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STRUCTURAL AND FUNCTIONAL EFFECTS OF RADIOISOTOPES INCORPORATED BY THE ORGANISM

Ed. by Prof. Yu. I. Bandazhevsky

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The publication presents the data of investigation of the condition of a number of organs and systems of man and laboratory animals under the effect of incorporated radioactive elements. Based on the clinical, experimental and morphofunctional methodological approaches, the authors discloses the pathological effects produced by radioactive elements, specifically by ^{137}Cs, unknown so far in the science.

The publication is intended for medical doctors of all specialities, researchers investigating the problems of effects of radioactive elements upon the human organism, it can be used as a manual at schools of medicine and biology.

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INTRODUCTION

This book is another one scientific labour of researchers of the Gomel State Medical Institute. It deals with the effect of incorporated radioactivity on human organism.

The book represents results of clinical and experimental investigations of state of vitally important systems of the organism: vegetative nervous, cardiovascular as well as the organs of vision, immuno-hematological status, the pregnancy flow and embryo evolution.

Special attention in the book is paid to incorporation of widely spread in the environment radioactive elements into the human organism. The factors affecting this process are also discussed.

In this connection, I think, quite interesting are the results of experimental study of the pectopal enterosorbent on laboratory animals. It can help to spread it widely in medicine practice.

I hope that materials presented in the book will be useful at projecting actions on preventing and treatment of diseases caused by effect of incorporated radioactive elements on human body.

Professor Yu. I. Bandazhevsky

Chapter 1

INCORPORATION OF RADIOACTIVE ELEMENTS BY THE ORGANISMS OF CHILDREN LIVING IN THE AREAS WITH DIFFERENT LEVELS OF RADIOACTIVE CONTAMINATION

The Chernobyl disaster has contaminated with radioactive elements extensive areas where a significant proportion of population resides. They are primarily ^{137}Cs and ^{134}Cs [2]. In particular, in a number of areas of the Gomel region the ^{137}Cs concentration in the soil exceeds 15 Ci/km^2 or even 40 Ci/km^2. The half life of this radioactive element is about 30 years and it is actively involved in biological processes when it is absorbed from the soil by the plants and penetrates into the organisms of various animals. Man incorporates this radioisotope basically through alimentary tracts with food, mostly with meat, beef, milk, grain, corn, forest berries and mushrooms [1].

The process of incorporation by living organisms through natural alimentary paths with food is intricate and has not yet been investigated, specifically in relation to ^{137}Cs and ^{134}Cs.

The objective has been to evaluate the accumulation of ^{137}Cs and ^{134}Cs by the organisms of children living in the areas contaminated with radioactive elements (the district of Vetka).

The study in 1996 covered 1,804 children and adolescents aged between 1 and 18 years living in the following communities with different levels of ^{137}Cs contamination:

– Vetka, Svetilovichi, Novoselki – 15–40 Ci/km^2;
– B. Nemki, Janovo, Stolbun, Perelevka – 5–15 Ci/km^2.

The medical and radiological net served for radiological studies and the results were processed using the Student's criterion.

The study has manifested that the average level of ^{137}Cs accumulation by the organisms of the above children amounts to 88.07±2.90 Bq/kg, with the maximum registered among the children in Svetilovichi and in Vetka (Table 1.1). The ^{137}Cs maxima registered in Svetilovichi amount to 1,525–1,882 Bq/kg (5.06–8.53 mSv/year), among school No.1 children in Vetka – 675–716 Bq/kg (2.92–3.23 mSv/year), among school No.2 children in Vetka – 727–835 Bq/kg (3.29–3.78 mSv/year). The figures strongly exceed the permissible threshold of 0.3 mSv/year introduced by the Ministry of Public Health for ^{137}Cs in children's food of all sorts or 37 Bq/kg (the permissible doses of 1990, 1992, 1996). Permissible concentrations of ^{137}Cs isotopes for adults are 111 Bq/l in milk, up to 185 Bq/kg in bread, up to 370 Bq/kg in potatoes which are equivalent to the internal exposure of 1 mSv/year (the permissible doses of 1992).

Consumption of locally produced food with excessive concentrations of ^{137}Cs, such as forest mushrooms, wild berries, milk, vegetables, potatoes, pork and beef meat, is the main cause of such impermissible accumulation of radioisotopes. There are significant variations of ^{137}Cs accumulation as a function of age with senior children having larger accumulated doses of gamma-sources and annual dose burdens (Fig. 1.1). Such larger ^{137}Cs doses among seniors at the same degree of contamination of food can be explained by different periods of half reduction which last 25–30 days among 5–7 year-old children and 70–80 days among adolescents of 15–18 years of age. No strong relation between the sex and the incorporated ^{137}Cs dose has been revealed.

It should be noted that children's organisms manifest larger ^{137}Cs concentrations in areas with heavier contamination.

When the children are grouped according to the incorporated ^{137}Cs doses it should be emphasized that the largest number of children (8%) have the concentration of this element about 30–40 Bq/kg (Fig. 1.2).

Table 1.1

Accumulation of ^{137}Cs by humans in the Vetka district

Community	Amount	Average accumulated dose of ^{137}Cs, Bq/kg	Amount	Average accumulated dose of ^{137}Cs, Bq/kg	Males	Average accumulated dose of ^{137}Cs, Bq/year	Females	Average accumulated dose of ^{137}Cs, Bq/year
3. Nemki '5–15 Ci/km²)	125	55.18±3.35	44* 66+ 15#	60.07±4.95 53.44±5.34 48.47±3.70	26 42 9	67.35±7.25 60.21±7.88 49.22±4.22	18 24 6	49.56±5.35 41.58±4.31 47.33±7.25
lanovo 5–15 Ci/km²)	72	45.96±3.16	18* 49+ 5#	70.89±9.62 38.22±1.75 32.00±3.86	10 25 2	73.70±15.33 38.92±2.52 33.50±3.50	8 24 3	67.38±11.19 37.50±2.48 31.00±6.66
lovoselki 15–40 Ci/km²)	34	50.21±5.72	–* 31+ 3#	– 52.81±10.86 23.33±0.33	– 22 3	– 61.55±14.72 23.33±0.33	– 9 –	– 31.44±7.18 –
'erelevka 5–15 Ci/km²)	86	75.12±5.72	30* 49+ 7#	96.20±13.36 61.69±4.47 78.71±18.86	16 26 4	86.81±17.26 60.08±7.18 67.75±17.25	14 23 3	106.93±21.06 63.52±5.13 93.33±41.33
;tolbun 5–15 Ci/km²)	171	78.74±4.62	35* 101+ 35#	101.57±11.20 77.01±6.40 60.91±4.92	18 53 17	121.06±18.92 83.09±10.12 64.59±7.62	17 48 18	80.94±9.73 70.29±7.51 57.44±6.40
ivetilovichi 15–40 Ci/km²)	226	128.38±13.38	43* 123+ 60#	197.00±42.72 124.00±17.87 87.00±19.40	21 69 37	244.76±84.51 151.00±30.36 97.81±31.03	22 54 23	151.41±20.98 90.80±11.14 69.61±8.66
'etka 15–40 Ci/km²)	1090	89.93±3.65	250* 536+ 304#	126.92±10.05 90.03±4.25 59.34±6.36	120 290 161	121.21±10.93 90.64±5.64 64.73±10.75	130 246 143	132.19±16.51 89.31±6.44 53.27±6.02
otal	1804	88.07±2.90	420* 955+ 429#	120.38±7.71 85.25±3.49 62.70±5.30	971	91.92±4.36	833	83.58±3.70

ote. * – 1978–1981 Years of birth;
+ – 1982–1988 Years of birth;
# – 1989–1996 Years of birth.

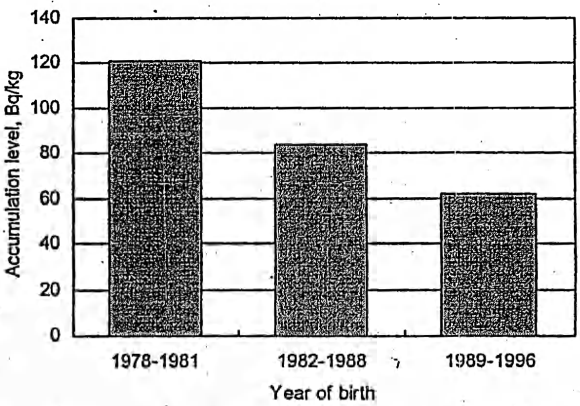

Fig. 1.1. Comparative break-up of accumulation of ^{137}Cs by people in the Vetka district as a function of age.

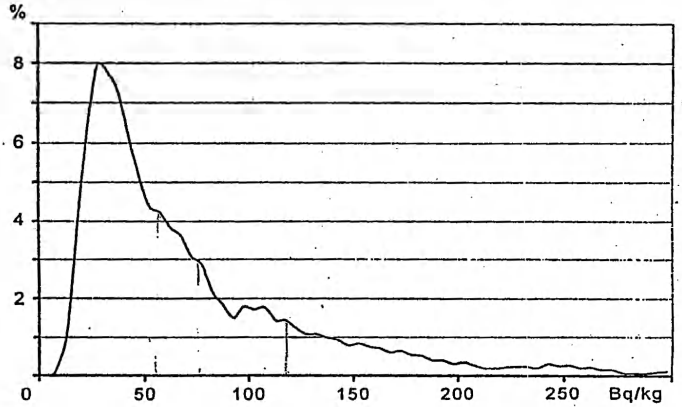

Fig. 1.2. ^{137}Cs ~~dose~~ charge distribution among the population in Vetka district.

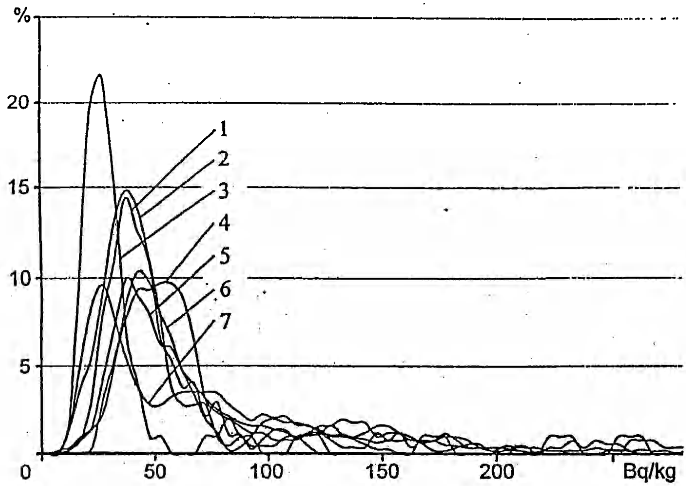

Fig. 1.3. ^{137}Cs accumulated dose distribution among the population in the Vetka district. *1* — Bolshie Nemki; *2* — Janovo; *3* — Novoselki ; *4* — Perelevka ; *5* — Stolbun ; *6* — Svetilovichi; *7* — Vetka.

Meanwhile, in the areas with contamination levels 5–15 Ci/km^2 with a relatively less pronounced accumulation of ^{137}Cs in the organism, the children with the concentrations within 40–50 Bq/kg number about 15% (Fig. 1.3).

The accomplished study evidences that ^{137}Cs is intensively accumulated by the children's organisms in the areas with the contamination level over 15 Ci/km^2.

The degree of incorporation directly depends upon the age of a child. The majority of the children in the Vetka district manifest concentrations of ^{137}Cs in their organisms within 30–50 Bq/kg.

The obtained data corroborate the need to project actions to prevent incorporation of radioisotopes by human organisms.

Considering the results of radiometric examinations of the children in this area and based on the information accumulated earlier, these actions are the following:

1. Reduction of concentrations of radioisotopes, primarily ^{137}Cs, by eliminating them with the help of enterosorbents and prevention of their incorporation with food.

2. A thorough and systematic monitoring of the health condition of children living in the areas contaminated with radioisotopes in excess of 5 Ci/km^2.

3. Identification of risk groups for implementation of efficient prevention and treatment actions.

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Chapter 2

ANTHROPOFUNCTIONAL CHARACTERISTICS OF THE CHILDREN LIVING IN THE AREAS CONTAMINATED WITH RADIOISOTOPES

Monitoring of the health condition, specifically among children and adolescents, belongs to the most essential actions aimed at minimizing the effects of the Chernobyl disaster, since children's and adolescents' organisms are most vulnerable to ionizing radiation.

Parameters of the physical development (PD) are known to belong to the most significant indicators of the health condition of children. Another highly informative parameter is their physical fitness [40, 41], physical development and functional state, because they reflect most fully the functional state, integrated relationships between the physiological ad functional systems (the cardiovascular, neuromuscular, endocrine systems) and energy potentials of the organism [42, 45] maintained by the regulatory functions of the central nervous system and its vegetative compartment.

Examinations of the children during the recent years in the areas contaminated with radiation have revealed significant disorders of many organs and systems [37], including the vegetative status [6, 23, 30] and the cardiovascular system [1, 18].

