage form.

5. Radioprotector should not weaken the organism resistance to other unfriendly environmental factors.

6. Radioprotector should not have adverse health effects after recurring medicine in taking and should not be accumulated in the organism.

7. Radioprotector should be stable upon storage and should conserve its properties at least during 3 years.

Disadvantages of existing synthetic radioprotectors were a reason for studying the radioprotecting properties of low-toxic substances having mineral and biologic origin [1-2].

For example, clinoptilyte from the class of zeolites can be considered as one of such mineral substances [3]. Natural zeolites belong to the most important natural ion exchangers. They form a group of aluminosilicate minerals with a regular spatial structure whose composition can be expressed by the formula [4,5]:

$$M_{x/n}\left[(AlO_2)_x (SiO_2)_y\right] \cdot WH_2O\,, \qquad (1)$$

where M - n is the valence cation capable to the ion exchange;

W is the number of water molecules;

x/y take the values from 1 to 5.

In the silicate lattice a part of Si^{4+} ions is substituted by Al^{3+} ions, and the insufficient positive charge is compensated due to the ions of alkali- and alkali-earth metals [4].

Sorption on zeolites has some significant distinctions from other sorbents. Interaction between the sorbate molecules is reduced to minimum, because they are separated them from each other by aluminosilicate atoms. Interaction between the sorbate molecules and the sorbent is enhanced as the sorbate

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molecules are surrounded by the sorbate on all sides [6].

The ion-change mechanism of sorption occurs as a result of Na^+ - Cs^+ interchange. Zeolites are selective relatively to the large univalent ions.

In the course of preliminary experiments in vitro the sorption-selective properties of clinoptilolyte and synthetic zeolites [7] were determined. High sorption properties of clinoptilolyte relatively to ^{137}Cs are conditioned by the nature of ion changers and by their structure peculiarities [3,4]. The experiments in vitro point to the high sorption activity of clinoptilolyte relatively to ^{137}Cs in the wide range of pH (from 0.2 to 8.5) [7]. Thus, it is possible to carry out experiments in vivo for the purpose of determining the sorption properties of clinoptilolyte under organism's conditions.

2. MATERIALS AND METHODS

In the present work we used natural zeolite, namely clinoptilolyte from the Sokirnitsky zeolite deposit (Zakarpattya region). Clinoptilolyte was preliminary grinded to the particle size no more than 0.1 mm. Then clinoptilolyte was subjected to the thermal treatment at temperature of $150^\circ C$ during one hour. Experiments were carried out on white male ruts with a body weight of $150...200\,g$. The animals were kept under usual vivarium diet. The clinoptilolyte influence on the process of ^{137}Cs removal was observed in the dynamics under conditions of 30-day experiment. ^{137}Cs was introduced orally once per day in the form of aqueous solution (pH =7.2, volume = 1 ml) in quantity 40 kBq per rat weight. This dose does not lead to changes of the animal's condition in whole. Therefore it is possible to observe during long time the process of radionuclide removal from the organism. The experience included two stages.

In the first stage the dynamics of ^{137}Cs removal by means of clinoptilolyte was determined as a function of zeolite introduction time. The animals were separated into three groups by 15 rats:

Control Group 1 was fed with zesium-137 only;

Group 2 was fed with clinoptilolyte after zesium-137 introduction;

Group 3 was fed with clinoptilolyte 4 days prior to the zesium-137 introduction.

Experimental animals obtained clinoptilolyte with the feed in the dose of 9 mg/kg.

In the second stage the dynamics of ^{137}Cs removal was determined as a function of clinoptilolyte dose changing. Clinoptilolyte was introduced 4 days prior to the zesium-137 introduction. The animals were separated into four groups by 15 rats:

Control Group 1 was fed with zesium-137 only;

Group 2 was fed with clinoptilolyte in the dose of 9 mg/kg;

Group 3 was fed with clinoptilolyte in the dose of 50 mg/kg;

Group 4 was fed with clinoptilolyte in the dose of 100 mg/kg.

