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**Yu. I. Bandazhevsky**

**RADIOACTIVE CAESIUM AND HEART**

(pathophysiologic aspects)

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This book is one from the series of the author's publications devoted to the effect of radioactive elements upon human organism. Here the author analyzes results of his own clinical and laboratory researchers, considering the studying of the state of cardiac activity in conditions of radioactive caesium influence. The publication is intended for various practitioners, researchers investigating the problems of incorporated radioisotopes' effect upon the human organism.

Reviewers:

**Michel Fernex** – Honorary Professor of the Medical Faculty of the University of Basel (Switzerland);

**V.B. Nesterenko** - Doctor of Engineering Sciences, Professor, Corresponding Member of the Belorussian National Academy of Sciences, Director of the Research Institute of Radiology.

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## Foreword

### CARDIAC PATHOLOGY AS A CONCEQUENSE OF ECOLOGICAL PROBLEMS.

Being the leading in the organism, cardio-vascular system is very sensitive to the influence of different environmental factors. But it is able to function in unfavorable conditions for a long period, because of rather high adaptable capacities. Besides, complex pathology processes, involving structures of the whole organism are formed. And sometimes it is hard to manifest all their links. The main reason in most cases doesn't usually manifested. In this connection, medical measures are mainly connected with weakening of illness passing, but not with its full liquidation. Multyfactoriality of the origin of numerous heart diseases couldn't be doubted in. Manipulation with that term sometimes disturbs manifesting of the main and leading reason of diseases. Besides the cure prescribed is not an ethiopathogenetic, but effects just single links of pathogenesis.

Pathogenetic physiology of the damaging of cardiac activity is based on manifesting of the total mechanisms of pathology processes, which are formed, in the result of violation of the activity of integrative systems: nervous and endocrine. Using of nervismus hypothesis promotes the appearance of the idea, that different environmental factors, at the particular power of influence, cause stress situation. This situation leads to the damaging of cardiac-vascular activity. It makes absolutely no difference what are these factors. Their influence leads to the same or almost the same effects: violation of cardiac rhythm, spasm of arterioles with arterial hypertension forming, violation of the systematic blood circulation, ischemia of hypoxia of cells and tissues.

Such approach doesn't allow successfully develop cardiology, because it doesn't take into consideration the specific character of the agent, that cause injure, and that is why it doesn't redound to prevention of cardiac-vascular diseases. The main principle of prophylaxis of cardiologic complications is a principle of perfection of adaptable capacities of cardiac-vascular and other systems to

unfavourable conditions. Beside adaptable capabilities of people are individual and depend on many factors. They are limited and often don't save from death.

Much more effective would become liquidation of the influence of factor, that causes injure. But in order to do that it is necessary to posses the data about entopathogenesis though of widely spread diseases of heart and vessels. Unfortunately, modern medicine doesn't posses them.

And in spite of the intensive development of medicine industry and cardiac surgery, people's death in many countries from cardiac-vascular pathology keeps growing year by year. But there are other examples. For instance in Sweden cardiac-vascular morbidity as well as onkological one is significantly lower, than in other countries [7, 18,37]. What does it connected with? First of all, with the state of environment. And different undertaking measures protect human's organism from the effect of agents of technogenic origin. Among them leading place is taken by radioisotopes.

Among radioactive agents, existing in the environment mostly spread the long lived elements –  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$  and also  $^{239}\text{Pu}$  and  $^{241}\text{Am}$ . It is connected with nuclear testing as well as with disasters on atomic power stations, among which the largest was Chernobyl one in 1996 [33].

In this connection, the contact of European population and population of the former USSR with mentioned radioisotopes and in higher degree with  $^{137}\text{Cs}$  should be stated. This contact lasted for nearly 40 years [26]. These agents not only round up people, but also penetrate in their organism and separate organs.

So, the question is – how does it reflected on human's health. Official statistics of Ministry of Health evidence about its declining. First of all the attention is paid to the constant growth of cardiac-vascular and onkological diseases [18, 37], which are the main reasons of young people's death. But at once the connection with radioisotopes incorporated in the organism is not analyzed. From one hand it is connected with disinclination or impossibility to do that. On the other hand - with the complexity of question solving because of the absence of useful methodical approach. Perhaps both of them take place. There are publications where affirming the harmless

effect of incorporated radioisotopes and, in particular  $^{137}\text{Cs}$ , on people's health [26].

The majority researches in the field of radiobiology and radiation medicine devoted to the effect of external radiation emission on the organism of people and animals. We have mentioned this fact in previous publications [5, 6].

At the same time there are no scientific publications analyzing the state of human's health and its individual systems in different age and at different degree of expression of radioisotope incorporation.

Perennial investigations about the state of people's health in conditions of prolonged radioisotope incorporation (sometime they last whole life), numerous experiments with laboratory animals, pathomorphological testing of autopsied material of individuals, lived on the contaminated with the given agents territories, allowed us to elaborate number of methodical approaches, concerning the following problem:

- 1) Assessment of the medical and biological effects with account of the dose of radioisotopes incorporated by the organism.
- 2) Investigation of pathological processes clinically and by experimental simulation among laboratory animals (the clinical and experimental approach).
- 3) Investigation of structural, functional and metabolic modifications evolving in the organism, its individual organs and systems.
- 4) Assessment of the severity of pathological conditions, such as disorders of the integrating processes in the organism. This approach allows pathological modifications in separate organs to be brought together.

Using of mentioned approaches allows to assess the state of organism, number of vital organs and systems during radioisotopes incorporation. First of all that concerns cardiac-vascular system, mostly affected vital system, and radioactive caesium, as mostly spread in biosphere long lived radioisotope. In this connection we undertook clinical, instrumental and laboratory investigations in children of different age, and also we carried out experiments with laboratory animals with the aim to study the effect of incorporated radioactive caesium on the state of cardiac activity.

## Chapter 1

### MODIFICATIONS IN CARDIAC-VASCULAR SYSTEM OF CHILDREN, LIVING IN CONTAMINATED WITH RADIOISOTOPES TERRITORY.

Clinical investigations included the following groups:

1. Children aged between 3 – 7 years (227 individuals), living in Gomel (soil contamination with  $^{137}\text{Cs}$  was 1-5 Ci/km<sup>2</sup>);
2. Children aged between 6 – 8 years (76 individuals), living in Vetka (soil contamination with  $^{137}\text{Cs}$  was 15 - 40 Ci/km<sup>2</sup>);
3. Children aged between 7 – 16years (55 individuals), living in Svetilovichi (soil contamination with  $^{137}\text{Cs}$  was 15 - 40 Ci/km<sup>2</sup>);
4. Children aged between 3 – 7 years (104 individuals), living in Grodno (soil contamination with  $^{137}\text{Cs}$  was less than 1 Ci/km<sup>2</sup>) – the first control group;
5. Children aged between 10 – 15 years (50 individuals), living in Minsk (soil contamination with  $^{137}\text{Cs}$  was less than 1 Ci/km<sup>2</sup>) - the second control group;
6. Children aged between 3 – 7 years (118 individuals), living in Zhlobin (soil contamination with  $^{137}\text{Cs}$  was less than 1 Ci/km<sup>2</sup>);
7. Children aged between 14 days and 14 months (155 individuals) and their mothers, constantly living in Gomel and in Gomel localities and having hospital treatment in Gomel Children's District Clinical Hospital;
8. Children aged between 8 – 15 years (211 individuals) with chronic pathology of gastro-intestinal tract, constantly living on the territory with the level of soil contamination with  $^{137}\text{Cs}$  from 1 to 15 Ci/km<sup>2</sup> and having hospital treatment in Gomel Children's District Clinical Hospital;
9. Students of Gomel Medical Institute aged between 18 – 20 years (197 individuals).

The state of cardiac-vascular system of children from all these groups was assessed electrocardiographically in 12 leads according to a standard method. In a number of cases the manifesting of accumulation of the most important indexes of metabolism and the activity of ferments in blood serum were being accomplished. Radioactive cesium accumulation in the organism of children was evaluated using the spectrometer of a person (the system of medical and radiologic control – MRC). The results of accomplished researches were statistically processed.

The carried out researches showed a high frequency of electrocardiographic modifications in all groups as a function of the amount of radioactive cesium in the organism of children and the level of territory contamination with given radioisotope (table 1).

In the areas with level of  $^{137}\text{Cs}$  contamination more than 15 Ci/km<sup>2</sup> and its concentration in organism more than 80 Bq/kg electrophysiological cardiac modifications appear in the organism of more than 80 % of children.

According the character one could divide the revealed pathologic processes into the following groups: arrhythmias and disturbance of oxidoreductive processes. Among the arrhythmias mainly the conduction impairment of electric impulse by myocardium (blockage of the bundles of His, atrioventricular blocks) is occurred. In majority of groups mostly the arrhythmias were occurred (table 2). In dependence of diapason of radioactive cesium incorporation in the organism of child each group was divided into 5 subgroups (table 3). That allowed to evacuate a direct proportional relation of electrocardiographic modifications from the amount of incorporated radioactive cesium.

This relation manifested especially vividly in the first group (Gomel) and was being formed, mainly, due to impairment of intraventricular conduction (fig. 1, 2). It should be noted that in Minsk  $^{137}\text{Cs}$  was absent in the organism of 16 children from 50 being tested (32 %). While in other groups its value decreased not lower than 11 Bq/kg. In children, where radioisotopes were absent, the electrocardiographic modifications were being manifested in 19% of cases. They were introduced by blockage of the right bundle of His. If take into account just the parameters of  $^{137}\text{Cs}$  incorporation and the frequency of electrocardiographic impairment, than the progressive

decreasing of relative amount of children without electrocardiographic modifications, as the amount of incorporated radioactive cesium increasing, could be stated (fig. 3).

Table 1

Frequency of electrocardiographic modifications and radioactive cesium concentration in the organism of children of different groups.

| Group                                                                   | Radioactive caesium accumulation in the organism, Bq/kg | Frequency of electrocardiographic alterations, % |
|-------------------------------------------------------------------------|---------------------------------------------------------|--------------------------------------------------|
| 1. Gomel                                                                | 30,32±0,66                                              | 72,3                                             |
| 2. Vetka                                                                | 82,50±7,32                                              | 86,8                                             |
| 3. Svetilovichi                                                         | 91,20±7,68                                              | 94,4                                             |
| 4. Grodno                                                               | 29,74±0,67                                              | 66,3                                             |
| 5. Minsk including:                                                     | 14,00±1,46                                              | 64,0                                             |
| Minsk-1                                                                 | 0                                                       | 18,8                                             |
| Minsk-2                                                                 | 20,50±0,75                                              | 85,0                                             |
| 6. Zhlobin                                                              | Wasn't determined                                       | 55,9                                             |
| 7. Children aged 14 days – 14 months                                    | 34,93±3,30                                              | 88,1                                             |
| their mothers                                                           | 27,10±2,80                                              | 80,3                                             |
| 8. Children with the disturbance of function of gastro-intestinal tract | 19,70±0,90                                              | 84,9                                             |
| 9. Students                                                             | 25,98±2,04                                              | 48,7                                             |

Table 2

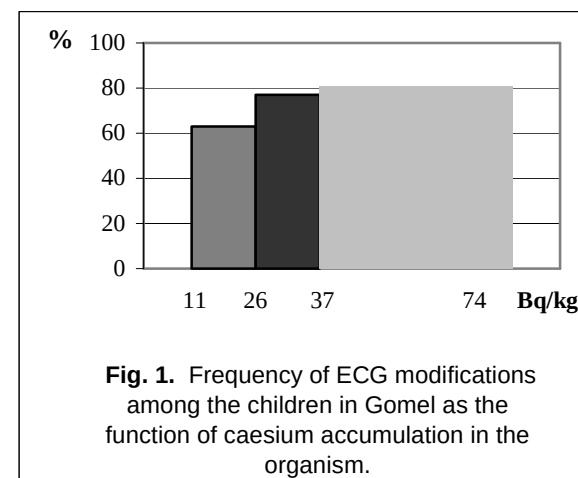
The character of electrocardiographic modifications of children of examined groups.

| Group                                                    | Arrhythmias |              | Impairments of oxidoreductive processes |              | Impairments of oxidoreductive processes and Arrhythmias |              | Normal ECG |              |
|----------------------------------------------------------|-------------|--------------|-----------------------------------------|--------------|---------------------------------------------------------|--------------|------------|--------------|
|                                                          | Abs.        | %            | Abs.                                    | %            | Abs.                                                    | %            | Abs.       | %            |
| 1. Gomel                                                 | 113         | <b>49,76</b> | 51                                      | <b>22,47</b> | -                                                       |              | 63         | <b>27,75</b> |
| 2. Vetka                                                 | 46          | <b>60,53</b> | 20                                      | <b>26,32</b> | -                                                       |              | 10         | <b>13,16</b> |
| 3. Svetilovichi                                          | 32          | <b>58,18</b> | 12                                      | <b>21,82</b> | 8                                                       | <b>14,55</b> | 3          | <b>5,46</b>  |
| 4. Grodno                                                | 41          | <b>39,42</b> | 28                                      | <b>26,92</b> | -                                                       |              | 35         | <b>33,65</b> |
| 5. Minsk                                                 | 23          | <b>46,00</b> | 5                                       | <b>10,00</b> | 4                                                       | <b>8,00</b>  | 18         | <b>36,00</b> |
| 6. Zhlobin                                               | 48          | <b>40,68</b> | 18                                      | <b>15,25</b> | -                                                       |              | 52         | <b>44,67</b> |
| 7. Children Mothers                                      | 7           | <b>4,50</b>  | 81                                      | <b>52,26</b> | 64                                                      | <b>41,30</b> | 3          | <b>1,94</b>  |
|                                                          | 18          | <b>29,02</b> | 7                                       | <b>11,29</b> | 31                                                      | <b>50,00</b> | 6          | <b>9,68</b>  |
| 8. Children with the diseases of gastro-intestinal tract | 149         | <b>70,62</b> | 30                                      | <b>14,22</b> | -                                                       |              | 32         | <b>15,68</b> |
| 9. Students                                              | 88          | <b>40,36</b> | 8                                       | <b>8,33</b>  | -                                                       |              | 111        | <b>51,30</b> |

Table 3.