The major proportion of infectious diseases among children is known to be of the functional origin, i.e. they are caused by disorders of the mechanisms of neurohumoral regulation [5]. Therefore, investigation of such states of regulatory mechanisms is most essential for evaluating the adaptation of the organism to the environmental condition, manifestations of compensation processes for early detection of preclinical pathologies, rather than the estimation of the functioning of individual systems or organs, as it is routinely practiced in contemporary clinical and physiological studies. Hence, the controlling systems [48] should be a primary target of studies rather than the controllable systems. The status of the vegetative nervous system belongs to the most essential link of an intricate mechanism maintaining the processes of adaptation and compensation in the organism requiring comprehensive studies, since their dysfunctions predetermine the responses of the organism's protective systems and may generate numerous somatic disorders evolving into diseases.

Cardiointervalography using clinical orthostatic tests is a very informative technique for evaluating such conditions. Cardiointervalography reveals [39] the parameters which precede modifications of clinical, laboratory, X-radiographic, electrocardiographic and other consequences during the population screening allowing to identify individuals on the borderline of pathological modifications, to detect the initial manifestations or indicate that the restoration of the normal health condition is at the expense of a stress burden upon the mechanisms of adaptation and compensation [3]. The CIG technique has been successfully employed in a number of studies for evaluating the original vegetative tone (ORT) and vegetative responses (VR) among children of various age groups living in the contaminated areas [4, 6, 35]. There are individual publications which report functional disorders of the central nervous system [4] and the mental condition [9, 19] of the children and adolescents [38]. V. I. Bronsky and S. V. Tolkanets implemented a psycho-somatic screening of various population groups [9] and revealed propagation of physical development defects in the communities in the Chernobyl-affected areas. Without attaching significance to the direct effect of the radiation factor upon the nervous system, G. I. Naumova [44] attributes the neurological consefitness was rated in watts in order to estimate the relative physical fitness expressed in watts per kg body weight [21].

The original vegetative tone and vegetative responses were rated with the help of cardiointervalography and clinical orthostatic tests [20, 39]. Electrocardiography served to register over 100 cardiointervals (R–R) in the lying position, the same number was registered immediately after standing up.

A laboratory counter LC-1 [24] and a cardiointervalometer [25] of our design served for mathematical processing of cardiointervalograms. The index of strain in the lying position (IS 41 0) and in the orthostatic position (IS 42 0) and their ratio (IS 41 0/ IS 42 0) were estimated based on the mode indicators (M_o), the amplitude (Am_o), the variation range (X) and served as a criteria of rating of the OVT and VR [5, 20, 27].

The kenotables [49, 51] served to rate the arterial blood pressure (AP) with the account of age, sex and size of children.

Spirometry, pneumotachometry, Shtange and Genchy tests with respiration delays served to analyze the functional state of the respiratory system. The lung capacity was determined using a spirometer. The volume rate of forced inhalation and exhalation was measured using a pneumotachometer PT-2. The rating of the condition of the respiratory system was based on the degree of deviations of the actual data from normal values.

The latent period (LP) of sensomotoric responses was determined using a fast diagnostic instrument 'Barrier' (ROK-1, Hungary) with light and sound stimulation [28]. The stimulating signals were generated stochastically and the responses were processed by a microcomputer to achieve an average time of 20 responses. The results were processed statistically using the STATGRAPH package and the Student criterion was evaluated [46].

RESULTS AND DISCUSSION

Body weight. It has been established that the body weight of boys varies as a function of age differently (Table 2.1).

While at the age of 8 and 9 years the average body weights basically coincide (about 7 kg) a significant weight gain is observed at the age of 10 to 11 years. The body weight of girls rises more evenly with age. Boys 10–13 years of age manifest valid differences of body weights compared with similar girls groups. Boys also manifested larger body weights in other age groups compared with girls, yet these differences are not valid

Table 2.1

Body weight (kg)

Age	Boys		Girls	
	Number	M±m	Number	M±m
8	15	29.5±1.1	6	26.5±2.1
9	14	29.4±1.0	11	27.8±1.3
10	20	36.0±2.2*	32	30.7±1.2
11	28	36.7±2.2	20	34.7±1.3
12	23	38.4±1.4	8	39.0±2.7
13	43	46.4±1.6*	44	50.4±1.8

Note. * $p < 0.05$.

Table 2.2

Annual body weight gain (% of the total gain)

Age	Boys		Girls	
	Weight, kg	%	Weight, kg	%
8–9	–0.1	–5.9	1.3	5.4
9–10	6.6	39.1	2.9	12.1
10–11	0.7	4.1	4.0	16.7
11–12	1.7	10.0	4.3	18.0
12–13	8.0	47.3	11.4	47.7
8–13	16.9		23.9	

statistically. The children at 12 years of age were the only exception with boys having the body weight 0.9 kg larger ($P < 0.05$). The observed dynamics of body weight variations with age basically coincides with the dynamics revealed by other studies [13, 16, 17]. However, children of all age groups had a typically larger body weight, according to our data. Table 2.1

Annual weight gains (Table 2.2) by boys and girls are typically irregular and different. During a 5-year period boys would gain 16.7 kg, girls 23.9 kg. The largest body weight gain is observed between 9 and 10 years and 12 and 13 years (39.1 and 47.3%, respectively). Girls manifest a constant annual boy weight gain with the peak between 12 and 13 years (47.7%) of the total during five years.

Body size. Boys of all age groups manifested continuous increase of the body size between 3 and 5 cm (Table 2.3). Junior and intermediate boys' age groups manifested larger growth. Girls were taller than boys between 12 and 13 years ($P > 0.05$).

The analysis of the annual body size gains (Table 2.4) manifests specific age and sex features when boys demonstrate the peak body growth at the age of 10- 11 and 12-13 years amounting to 31.8% and 25.1% of the total, respectively. Girls demonstrate the peaks at the age of 11–12 (35.5%, 9–10 (20.5%) and 10–11 (22.6%) years.

Our data about annual body size gains strongly differ from other publications which report more regular body size gains from 3–4 cm [10, 1] to 4–6 cm [7] both among boys and among girls. However, the children in the study manifested larger body size gains, specifically in junior and intermediate age groups.

The constitution proportionality and harmony. This indicator manifests no strong variations among the children aged between 8 and 13 years both in respect to age or sex (Table 2.5) staying within 0.45 to 0.48 among boys and 0.44 to 0.48 among girls on the average. Children aged 10 years manifested valid age-sex variations of the indicator.

Table 2.3

Body size (cm)

Age	Boys		Girls	
	Number	M±m	Number	M±m
8	15	130.3±1.3	6	129.3±2.3
9	14	133.8±1.0	11	131.0±1.5
10	20	137.4±1.3	32	136.1±1.5
11	28	144.5±1.3	20	141.7±1.1
12	24	147.0±1.0	8	150.5±2.1
13	44	152.6±1.2	45	154.1±3.6

Table 2.4

Annual body size gain (% of the total gain)

Age	Boys		Girls	
	cm	%	cm	%
8–9	3.5	15.7	1.7	6.85
9–10	3.6	16.1	5.1	20.5
10–11	7.1	31.8	5.6	22.6
11–12	2.5	11.2	8.8	35.5
12–13	5.6	25.1	3.6	14.5
8–13	22.3		24.8	

Table 2.5

Parameters of body proportionality total gain

Age	Boys		Girls	
	Number	M±m	Number	M±m
8	15	0.47±0.009	6	0.45±0.007
9	14	0.46±0.006	11	0.46±0.007
10	20	0.47±0.090	32	0.45±0.004
11	28	0.45±0.006	20	0.44±0.010
12	25	0.45±0.007	8	0.46±0.014
13	44	0.48±0.006	44	0.48±0.007

Table 2.6

Body weight-size parameter

Age	Boys		Girls	
	Number	M±m	Number	M±m
8	15	0.22±0.008	6	0.20±0.014
9	14	0.22±0.007	11	0.21±0.009
10	20	0.25±0.013*	32	0.22±0.006*
11	48	0.25±0.004	20	0.24±0.008
12	23	0.26±0.008	8	0.26±0.015
13	23	0.30±0.009	44	0.32±0.010

Note. * $p < 0.05$.

Table 2.7

Chest mobility

Age	Boys		Girls	
	Number	cm	Number	cm
8	15	3.67±0.42	6	3.83±0.79
9	14	4.93±0.47	11	4.09±0.34
10	20	4.93±0.47*	30	4.90±0.19*
11	28	5.60±0.21	20	5.15±0.27
12	24	5.29±0.23	8	6.88±0.77
13	46	5.87±0.29	43	6.19±0.25

Note. * $p < 0.05$.

Weight-size indicator. This indicator (Table 2.6) is characterized by a practically one and the same value among junior (0.22) and intermediate (0.25) school age boys. Compared with the age of 12 years, this indicator shows a significant 15.4% rise by 13 years. It also rises among girls as a function of age with the peak rise by 13 years (23.1%). Other age groups manifest a somewhat smaller and a more regular rise.

Chest mobility. This parameter has been estimated based on the differences of the circumference during inhalation and exhalation increasing both among boys and girls with the age (Table 2.7).

Among boys and among girls aged 8 years the indicator has been 3.67±0.42 cm and 3.83±0.79 cm. The mobility increases with age and at the age of 13 years it amounts already to 5.87±0.29 among boys and 6.19±0.025 cm among girls, i.e. the average rise of 2.20 and 2.36, respectively, compared with the age of 8 years. Valid differences in the chest excursion ($P < 0.05$) have been observed among 10-year old children with this indicator higher among boys than among girls [13, 33].

It should be noted that the examined children typically had smaller mobility of the chest compared with the children in the Belorussian Polessje countryside screened by G.I. Verenich [11] in 1976–1978.

Physical development harmony. It has been manifested by over half of the children (61.2%) (Table 2.8). Pronounced disharmony was observed in 9.7% due to the excessive body weight of the 2nd degree and of the 1st degree in the majority of the cases. Disharmony of the 1st degree was manifested by 1.5% and pronounced disharmony of the 2nd degree was manifested primarily by 8-year-old children (41.2%). It has been remarked among 21.4–26.3% of 9- and 10-year old boys and among 26.3% of 10-year old girls.

Manifestations of the physical development disharmony of the 1st and 2nd degrees may be assumed to be due to metabolic disorders and failures of control mechanisms among which the hormonal factor is noteworthy.

Strength features. Both hands among girls and boys manifest rising strength with age (Table 2.9). Right hands of boys in almost all age groups are much stronger than among girls. This difference is 2.3 kg at the age of 9 years, 3.3 kg at the age of 13 years. Compared with the 8-year old children this indicator is 10.5 kg higher among the boys and 7.6 kg higher among the girls of 13 years.

Left hands of boys manifest stronger muscles than girls with the difference at the age of 9 years being 3.2 kg and at the age of

Table 2.8

Harmony of physical development

Harmony	Number	%
Pronounced lack of harmony, EBW 2nd degree	26	9.70
Disharmony, EBW 1st degree	65	24.25
Harmonious	164	61.19
Disharmonious, BWD 1st degree	4	1.49
Pronounced disharmony, BWD 2nd degree	9	3.35

Note. EBW – excessive body weight; BWD – body weight deficit

Table 2.9

Parameters of right (RH) and left (LH) dynamometry (kg)

Age		Boys		Girls	
		Number	M±m	Number	M±m
8	RH	15	9.1±0.6	6	8.7±0.3
	LH		10.0±0.5		9.0±1.2
9	RH	14	10.4±0.5*	11	8.1±0.5*
	LH		11.3±0.5*		8.1±0.4*
10	RH	19	12.7±0.7*	32	9.8±0.3*
	LH		12.4±0.5*		9.6±0.4*
11	RH	28	14.7±0.6*	20	10.4±0.4*
	LH		14.3±0.5*		10.9±0.5*
12	RH	24	14.7±0.5*	8	11.5±1.0*
	LH		15.2±0.5*		11.4±0.5*
13	RH	44	19.6±0.7*	45	16.3±0.7*
	LH		18.8±0.6*		17.0±0.6*

Note. * $p < 0.05$.

13 years 1.8 kg. The hand muscles gain most strength at the age of 13 years compared with relatively regular gains from 8 to 12 years.

The obtained data of the hand strength among the screened children somewhat differ from other reported data [11] collected after screening children in other areas of the Belorussian Polessje, Gomel children specifically manifest weaker muscles. Neither right nor left hands of girls or boys manifest any significant asymmetry, the fact fails to correlate fully with other reports [13] which show its appearance after 10 years of age.