To estimate the ^{137}Cs content a direct method was applied as the most exact and adequately representing the radioprotector action: decrease of radionuclide accumulation [8]. The rat radioactivity was measured using the γ -analyzer LP-4900 with Ge /Li/ having a detector of a large volume (160 dm^3). The radioactivity was measured in living rates. The error of radiometric measurements was not less than 5%.

3. RESULTS AND DISCUSSION

The residual content of ^{137}Cs (A,%) in the animal organism at the given moment was calculated by the formula

$$\mathrm{A} = \frac{\mathrm{A}_{res}}{\mathrm{A}_{init}} \cdot 100\,, \qquad (2)$$

where A_{res} is the ^{137}Cs radioactivity in the rat organism at the given moment, Bk; A_{init} is the ^{137}Cs radioactivity in the rat organism immediately after the radionuclide introduction, Bk.

The estimate of the protective action (E_{pr}) was calculated by the formula [9]

$$\mathrm{E}_{pr} = \left[1 - \frac{\mathrm{A}_{exp}}{\mathrm{A}_{contr}}\right] \cdot 100\,, \qquad (3)$$

where A_{exp}, % is the residual radionuclide content as a function of the introduced amount in the organism of experimental animals; A_{contr}, % is the residual radionuclide content as a function of the introduced amount in the organism of control animals.

The ^{137}Cs -to-alkali ratio determines its behavior and distribution in the organisms. In the acid media of the stomach cesium transforms into the solution independently on its initial form and then does not interact with biochemical structures of the organism. Thus, there are developed favorable conditions for cesium absorption by radioprotectors and it is unimportant how the radioprotectors have been introduced: as preventive or immediately after the radionuclide entry into the stomach. Radioactive cesium is well-assimilating in the gastrointestinal tract, its absorbability is 100%. After the radionuclide oral entering its significant absorbed part is secreted in the intestine canal with subsequent reasorption in the lower bowels. After coming into the blood the radionuclide is rather uniformly distributing in the organs and tissues.

Kinetics of ^{137}Cs removal from the rat organism can be described by the curve with two exponents:

Exponent 1 describes therapid ^{137}Cs removal during 2-3 days;

Exponent 2 describes the slow ^{137}Cs removal. The slowing occurs because cesium forms stable complexes with the organism biosubstrate.

According to the L.A.Ilyin's classification of radioprotectors by the protective action efficiency, all substances with antiradiation properties can be separated into three categories [9].

The first category includes radioprotectors having the protective action efficiency from 0 to 30%.

This is the category for radioprotectors having insufficient protective action. The second category includes the radioprotectors having the protective action efficiency from 30% to 60%. The radioprotectors of this category are considered as efficient and can be applied as preventives. The third category includes the radioprotectors having the protective action efficiency from 60 to 100%. The radioprotectors of this category are considered as high-efficient radioprotectors.

Taking into account the data on the dynamics of ^{137}Cs removal from the rat organism (Fig.1) a conclusion may be drawn about the efficiency of clinoptilolyte presence in the organism before and after radionuclide introduction.

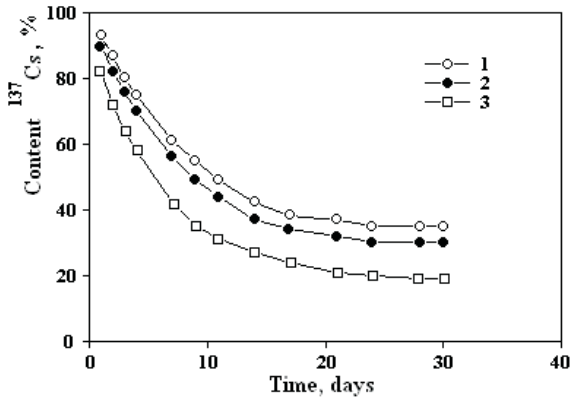

Fig.1. *Dynamics of ^{137}Cs removal from the rat organism: 1-control group; 2- group, which obtained clinoptilolyte after the ^{137}Cs introduction; 3- group, which obtained clinoptilolyte prior to the ^{137}Cs introduction*