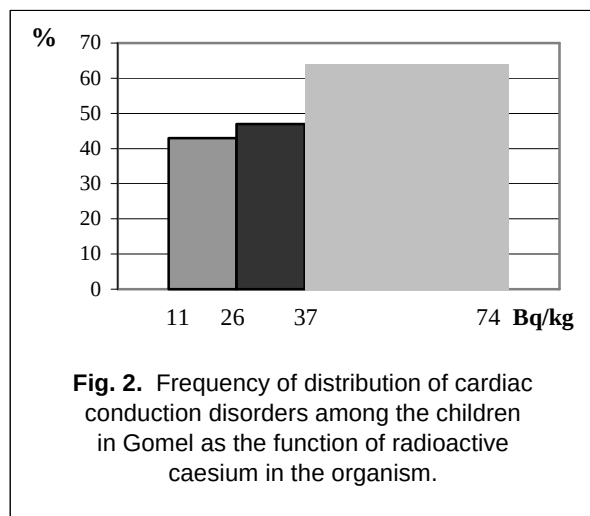
The frequency of electrocardiographic modifications as a function of the level of cesium incorporation.

| Group           | <sup>137</sup> Cs accumulation in the organism of children, Bq/kg |         |         |       |       |
|-----------------|-------------------------------------------------------------------|---------|---------|-------|-------|
|                 | 0                                                                 | 11-25,9 | 26-36,9 | 37-74 | >74   |
| 1. Gomel        | -                                                                 | 62,8%   | 77,6%   | 80,7% | -     |
| 2. Vetka        | -                                                                 | -       | 82,4%   | 92,3% | 87,9% |
| 3. Svetilovichi | -                                                                 | -       | 100%    | 92,3% | 96,0% |
| 4. Grodno       | -                                                                 | 62,5%   | 65,5%   | 78,6% | -     |
| 5. Minsk        | 18,8%                                                             | 83,8%   | 100%    | -     | -     |

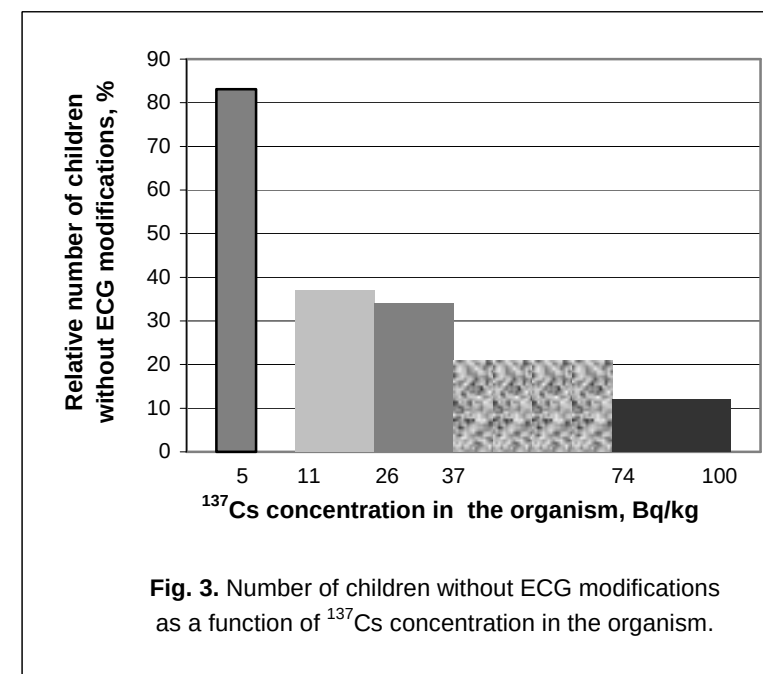


The testing of children with average level of radioactive cesium accumulation – 100 Bq/kg, in Svetilovichi has manifested significant

clinical signs. They were pain in heart area, quiet heart sounds and systolic murmur during the auscultation. The fact of combination of arrhythmias and impairments of oxidoreductive processes on the same electrocardiogram is noteworthy. It was observed that the level of radioactive cesium incorporation in this case was significantly higher than at the individual kinds of these modifications –  $165,10 \pm 8,47$  Bq/kg (children with arrhythmias –  $84,61 \pm 9,29$  Bq/kg,  $p < 0,05$ ).



Radioactive cesium accumulation was also registered in the organism of children of earlier ages and in their mothers (table 1). Electrocardiographic alterations were registered respectively in 98,1 and 90,3 % cases. They were introduced, mainly, by myocardium impairments and arrhythmias. In children the metabolic modifications of myocardium constituted 88,4 % (47,1 % - isolated and 41,3% - in combine with impairments of intraventricular conduction). Conduction impairments, introduced, mainly, by the incomplete blockage of the right bundle of His, were observed in 45,8 % of children. Normal electrocardiogram was registered only in 3 children (1,9 %).



Electrocardiographic modifications in mothers included also metabolic impairments and arrhythmias (disturbance of automatism and conduction). Hypocalcemia was being observed in 83,2 % of examined children, increasing of the activity alanin amino transferase was manifested in 39,5 % of children, asparate aminotransferase – in 74,6 %. These facts evidence about impairments of metabolic processes in liver and heart.

Accomplished researches have shown high sensitivity of the system mother – child to the influence of radioactive cesium. Relatively small amounts of the given radioisotope cause damaging of cardiac-vascular system of mother as well as a child, damaging its forming in the latter.

Using of enterosorbents “Belosorb – 11” during 5 – 6 days caused decreasing of the level of  $^{137}\text{Cs}$  to  $25,43 \pm 2,54$  Bq/kg (home

level –  $34,93 \pm 3,30$  Bq/kg) and reducing of the amount of cases of metabolic impairments in myocardium.

Studying of electrocardiograms of children with chronic pathology of gastro-intestinal tract, living in conditions of constant penetrating of radioactive cesium in the organism, has shown high frequency of disturbance of cardiac activity – 84,9 %.

Very often were observed metabolic modifications in myocardium (54,5%), impairments of conduction in the form of incomplete blockage of the right bundle of His (32,7%), disturbances of automatism of sinus node (36,0 %). In children with the level of  $^{137}\text{Cs}$  accumulation more than 20 Bq/kg disturbances of automatism were manifested in 73,3% cases, and in children with lower level - in 21,0% cases. Metabolic disturbances are manifested, respectively, in 66.6 % and 42.1 % of cases. And unaltered electrocardiograms are registered, respectively, in 6.7 % and 19.3 % cases. In 83.8 % of children with the level of accumulation over 20 Bq/kg the hypersympathocotonic variant of vegetative reactivity was occurred. Meanwhile in children with the accumulation level less than 20 Bq/kg it occurred in 50.8 % of cases.

Thus, in children with chronicle pathology of gastro-intestinal tract, reside on the territory contaminated with radioisotopes, take place the tension of adaptive and compensator mechanisms of vegetative regulation. It is expressed in dominating of hypersympathocotonic variant of vegetative reactivity. Its frequency is directly proportional to the quantity of radioactive caesium in organism. At once the level of cortisol increases and level of free thyroxin in blood serum decreases (table 4). Clinically the syndrome of vegetative dysfunction was being manifested in the form of neurocirculatory dystonia and bile-excreting ducts dyskinesia. Their frequency depended on the amount of radioactive caesium in the organism. In 93.3% of cases that syndrome appeared when incorporation was more than 20 Bq/kg and in 68.8% - less than 20 Bq/kg.

Table 4

Hormone concentration in blood serum in children with different variants of vegetative reactivity.

| Variant of vegetative reactivity | Normal<br>n=48     | Hypersympat<br>hocotonic<br>n=47 | Asympathoc<br>otonic<br>n=28 |
|----------------------------------|--------------------|----------------------------------|------------------------------|
| Cortisol, nMol/l                 | 622,49 $\pm$ 42,10 | 771,19 $\pm$ 50,67*              | 706,16 $\pm$ 89,29           |
| Free thyroxin, mMol/l            | 13,40 $\pm$ 0,49   | 12,21 $\pm$ 0,29*                | 12,90 $\pm$ 0,31             |

\* -  $p < 0,05$

In young people aged between 18 and 20 and reside in Gomel the alterations in ECG occurred in 48.7 % of cases when the average concentration of radioactive caesium was 24.5 %. At the same time arrhythmias and preferentially intracardiac conduction impairments predominated. The latter constituted 56.3% of all ECG alterations.

It is noteworthy that the impairments of the process of repolarization of different areas of left vehicle with the syndrome of early repolarization were manifested in 7 students (7.3 %).

This state could promote vehicle fibrillation with preceding trachearrhythmia and become the reason of sudden death. The concentration of thyroxin was increased in blood plasma –  $13.44 \pm 0.01$  mmol/l (in control –  $11.35 \pm 0.26$  mmol/l,  $p < 0.05$ ). In this connection we couldn't eliminate the involvement of the given hormone in disordering of cardiomyocytes function, due to the effect upon mitochondrial complex and energetic system, which provides ionic balance. The concentration of thyreotropic hormone, triiodine thyronin, thyroxin and cortisol in blood of individuals, having the signs of arrhythmia in ECG, were similar to those seen in control group.

The researches showed that in children reside on the polluted with radioactive caesium territory as well as in clear regions is

observed a high frequency of ECG alterations (more than 50 % of all being tested). The levels of incorporation of the given radioactive element in child's organism correlate with contamination with it the territory of residence. Nevertheless cases of its high concentration in child's organism are observed even in control regions (Grodno, Minsk). If take as a base the frequency of occurrence of ECG alterations limited by particular dose's intervals of  $^{137}\text{Cs}$  in the organism, than highly pronounced lineal dependence of the appearance of ECG alterations from the level of incorporation of given radioisotope is manifested. At the same time even little concentration of this radioisotope (more than 10 Bq/kg) is able to cause high frequency of above-mentioned impairments, while lack of it is almost eliminate their appearance.

Particular attention should be paid to the state of cardiac-vascular system in children with  $^{137}\text{Cs}$  incorporation more than 150 Bq/kg. Combination of the impairments of metabolic processes in myocardium of growing organism with disorder of electric impulse conduction is a result of a prolonged chronic affect of radioactive caesium. Because myocardium incorporates radioactive caesium intensively than other organs and systems [8] it is possible to imagine what is the concentration of given radioisotope in its tissue (in rats the concentration of the given radioisotope in heart ten times and more as large as in skeleton muscles). So it is not a surprise that after reaching complete (100 %) realization of pathologic sign in ECG on the particular level of  $^{137}\text{Cs}$  (100 Bq/kg and higher) concentration clinical heart pathology appears.

The researches showed the relation between the amount of radioactive caesium in children of different age and the frequency of ECG modifications. Taking into account lineal dependence between mentioned parameters, prolonged period of  $^{137}\text{Cs}$  half-life and, therefore, its existence as a chemical element, small, in terms of radiation effect, levels of its accumulation in the organism, one could assume not only its radiation but pretty much its toxic influence on cardiac muscle. Together the interrelated impairments of energetic, ionic and plastic metabolisms are taken place. They lead to the dystrophic and necrobyotic processes. The following hypothesis allows to envisage the problem of long-lived radioisotopes influence upon human organism from other positions. And this fact is very

important in terms of understanding of the mechanisms of their harmful influence on the vital organs and system and, in particular, on the cardiac-vascular system. Obtained results evidence that in conditions of prolonged chronic radioactive caesium intoxication cardiac-vascular system of growing organism is the most attackable. This fact of course should foredoom the elaboration of appropriate medical, prophylactic and rehabilitation measures.

## Chapter 2

### STRUCTURAL MODIFICATIONS OF MIOCARDIUM IN RESIDENTS OF GOMEL REGION ACCORDING TO THE AUTOPSIED DATA.

In order to prove harmful influence of radioactive caesium on heart we studied the building of myocardium of children and adults who lived in Gomel region, and died from various reasons (sum total 408 cases). We also considered the concentration of radioactive caesium in this organ. Microscopic testing showed availability of diffused disorder of myocardium cells in 99 % of cases of death. It manifested in the form of contractures or contraction of muscular fibers, primary lumpish destruction of myofibrils of different degree of demonstration, dystrophic processes and necrosis. Undoubtedly, that alterations in myocardium, appeared under the influence of incorporated radioactive caesium (concentration from 20 to 500 Bq/kg), became one of the main reason of death. Especially vividly it manifests in regard to the children organism. Here is an example:

Child, 7 months, lived in Kormyansk region, was taken into hospital with the signs of acute respiratory virus infection. Hereinafter, respiratory and cardiac-vascular insufficiency and also intoxication were accruing. On day 7 after admission the child died from septicaemia. In the internal organs, including heart, significant amounts of radioactive caesium were manifested (table 5).