Grouping of the children based on the relative right and left hand strength is shown in Table 2.10. A more objective evaluation of the strength of hand muscles was achieved by correlating it with the body weight. The indicator of the right hand rises among boys with age showing 37.1 units at the age of 9 years, 37.7 units at the

Table 2.10

Distribution (%) of relative strength of right (R) and left (L) hands (units)

Age	Hand	Relative strength of muscles, units				
		<25	25–31	32–38	39–45	>45
Boys						
8	R	20	47	13	13	7
	L	13	40	27	13	7
9	R	–	43	21	28	7
	L	–	21	36	36	7
10	R	5	21	37	21	16
	L	5	11	37	42	5
11	R	–	14	29	36	21
	L	7	7	32	25	29
12	R	4	13	33	25	25
	L	4	4	42	29	21
13	R	2	12	21	25	40
	L	2	5	30	35	28
Girls						
8	R	–	50	33	17	–
	L	–	66	17	17	–
9	R	18	55	18	–	9
	L	18	63	–	9	9
10	R	16	31	22	28	3
	L	22	34	10	28	6
11	R	30	20	35	15	–
	L	20	35	25	10	10
12	R	13	38	25	12	12
	L	–	63	25	12	–
13	R	24	29	24	14	9
	L	19	26	26	22	7

Table 2.11

Standing strength parameters (kg)

Age	Boys		Girls	
	Number	M±m	Number	M±m
8	15	32.3±3.1	6	31.7±6.8
9	14	42.1±4.3*	11	30.2±3.0
10	20	46.1±2.5*	32	39.7±2.1
11	28	57.2±2.7*	19	43.7±2.6
12	24	60.3±2.5*	8	48.6±4.2
13	43	77.0±2.9*	44	63.4±2.0

Note. * $p < 0.05$.

age of 11 years (19%), 41.6 units (31.2% at the age of 13 years. The left hand indicator is 32.8 units at the age of 8 years, rising to 39.0 units (19%) at the age of 9 years and then it remains basically unchanged (40.9) until the age of 13 years. Girls at the age 8-13 years show no difference of the strength of both hands. It is 32.7 units for the right hand at the age of 8 years, 31.1 units for the left hand, 30.7 and 31.1 units for the right hand at the age of 13 years, respectively.

The body strength increases with the age (Table 2.11) with boys having it larger in all age groups than girls. Exception are 8-year old children who manifest no difference between the sexes. On the average, it is 11.9 kg at the age of nine and 13.6 kg at the age of 13 years. The back erectors and hip muscles manifest annual gains which strongly leap at the age of 13 years.

Some researchers believe [42, 45] that they are due to a fast rate of evolution of the nervous control of spontaneous muscle activities and to the modifications of the biochemical composition and the histological structure of the muscles at this age.

At the age of 8 years both and girls basically have identical body strength (1.04 and 1.08 units). Senior boys manifest the rise up to 1.68 units. Girls show a noticeable rise of the body strength after the age of nine. While it is 1.8 units at the age of 8 and 9 years on the average, after 10 years of age it rises to 1.28–1.32 units [31].

Physical fitness. Sex difference are age dependent (Table 2.12) with an average rise among boys at the age of 8 years from 116.6±7.7 W to 205.7±12.0 W at the age of 13 years. Statistically valid rises start among boys after 11 years compared 8 years and after 13 years compared with other age groups (Table 2.13). Girls manifest a general rise of their physical fitness with age, though with some variability, in the majority of case the age differences of physical fitness are statistically valid (see Table 2.13). Comparison of the physical fitness of boys and girls shows somewhat higher figures than those reported by other researchers [40, 41] for other communities of the Republic, based on the studies accomplished over a decade ago before the disaster. In our view, the main reasons of these differences are due to a different methodological approach to application of the step-test.

Grouping of the children based on their physical fitness (Table 2.14) indicates that the majority of the boys have this indicator within the range of 60.01–146.9 W at the age of 8–9 years and 89.0–175.9 W at the age 11–13 years, girls within 60.0–146.9 at the age 8–10 years and 89.0–146.0 at the age 11–13 years. Still, a considerable number have typically stronger bodies, specifically boys and primarily those with excessive body weight of the 1st and 2nd degrees.

No significant variations of the average physical strength development has been registered within the age groups (Table 2.15) which remains within 3.41±0.18 W/kg to 3.97±0.28 W/kg, excepting that it is somewhat higher at the age of 11–13 years amounting to 4.04±0.34 W/kg and 4.68±0.25 /kg, respectively.

Girls have this indicator 11.0-35.3% lower than the boys, excepting the age of 12 years when it is somewhat higher ($P > 0.05$). On the average, 2.92±0.011 W/kg to 3.98-10.o W/kg is a typical parameter.

Table 2.12

Age-sex parameters of absolute physical fitness (W) (step-test, PWC 4170 0)

Age	Boys		Girls			
	M±m	%	M±m	%	t	p
8	116.6±7.7	100.0	84.6±6.4	72.5	2.93	<0.01
9	127.6±10.2	100.0	84.1±4.4	65.9	3.81	<0.001
10	127.7±9.4	100.0	118.9±8.1	93.4	0.63	>0.05
11	157.9±11.9	100.0	98.7±2.6	62.5	2.48	<0.02
12	148.2±10.1	100.0	172.3±38.6	116.3	0.08	>0.05
13	205.7±12.0	100.0	151.9±6.7	73.8	3.97	<0.001

Table 2.13

Statistically valid age-sex differences of physical fitness

Age		9	10	11	12	13
Boys						
8	t	0.77	0.01	2.85	2.48	5.22
	p	>0.05	>0.05	<0.01	<0.02	<0.001
9	t	–	0.00	1.91	1.35	4.51
	p	–	>0.05	>0.05	>0.05	<0.001
10	t	–	–	1.72	1.41	3.61
	p	–	–	>0.05	>0.05	<0.001
11	t	–	–	–	0.55	2.59
	p	–	–	–	>0.55	<0.01
12	t	–	–	–	–	2.93
	p	–	–	–	–	<0.01
Girls						
8	t	0.00	3.10	1.30	3.96	5.80
	p	>0.05	<0.01	>0.05	<0.001	<0.001
9	t	–	3.78	1.56	4.92	7.09
	p	–	<0.001	>0.05	<0.001	<0.001
10	t	–	–	1.27	2.18	3.03
	p	–	–	>0.05	<0.05	<0.01
11	t	–	–	–	2.38	2.97
	p	–	–	–	<0.05	<0.01
12	t	–	–	–	–	0.83
	p	–	–	–	–	>0.05

Table 2.14

Distribution (%) of children based on the absolute physical fitness parameters

Age	Intervals of the APF (W)							
	60.0–88.9	89.0–117.9	118.0–146.9	147.0–175.9	176.0–204.9	205.0–233.9	234.0–262.9	>262.0
Boys								
8	26.1	30.4	17.4	17.4	–	4.3	–	4.3
9	26.0	30.0	20.0	12.0	12.0	–	–	4.0
10	7.7	23.1	46.1	15.4	7.7	–	8.7	–
11	–	30.4	30.4	17.4	8.7	–	8.7	4.3
12	–	23.5	29.4	17.6	23.5	–	5.9	–
13	–	7.7	26.9	25.6	17.9	10.3	2.6	9.0
Girls								
8	57.6	23.7	18.7	–	–	–	–	–
9	52.0	28.0	16.0	–	–	–	4.0	–
10	21.7	30.4	21.7	13.0	8.7	–	–	4.4
11	–	85.7	–	–	14.3	–	–	–
12	–	25.0	25.0	–	25.0	–	–	25.0
13	–	16.3	48.8	11.6	11.6	4.6	2.3	4.6

Table 2.15

Age-sex parameters of relative physical fitness (W/kg)

Age	Boys		Girls	
	Number	M±m	Number	M±m
8	3.97±0.28	100.0	3.00±0.13	75.5
9	3.55±0.20	100.0	3.11±0.19	87.6
10	3.66±0.30	100.0	3.29±0.18	89.9
11	4.04±0.34	100.0	2.92±0.11	72.8
12	3.41±0.18	100.0	3.98±1.00	116.7
13	4.68±0.25	100.0	3.03±0.10	64.7

Таблица 2.16

Distribution (%) of children based on the relative physical fitness

Age	Intervals of RPF (W/kg)						
	1.0–1.9	2.0–2.9	3.0–3.9	4.0–4.9	5.0–5.9	6.0–6.9	>7.0
Boys							
8	8.0	38.0	34.0	16.0	4.0	–	–
9	4.0	42.0	30.0	12.0	4.0	8.0	–
10	4.0	52.0	24.0	20.0	–	–	–
11	–	28.1	36.4	21.8	4.5	–	9.1
12	–	35.3	35.3	23.5	5.9	–	–
13	–	7.5	40.0	27.5	12.5	2.5	5.0
Girls							
8	–	51.2	42.9	–	–	–	5.8
9	4.0	48.0	24.0	20.0	–	–	4.0
10	4.8	38.3	37.8	14.3	–	4.8	–
11	–	42.8	42.8	–	–	14.3	–
12	–	40.0	41.5	12.0	6.5	–	–
13	–	53.5	39.5	7.0	–	–	–

Grouping the children and adolescents according to their general body physical development (Table 2.16) evidences that the majority of the boys at the age 8–9 years have a typical physical fitness 2.9–3.9 W/kg. The rest show a typical rise of the indicator, with stronger children manifesting excessive body weight of the 1st and 2nd degrees. It ranges between 2.0 and 3.9 W/kg among girls. Boys of other ages typically have a larger body strength compared with the girls, among 72–85% it ranged within 2.0–3.9 W/kg. It is noteworthy that girls at the age 9 and 10 years have it 4.0 and 4.8% lower, respectively, the general body strength remains also comparatively low within 1.0–1.9 W/kg.

Hence the general body strength is predominantly 2.0–3.9 among the children and adolescents or basically the same or somewhat higher than body strength reported by other researchers after screening the children in other regions of Russia, Ukraine and Belarus. Still, the school children covered by our screening have

Table 2.17

Distribution (%) of children based on the original vegetative tone (OVT) and vegetative responses (VR)

	OVT and VR variants	Numbers examined	%
OVT	Eutonia	98	36.6
	Sympathicotonia	102	38.0
	Hypersympathicotonia	44	16.4
	Vagotonia	24	8.9
VR	Normal	117	43.6
	Asympathicotonic	43	16.1

manifested a comparatively high general body strength (based on our studies of the harmony of physical development) due to excessive body weights of the 1st and 2nd degrees strongly affecting the results of the step-tests.

The status of the vegetative nervous system. Cardiointervalography has manifested [3, 36, 47] that a significant proportion of the children have modifications of the original vegetative tone and vegetative regulation (Table 2.17). Girls manifest the condition of eutonia mostly at the age of 13 years (41.7%), while other age groups have it at a level between 31.0–36.8%. A very low percentage of girls at the age of 9 and 12 years (16.7% and 28.6%, respectively) with the normal vegetative nervous system status is noteworthy. Boys manifest the state of eutonia at a level between 41.7–50.0% at the age of 13 years and there are comparatively fewer such cases at the age of twelve.

Both girls (Fig. 2.1) and boys (Fig. 2.2) have manifested a significant number of the sympathicotonic original vegetative tone (Table 2.18). Sympathicotonias have been observed among a better half of the girls. This state of the vegetative nervous system is specifically noticeable at the age 9 and 10 years (62.0 to 83.3%). Boys have manifested a significant number of sympathicotonic modifications of the vegetative tone (28.6–63.7%) specifically at the age of 9 and 10 years (58.3–63.7%).

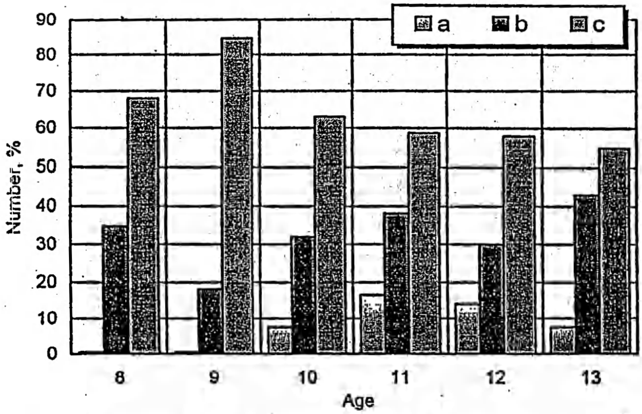

Fig. 2.1. Distribution of girls based on variants of original vegetative tone: *a* – vagotonia; *b* – eutonia; *c* – sympathicotonia

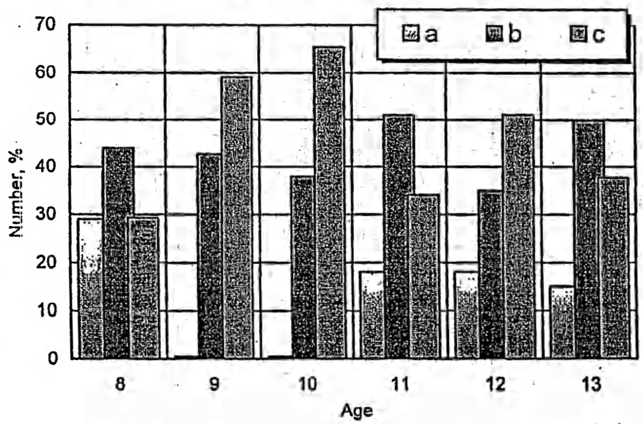

Fig. 2.2. Distribution of boys based on variants of original vegetative tone: *a* – vagotonia; *b* – eutonia; *c* – sympathicotonia

Table 2.18

Distribution of children (%) based on the variants of the original vegetative tone and vegetative responses

Age		OVT			VR		
		Eutonia	Sympathicotonia	Vagotonia	Normal	Hypersympathicotonia	Asympathicotonia
8	G	33.3	66.7	–	40.0	40.0	20.0
	B	42.8	28.6	28.6	57.1	42.8	–
9	G	16.7	83.3	–	66.7	16.7	16.7
	B	41.7	58.3	–	15.4	53.9	30.8
10	G	31.0	62.0	6.9	34.5	51.7	13.8
	B	36.4	63.7	–	36.4	45.5	18.2
11	G	36.8	57.9	16.7	57.9	36.8	5.2
	B	50.0	33.3	16.7	33.3	55.5	11.1
12	G	28.6	57.1	14.3	42.8	28.6	28.6
	B	33.3	50.0	16.7	33.3	50.0	16.7
13	G	41.7	54.3	5.5	33.3	50.0	13.9
	B	48.8	36.6	14.63	36.6	48.8	14.6

Note. G – Girls; B – Boys.