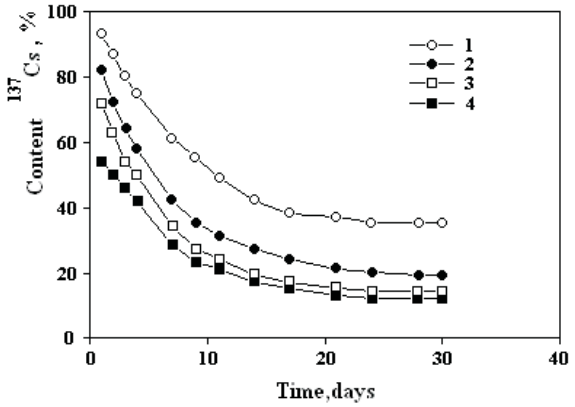

Fig.2. *Dynamics of ^{137}Cs removal from the rat organisms as a function of the dose 1-control group; 2- group, which obtained 9mg/kg clinoptilolyte prior to the ^{137}Cs introduction; 3- group, which obtained 50 mg/kg clinoptilolyte prior to the ^{137}Cs introduction; 4 - group, which obtained 100 mg/kg clinoptilolyte prior to the ^{137}Cs introduction*

The efficiency of protective action of clinoptilolyte introduced after the ^{137}Cs introduction is 14%. It follows from this that, according to the L.A.Ilyin's classification, clinoptilolyte does not reveal a protective action when it enters into the organism after radionuclide introduction. The efficiency of protective action of clinoptilolyte introduced 4 days prior to the ^{137}Cs entering is 46%. Consequently, clinoptilolyte may be referred to the moderate-efficient radioprotectors and can be used in low doses as a preventive.

During experiments at the second stage the dynamics of ^{137}Cs removal was determined as a function of the changing amount of clinoptilolyte introduced in the rat organism. The experimental results obtained (Fig.2) show that the clinoptilolyte dose increase accelerates the ^{137}Cs removal from the rat organism. It has been established that with the clinoptilolyte dose of 50 mg/kg the protective action efficiency is 60%, and with the clinoptilolyte dose of 100 mg/kg the protective action efficiency is 66%.

4. CONCLUSIONS

The experiments demonstrated that the efficiency of clinoptilolyte protective action depends on the time of its introduction into the organism (prior or after radionuclide entering).

Low doses of clinoptilolyte (9mg/kg) preliminary introduced into the organism exert a moderate protective action (46%), consequently, clinoptilolyte can be used as preventive.

The clinoptilolyte dose increase leads to the acceleration of ^{137}Cs removal from the experimental animal organism.

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ВЛИЯНИЕ КЛИНОПТИЛОЛИТА НА ВЫВЕДЕНИЕ РАДИОНУКЛИДА ^{137}Cs ИЗ ОРГАНИЗМА ЖИВОТНЫХ

А.Ю. Лонин

Исследована возможность использования цеолитов для выведения радионуклидов из организма животных при внутренних облучениях. Установлено влияние на динамику выведения ^{137}Cs из организма животных следующих факторов - времени введения клиноптилолита и дозировки.

ВПЛИВ КЛІНОПТИЛОЛІТУ НА ВИВЕДЕННЯ РАДІОНУКЛІДУ ^{137}Cs З ОРГАНІЗМУ ТВАРИН

О.Ю. Лонін

Досліджено можливість використання цеолітів для виведення радіонуклідів з організму тварин при внутрішньому опромінюванні. Встановлено вплив на динаміку виведення ^{137}Cs з організму тварин слідуючих факторів - часу введення кліноптилоліту та його дози.