Disturbance of cardiomyocytes manifested by alternative modifications in the form of hyaline drop and focal hydropic dystrophy. Muscular fibers were loosed, had weakly marked crosstrip striation, blind outline. Spot lysis of myofibrils with their fragmentation was observed. Nucleus of cardiomyocytes differed with polymorphism and hyperchromia, in separate areas karyopyknosis and karyolysis were evacuating. Myocardium vessels were sharply full-blooded. Plasmorrhagia and proliferation of endothelium of vessels was being observed.

Table 5

Amount of  $^{137}\text{Cs}$  in the internal organs of child L.

| Organs          | Amount of $^{137}\text{Cs}$ , Bq/kg |
|-----------------|-------------------------------------|
| Lungs           | 450                                 |
| Heart           | 2410                                |
| Stomach         | 250                                 |
| Small intestine | 1250                                |
| Large intestine | 1200                                |
| Kidneys         | 710                                 |
| Pancreas        | 240                                 |
| Thymus          | 80                                  |
| Thyroid gland   | 470                                 |
| Spleen          | 130                                 |
| Brain           | 650                                 |
| Liver           | 670                                 |
| Adrenals        | 2500                                |

Vascular cellular infiltration and intermuscular edema were observed in strome. The former was introduced with cells of lymphocytic and plasmatic range (fig. 4).

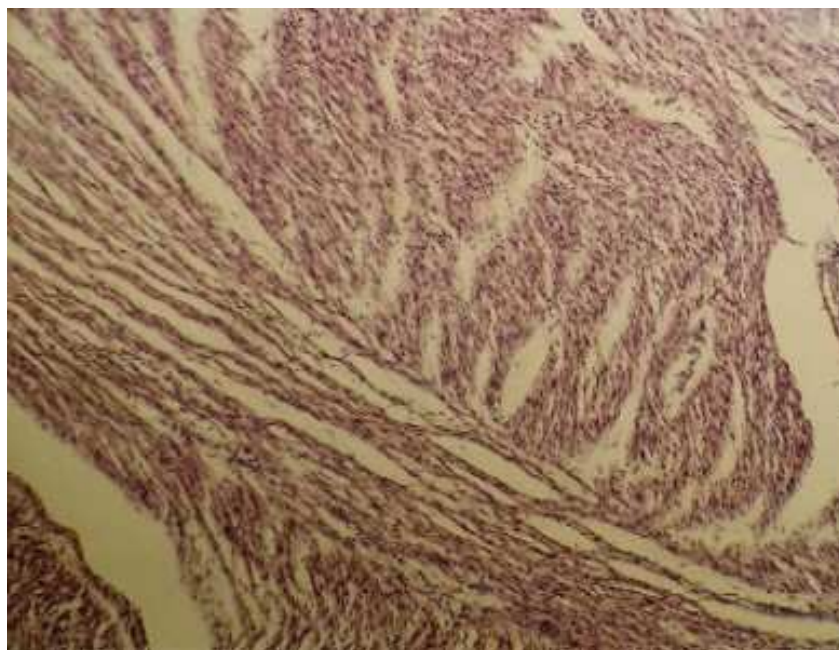
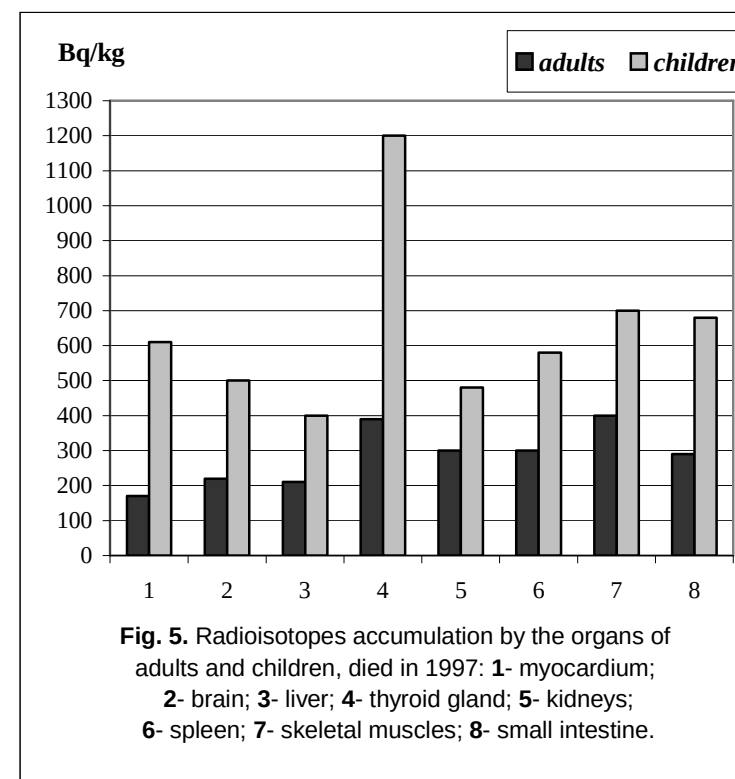


**Fig. 4.** Histological structure of myocardium of a child, 7 months. Concentration of radioactive caesium in cardiac is 2.410 Bq/kg. Marked intermuscular edema. Muscular fibers are loosed, their contours are blind and crosstrip striation is weakly marked. Focal lysis of myofibrils with their fragmentations. Polymorphism and hyperchomia of cardiomyocytes nucleus, in separate areas is karyopyknosis and karyolysis. Staining with hematoxylin and eosin. Magnification X250

It should be noted, that radioactive caesium is accumulated intensively in the internal organs of children than in adults' (fig.5). And this is the danger for their future formation and function on different phases of the development.



### Chapter 3

#### STRUCTURAL AND METABOLIC ALTERATIONS IN THE ORGANISM OF LABORATORY ANIMALS DURING INCORPORATION OF RADIOACTIVE CAESIUM

In experiment with laboratory animals (albino rats) the structural and metabolic alterations were being studied. They were appearing in heart, liver, kidneys and lungs during  $^{137}\text{Cs}$  incorporation. This radioisotope penetrated in the organism with enteric tract in the form of aqueous solution or together with oat's grain.

In this connection we used 121 males of underbred albino rats and rats of Vistar line. Their weight ranged from 180 to 200 grams. All the animals were keeping in vivarium. The first part of experiments included keeping the animals from test group on the ration (oat grains) with the level of radiation – 400 Bq/kg (daily dose of oat grains for each animal in both groups was 35 grams) during 45 days. Animals from control group during this term were getting together with oat grains radioactive caesium with concentration of 40 Bq/kg.

39 test animals and 29 controls were decapitated after inhalation ether anesthesia on the day 11 after beginning of the experiment, and 10 test animals and 10 controls on the day 45. Before being killed, in their organism the concentration of  $^{137}\text{Cs}$  was measured with the help of radioactive counter RYG – 2 (produced by Belorussian Institute of Radiation Safety).

The second part of the experiment included daily intragastric administrating of  $^{137}\text{Cs}$  in aqueous solution (5ml) to 19 males from experimental group in the amount of 45 Bq. This process had been lasted for 6 days. 20 animals from control group at the same terms were receiving daily intragastrically 5 ml of physiologic solution of sodium chloride. During the whole experiment the regular registration of radioactive caesium accumulation in the organism of animals was carried out using RYG – 2.

On the days 4, 6 and 8 after beginning of the experiment part of the animals from experimental and control groups were killed using the method of decapitation after previous etherizing.

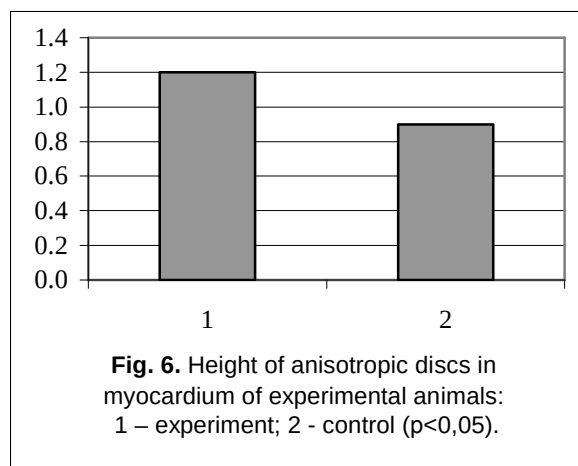
The third part of the experiments included daily intragastric administrating of  $^{137}\text{Cs}$  in aqueous solution (5ml) to 12 males from experimental group in the amount of 180 Bq. It had been lasted for 6 days. 12 controls animals at the same terms were receiving daily intragastrically 5 ml of physiologic solution of sodium chloride. During the whole experiment the regular registration of radioactive caesium accumulation in the organism of animals was carried out using RYG – 2. On the day 8 after beginning of the experiment animals from experimental and control groups were being killed using the method of decapitation after previous etherizing.

After decapitation of the animals from all experimental and control groups we carried out macroscopic investigation of the internal organs. We were fixing parts of liver, kidneys, myocardium and lungs a 0.5 – 1.0 cm thick in 10 % formalin solution, then were whelming in paraffin and microtoming of 5 – 8 mkm thick with staining with hematoxylin and eosin. Histological preparations were being investigated in binocular microscope. On the day 11 of the experiment we used method of polarized microscopy with defining of A-discs with the help of morphologic and optic system Vidas-Video by the firm Opton (Germany). It was made in order to determine the alterations of contraction apparatus of cardiac muscle in animals of first part. In 8 animals we cut off cardiac muscle tissue with preparing of homogenate and manifesting their alkaline phosphatase activity, acid phosphatase, lactat dehydrogenase, creatin phosphokinase, alanin amino transferase, asparate aminotransferase, gamma-glutamyl transferase.

The blood was taking from all the animals of all parts of the experiments. There was evacuated blood serum where concentration of total protein, albumin, urea, creatin, activity of asparate aminotransferase and alanin amino transferase were being determined.

Determination of ferments' activity and concentration of biologically active substances were performed using automatic tester "Synchron" by firm Beckman. Results of investigations were statistically processed with the help of methods of variation statistic.

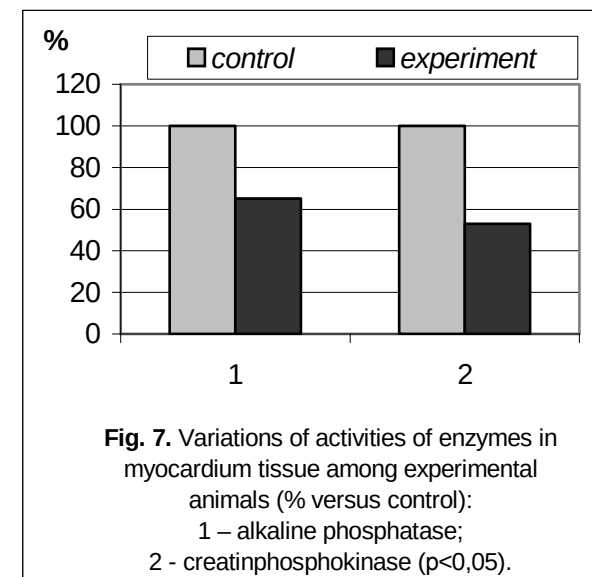
Researches showed that daily penetration in the organism of albino rats of radioactive caesium with food causes its progressive accumulation. In particular, concentration of this radioisotope in experimental group on the day 11 of the experiment constituted  $63.35 \pm 3.58$  Bq/kg, in control group –  $5.43 \pm 0.87$  Bq/kg ( $p < 0.001$ ). Microscopic investigation of tissues of the internal organs of animals from experimental group on the day 11 of the experiment didn't evacuate any rough modifications, but registered modification of polarizing features of cardiomyocytes in the form of increasing of A-discs compare to control group (fig. 6). In myocardium cells we revealed the reduction of the activity of alkaline phosphatase and creatin phosphokinase (fig. 7). In blood serum of these animals was being observed magnification of the activity of asparate aminotransferase and creatin amount (fig. 8). We also manifested the signs of proteinosis and circulatory disturbance in liver tissue.



In kidneys tissue against the background of infiltration of the loop of glomerules with lymphohistiocytary cells in number of cases the fragmentation and distruction of glomerules was manifested.

Radioactive caesium accumulation in the amount of  $101.05 \pm 1.69$  Bq/kg caused in the organism of albino rats significant

alterations. Pathologic modifications in kidneys should be noted. They manifested in the way of proliferation of mesangic cells, infiltration of the loop of glomerules, lymphohistiocytary cells, fragmentation and death of glomerules. Granular and hyaline drop dystrophy of the epithelium of direct and meandering tubules were being determined.