Cases of vagotonias are somewhat fewer both among girls (5.5–16.7%) at the age of 10–13 years and among the boys of the same age (14.6–16.7%). A comparatively larger number of vagotonias among 8-year old boys is noteworthy. No such cases of modifications of the vegetative tone have been observed among girls at the age of 8–9 years and among boys at the age of 9–10 years.

A significant number of the children has been registered with modified vegetative regulation. Normal conditions have been observed among 33.3–34.5 percent of the girls at the age 10–12 years (Fig. 2.3) and a somewhat greater number in other age groups (40.0–66.7%). Mostly girls at the age of nine manifest normal vegetative regulation and fewer girls at the age of 10 and 13 years (just 34.5% and 33.3%, respectively). Among boys 57.1% manifested normal vegetative regulation at the age of eight and 36.6%

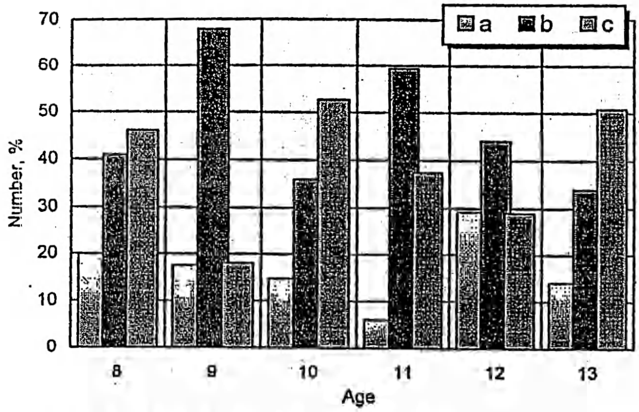

Fig. 2.3. Distribution of girls based on variants of vegetative responses: *a* – asympathicotonic; *b* – normal; *c* – hypersympathicotonic

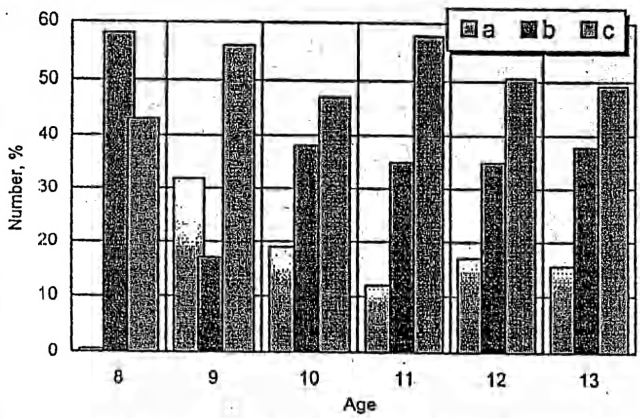

Fig. 2.4. Distribution of boys based on variants of vegetative responses: *a* – asympathicotonic; *b* – normal; *c* – hypersympathicotonic

at the age from 11 to 13 years. Just 15.4% boys at the age of nine manifest normal vegetative regulation (Fig. 2.4).

Almost half of the girls at the age 10–13 years manifested hypersympathicotonic vegetative regulation, somewhat fewer at the age of 8 years (40.0%) and 11 years (36.8%) and the fewest number at the age of nine (16.7%). This vegetative regulation variant has been observed among 42.8% to 55.5% boys in all age groups.

There are fewer cases of asympathicotonias among the children – 20.0 and 16.7 percent among the girls aged 8 and 9 years, respectively. Girls at the age of 10 and 13 years manifest basically the same numbers (13.8% and 13.9%). Asympathic vegetative regulation is more frequent (28.6%) among girls aged twelve. This vegetative regulation variant has been manifested by 11.1–18.2% of boys at the age 10–13 years and no such cases at the age of eight. Asympathicotonias are rather frequent among boys aged nine.

Both boys and girls have manifested different combinations of the original vegetative tone and vegetative regulation, it is noteworthy that these modifications are individual. Several such combinations are shown in the cardiointervalograms in Fig. 2.5–2.7 recorded in the lying position for evaluating the modifications of the vegetative tone and in the orthostatic position for evaluating vegetative regulation. The age-sex relationships of modifications of the vegetative tone have been revealed. In particular, sympathicotonias have been detected more among girls in all age groups, specifically at the age 8, 9, 11 and 13 years, compared with the boys. The number of eutonias among the boys shows an opposite trend. Significant age-sex features of disorders of the vegetative responses have been detected.

Arterial blood pressure. Definite age-sex dynamics (Table 2.19) of variations of the systolic arterial pressure (SAP) have been revealed. Boys aged 10–13 years have a somewhat higher SAP than girls. Annual SAP variations among the children are irregular, girls have SAP at the age of 8 higher than at the age of 9

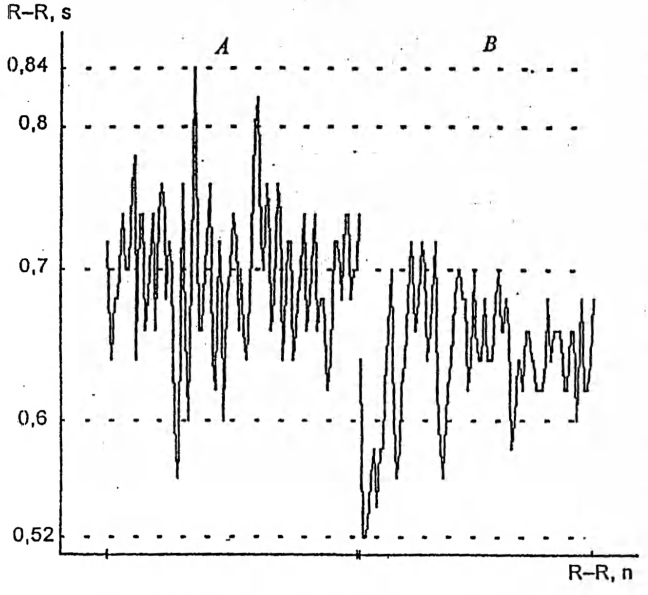

Fig. 2.5. Cardiogram of boy K. 10-year old: *A* – lying; *B* – standing, OVT – vagotonia; VR – normal

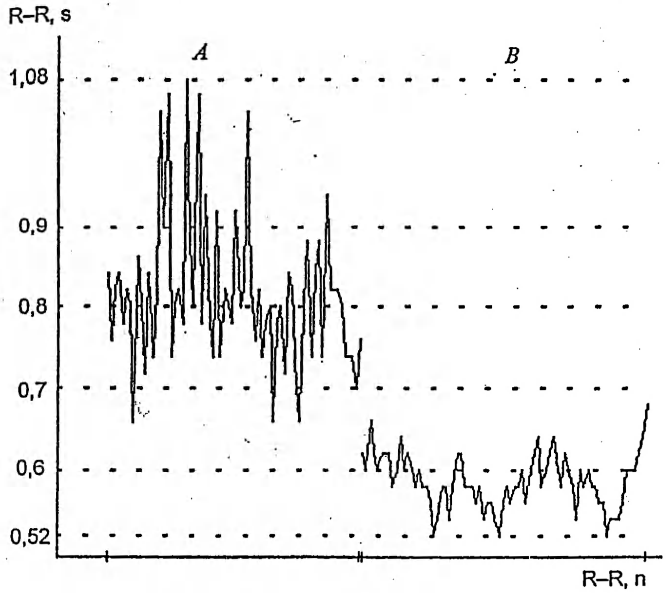

Fig. 2.6. Cardiogram of boy K. 8-year old: *A* – lying; *B* – standing, OVT – vagotonia; VR – hypersympathicotonic

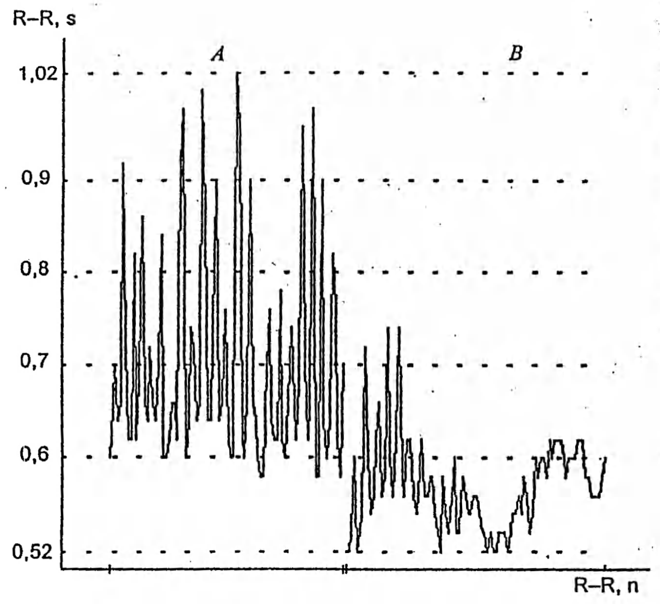

Fig. 2.7. Cardiogram of girl K. 8-year old: *A* – lying; *B* – standing, OVT – eutonia; VR – hypersympathicotonic

Table 2.19

Systolic and diastolic blood pressure (mm M.C.)

Age	Boys			Girls		
	Number	mm M.C.		Number	mm M.C.	
		max	min		max	min
8	15	100.7±2.0	77.0±1.8	6	109.2±3.7	81.7±1.1
9	14	102.5±2.3	74.6±2.1	11	107.3±2.0	77.3±2.6
10	20	112.3±3.4	80.3±1.5	33	102.3±3.4	75.9±1.6
11	28	110.9±1.4	83.8±1.4	20	109.8±1.9	81.3±1.9
12	20	112.3±2.6	82.5±2.3	8	109.4±2.9	76.9±3.0
13	38	113.6±2.3	71.9±4.7	45	112.9±1.5	82.0±1.4

and 10 years. SAP indicators almost coincide among the children at the age of 11 and 12 years. The SAP of boys at the age of 10 to 13 years and girls 8 to 9 years is somewhat higher than the systolic arterial pressure of the children in the Belorussian Polessje reported in other studies accomplished in 1976–1978 [17].

The SAP stays in the region of a moderate rise among the children of all age groups, at the same time it is superior than the SAP among the children of the same age in Minsk, Vitebsk and Polotsk [17]. Exception are the girls at the age 10 and 12 years and boys at the age of 13 in Minsk which have no significant difference between their SAP and the SAP of the children in Gomel.

Noticeable age-sex variations of the diastolic arterial pressure have been detected (see Table 2.19).

No significant sex-dependent difference of the pulse pressure (Table 2.20) has been detected, yet its rise with the age has been detected among the boys aged eight years from 23.7±1.7 to 27.5±3.8 mm M.C. and among the girls of the same age up to 30.3±2.0 and up to 30.7±1.3 mm M.C. at the age of 13 years.

Evaluation of the arterial blood pressure as a function of body weight, sex and age using the conversion tables has revealed that disorders of haemodynamics have been predominantly due to the borderline arterial hypertension and arterial hypertension (Table 2.21).

Table 2.20

Pulse pressure (mm M.C.)

Age	Boys		Girls	
	Number	M±m	Number	M±m
8	15	23.7±1.7	6	27.5±3.8
9	14	28.2±2.3	11	30.0±2.4
10	20	29.0±1.5	32	29.5±1.6
11	28	27.1±1.4	20	28.0±2.5
12	20	29.8±2.4	8	32.5±2.8
13	38	30.3±2.0	45	30.7±1.3

Table 2.21

Distribution (%) of children based on the arterial pressure

Examined children	Normal	Borderline arterial hypertension	Arterial hypertension	Borderline hypotension	Arterial hypotension
Boys	58.7	26.1	9.7	3.7	1.8
Girls	71.3	18.8	4.0	1.0	4.9
Per group	65.0	22.4	6.8	2.3	3.3

Table 2.22 shows the distribution of the children based on the condition of arterial blood pressure as a function of age and sex. The Table shows that the cases of arterial hypertension and its borderline cases are fewer among the children. One out of three girls at the age of 8 years has manifested arterial hypertension, fewer such cases have been remarked among the boys at the age of 10 (15.0%) and at the age of 12 years (16.7%). A significant number of the children of all ages (both boys and girls) have manifested the case of borderline arterial hypertension.

It is assumed that the dysfunction of the vegetative nervous system plays a significant role in the disorders of arterial pressure, it is evidenced by our data of cardiointervalography relating to the modifications of the vegetative tone and vegetative regulation. Our

Table 2.22

Distribution (%) of children based on the arterial pressure

Age		Normal	Borderline arterial hypertension	Arterial hypertension	Borderline hypotension	Arterial hypotension
8	B	80.0	6.7	6.7	–	6.7
	G	50.0	16.7	33.3	–	–
9	B	85.7	–	7.1	–	7.1
	G	81.8	18.2	–	–	–
10	B	60.0	25.0	15.0	–	–
	G	84.4	12.5	3.1	–	–
11	B	64.3	28.6	7.1	–	–
	G	70.0	25.0	5.0	–	–
12	B	50.0	33.3	16.7	11.1	–
	G	75.0	25.0	–	–	–
13	B	44.7	39.5	7.9	7.9	–
	G	63.6	20.5	2.3	13.6	2.3

Note. B – Boys; G – Girls.

data about the disorders of the vegetative nervous system as a governing factor of pathogenic disorders of the functions of the blood circulation system among the children living in the areas contaminated with radiation fully correlate with similar conclusions made by other researchers [47].