During microscopic investigation of liver tissue, were manifested the granular and vacuum dictrophy of hepatocytes, dilatation of Disse's spaces. Also moderately marked impairments of blood circulation in the form of plethora of central intralobular veins were noted. Diffused myocytolysis, focal lymphohistiocytary infiltrates and vessels plethora were being registered in myocardium tissue. In blood serum of mentioned animals we noticed veracious, compared to control, increasing of creatin concentration –  $41.20 \pm 1.60$  Nmol/l (in control –  $33.11 \pm 2.45$  Nmol/l,  $p < 0.001$ ).

Administration of  $^{137}\text{Cs}$  intragastrically in the amount of 45 Bq daily led to the fact that on the day 4 of the experiment its concentration in rat's organism was  $40.91 \pm 10.62$  Bq/kg, in control –

2.67±1.05 Bq/kg ( $p<0.005$ ), on the day six – 104.55±24.73 Bq/kg, in control – 12.13±4.75 ( $p<0.001$ ), on the day eight – 150.58±52.06 Bq/kg, in control – 10.66±4.82 ( $p<0.001$ ). During microscopic investigation dystrophic and necrobolytic alterations in myocardium, liver and kidneys were evacuated. They conformed to the alterations manifested during radioactive caesium effect, which was penetrating in the organism of animals together with oat grains. In blood of these animals was manifested a progressive, as incorporated in the organism radioactive caesium increases, reduction of concentration of total protein and also raising of creatinin. Total protein decreased mainly due to the degression of  $\alpha$ -1 and  $\alpha$ -2 globuline fractions (table 6).

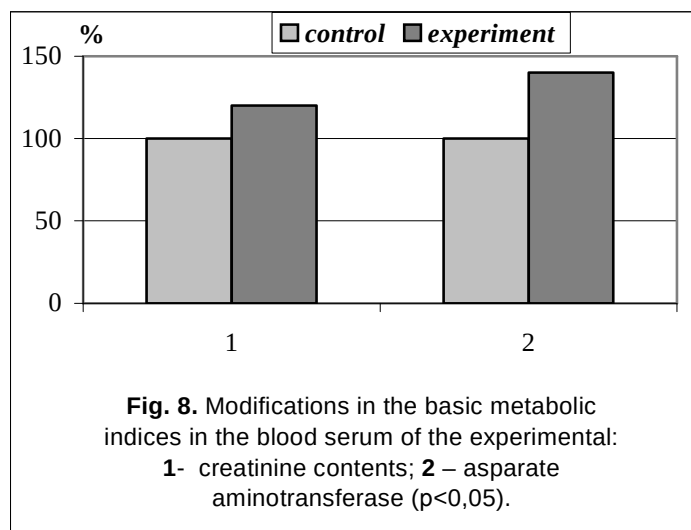


Table 6

Concentration of protein fractions in laboratory animals (albino rats) with different  $^{137}\text{Cs}$  concentration.

| The indices                         | Radioactive Caesium concentration, Bq/kg |                                       |                                       |
|-------------------------------------|------------------------------------------|---------------------------------------|---------------------------------------|
|                                     | group №1<br>40, 91±10,62                 | group №2<br>104,55±24,73 <sup>+</sup> | group №3<br>150,58±52,06 <sup>+</sup> |
| Total protein g/l                   | 65,56±3,74                               | 62,98±3,26                            | 49,08±2,01 <sup>+</sup>               |
| Albumines (%)                       | 36,32±1,70                               | 39,95±2,26                            | 41,68±0,97 <sup>+</sup>               |
| $\alpha_1$ -globulines (%)          | 13,84±1,01                               | 12,93±1,93                            | 10,16±0,54 <sup>+</sup>               |
| $\alpha_2$ - globulines (%)         | 15,63±0,91                               | 11,65±1,23                            | 12,12±0,45 <sup>+</sup>               |
| $\beta$ - globulines (%)            | 14,52±0,88                               | 13,78±2,18                            | 14,76±0,76                            |
| $\gamma$ - globulines (%)           | 19,69±1,41                               | 21,70±1,40                            | 21,28±1,24                            |
| Albumines to globulines ratio (A/g) | 0,58±0,04                                | 0,67±0,06                             | 0,72±0,03 <sup>+</sup>                |

<sup>+</sup> -  $p<0,05$  as compared to group №1

Administration of  $^{137}\text{Cs}$  intragastrically in the amount of 180 Bq during 6 days led to the fact that on the day 8 of the experiment the average concentration of given radioisotope in living organism was 991.00±76.00 Bq/kg (in control – 6.70±2.36 Bq/kg,  $p<0.01$ ). It should be noted that in experimental group on the days 5 and 6 of the experiment died 5 animals (41.7 %). Radioactive caesium accumulation in their organism at this time was more than 1000 Bq/kg. During microscopic investigation were evacuated marked hemorrhages into internal organs. During microscopic investigation in kidney's tissue impairments of structural elements of glomerules were being registered. Their extreme was necrosis of epithelium and vessels net with their complete disappearing and in the result cavity

formation. In tubules vacuum and grain dystrophy and also necrosis of epithelium cells were manifested, in liver – venous congestion, mainly marked in central comparements of lobes, proteinosis and adipose dystrophy and hepatocytes necrosis, in lungs – pronounced vessels plethora, availability of erythrocytes in lumens of alveolus, inflammatory modifications of the pleura. In myocardium – marked manifesting of interfibers intracellular edema, majority of myocytes in the state of cytolysis with nucleus destruction. In number of cases inflammatory infiltrates were evacuated in the area of myocardium and pericardium.

Thus, penetration of  $^{137}\text{Cs}$  in the organism of albino rats through gastro-intestinal tract, both in clear form and together with oat grains, caused structural and metabolic alterations in vital organs. Degree of expression of these modifications is determined by the quantity of incorporated radioisotope, from manifesting of proteinosis to the hard necrobolytic and alternative modifications. These evidences about toxic effect of radioactive caesium upon vital organs like heart, liver and kidneys.

It is noteworthy that toxic effect of mentioned long-lived radioisotope concerns first of all highly specialized cells, which don't possess any proliferative capacity, or possessing it in a less degree. Also there are significant alterations in myocardium, which concern mitochondrion's building [9], reducing of the activity of creatin phosphokinase – a key ferment of energetic metabolism - promoting interrelations of macroergic phosphate and creatin. Impairments of the energetic processes in cardiac and development of intracellular hypoxia lead to the alteration of its retractor apparatus, in particular, to the myofibrils modifications in the form of various degree of expression of contractures or their desaggregation and lysis [30]. Alteration of the state of ultrastructures of retractor apparatus manifests as a modification of polarizing features of muscle fibers. Increasing of concentration of radioactive caesium in the organism lead to the death of cardiomyocytes. It should be noted that at the accumulation within 100-150 Bq/kg it is possible to manifest reaction of immune system upon myocardium disorder in the form of lymphohistiocytary infiltrates. But ten times larger accumulation causes total dystrophy and death of significant number of cardiomyocytes. And that is inconsistent with life.

Besides myocardium there were impairments of cellular structures under the influence of radioactive caesium in liver and kidneys. Alternative processes in kidneys, in particular, in glomerular apparatus are worth to be paid attention to. The death of cell elements of single glomerules with the formation of characteristic cavities has already been registered at relatively slight incorporation of radioactive caesium. It is possible that impairment of vessels link on the level of arterials and capillaries became the leading in that process. Disorder of epithelium of the tubules are manifesting with different forms of proteinosis and cells necrosis. Taking into account that kidneys are the main organ of exertion of radioactive caesium out of the organism it is possible to confirm that disturbance of their excretory function leads to the accumulation of metabolic products and radioactive caesium in the organism. Such products have a toxic influence upon vital organs and, in particular, on myocardium. Disturbance of process of exertion from the organism, increasing of concentration in blood, drives radioactive caesium in cells (for example cardiomyocytes) with the highest metabolic activity, structural and functional specialization. At once there is the impairment of permeability of cytoplasmatic membrane and as a result – penetration of ions of  $\text{Na}^+$  and water, development of intracellular edema and then cytolysis. The consequence of the given process is disorder of cardiac activity, leading to the death of the organism.

Thus, impairment of excretion of radioactive caesium as a result of death of the nephron leads to the development of toxic myocardioapathy – the main reason of death. Morphologic manifesting of that pathologic process is also observed in the following picture: inflammation of pericardium and pleura, which is specific for renal insufficiency. Radioactive has toxic influence on liver tissue. That influence is reflected on the state of metabolism. Obtained results allow to guess that caesium during incorporation by the organism of laboratory animals, even in small concentration, toxic influence upon cells of myocardium, liver and kidneys, which could become the main reason of death.

## Chapter 4

### PATOPHYSIOLOGIC CHARACTERISTIC OF THE DISTURBANCE OF CARDIAC WITH RADIOACTIVE CAESIUM.

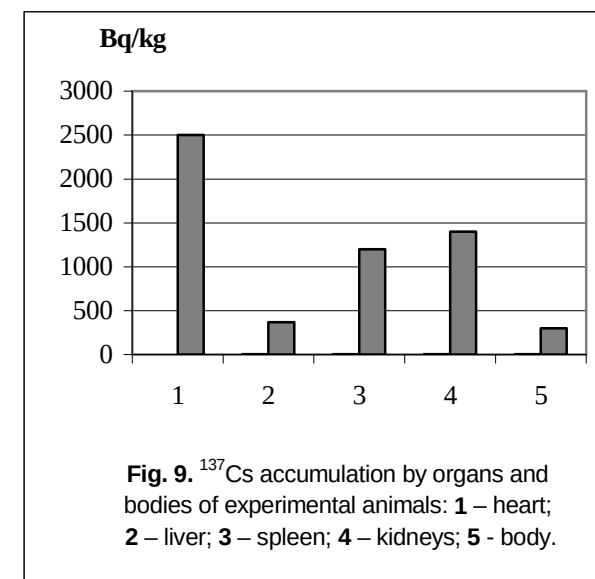
So, after analysis of the results of ECG examination of the children of different age with various level of incorporated radioactive caesium in the organism, after microscopic investigation of the organs of individuals, lived on the territories suffered from Chernobyl disaster and at least after experiments with laboratory animals, it is possible to make a conclusion about harmful influence of the given radioisotope on the state of cardiac-vascular system. That effect is actualized due to its direct influence on the cellular structures as well as due to its mediate effect through the number of systems and in particular through nervous and endocrine systems.

Direct influence of radioactive caesium on heart is bound up with its selective accumulation by the myocardium cells as compared with other organs and tissues (fig. 9, 10). Perhaps it is ridden by intensive functioning of  $\text{Na}^+ - \text{K}^+$  pump. At once  $^{137}\text{Cs}$  as an affined to potassium element, penetrates in cardiomyocyte easily. In this process membrane structures take participation and radioisotope actively interrelates with them [15]. During the process there is a suppression of a very essential ferment like creatinin phosphokinase, participating in energetic cellular metabolism: accumulation, transportation and utilization of highly energetic phosphate. Creatinin phosphokinase catalyzes convertible reaction of phospholation – transfer of phosphorus remnant from ATP to creatinin and from creatinin to ADP [1].

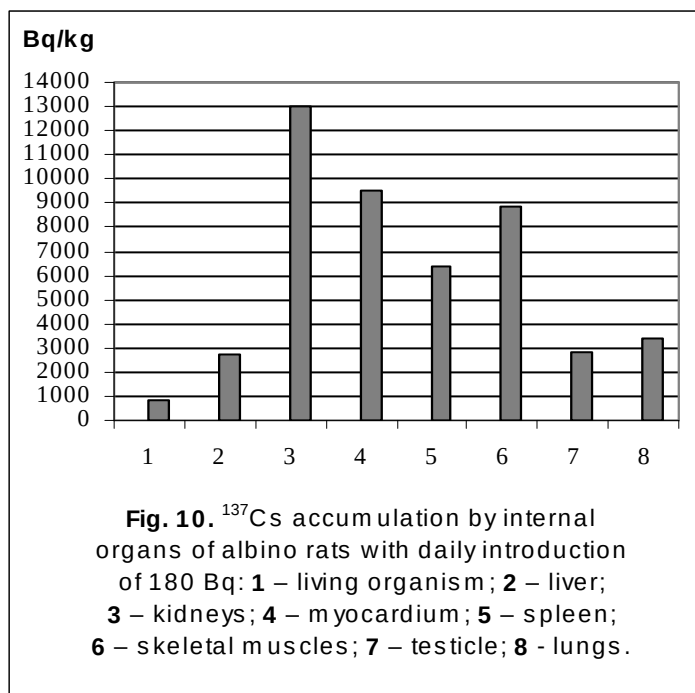
Creatinin pphosphokinase is localized in different subcellular structures such as cytoplasm, mytochondrions, microsomes, nucleus, sarcomplasmic reticulum and myofibrils. According to the existing concept mitochondrional's creatinkinase catalyzes formation of creatinin phosphate from ATP. The latter is produced inside of mitochondrional's matrix as a result of oxidative phospholation. Formed creatinphosphate moves into the cytoplasm according to the

gradient of concentration or with the way of hasten diffuse to the defined isoferments of creatinkinase and in particular to the:

- Connected with the structures that are responsible for the muscle contraction – M-line myofibrils;
- Connected with sarcoplasmic reticulum and  $\text{Ca}^{2+}$  adenosintriphosphatase;
- Connected with sarcoplasm and  $\text{Na}^+ - \text{K}^+$  adenosintriphosphatase;
- Connected with postsynaptic membrane, abundant with acetylcholine receptors and ATP-ases.



Mitochondrional creatinin phosphokinase holds together external and internal surfaces of mitochondrions' membrane, performing structural function [1].



Localization of creatinase in the area of M-line creates conditions for constant renovation of ATP and also conditions that guarantee the availability of contraction function of myofibrils (fig.11). Formed creatinin turns back in mitochondrions in order again to become a substratum for phosphorylation.

Thus, reducing of the activity of the given ferment signal about serious structural and metabolic impairments in energetic complex of cardiomyocyte. This is proved by the modification of the mitochondrial system in the form of increasing of the amount and size of mitochondrions and exceeding of the quantity of laminated crystals with their following destruction. It is also proved by the aggregations of mitochondrions and modifications of the number of intermitochondrionals contracts (fig. 12).

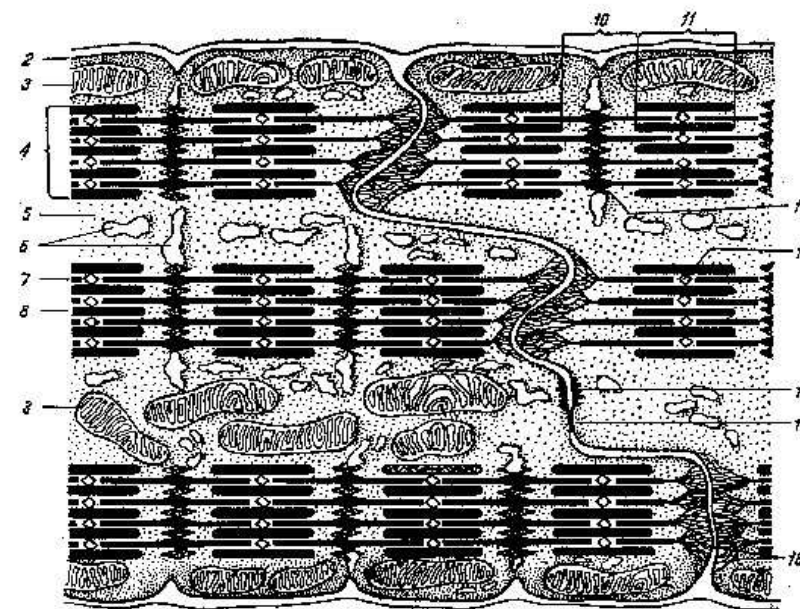


**Fig.11.** Intercalated disks of cardiac muscles (scheme)

1 – basal membrane of myocyte; 2 – plasmalemma of myocytes; 3 – mithohondrions; 4 – muscular fibris; 5 – sarcoplasma; 6 – cytoplasmatic net; 7 – small protofibrill; 8 – large protofibrila; 9 – insertable disc; 10 – light disc; 11 -dark disc; 12 – fragma of body; 13 –M disk (mesofragma); 14 – dismosome; 15 - solid suturing (nexus); 16 - fascia adcherens (according the Bargman, Schulce; changed).

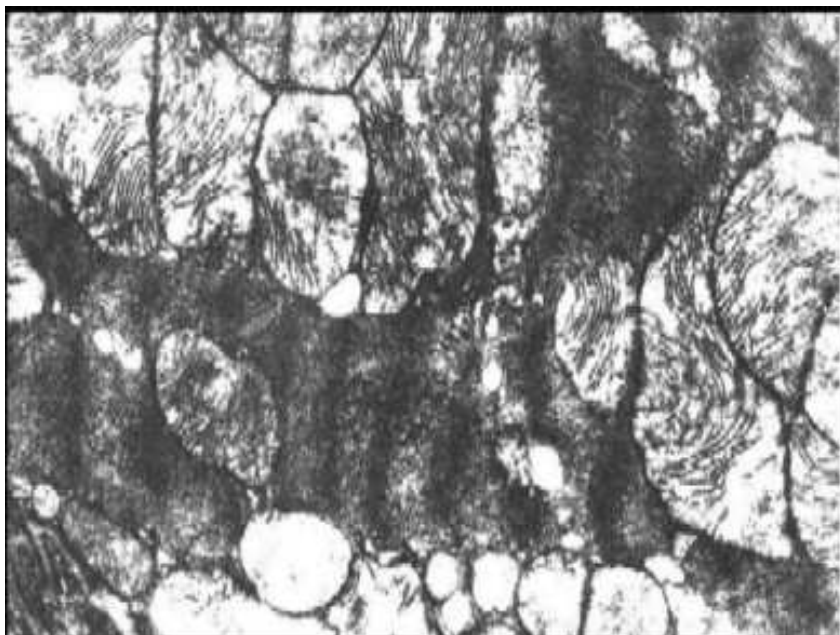
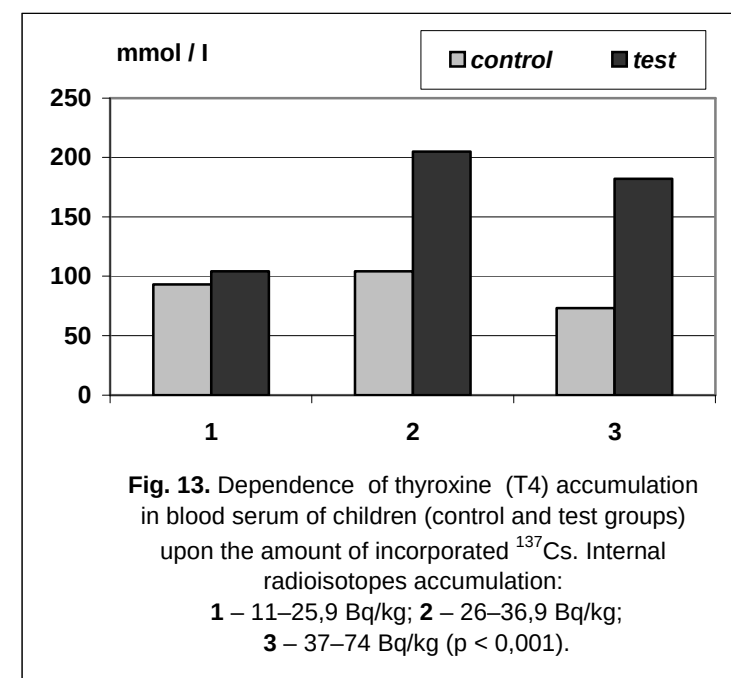


**Fig 12.** Agregation, increasing of the amount and size of motochondrions of cardiomyocytes of rat during radioactive caesium incorporation by the organism – 45 Bq/kg. Magnification x 30000.

Oppression of energetic complex could be connected both with direct effect of radioactive caesium on the membrane structures and with the influence of the number of metabolites and in particular hormones of thyroid gland, taking into account that these hormones have toxic influence on the mitochondrional system [13]. In this connection during Basedow's disease of experimental hyperthyroidism there is an oppression of the creatinkinase activity [1]. Perhaps during the influence of radioactive caesium increased

amount of free thyroxin causes impairments of myocardium cells through the influence upon mentioned ferment. This point of view is proved by the parallel increasing of the frequency of ECG alterations and the level of the given hormone in blood of children with radioactive caesium incorporation higher than 37 Bq/kg (fig.13). So it is possible to guess the defined role of thyroxin in the appearance of arrhythmias.



In men the activity of creatinkinase is higher than in women [1]. It couldn't be eliminated that vulnerability of the given ferment in myocardium cells under the influence of radioactive caesium is the main reason of sudden death of men.

One should pay attention on the reducing of the activity of alkaline phosphatase in the myocardium structures, proclaiming the development of degenerative processes and peculiar to the influence of ionizing radiation [36].

The character of structural modifications in myocardium cells of laboratory animals and individuals, lived on the contaminated with radioactive caesium territory, denotes the impairment of permeability of membrane of sarcoplasmic reticulum for the ions of  $\text{Ca}^{2+}$ . It could be connected with direct influence of the given radioisotope on the cellular membrane as well as with radiation appearing during its destruction [8,29,41]. Peroxidal groupings, which are formed in adipoid acid chains of phospholipides, lead to the modification of their structure and permeability for various ions, including ion of  $\text{Ca}^{2+}$ . Besides the activity of ferments, coupled with membranes, is naturally changing. Hyperproduction of free hydroxical radicals and amplification of the processes of peroxidal oxidizing of lipids promote the destruction of cellular membrane.

$\text{Ca}^{2+}$  transport system of sarcoplasmic reticulum of myocardium take an active participation in the process of contraction – relaxation of myofibrils in the way of outbreak and accumulation of  $\text{Ca}^{2+}$ . In case of injure of the system by different agents, including radioactive caesium, the level of not coupled  $\text{Ca}^{2+}$  in cardiomyocytes increasing and the process of myofibrils' relaxation disturbing.

Alterations in contraction apparatus are reflected in modification of doublerayrefraction of myofibrils, in appearance of contractures of segmental and subsegmental types of intracellular myocytolysis, primary lumpish disturbance of myofibrils, cytolysis, and at least in coagulative or colliquative necrosis [32].

Contractive alterations of segmental and subsegmental types are defined in polarized light by increasing of anisotropy of A-discs of myofibrils. They look like a radiant cross strip and between them there are crossly striated areas of myofibrils. During examination under light microscope they were seen because of large density and eosinophilia. Ten day's incorporation of radioactive caesium by the organism of rats of Vistar line (caesium concentration was 60 –100 Bq/kg) also led to the above mentioned alterations (fig. 14).

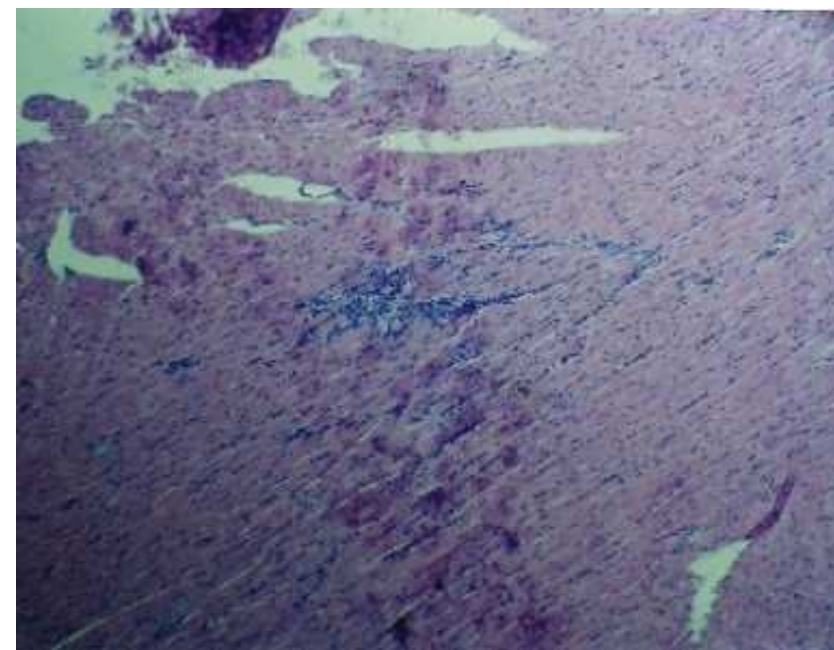


**Fig.14.** Histological structure of animal myocardium after incorporation of radiocaesium with food (concentration in the organism 100 Bq/kg). Diffused contractures modifications of myofibrils of cardiomyocytes. Diffused myocytolysis. Focal infiltration of lymphohistiocytary elements. Straining with hematoxylin and eosin. Magnification x 125.

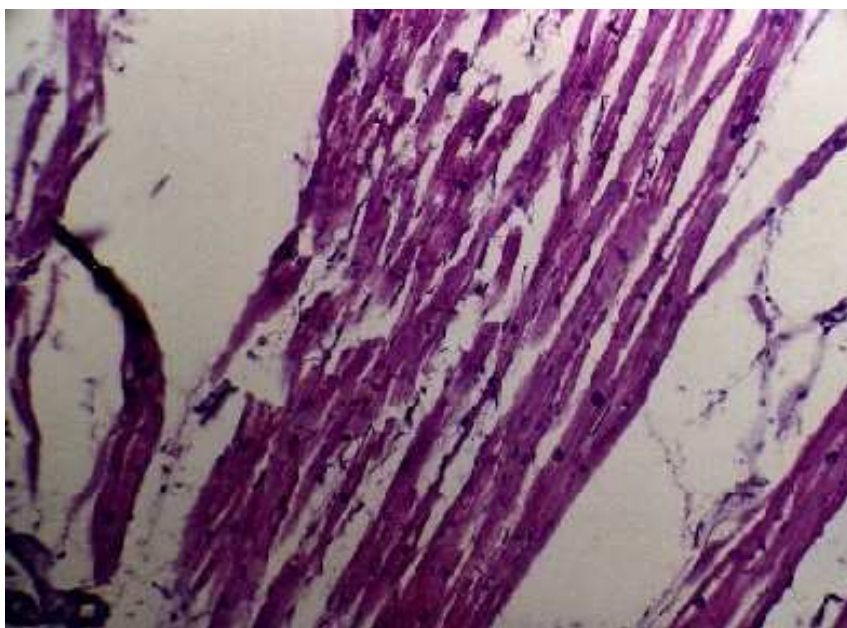


**Fig. 15.** Histological building of the myocardium of a woman, died during labor. Radioactive caesium concentration in heart – 105 Bq/kg. Primary lumpish destruction of myofibrils. Loosing of muscular fibers, intermuscular edema. Staining with hematoxylin and eosin. Magnification x 250

At primary lumpish disturbance of myofibrils the isotropic spaces are manifested between anisotropic lumps (fig.15). That is, unlike contractures, hard and unconvertible damage of cardiomyocytes, proclaiming their death. It should be noted that primary lumpish disturbance is very often manifested at acute cardiac insufficiency [30, 31].