Respiratory system. Investigation of the lung vital capacity and its age dynamics [26] has manifested its average rise among the boys at the age of 8 from 1.8±0.05 l to 2.8±0.08 l at the age of 13 years and among girls from 1.67±0.11 l at the age of 8 to 2.79±0.50 l at the age of 13 years (Table 2.23).

In contrast to the 8-year old children the vital capacity among both boys and girls increases respectively 1.57 and 1.67 times evidencing a higher tempo of development of the respiratory system among girls at the age 8-13 years. The vital capacity among boys is superior to the vital capacity among girls in parallel age groups.

Table 2.23

Average parameters of lung capacity (LC), indicators of the pneumotachometry of exhalation (PTMexh) and inhalation (PTMinh), respiration delay tests in inhalation (the Shtange test) and exhalation (the Genchy test)

Age	Sex	LC, l	PTMexh, l/min	PTMinh, l/min	Shtange test, s	Genchy test, s
8	B	1.81±0.05	1.89±0.07	1.51±0.06	30.7±4.0	21.3±3.0
	G	1.67±0.11	1.75±0.11	1.43±0.36	42.7±8.0	91.3±8.1
9	B	1.95±0.07	1.91±0.09	1.72±0.10	28.4±3.5	27.9±5.4
	G	1.68±0.04	1.55±0.05	1.28±0.04	27.7±3.6	21.0±3.1
10	B	2.10±0.04	1.95±0.07	1.82±0.05	29.7±3.7	26.7±4.8
	G	1.92±0.05	1.89±0.07	1.71±0.06	28.1±2.9	22.8±2.3
11	B	2.39±0.07	2.27±0.06	2.08±0.07	32.5±2.3	22.4±2.0
	G	2.07±0.04	2.07±0.04	1.74±0.06	31.1±3.8	17.8±1.7
12	B	2.59±0.12	2.43±0.13	2.13±0.10	37.5±3.3	22.3±3.3
	G	2.56±0.14	2.17±0.22	1.89±0.14	25.8±4.2	19.9±4.2
13	B	2.84±0.08	2.43±0.12	2.17±0.13	44.0±3.3	28.5±2.7
	G	2.79±0.50	2.41±0.07	2.04±0.07	26.7±1.9	16.4±1.0

Note. B – Boys; G – Girls.

These data correspond to those reported in available publications which indicate the vital capacity dependence on the age and sex features among school children. Significant differences between boys and girls have been observed when the reduced vital capacity parameters is contrasted with the required parameters . All girls at the age of 8, 9 and 11 years manifest normal parameters indicating their better physical development. Boys demonstrate a tendency of reduced vital capacity (versus the normally expected value), while girls demonstrate opposite modifications. It may evidence that the organism development decelerates at the age 12–13 years.

Comparison of the vital capacity with the expected parameters has revealed its reduction by 20 and more percent among 16% children. The average vital capacity reduction has been observed among 18% boys and 13% girls. Exception were senior children, with vital capacity reduction among boys amounting to 14 - 27% compared with the girls. The number of the girls of junior and intermediate ages with the reduced vital capacity compared with the expected amounts to 25% and to 49% in the senior group.

The average maximum air volume rate registered by pneumotachometry during exhalation amounted to 1.89±0.07 l/min among boys and to 1.75±0.11 l/min among girls at the age of 8 years. This parameter both among boys and girls increases by 13 years to 2.43±0.12 and 2.41±0.07 l/min, respectively. The maximum air volume rate during inhalation changes with age both among boys (from 1.51 air 0.06 l/min at the age of 8 to 2.17 air 0.13 l/min at the age of 13 years) and among girls (from 1.43 air 0.36 l/min to 2.94 air 0.07 l/min).

Comparison of the actual pneumotachometric data with the expeted values (Table 2.24) has revealed the reduced parameters among 45% boys and 46% girls. Reduction of the actual pneumotachometric values during inhalation compared with the standard parameters has been detected among 20% boys and 28% girls. Girls at the age of 8 and 11 years have manifested no significant disorders of the volume rate of inhalation, while this parameter deviated from the standard among 90% of girls at the age of 13 years.

The average duration of the inhalation delay varies from 31 s among boys at the age of 8 to 44 s at the age of 13 years (see Table 2.23). The duration of exhalation delay (the Genchy test) varies from 21 s among boys at the age of 8 to 29 s at the age of 13 years. The Shtange and Genchy tests have yielded the best results among the girls at the age of 8 (43 s - the Shtange test and 91 s — the Genchy tests). These tests would yield somewhat smaller figures among girls at the age of 9 years anbd the figures would remain basically unchanged at senior ages [33].

Pneumotachometry has revealed a slight continuous growth of the capacities of the respiratory system among boys and girls. The total numbers of disorders of the volume and rate parameters

Table 2.24

Parameters of spirometry and pneumotachometry (PTM) among boys and girls

Age	Sex	% of LC reduction versus normal	% of exhalation reduction versus normal	% of exhalation reduction versus normal
8	B	27	20	7
	G	0	17	0
9	B	14	21	14
	G	0	72	45
10	B	15	65	5
	G	6	35	23
11	B	18	11	11
	G	0	5	0
12	B	17	63	38
	G	25	71	57
13	B	16	89	90
	G	49	73	43

Note. B – Boys; G – Girls.

of the respiratory system in the groups of boys and girls basically coincide.

A significant rise of obstructive disorders among boys and girls with age is worthwhile to note. At the same time the disorders of external respiration have mostly related to the exhalation phase rather than to inhalation. It is manifested by a larger percent (45%) of disorders of the volume exhalation rate than inhalation rate (28%).

Sensomotoric responses. Age and sex features of the duration of latent periods of sensomotoric responses to light and sounds (Table 2.25) have been identified. Boys at the age of 8 years manifest the latent period of motoric response to light 318±7.2 ms, it would reduce in other groups and reach 238±4.3

Table 2.25

Latent period of sensomotoric responses (ms)

Age	To light		To sound	
	Boys	Girls	Boys	Girls
8	318±7.2	331±11.9	295±9.2	324±12.5
9	297±8.6	308±11.1	271±6.9	280±9.8
10	260±9.3	297±9.9	246±13.2	261±9.4
11	259±7.2	268±12.6	248±8.7	246±13.2
12	254±10.6	296±22.2	226±10.8	248±8.7
13	2387±4.3	252±6.9	209±5.3	225±5.6

ms among 13-year old adolescents [14]. A similar tendency is observed among girls. In particular, the duration of the latent period of motoric response to light reduces to 252±6.9 ms among girls at the age of 13 years from 331±11.9 ms at the age of 8 years. Faster motoric responses to light among boys than among girls are specifically noteworthy. It should be noted that reduction of the latent period of motoric responses to light among boys and girls with age is characterized by a certain parallelism evidencing a rather narrow range of variations of the ratio between the latent period of motoric responses to light among boys and the latent period of motoric response to light among girls of the respective age groups (0.86–0.96).

The duration of the latent period of motoric responses to sound among boys at the age of 8 years is 295±9.2 ms on the average, they reduced with age down to 209±5.3 ms at the age of 13 years. Unlike the boys, the latent period of motoric responses to sound lasts longer, they reduce with age reaching 209±5.3 ms at the age of 13 years, from 12.5 ms at the age of 8 years to 225 ms, and with age to 209±5.3 ms at the age of 13 years; or 5.6 ms at the age of 13. Similarly to the light stimulation, the reduction of the latent period of motoric responses to sound with age both among the boys and the girls is characterized by a certain parallelism, because the ratio between the latent period of motoric responses to light among the boys and the latent period of motoric responses to sound among girls of the relevant age groups are within 0.92–1.00. Table 2.26 shows valid differences between the latent periods of sensomotoric responses among boys and girls. The latent period of motoric responses to sound is shorter both among the girls and the boys than latent period of motoric responses to light.

Analysis of the individual features of the LP of sensomotoric responses among the school children in the age groups proves a significant variability of their distribution (Table 2.27). The Table shows that the overwhelming majority (61%) of boys aged 8 years have the latent period of motoric responses to sound within 300–399 ms, 31% within 250–299 ms and 4% have typically fast responses (200–249 ms) and approximately the same number have rather retarded responses (400–450 ms). The next age groups manifest a typical gradual growth of the number of boys with the latent period of motoric responses to sound tending to be retarded. The number of 9-year old boys with the LP duration within 300-399 ms reduces compared with the 8-year olds and amounts to 56%, yet the number with faster sensomotoric responses increases (36% versus 31%). The next age groups manifest a larger number of boys with a shorter latent period of motoric responses to sound. For example, 57% of 13-year old boys have them within 200-249 ms and 8% within 150–199 ms.

Similar variations of the latent period of motoric responses to light are observed as a function of age. While the interval of these responses ranges between 250–299 ms among 52% of 8-year old boys, 64% among 9-year old, 53% among 10-year old, it shifts to 200–249 ms among the majority (44%) of 11- and 12-year old and to 150–199 ms among 13-year old children. Yet, a large percentage of boys with a comparatively protracted latent period of motoric responses to sound (300–399 ms) is noteworthy. Compared with boys, girls of 8 years of age have a longer latent period of motoric responses to sound ranging between 300–399 ms among 67% and 250–299 ms among 22%. A comparatively large propor-

Table 2.26

Statistical validity of age-sex differences of sensomotoric responses (t/p)

Age	Irritant	Age				
		9	10	11	12	13
		Boys				
8	light	1.9/>0.05	4.9/<0.01	5.8/<0.01	5.8/<0.01	9.5/<0.01
9		–	2.9/<0.05	3.4/<0.01	3.2/<0.01	6.1/<0.01
10		–	–	0.1/>0.05	0.4/>0.05	2.1/<0.05
11		–	–	–	0.4/>0.05	2.5/<0.01
12		–	–	–	–	1.4/>0.05
13		–	–	–	–	–
8	sound	2.1/<0.05	3.1/>0.05	3.7/<0.01	4.8/<0.01	8.2/<0.01
9		–	1.8/>0.05	2.0/>0.05	3.5/<0.01	7.1/<0.01
10		–	–	0.1/>0.05	1.2/>0.05	2.5/<0.05
11		–	–	–	1.6/>0.05	3.8/<0.01
12		–	–	–	–	1.4/>0.05
13		–	–	–	–	–
		Girls				
8	light	1.4/>0.05	2.1/<0.05	3.6/<0.01	1.4/>0.05	5.7/<0.01
9		–	0.7/>0.05	2.5/<0.05	0.5/>0.05	4.4/<0.01
10		–	–	1.8/>0.05	0.1/>0.05	3.7/<0.01
11		–	–	–	1.1/>0.05	1.1/>0.05
12		–	–	–	–	1.9/>0.05
13		–	–	–	–	–
8	sound	2.8/<0.01	4.0/<0.01	5.5/<0.01	2.8/<0.01	7.2/<0.01
9		–	1.4/>0.05	3.2/<0.01	1.4/>0.05	4.9/<0.01
10		–	–	1.9/>0.05	0.7/>0.05	3.3/<0.01
11		–	–	–	0.2/>0.05	0.6/>0.05
12		–	–	–	–	0.5/>0.05
13		–	–	–	–	–

Table 2.27

Distribution (%) of children based on the duration of the latent period of sensomotoric responses to light and sound

Age	Irritant	Intervals of responses, ms				
		150–199	200–249	250–299	300–399	400–450
Boys						
8	light	–	4	31	61	4
	sound	–	13	52	35	–
9	light	4	4	36	56	–
	sound	–	24	64	12	–
10	light	8	38	46	8	–
	sound	8	31	53	8	–
11	light	4	33	52	11	–
	sound	15	44	30	11	–
12	light	5	37	42	16	–
	sound	28	44	22	6	–
13	light	8	57	35	–	–
	sound	45	42	10	3	–
Girls						
8	light	–	–	22	67	11
	sound	–	11	16	67	6
9	light	–	8	48	40	4
	sound	–	24	44	32	–
10	light	–	17	39	44	–
	sound	–	48	30	22	–
11	light	–	40	30	30	–
	sound	20	40	40	–	–
12	light	–	25	25	50	–
	sound	50	–	25	25	–
13	light	4	53	25	18	–
	sound	29	49	18	4	–

tion of girls (11%) with a rather slow latent period of motoric responses to sound (400–450 ms) is noteworthy. Among the children of other ages there is a gradual increase of the proportion of the girls with a longer latent period of motoric responses to sound ranging between 200–249 ms among 53% of 13-year old girls. A clear tendency of deceleration of the latent period of sensomotoric responses to the sound stimulus as a function of age is observed among girls. The latent period of motoric responses to light ranges between 300–399 ms among 67% of 8-year old children, while 9-year old (44%) have faster LP responses (250–299 ms), 10-year old – 200–249 ms (44%). No girl manifests the latent period of motoric responses to light below 200 ms, while 11-, 12- and 13-year old children with the latent period within 150–199 ms number 20, 50 and 29%, respectively.