Cytolysis or autolysis *inter vivos* of muscle cardiac cells are also unconvertible states. During radioactive caesium influence it has diffused character (fig. 16, 17).

Alterations described above are observed not only during radioactive caesium effect but also when there are metabolic injuries, appearing as a result of intoxication, hypoxia or functional overfreights [14, 24, 40] and during the effect of extreme ecological factors, causing development of stress – reactions [27, 28, 31]. It was proved that mentioned reactions the exceeding of  $\text{Ca}^{2+}$  in cardiomyocytes takes place.

In the capacity of a damaging mechanism a leading role is performed by the effect of catecholaminase (noradrenaline, adrenaline) on the beta-adrenoreceptors of myocardium against the background of coronary blood flow. Beside there is no connection with ischemic heart impairments [28].

The total scheme of the influence upon the given organ is proposed for a great variety of factors through stress-reaction. Large concentrations of catecholamines increase the number and time of potential- and receptorally dependent calcium canals and as a result that causes accumulation of  $\text{Ca}^{2+}$  in cardiomyocytes. Beside, cells of conducting system are damaged earlier and in greater degree, because they possess low potential of rest, and input ionic current, responsible for the potential of action, is mainly calciumic [10]. Besides that system is the richest with adrenoceptive innervation [28].

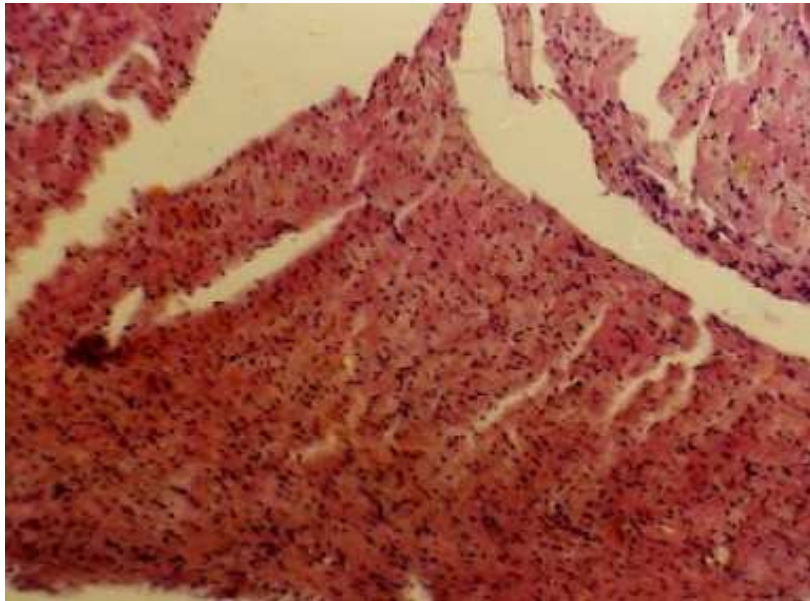


**Fig.16.** Histological structure of animal myocardium after incorporation of radiocesium (concentration in the organism 900 Bq/kg). Diffused myocytolysis. Pronounced intertissue edema. Straining with hematoxylin and eosin. Magnification x 125.

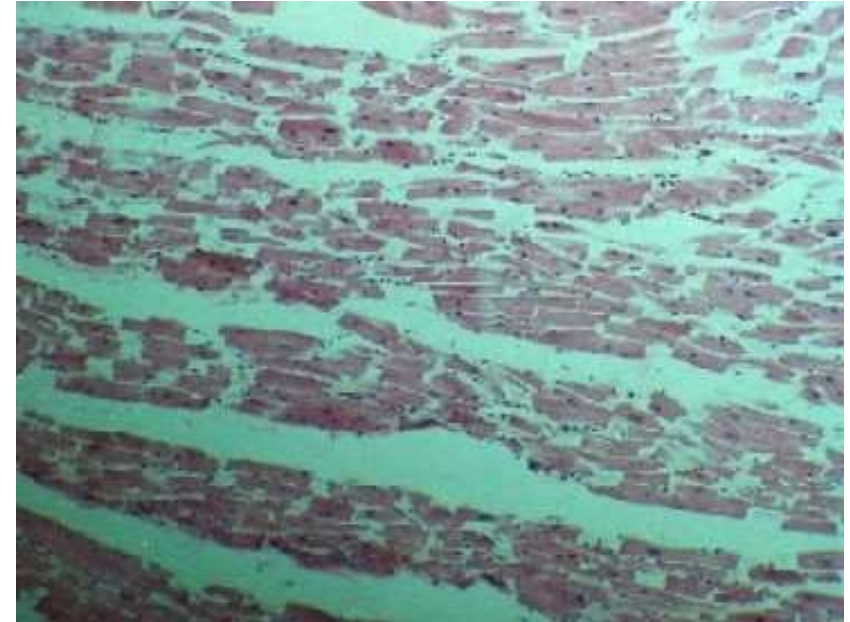


**Fig.17.** Histological structure of myocardium of suddenly died resident of Dobrush of 43 years of old. Radiocesium concentration in heart – 45 Bq/kg. Diffused myocytolysis. Intertissue edema. Fragmentation of muscle fibres. Straining with hematoxylin and eosin. Magnification x 125.

As a result of the process, high concentration of  $\text{Ca}^{2+}$  is formed in cell. In case of its wrong exertion from the cell appear the impairments of rhythm or arrhythmias. We underline that it is directly connected with the work of cationic pumps. In their energetic security an essential role is plaid by creatininkinasic and glycolytic systems [28]. In order to cause relaxation of myocardium and to burst bridges between small actinic and large myosin myofibrils it is necessary to coordinate the work of both of the systems, including sarcoplasmic ATP-ase, which transport  $\text{Ca}^{2+}$  back into the cistern of sarcoplasmic reticulum. It should be noted that this is an energetically dependable process, when expended nearly 15 % of all energetic costs of cardiac muscle [25].

Considering the duration of the influence of radioactive caesium on the organism of people, reside on the contaminated territories, and also suppression of noradrenaline's production in cells of cerebral hemispheres [23] it is hard to imagine the leading role of cathecholamines in the appearance of contractures of muscle fibers. It could happen just in case of strong stress reactions. In real conditions accumulation of  $\text{Ca}^{2+}$  in cells during the influence of radioactive caesium can appear due to the energetic deficit ridden by disturbance of membrane energy providing systems, including mitochondrions and structures of sarcoplasmic reticulum. That is why cell can't evacuate  $\text{Ca}^{2+}$  in time. And it penetrates in cell very intensively due to the destruction of membrane's phospholipids by free radical hidroxical groupings. In such situation one needn't strong efforts to cause significant impairments of myocardium. Death of cardiomyocytes can befall because of a long period of energetic deficit, ridden by physical loads, acute infectious process and alcohol intoxication.

Cardiac activity could be stopped by increasing of concentration of radioactive caesium by the organism. In particular, rapid administrating of large amounts of the given radioisotope (achievement of 1000 Bq/kg concentration within 5 days) causes cardiac arrest in rats. In this case the radiation agent itself becomes the direct reason of death. In less degree the source of reconstructions of cardiomyocytes' myofibrils at radioactive caesium accumulation could be emotional stress, leading to the output of cathecholamines. The reason is that in conditions of long caesium

intoxication the progressive suppression of the function of sympathoadrenal system and reducing of adaptable reserves of the organism take place [17]. At the same time it is impossible completely except the role of cathecholamines in cardiac disturbance at the given effect.

It is proved by the results of clinical and laboratory testing of children with chronicle pathology of gastro-intestinal tract. Directly proportional dependence between frequency of hypersympathycotonic variant of vegetative reactivity and the quantity of radioactive caesium in the organism was registered. Using above mentioned data it is necessary to make a conclusion that energetic deficit in calcium – transport system, appearing during radioactive caesium incorporation, leads to the impairment of rhythm of cardiac activity, disorder of contraction apparatus of cardiomyocytes and at least to the cardiac arrest.

Injure of cardiac-vascular system couldn't be examined separately from other organs and systems and, in particular, from kidneys. Being the main organ of radioactive caesium exertion from the organism [16], kidneys face significant effect even when its concentration is small. At once suffers also cardio-vascular system, beginning from glomerular apparatus [6,7]. In muscle fibers bringing by arterioles befall the same changes as we observed in myocardium. Contractures of myofibrils lead to the prolonged arterioles' spasm and therefore to the stopping of blood circulation in the structures of nephron. Then appears the death of cellular elements with formation of specific structural modifications in glomerules in the form of phenomenon of melting ice-floe. Gradually, appear dystrophic and necrobiotic alterations, accompanied by wrinkling and glomerules fragmentation (fig. 18, 19). Cavity formation without any marked cellular reaction is a typical for the influence of radioactive caesium on kidneys' tissue. Possessing the capacity to cause hypercontractions of muscle fibers in arterioles, this radioisotope disorder the processes of blood microcirculation in the given organ. The absence of necessary inflammatory reaction of the organism in response to the impairment of kidneys and other organs should be noted. To our opinion it is connected with suppression of synthesis of biologically active substances – inflammation mediators in specialized cells.

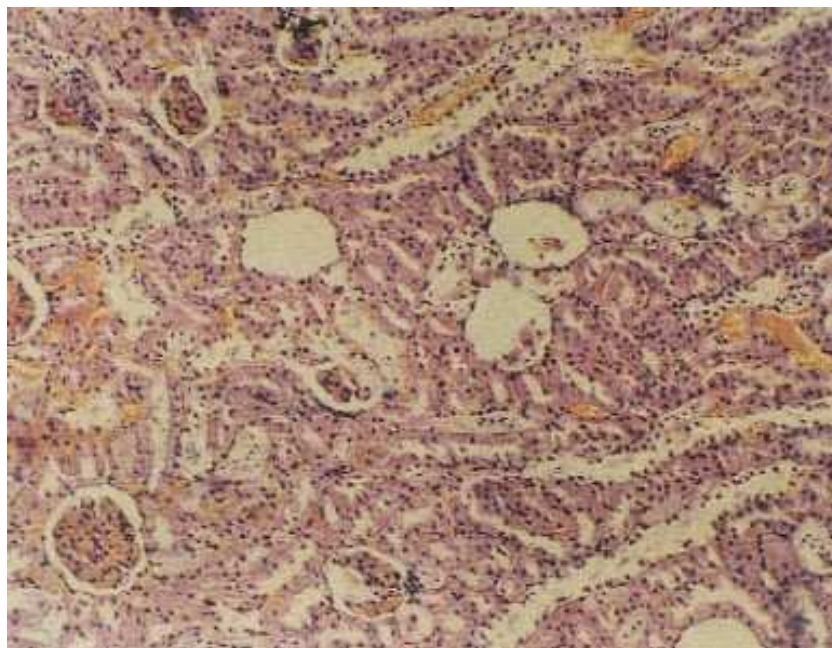


**Fig.18.** Histological structure of albino rat kidney with radiocesium concentration in the organism – 900 Bq/kg. Necrosis and fragmentation of glomerules with cavity formation. Necrosis and hyaline drop dystrophy of epithelium of tubules. Straining with hematoxylin and eosin. Magnification x 125.

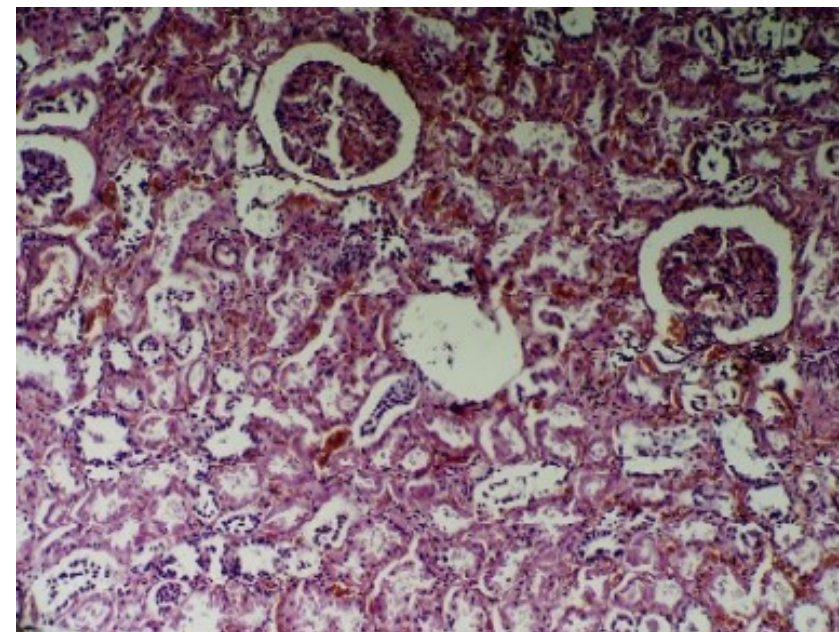


**Fig. 19.** Histological structure of kidney of sick woman A., 71, lived in Gomel. Commissural disease of abdominal cavity and sharp right-sided upperlobar, fusion, fibrinous purulent, lobular pneumonia, complicated by double lungs edema, became the reason of death. Radiocesium concentration in kidneys - 300 Bq/kg. Fluid accumulation in glomerular cavities. Cavities formation. Hyaline drop and hydropic dystrophy of epithelium of tubules. Edema of interstitial tissue. Straining with hematoxylin and eosin. Magnification x 125.

Damaged glomerules stop functioning. Gystologic picture of organ at radioactive caesium influence remain one at thrombotic microangiopathy [2]. And it is not accidental. In both cases the system of microcirculatory channel of nephron is blocked on the level of arterioles. This blocking leads to the necrobiotic processes.

Developing renal insufficiency is the reason of accumulation in the organism of metabolic stuffs and scum. They have toxic influence as well as radioactive caesium on the vital organs and systems. Beside inflammatory processes of serous membranes and, in particular, of pericardium (fig. 20) and pleura (fig. 21) are characteristic.

Injure of vessel system of kidneys could become one of the main reason of increasing of arterial pressure in children and first of all of diastolic pressure. But considering the hidden, latent character of passing of the given pathologic process it could be manifested late, when banal medical measurements almost inefficient. That is why the assessment of kidneys' function in children, living on the contaminated with radioactive caesium territories, as well as cardiac function, must be carried out constantly, using modern laboratory and instrumental diagnostic methods.

Liver also suffers during radioactive caesium effect. In liver of individuals, lived in Gomel region, were fixed significant levels of concentration of the radioisotope [6]. And in most cases during gystologic investigation there were observed dystrophic and necrobiotic alterations from the side of cardiomyocytes (fig.22).

The same alterations were manifested in experimental animals during radioactive caesium influence. At once there is disorder of hepatocyte functions, in particular, of synthetic and detoxicative.

Impairment of synthetic function of hepatocytes is manifested by the progressive reducing of synthesis of  $L_1$  and  $L_2$  – globulines as concentration of radioactive caesium in the organism increases. That is undoubtedly reflected on the state of metabolism and other organs, including heart.

In liver takes place oxidizing of steroid hormones, in particular, hormone of adrenal cortex and also destruction of cathecholamines, which are hormones of adrenal medulla of noradrenals or adrenaline with the help of methylizing reaction. The great role of given organ is

in detoxication of ammonia, due to its including in urea synthesis. Inefficiency of both synthetic and detoxicative liver function leads to the appearance of metabolic discomfort, which is badly reflected on the state of myocardium.

Thus, metabolic disfunction, appearing in the organism during radioactive caesium incorporation could promote the appearance of the impairments in building and function of cardiomyocytes.

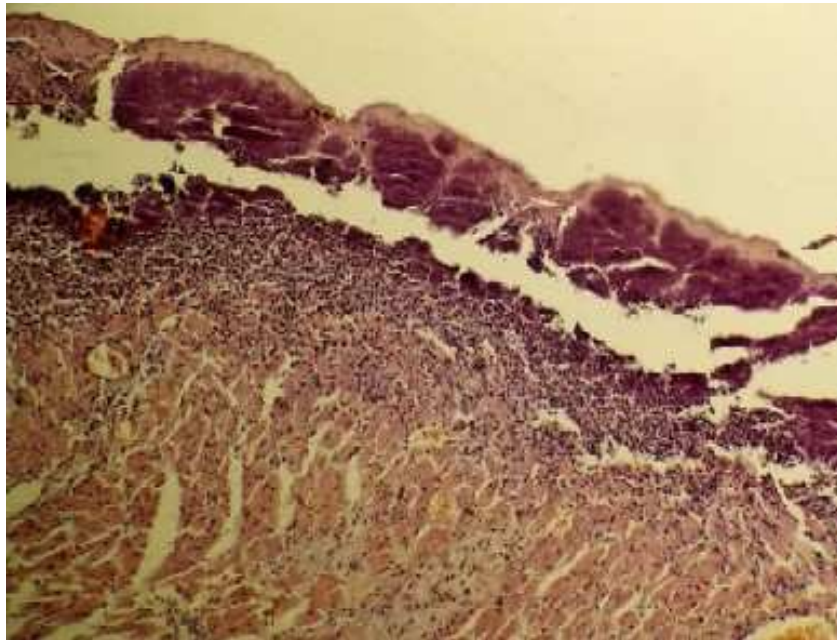


**Fig. 20.** Histological structure of animal myocardium after incorporation of  $^{137}\text{Cs}$  (concentration in the organism – 900 Bq/kg). Infiltration of neutrophil leukocytes, lymphocytes into epicardium and pericardium. pronounced myocytolysis. Staining with hematoxylin and eosin. Magnification x 125.

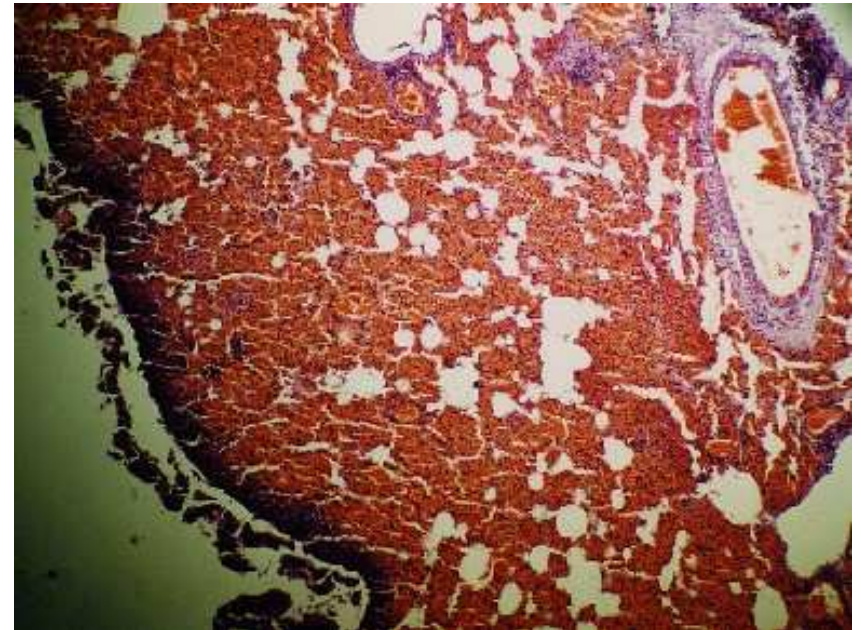


**Fig. 21.** Histologic structure of lung of animal, getting  $^{137}\text{Cs}$  (concentration in organism 900 Bq/kg). Plethora of vessels, blood rupture in the lumen of alveolus. Infiltration of visceral pleura with neutrophilic leukocytes, lymphocytes and cystocytes. Staining with hematoxylin and eosin. Magnification x 125.

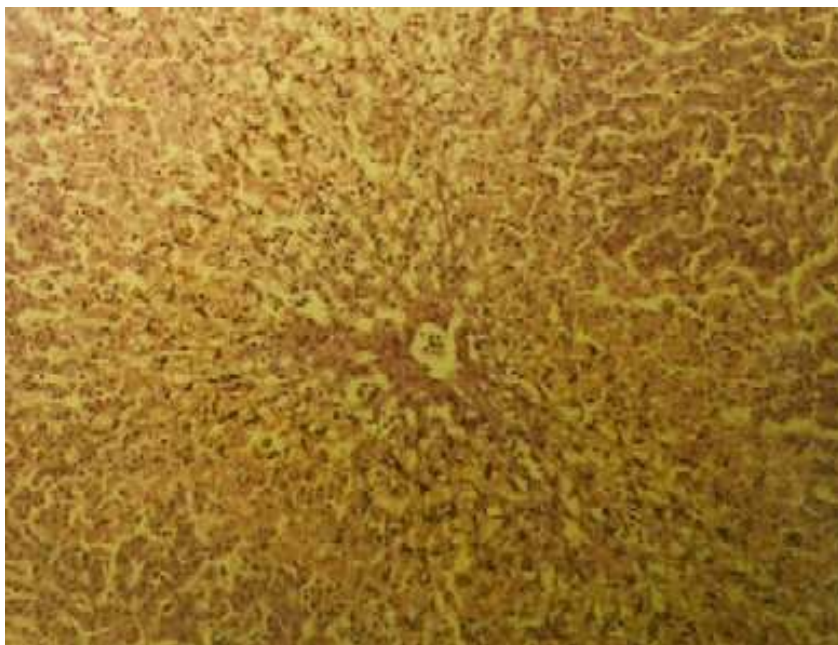
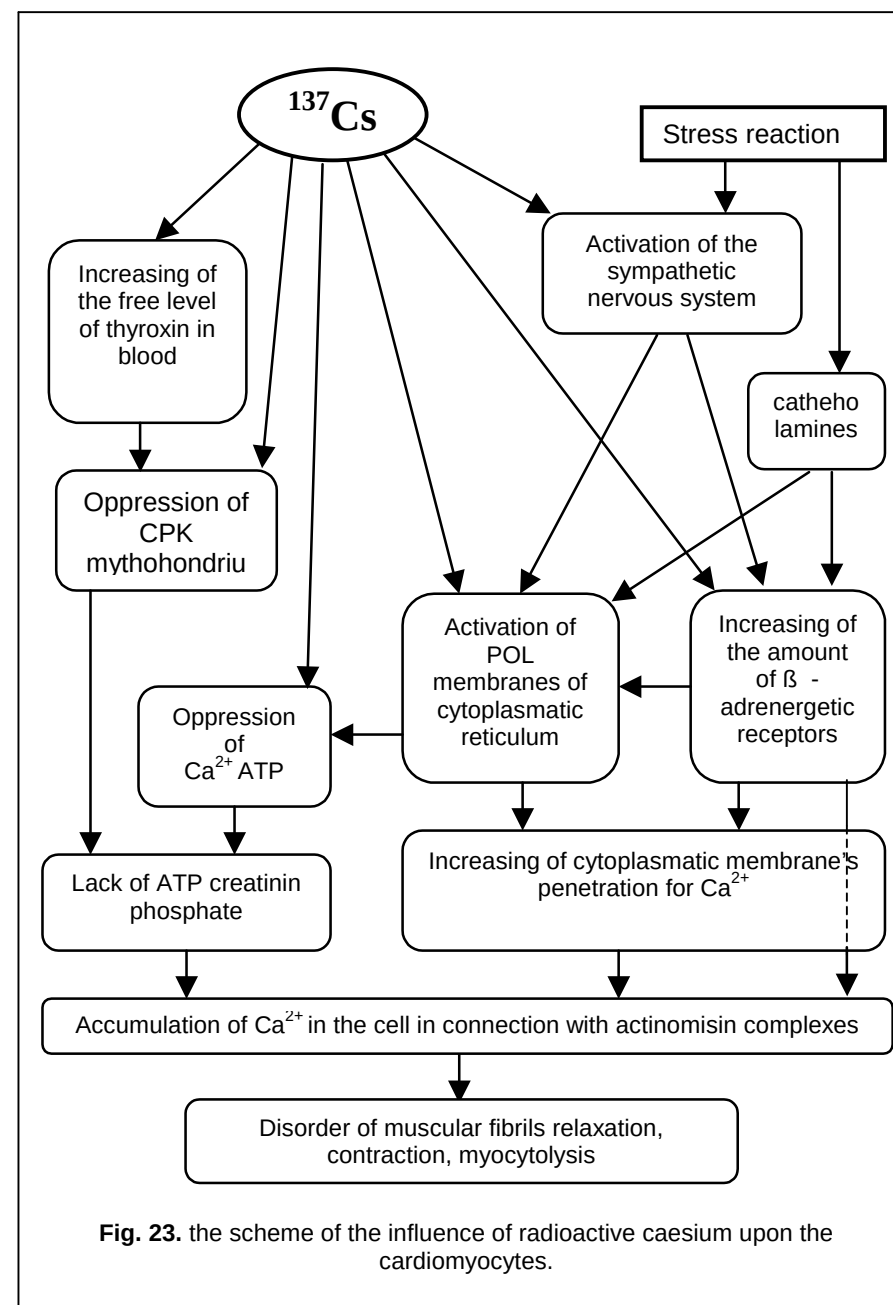


**Fig.22.** Histological structure of liver of suddenly died resident of Gomel of 40 years of old. Radiocesium concentration in liver – 142 Bq/kg. Proteinosis and adipose degeneration, necrosis of hepatocytes. Straining with hematoxylin and eosin. Magnification x 125.



## CONCLUSION

While hammering away the book, I was constantly thinking about the necessity to bring to the notice of any civilized person the information about harmful influence of radioactive substances when they incorporated by the organism. Unfortunately in society there is, at best, indifferent attitude to that problem. That is why we pay a very high price, which is human's life. Intellectual dark turns about the tragedy. To a great extent the blame rests with medical scientists. They don't only try to inform population, using earlier obtained data, but don't even study alterations, appearing in the organism when radioisotopes incorporate.