Conclusion. The accomplished study indicates that the children aged between 8–13 years living in the area contaminated with radioisotopes in the amounts 1–5 Ci/km^2 in the industrial area of the Gomel Agricultural Machinery Works manifest significant modifications of both their physical development and the functional condition of the vegetative nervous, cardiovascular, respiratory systems and the elementary level of the mental activities as a function of age and sex.

Specifically, a sizable proportion of the children is characterized by significant deviations of anthropometric parameters, the harmony of physical development, physical fitness, which are comparatively poor compared with the normal original vegetative tone, meanwhile there is a strong manifestation of sympathicotonic and hypersympathicotonic vegetative responses. It may be considered as a factor leading to the appearance of risk groups with a potential evolution of the vegetovascular syndrome with other ensuing vegetative disorders on the part of other organs and systems of the juvenile organism.

A relationship has been established between the duration of latent periods of motoric responses to light and sound and age and sex. Reduction of this parameter with age proves the restoration of the functional condition of the central nervous system and psychic responses among the school children. However, these processes evolve differently as it is evidenced by a broad range of latent periods in each age group. There has been no possibility to make any valid comparison of the results of the present study with other reported data because of the problems of evaluation of the functional condition of the central nervous system and relevant elementary mental responses among the children and adolescents exposed to adverse ecological conditions. Moreover, these effects are insufficiently disclosed in the available publications.

The observed disorders of the status of the vegetative nervous system can be assumed to result from the effect of a variety of chemophysical factors, including small doses of ionizing radiation, aggravated by the existing socioeconomic factors.

The obtained results of the longitudinal studies will allow to predict the tendencies of deviations of the physical development and the functional conditions of the children and will be employed for further monitoring and prediction of their health condition as a function of exposure to the adverse ecology in the area contaminated with radiation, for projection of health improvement actions.

Also, a bulk of the data can be treated as a basis for further observation of health dynamics among the children and adolescents in Gomel when poor ecology is aggravated by the Chernobyl fallout.

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Chapter 3

THE STATUS OF THE VEGETATIVE NERVOUS SYSTEM AND ARTERIAL BLOOD PRESSURE AMONG CHILDREN WITH DIFFERENT LEVELS OF INCORPORATED ^{137}Cs

Studies by a number of researchers accomplished during the years after the Chernobyl disaster have clearly revealed a total rise of the numbers of various diseases among the children and adults exposed to the radiation factor. These diseases evolve in a more severe way, with more frequent relapses and complications, also they feature the polymorphism of clinical manifestations.

Therefore, monitoring of public health, specifically among children and adolescents, is one of the most crucial tasks for comprehensive evaluation of the actions aimed at minimizing the Chernobyl consequences, since, unlike adults, the juvenile organism is most vulnerable to the effects of various adverse ecological factors, including ionizing radiation.

The condition of the regulatory mechanisms yields a better assessment of the adaptation of the organism to the environmental conditions and of the degree of manifestations of the compensatory processes for early detection of preclinical forms of pathologies than evaluation of the performance of individual systems and organs, as it is common in the present day clinical and physiological studies. Hence, the controlling, rather than controlled, systems should be a primary subject of investigation [31].

Therefore, it is highly essential to perform comprehensive investigation of the status of the vegetative nervous system (VNS) of the children, since it plays the most influential in maintaining the intricate mechanism of the processes of adaptation and compensation in the organism and, in case of a dysfunction, it is the factor governing the condition of the reactive protective systems of the organism being a precursor of a variety of somatic diseases.

It has been demonstrated that a significant number of non-infectious diseases among children, including also the vegetovascular dystonia syndrome, has functional origin, i.e. it is caused by disorders of the neuro-humoral regulation [10]. This syndrome has been detected among a considerable number of the people living in the areas contaminated with radioisotopes and among the liquidators of the Chernobyl contamination [28]. Cardiointervalography (CIG) with the use of the clinical orthostatic test (COT) is a very informative technique for evaluating the VNS status. It has been established [4, 25] that variations of the CIG parameters precede the modifications of clinical, laboratory, X-ray, electrocardiographic and other indicators, therefore mass screening using this technique allows to identify individuals with borderline pathologies, to detect their initial manifestations and to realize that a normally healthy condition in appearance is at the expense of stress upon the mechanism of adaptation and compensation [3, 5]. It has compelled to use the CIG technique rather extensively for evaluating the performance of the vegetative regulation of cardiac functions among the children with the inherited predisposition to hypertension [30], specifically the vegetative reactivity and vegetative performance among school age children [22, 23], for predicting the borderline, normal and pathological conditions [3]. The technique has been successfully employed for prenosological diagnostics during screening of the population [15], including evaluation of the status and the reactivity of the VNS among the children of different ages living in the radiation contaminated areas [6, 11, 18, 22, 23].

Significant disorders of many organs and systems have been detected among these children, including disorders of the cardiovascular system (CVS) [2, 14, 24, 28, 29] evidenced by the disorders of the cardiac contractility [33], the rhythm of cardiac contractions, the arterial blood pressure [12, 13, 28, 29]. Also, modifications of the metabolic and electrocardiographic parameters [7, 34] have been registered. A more pronounced and a valid direct dependence of the electrocardiographic modifications upon the dose of accumulated radiation has been manifested both clinically and experimentally [7].

Studies of the peripheral blood circulation among the children in the Southern parts of the Gomel and Brest regions have revealed that the hypertonic type of the curve dominates over the hypotonic type [2]. Vessels and perivascular tissues manifest significant modifications, in addition to various morphofunctional modifications [1, 33] which play as important role in the disorders of the CVS. In particular, experimental studies reveal that accumulation of radioisotopes in the organisms of rats is accompanied by pronounced structural, functional and metabolic modifications of the myocardium. The polarization behavior of cardiomyocytes is modified through the growth of A-discs, inhibition of the reactivity of the alkaline phosphatase and creatinophosphokinase in them [8].

Experimental studies of rats kept during 30 days within 10-km zone of the Chernobyl reactor have manifested that the radioecological situation, with ionizing radiation playing the key role, modifies the functions of the central and peripheral mechanisms of adaptation inhibiting then in different systems, including the CVS [32]. The pathogenesis of these modifications of the CVS shows that ionizing radiation causes disorders of the neurohumoral mechanisms of regulation of the contractility of the myocardium and upsets the condition of the vascular tone [24].

Therefore, continuous monitoring of the children and adolescents in the areas with moderate contamination requires to control both the status of the VNS and the functional condition of the CVS, specifically, the arterial pressure as one of the integral indicators of the vegetative homeostasis.

It should be emphasized that evaluation of the extent of relationships between the vegetative homeostasis and ionizing radiation has been peformed by researchers with the consideration of the level of radiation contamination of the areas where these cohorts live ignoring the concentrations of incorporated radioisotopes.

The present objective has been to evaluate the status of the VNS and AP among the children with different concentrations of accumulated radiocesium. The study covered 144 school children aged 8–13 years in Vetka (^{137}Ci soil contamination is 19.1 Ci/km^2), among them 74 boys and 70 girls. Cardiointervalography and clinical orthostatic tests (COT) served to evaluate the original vegetative tone (OVT) [4, 5, 25]. At least 100 cardiointervals were registered in the lying position and then the same number immediately after standing up. A laboratory counter SL-1 [16] and a cardiointervalometer of our design [17] served for initial mathematical data processing. The mode (Mo), its amplitude (Amo), the variation span (X) served to estimate the index of stress in the lying position (IN_{10}) and in the standing position (IN_{20}) and their ratio (IN_{10}/IN_{20}) which served as a criterion of evaluation of the OVT and VR [25]. The method of N.S. Korotkov was employed to measure AP using collars the width of which corresponded to the shoulder circumference [19]. The age tables [35] served to determine the AP level with the account of sex, age and body size. The biomedical monitoring system (BMS) served to determine the concentration of incorporated ^{137}Cs. The obtained data were processed statistically and graphically using the STATGRAPH package developed by V.V. Abramovich.

Analysis of the cardiointervalographic data has revealed eutonia among 43.7% of the children, sympathycotonia among 25.7%, hypersympathicotonia among 25.7% (Table 3.1), vagotonia was revealed among 14.6% of the children. Along with modifications of the OVT almost half of the children have manifested asympathicotonias (25.5%) and hyperasympathicotonias (26.4%) VR ,

Table 3.1

Distribution of children (%) based on the OVT and VR

OVT and VR variants	Number examined	%
OVT		
Eutonia	63	43.7
Sympathicotonia	23	15.9
Hypersympathicotonia	37	25.7
Vagotonia	21	14.6
VR		
Normal	75	52.1
Asympathicotonia	31	21.5
Hypersympathicotonia	38	26.4

the normal condition has been registered only among 52.1% of the children, with 22.9% of the children having a combination of the normal OVT and VR (Fig. 3.1). No significant differences between sexes have been revealed in the latter case (Table 3.2). The rest of the children had various combinations of the OVT and VR, some of them are represented in Fig. 3.2–3.4 in the form of cardiointervalograms. Combinations of the eutonic and normal VR among boys and girls number about equally (24.3% and 21.4%, respectively).

The accomplished anthropometric studies have revealed [21] that children in Vetka living in the area with the same level of radioactive contamination have strongly different individual accumulated doses of ^{137}Cs (Fig. 3.5) which range rather extensively (from 20 to 496 Bq/kg) with the average figures being 89.5±6.2 Bq/kg. The overwhelming majority (72.0%) of the children have accumulated doses typically within 20–100 Bq/kg. Somewhat fewer children have the accumulated doses within 100–150 Bq/kg (16.7%) and within 150–500 Bq/kg (11.4%).

The obtained data about different accumulated doses of ^{137}Cs in the organisms of the children in the area with the same level of radioactive contamination have urged to investigate the relation-

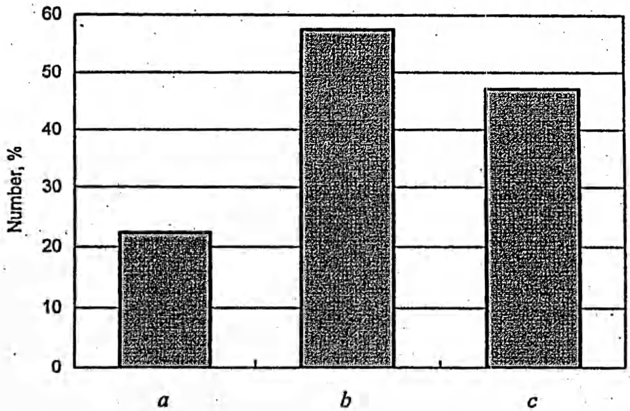

Fig. 3.1. Distribution of children based on combinations of OVT and VR variants: *a* – normal OVT and normal VR; *b* – disordered OVT; *c* – disordered VR

Table 3.2

Number of the children with normal OVT and VR

Examined children	Total	Children with normal VNS status	
		Number	%
Total	144	33	22.9
including			
boys	74	18	24.3
girls	70	15	21.4

ship between the VNS status and the incorporated ^{137}Cs dose, which is quite justifiable following from the concept of individual radiological risk [26, 27].

The accomplished analysis of the relationships between the number of the children with the modified OVT and the incorporated ^{137}Cs dose has revealed a clear direct relation between the

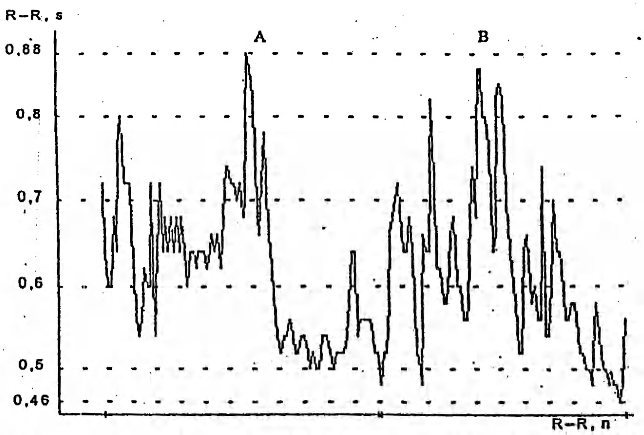

Fig. 3.2. Cardiointervalogram of girl 3., 10 years. A – lying; B - standing. OVT – eutonia. VR – normal

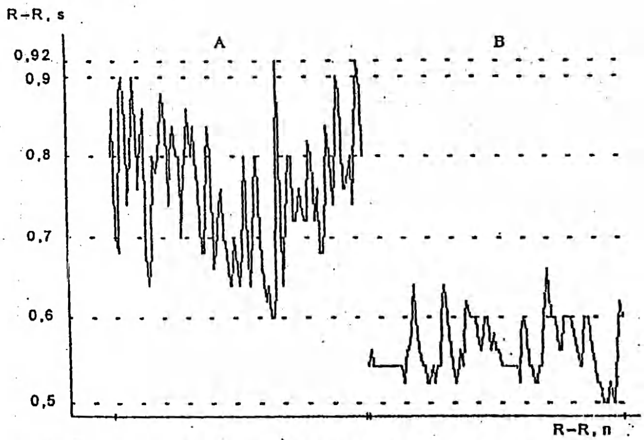

Fig. 3.3. Cardiointervalogram of boy B., 12 years. A – lying. B – standing. OVT – vagotonia. VR – hypersympathicotonic