I understand that this small book couldn't supply the lack of information about that problem. Nevertheless I hope it will cause interest and the problem will be discussed. And it will be very useful.

Using obtained data it is possible to make some conclusions.

Radioisotopes and, first of all, radioactive caesium lie in our environment and without any protective measurements, they penetrate in people's organism mainly with food stuffs and water and incorporated in organs and tissues. The most dangerous for human life is radioactive caesium incorporated in cardiac muscle of growing organism.

Its penetration in myocardium cells causes structural and metabolic alterations, leading to the energetic deficit and to the impairment of their functions and in some cases to death. At once appears the complex of modifications, evidencing about direct injure of cardiac muscle as well as about disturbance of numerous organs and systems, regulating its activity. Cardiomyocytes are damaged not only with radioactive caesium, but also with natural metabolites when there are any violations in the process of their forming, transporting, bonding, exertion and destruction (fig. 23).

Degree of expression of pathologic alterations is in direct dependence from the amount of radioactive caesium in the organism and cardiac muscle. Prolonged incorporation of radioisotope in the organism more than 30 Bq/kg is very undesirable, because could lead to the serious consequences.

In most cases effect of existing concentrations of radioactive caesium in the organism (10 – 20 Bq/kg) doesn't cause its death, but influencing the energetic apparatus of cardiac cells significantly reduces their adaptable possibilities, and as a result functioning during stress situations and banal loads (physical and mental tension, hypoxia, disorder of temperature regime, alcohol drinking, infections and allergic diseases) becoming impossible.

It should be accepted that radioactive caesium is a powerful, damaging agent and attitude toward it should be like toward delayed cell's poison. Cutting up energetics of cardiac cells it causes cardiomyopathy. And as result - cardiac rhythm disturbance, and contraction function of myocardium, spasm of peripheral vessels. It should be noted that the effect of incorporated radioactive caesium on human's and animals' organism assumes its participation in plastic and metabolic processes and first of all like chemical element and not as a source of radiation. Nevertheless the latter couldn't be completely excepted. It is vividly expressed during prolonged influence of small amounts of given radioisotope by pathologic alterations from the side of kidney, where appearing under the influence of radioactive caesium arterioles spasm is the main reason of necrosis of glomerules' loops and destruction of nephron structures. The effect of narrowness of caesium noted in 1888 S. S. Botkin [11].

Thus, radioactive caesium is one of the leading ethiologic factors of rising in arterial pressure in children, living on the territory contaminated with radioisotopes. Numerous observations evidence that [20].

So, as a base of prophylactic of cardiac-vascular diseases in population, living on suffered from Chernobyl disaster territory the questions are actual, concerning reducing of the amount of radioisotopes and first of all radioactive caesium, due to the decreasing of its concentration in stuffs, and also its penetration using sorbtion agents. Important role is plaid by the measurements, directed to the improving of metabolic processes in myocardium.

## REFERENCES

1. A. E. Antipenko, M. I. Kalinski, S. N. Lyslova myocardium metabolism at different functional states. – Ekateriburg. Ed. Ural univ, 1992. – 216 p.
2. T. T. Antonovich, F. K. Mostofi, Atlas of kidney biopsies. Armed Forus Institute of Psthology. Washington. – 1980. – 386 p.
3. G. S. Bandaxhevskaya, the state of cardiac activity in children, living in areas contaminated with radioisotopes / Materials of World Scientific Symposium “Medical Aspects of Radioactive Effect on Population, Living on the Contaminated Territory after Chernobyl Disaster”. – Gomel, 1994. – 27 p.
4. G. S. Bandaxhevskaya, Functional modifications of myocardium in postnatal onthogenesis at effect of incorporated radioisotopes. – Autoref. cand. dis. – Moscow, 1996. – 28 p.
5. Yu. I. Bandazhevsky, Pathophysiology of Incorporated Radiation Emission. – Gomel, Gomel State Medical Institute, 1997. – 104 p.
6. Yu. I. Bandazhevsky, Pathology of the Incorporated Radiation Emission. – Minsk: BSTU, 1999. – 136 p.
7. Yu. I. Bandazhevsky, medical and biological effects of radiocesiumincorporated into the human organism. Minsk: “Belrad”, 2000. – 70 p.
8. Yu. I. Bandazhevsky, G. S. Bandaxhevskaya, Effect of Radioactive Elements, Getting in the Environment as a Result of Chernobyl Disaster, on the State of Myocardium / In book: Clinical and Experimental Aspects of the Effect of Incorporated Radioisotopes upon the Organism. Ed. by Yu. I. Bandazhevsky and V.V. Lelevich. - Gomel, 1995. – pp. 48 – 73
9. Yu. I. Bandazhevski, T. G. Matjukhina and G. A. Zelenko. Ultrastructural Response of the Ventricular Cardiomyocytes to the Radiocesium Penetration. Morphofunctional Aspects of the Radiocesium Effect upon

- the Antenatal and Postnatal Development, Gomel, 1998. - pp. 15-20,
10. T. V. Berchova, M. I. Bakanov, L. A. Bokeria et. al. Cellular Mechanisms of Calcium Regulation of Cardiac Rhythm in Children with Ectopic Arrhythmias // Questions of Medical Chemistry. – 1994. - №4. – pp. 50 – 53.
  11. S. S. Botkin. Influence of Rubidium Salts and Caesium on Heart and Blood Circulation. Dissertation on the Degree of Doctor of Medicine. – S. Petersburg. – 1887 –1888. – p. 41.
  12. N. T. Vatutin, N. V. Kalinkina. Damaging of Heart with Cytostastics. // Cardiology – 1998. - №11. – p. 53 – 57.
  13. G. A. Vechersky, L. G. Baranov, V. G. Lisyutin. Directory on Clinical Electrocardiography. Minsk: Belarus. – 1985. – p. 79.
  14. N. E. Golancev, T. G. Sazontov. Alteration of Resistance of Ca- transported System of Sarcoplasmic Reticulum of Miocardium at “Urgent” and “Permanent” Adaptation to Physical Load // Bul. Of Experimental Biology and Medicine. – 1998. - №1. – p. 40 – 44.
  15. N. L. Dolgy, V. M. Danilova, V. S. Tregubov. Studying of Localization of Radioactive Caesium in Muscular Tissue of Cattle. // Radiobiology. – 1992. – T. 32. – Ed. 2. – p. 284 – 287.
  16. F. Zhuravlev. Toxicology of Radioactive Substances, 2nd ed., Revised. – Minsk: Energoatomizdat, 1990. - 336 pp.
  17. V. A. Zaicev, V. G. Balakleevskaya, S. V. Petrenko. About Functional State of Hypophysial – Kortikoadrenal System of Adaptation of Belarussian Children, Living in Conditions of the Effect of Small Radiation Doses after Chernobyl Disaster // Radiobiology. – 1992. – Tome. 32. – Ed. 4. – pp. 483 – 487.
  18. The Population Health in Europe. Report on Monitoring Measures to Obtain Health for Everyone in 1993-1994. Regional VOZ publications, European edition, №56, Copenhagen, 1995.
  19. G. G. Ivanov, A. S. Smetnev, A. L. Syrkin et. al. Main Mechanisms, Principles of Forecast and Prophylaxis of Sudden Cardiac Death // Cardiology. – 1998. - №12. – pp. 64 – 73.

20. Kienja and N. M. Ermolitski. Vegetative Component of the Reactivity of the Organisms of Children with Different Levels of Incorporated  $^{137}\text{Cs}$ . Structural and Functional Effects of Incorporated Radioisotopes upon the Organism. Ed. by Yu. I. Bandazhevsky. - Gomel, 1997. - pp. 61-82.
21. Clinical and Experimental Aspects of the Effect of Incorporated Radioisotopes upon the Organism. / Yu. I. Bandazhevski, V. V. Lelevich, V. V. Strelko, et al. Ed. by Yu. I. Bandazhevsky and V.V. Lelevich. - Gomel, 1995. - pp.152.
22. e. F. Konoplija, I. M. Bagel, and E. V. Shafranovskaja. Effect of Small Doses of Ionizing Radiation upon the Reactivity of the  $\text{Ca}^{2+}$  ATPase of the Membrane of the Sarcoplasmic Reticulum of the Skeleton Muscle. Report of the Belorussian Academy of Sciences. Biological Series (in Russian). - 1996. - Tome 40. - №3. - pp. 86 - 89.
23. V. V. Lelevich, and E. M. Doroshenko. Effect of Incorporated Radioisotopes upon the Bank of Neuromediators in the Brain of Rats. In: Clinical and Experimental Aspects of the Effect of Incorporated Radioisotopes upon the Organism. / Ed. by Yu. I. Bandazhevsky and V.V. Lelevich. - Gomel, 1995. - pp.74 - 87.
24. A. P. Malyhina. Bioelectric Activity of Cardiomyocytes of Irradiated Organism during Hypoxia. - Autoref. Dys. Cand. Minsk. - 1998. -p. 20.
25. T. Mann,, S. Goldberg, G. N. Mudge, W. Grossmann. Factors Contributing to Altered Left Ventricular Diastolic Properties during Angina Pectoris. Jbid. - 1979. - Vol. 59. - pp. 14 - 19.
26. A.N.Marei, R.M.Barhudarov, and N. Ya. Novikova. Global  $^{137}\text{Cs}$  Contamination and a Man. Moscow, Atomizdat, 1974. - pp. 168.
27. F. Z. Meerson. Adaption Medicine: Mechanisms and Protect Effects of Adaptation. Ed. Hypoxia Medical LTD. Moscow. - 1993. - pp. 331.
28. F. Z. Meerson. Previous Stress Injure of Miocardium and Arrhythmic Cardiac Disease. Part 1 // Cardiology. -1993. - №4. - pp. 50 - 59. Part 2 // Cardiology. - 1993. - №5. - pp. 58 - 64.

29. A. A. Miljutin, T. M. Kirpicheva, and L. M. Lobanok. Effect of Incorporated  $^{137}\text{Cs}$  upon the Structure of Erythrocytal Membranes. Radiobiology. - 1993. - Vol. 33. - Ed. 2. - pp. 302 - 305.
30. L. M. Nepomnjashchikh. Basic Forms of Acute Damage of Cardiomyocytes based on the Data of Polarization Microscopy of Myofibrils. Bulletin of Experimental Biology and Medicine. - 1996. - №1. - pp. 4 - 13.
31. L. M. Nepomnjashchikh. Structural Reorganisation of Miocardium during Extreme Ecologic Effects // Morphology. - 1997. - №6. - pp. 18 - 24.
32. L. M. Nepomnjashchikh. Morphology of Adaptable Reactions of Miocardium during Extreme Ecologic Effects // Messenger of Russia Academy of Medical Sciences. - 1997. - №3. - pp. 49 - 54.
33. V.B.Nesterenko. The Scale and the Consequences of the Chernobyl Disaster in Belarus, Minsk: Law and Economy.,1996. - pp. 72.
34. V. S. Paukov., D. D. Procenko. Recombinationed Modifications of Mithochomdrions in Damaged Cardiomyocytes // Bul. Of Experimental Biology and Medicine. - 1998. - Vol. 125. - №3. - pp. 244 - 250.
35. I. A. Polyakova, M. V. Shorshnikova, I. V. Samorukova, Yu. S. Chetsov. Ultrastructure of Cardiomyocytes Chondriom of Rats During Clinical Death in Postresuscitation Period // Bul. Of Experimental Biology and Medicine. - 1999. - №1. - pp. 95 - 100.
36. S. Schultz - Hector. Radiation induced Heart Disease: Review of Experimental Data on Dose Reponse and Pathogenesis // Jut J. Radiat. Biol. - 1992. - Vol. 61. - 12. - pp. 149 - 160.
37. G. I. Sidorenko. Prevention of Cardiac-Vascular diseases - Actual Task of Modern Medicine // Medical News. - 1999. - №1-2. - pp. 4 - 8.
38. Yu. V. Stepanov, V. I. Vojnitskii, T. D. Preobrazhenskaya, et. al. Effect of X-Irradiation upon the Fat - Acid Composition of the Lipids of the Membranes of the Sarcoplasmic Reticulum. Radiobiology. - 1992. - Vol. 32. - Ed. 6. - pp. 807 - 814.

39. Structural and Functional Effects of Incorporated by the Organism Radioisotopes / Ed. by Yu. Bandazhevsky. – Gomel. – 1997. – pp. 152.;
40. N. K. Hitrov, V. S. Paukov. Cardiac Adaption to the Hypoxia. – Moscow: Medicine, 1991. – pp. 240.
41. A. S. Shevchenko, V. L. Gaban, V. O. Kobjalko et. al. Increasing of Permeability of Plasmatic Membrane for  $\text{Ca}^{2+}$  at Radiationally Induced Apoptose of Thymothys // Radiation Biology. Radioecology. – 1997. – Vol. 37. – Ed. 2. – pp. 220 – 227.

## LIST OF ABBREVIATIONS

**ATP** – adenosintriphosphatase  
**CPK** – creatinin phosphokinase  
**POL** – peroxide oxidation of lipids

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