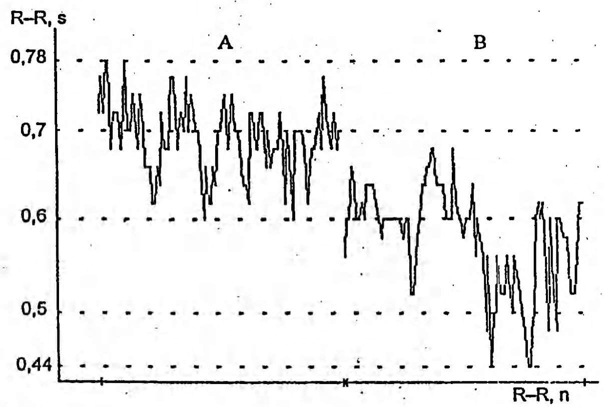

Fig. 3.4. Cardiointervalogram of girl H., 12 years. A — lying. B — standing. OVT – eutonia. VR – hypersympathicotonic

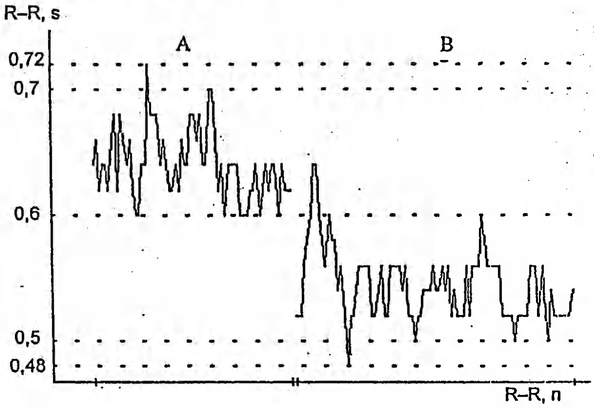

Fig. 3.5. Cardiointervalogram of girl M., 12 years. A — lying. B — standing. OVT – eutonia. VR – hypersympathicotonic

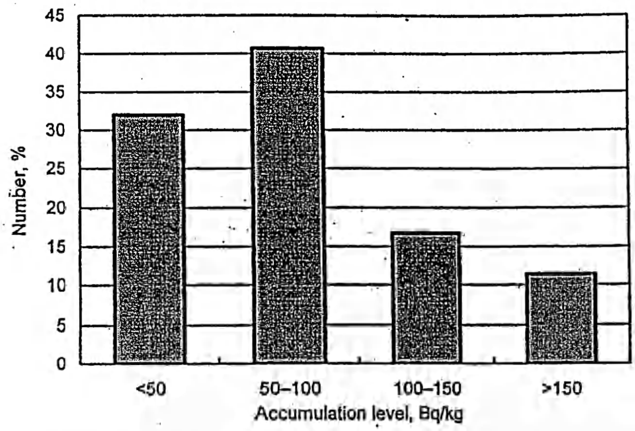

Fig. 3.6. Distribution (%) of children based on accumulation of ^{137}Cs

reduction of the number of the children with eutonias and the rise of the number with the VNS dysfunctions (Fig. 3.6) as the incorporated dose increases. While the condition of eutonia has been registered among 50.0% of the children with the accumulated dose up to 50 Bq/kg, when the incorporated dose is 50–100 Bq/kg the number of the children with the normal OVT of the VNS reduces to 42.5%, when the dose is 100–150 Bq/kg it reduces to 31.4%, when the dose is above 150 Bq/kg the number is just 21.4%. Larger accumulated ^{137}Cs doses lead to larger numbers of the children with the sympathicotonic and hypersympathicotonic variants of the OVT. While the elevated tone of the sympathic nervous system was registered among 35.0% and 34.6% of the children when the incorporated ^{137}Cs dose ranged within 20–50 Bq/kg and 50–100 Bq/kg, respectively, this condition of the VNS would rise to 45.9% and 57.1%, respectively, when the incorporated dose reaches 100–150 Bq/kg and up.

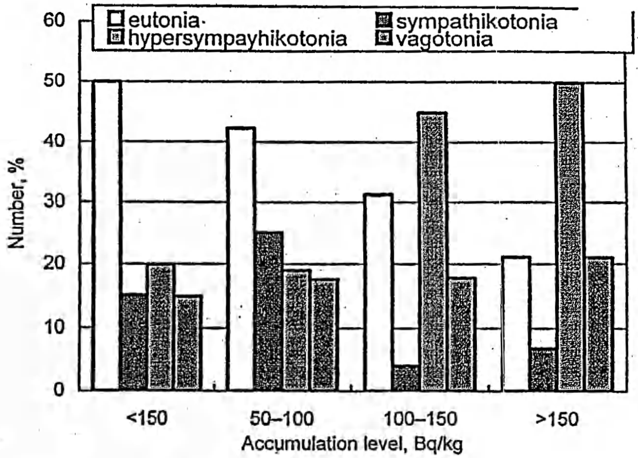

Fig. 3.7. Distribution of children (%) with different levels of incorporated ^{137}Cs based on OVT and VR

A regularity is noteworthy that in case the incorporated ^{137}Cs dose exceeds 100 Bq/kg, the number of sympathicotonic cases reduces, while the number of hypersympathicotonias increases sharply, i.e. when radiocesium is accumulated, the condition of sympathicotonia evolves into hypersympathicotonia. It is exclusively essential in order to conceive different sympathicodependent effects on the part of various tissues, organs and systems among individuals with different accumulated doses of the radioisotope. The established phenomenon allows to assume that the radiation factor is one of the most essential etiologic factors quite common among the children and adults living in the radiation contaminated areas leading to the vegetovascular dystonia syndrome. Hence, actions of health protection in these areas should be aimed at reducing incorporation of the radioisotope, eliminating it

Table 3.3

Distribution of children (%) with different levels of incorporated radioisotopes based on VR

VR	Specific radioactivity, Bq/kg			
	<50	50–100	100–150	>150
Norm	57.5	44.7	50.0	50.0
Asympathicotonia	22.5	25.5	22.7	21.4
Hypersympathicotonia	20.0	29.8	27.2	28.5

from the organism, including various techniques and means of enterosorption jugdged in accordance with individual incorporated doses. As the incorporated ^{137}Cs dose goes up, the number of children with vagotonias increases (Fig. 3.7).

No significant dose-dependent effect upon the VR modifications among the children in response to the accumulated dose has been observed (Table 3.3). Most probably it can be explained by the VNS hypersympathicotonic condition among the majority of the children with the incorporated ^{137Cs} dose in excess of 100 Bq/kg. It fully corresponds to the law of the original level of homeostasis (the law of the "initial value" of Wilder) which states that the lower the level of the original activity of the physiological condition the smaller are the relative variations of the effect of the stimulus of one and the same intensity [10]. Still, sex differences in the OVT and VR in response to the incorporated ^{137}Cs dose have been revealed (Table 3.4).

Analysis of the AP data has indicated [20] that a significant number of the children (41.6%) have elevated arterial pressure and just 57.1% have normal pressure. The majority have manifested the borderline arterial hypertension (24.7%) and arterial hypertension (16.9%). Hypotension has been registered just among 7.2% of the children.

Analysis of the AP levels among the children with different incorporated doses (Fig. 3.8) has revealed a clear dose-dependent effect. While 64.0% of the children have normal AP when doses

Table 3.4

OVT and VR among boys (B) and girls (G) with different levels of incorporated radioisotopes

VNS status	Specific radioactivity, Bq/kg							
	<50		50–100		100–150		>150	
	B	G	B	G	B	G	B	G
OVT								
Eutonia	48.3	54.5	31.2	48.3	40.0	25.0	22.2	20.0
Sympathicotonia	10.3	27.3	37.5	19.4	10.0	–	11.1	–
Hypersympathicotonia	20.6	18.2	12.5	22.6	30.0	58.3	33.3	80.0
Vagotonia	20.6	–	18.7	9.7	20.0	16.7	33.3	–
VR								
Normal	58.6	54.5	50.0	41.9	50.0	50.0	44.4	60.0
Asympathicotonia	13.8	45.5	12.5	32.2	20.0	25.0	22.2	20.0
Hypersympathicotonia	27.6	–	37.5	25.8	30.0	25.0	33.3	20.0

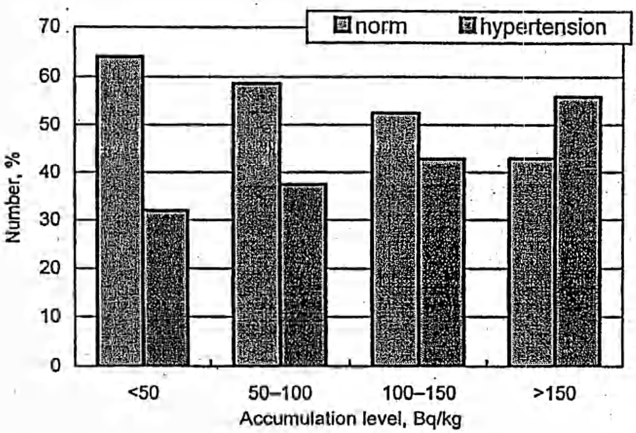

Fig. 3.8. Distribution of children (%) based on arterial blood pressure

Table 3.5

Distribution of children (%) with different doses of incorporated ^{137}Cs based on the arterial blood pressure

Arterial pressure	Specific radioactivity, Bq/kg							
	<50		50–100		100–150		>150	
	n	%	*n*	%	*n*	%	*n*	%
Normal	32	64.0	29	59.3	12	53.3	7	43.7
Borderline arterial hypertension	11	22.0	11	22.4	7	30.4	5	31.3
Arterial hypertension	5	10.0	8	16.2	3	13.0	4	25.0
Arterial hypotension	2	4.0	7	2.0	1	4.3	–	–

are below 50 Bq/kg, as the dose increases to 100 Bq/kg their number reduces to 59.3%, at the doses within 100–150 Bq/kg they number 53.3% and at the doses above 150 Bq/kg the number of the children with normal AP reduces to 43.7%.

Meanwhile, the number of the children with the borderline arterial hypertension (Table 3.5) amounts to 22.0% at a dose below 50 Bq/kg, to 22.4% at 50–100 Bq/kg and rises to 31.3% at a dose between 100–150 Bq/kg and up. Arterial hypertension has been registered among a fewer number of the children, still the dose-dependent effect appears at the dose 50 Bq/kg amounting to 10.0% of the children, rising to 25.0% at a dose above 50 Bq/kg. Both sex (Table 3.6) and age (Table 3.7) features of the AP disorders appear.

No significant relationship between the number of the cases of arterial hypertension and the incorporated dose has been observed, excepting 13-year old boys. Thus, the obtained data prove a direct relationship between the elevated AP and the accumulated dose, vis. the number of hypertensions rises proportionally to the incorporated dose. Without ignoring the effect of a variety of adverse ecological factors of different chemophysical origin, the influence of socioeconomic conditions, a definite role of ionizing radiation in the observed AP modifications should be admitted.

Table 3.6

Distribution of boys (B) and girls (G) with different doses of accumulated radioisotopes based on the arterial pressure

Arterial pressure	Sex	Specific radioactivity, Bq/kg							
		<50		50–100		100–150		>150	
		n	%	*n*	%	*n*	%	*n*	%
Normal	B	21	70.0	8	47.1	4	40.0	5	45.4
	G	6	46.1	21	65.6	8	61.4	2	40.0
Borderline arterial hypertension	B	7	23.3	3	17.6	5	50.0	3	27.3
	G	4	30.8	8	25.0	2	15.4	2	40.0
Arterial hypertension	B	2	6.7	6	35.3	1	10.0	3	27.3
	G	–	–	1	3.1	1	7.8	–	–

Table 3.7

РАСПРЕДЕЛЕНИЕ (%) ДЕТЕЙ ПО СОСТОЯНИЮ АРТЕРИАЛЬНОГО КРОВЯНОГО ДАВЛЕНИЯ

Age		Normal	Borderline arterial hypertension	Arterial hypertension	Borderline arterial hypotension	Arterial hypotension
8	B	41	35	24	–	–
	G	72	17	11	–	–
9	B	67	33	–	–	–
	G	75	–	25	–	–
10	B	80	20	–	–	–
	G	45	45	10	–	–
11	B	63	31	6	–	–
	G	33	33	23	11	–
12	B	59	9	32	–	–
	G	50	25	25	–	–
13	B	66	17	–	–	17
	G	77	23	–	–	–

Note. B – Boys; G – Girls.

A significant role of modifications of the OVT and VR with the domination of sympathicotonias and hypersympathicotonias should be assumed in the mechanisms of origination of hypertensic conditions.

Thus, fewer children aged 8–13 years exposed to adverse ecological conditions have normal OVT with a significant number of sympathicotonic and hypersympathicotonic manifestationsresponses by the VNS. It can be considered as a factor leading to the appearance of the groups with a risk of evolution of the syndrome of vegeto-vascular dystonia with ensuing vegetative disorders in different organs and systems of the juvenile organism. A clear relationship has been established between the number of the children with the VNS dysfunction and the dose of incorporated ^{137}Cs. Accumulation of radiocesium in the organisms of children leads to a growing number of sympathicotonic and hypersympathicotonic variants of the VNS condition and hypertension.

It should be assumed that the revealed vegetative dysfunctions of the organisms of the children are provoked by a variety of factors of both chemophysical nature, including ionizing radiation in small doses, and by socioeconomic factors as well. Yet, our data make apparent the role of ionizing radiation among other etiologic factors in the evolution of VNS dysfunctions. Hence, the factor of radiation plays a rather substantial role in the pathogenesis of CVS disorders, presumably in the pathogenesis of disorders of other systems, tissues and organs among individuals in the radiation contaminated areas through an indirect effect of radiation upon the VNS.

The results of the longitudinal studies will serve as a tool to predict the tendencies of disorders of the vegetative homeostasis and to continue monitoring of the condition of health of the children and adolescents in the areas with adverse ecology, to project intelligently the actions of treatment and health improvement.

The obtained data dictate the need to perform radioanthropometric examinations of the children in these areas in order to evaluate individual radiation burden in order to identify targeted approaches and both to achieve reduction of the incorporation of radioisotopes and their elimination deploying various techniques and means of enterosorption [9].

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Chapter 4

CONDITION OF THE CARDIOVASCULAR SYSTEM AMONG THE STUDENTS OF THE GOMEL MEDICAL INSTITUTE

Pathologies of the cardiovascular system are leaders among the causes of morbidity and mortality in the world. During the last decade the registered incidence of cardiovascular diseases in the Republic of Belarus has increased three times. It is due to improved diagnostics of these pathologies and their actual propagation. It is confirmed by the rise of myocardium infarctions which have doubled and amounted to 11.7 per 10 thousand of adults in 1994 [2]. The incidence of cardiovascular disorders has increased among children and adolescents.

The problem has become specifically acute after identification of a number of adverse environmental factors in the Gomel region, among them ionizing radiation is the dominating factor; the major source being ^{137}Cs. The effects of ionizing radiation (both external and internal) upon the cardiovascular system require more profound studies. There are few publications relating to the evaluation of the condition of the cardiovascular system in response to the endogenous accumulation of radioisotopes among children [1].

Still there is a lot of ambiguity about the effect of ionizing radiation upon the cardiovascular system, specifically upon the electrophysical functions of the heart among young people aged between 17 and 20 years who are exposed both to the external and internal irradiation with ^{137}Cs. Hence, it has been believed quite essential to implement a comprehensive investigation of the cardiac functions, the pattern of metabolic processes among the individuals of this age group exposed to incorporated radioisotopes.

The objective has been to investigate the condition of the cardiovascular system among the 1st and 4th year students of the Gomel Medical Institute aged between 17 and 20 years living in the area with ^{137}Cs contamination 1–5 Ci/km^2 and exposed to the endogenous incorporation of radiation.

THE MAJOR TASKS

The major tasks have been the following:

1) To evaluate accumulation f radioactive elements from gamma-sources (primarily ^{137}Cs) among the students of the 1st and 4th years of the Gomel Medical Institute using a medical and radiological network.

2) To investigate the cardiac functions using cardiography among these groups of students.

3) To investigate the original vegetative status and the reactivity of the vegetative nervous system among these groups of students using cardiointervalography.

4) To assess the parameters of metabolism in the blood serum: triiodine thyronin, thyroxin, cortisol, alanin-aspartate aminotransferase, cholinesterase, gamma glutamil transferase, general protein concentration, albumin, general billirubin, urea, uric acid, creatinin, cholesterol, triglycirides, phosphorus, calcium, potassium, the erythrocyte, leukocyte count, the leukocytary formula.

5) To analyze the relationships between the indicators of electrocardiography, cardiointervalography and the concentration of radioactive elements accumulated by the organism.

MATERIALS AND METHODS

The present study has been implemented during 1994–1996 among the 1st and the 4th year students of the Gomel Medical Institute. The group included 325 individuals, among them 242 aged 17–20 years with 145 permanently residing in Gomel and in the

Gomel region with the ^{137}Cs soil contamination 1–5 Ci/km^2, 97 arrived from Grodno , Vitebsk and Minsk to continue their studies in Gomel, or from the areas with the ^{137}Cs soil contamination under 1 Ci/km^2. It is a worthwhile fact that this group who came from the "clean" areas had resided in Gomel for two years at the time the study started. At that time the students had no complaints about their health condition or any chronic diseases. In addition to general examinations and interviewing the cardiovascular system condition was evaluated at rest cardiographically in 12 standard connections using standard techniques. The condition of the vegetative nervous system and its reactivity were evaluated by orthostatic testing using the technique of cardiointervalography of Belokon, Curberg (1987) in order to determine the system's influence upon the cardiovascular system. For investigating humoral effects upon the cardiovascular system the concentrations of triiodine thyronin (T3), thyroxin (T4) and cortisol were determined in the blood serum, hematological studies and determination of biochemical indicators has been performed þ the human blood serum, ALT, AST, cholinesterase, gamma glutamin transferase, concentration of the general protein, albumin, general billirubin, urea, uric acid, creatinin, cholesterin, triglycerides, phosphorus, calcium, potassium.

Doses of internal accumulation of radionucldes as sources of radiation were determined using the medical and radiological monitoring network (MRM). The radiological soil studies served to identify the areas of living. Based on the endogenous accumulation of radiation 242 individuals were divided into three groups: the 1st group (53 individuals) with the doses of endogenous accumulation below 25 Bq/kg; the 2nd group (111 individuals) with the doses of endogenous accumulation below 45 Bq/kg; the 3rd group (78 individuals) with the doses of endogenous accumulation above 45 Bq/kg. Among the above groups a comparative analysis of variations of the cardiac electrophysiology, the hormonal and vegetative status have been most informative in the subgroups of

Table 4.1

Distribution of students among groups and subgroups

Groups	< 25 Bq/kg		26–45 Bq/kg		> 45 Bq/kg	
	I		II		III	
Numbers	53		111		78	
Subgroups	1	2	3	4	5	6
Numbers	27	26	71	40	47	31

the students (the 1st year students – subgroups 1, 3, 5; the 4th year students – subgroups 2, 4, 6). The qualitative distribution among the subgroups is the following (Table 4.1):

The following methods have been employed to solve the above tasks:

1) A synchron CX analyzer of Beckman Co. (USA) served for determination of biochemical indicators in the blood serum.

2) A standard method has been employed to determine the concentration of hemoglobin, erythrocytes, leukocytes and the leukocytary formula in the peripheral blood.

3) A set of reagents of the Institute of Biochemistry of the Belorussian Academy of Science has been used to determine the hormones of the thyroid gland and cortisol in the blood serum using a radioimmunological technique.

4) An electrocardiograph EKIT-03M2 plotted the heart functions at rest in 12 standard connections.

5) Cardiointervalography with registration of 100 complexes at rest on the back was performed during orthostatic sampling to evaluate the vegetative nervous system.

6) Variations of accumulation of radioisotopes as gamma sources were measured with the help of a radiological screening module (whole body screening).

The numerical material was processes using a variational statistics package.

RESULTS AND DISCUSSION

Electrocardiointervalography revealed 186 (76.85%) with disorders of cardiac functions from among 242 individuals. Modifications of cardiograms are the following: disorders of the rhythm and conduction – 49.50% (120 individuals); metabolic modifications 30.90% (75 individuals); modifications of repolarization processes in the myocardium and the vegetative nervous system (the parasympathetic compartment most often) 31.40% (76 individuals). An incomplete His right pès blockade is the most frequent rhythm and conduction disorder – 29.75% (72 individuals).

The numbers of cardiac disorders among the 1st and 4th year students in the examined groups basically coincide. Among 97 fourth-year students 71 individuals or 73.2% manifested such disorders, among 145 first-year students 115 individuals or 79.30% did. The average dose of accumulation of radiation in the groups of the 1st and 4th year students manifests basically no difference amounting to 44.59(1.93 among the 1st-year and to 48.32(3.76 among the 4th-year students, respectively ($P > 0.1$).

Investigation of the incidence of electrocardiographic disorders in response to the dose of endogenous accumulation of radiation has manifested a statistically valid growth of the number of the disorders as a function of the accumulated dose: group I – 54.70% and group III – 92.40% ($P < 0.05$). Similar statistics have been manifested by the 4th-year students with a more pronounced growth, the differences between subgroups 2 and 4 being 38.50% and 77.50%, respectively ($P < 0.05$); between subgroups 2 and 6 – 38.50% and 97.00%, respectively ($P < 0.02$). A pronounced tendency of the numbers of individuals with cardiographic disorders to rise has been manifested by the 1st-year students in the subgroups with larger accumulated doses.

A statistically valid difference among the cardiac disorders in the subgroups with the least accumulated doses (below 25 Bq/kg) has been observed among the 4th-year students (subgroup 2) – 38.50%, and the 1st-year students (subgroup 1) – 70.00% (P <

Table 4.2

Cardiography results

	< 25 Bq/kg		26–45 Bq/kg		> 45 Bq/kg	
Total examined in groups	53		111		78	
Cardiographic disorders in the groups	I		II		III	
	29(54.70%)		85(76.60%)		72(92.40%)	
Cardiographic disorders in the subgroups	1	2	3	4	5	6
	19 70.00%	10 38.50%	54 76.00%	31* 77.50%	42 89.00%	30** 97.00%

Note. * – $p < 0.05$; ** – $p < 0.02$.

0.05) (Table 4.2). Arrhythmias and blockades dominate in the incidence of cardiographic disorders with blockades of the right His pes scoring most. Numerical differences both between groups (between I and III) and subgroups IV (between 2 and 6) and I (between 1 and 5) have been validated statistically ($P < 0.05$) (Tables 3, 4). The analysis of metabolic disorders in the myocardium among the groups indicates that there are valid differences between the numbers of individuals in the groups with the above disorders: I – 18.86% and III – 39.74% ($P < 0.05$); such valid differences exist in the subgroups among the 4th-year students (subgroup 2 – 15.40% and subgroup 6 – 45.16%) ($P < 0.05$), meanwhile the subgroups of the 1st-year students manifest just a pronounced tendency (Tables 4.3, 4.4).

A similar situation is manifested by the analysis of the manifestations of the effects of the vegetative nervous system upon the myocardium: there are valid differences in the numbers of individuals in the groups (between I and III) and in the subgroups of the 4th-year students and just a tendency to rise in the subgroups of the 1st-year students. Thus, there is a statistically valid relationship between the dose of endogenous accumulation of radiation and the incidence of cardiovascular pathologies manifested by electrocardiography among young individuals, also among the stu-

Table 4.3

Distribution of the types of cardiographic disorders among the groups

Groups	< 25 Bq/kg I	26–45 Bq/kg II	> 45 Bq/kg III
Arrhythmias and blockades	19 (35.84%)	47 (42.34%)	54* (69.23%)
Metabolic modifications	10 (18.86%)	34 (30.63%)	31* (39.74%)
Manifestations of the effect of the vegetative nervous system upon the myocardium	7 (13.20%)	31 (27.92%)	38* (48.71%)

Note. * – $p < 0.05$.

Table 4.4

Distribution of cardiographic disorders according to their types among groups

	< 25 Bq/kg		26–45 Bq/kg		> 45 Bq/kg	
Subgroups	1	2	3	4	5	6
Arrhythmias and blockades	11 40.74%	8 30.76%	27 38.02%	20 50.00%	34* 73.84%	20* 66.68%
Metabolic modifications	6 22.22%	4 15.40%	19 26.70%	15 37.50%	17 36.17%	14* 45.16%
Manifestations of the effect of the vegetative nervous system upon the myocardium	5 18.51%	2 7.58%	21 29.57%	10 25.00%	22 46.80%	16* 51.61%

Note. * – $p < 0.05$.

dents who arrived from 'clean' areas of the Republic (the 4th-year students) and had lived in Gomel about two years by the time of the study. The latter manifest stronger modifications of the cardiovascular system compared with the students permanently residing in the contaminated area (the 1st-year students).

The analysis of the manifestations of the effects of the vegetative nervous system upon the myocardium manifests an identical situation: there are valid differences among the groups (between I and III) and among the subgroups of the 4th-year students and there is just a tendency to rise in the subgroups of the 1st-year students.

Thus, there is a statistically valid relationship between the dose of endogenous accumulation of radiation and the incidence of cardiovascular pathologies manifested by the ECG among the young individuals. The students who arrived from 'cleaner' areas of the Republic (the 4th-year students) and who had lived for two years in Gomel before the study demonstrate a stronger variability of the cardiovascular system compared with the students permanently residing in the contaminated area (the 1st-year students).

When evaluating the status of the vegetative nervous system among the students based on the cardiointervalographic data a rise of the number of individuals with the vagotonic original status and higher doses of accumulation are observed both in the groups (I – 11.32% and III – 25.64%) and in the subgroups of the 1st-year students (1 – 7.42% and 5 – 29.79%, which is not valid statistically), this relationship is not manifested by the 4th-year students, though the numbers with the sympathicotonic original status tend to reduce in the subgroups (2 – 30.78% and 6 – 16.40%).

The analysis of the vegetative nervous system's reactivity after the orthostatic test manifests that the number of individuals with larger accumulated doses manifesting the asympathicotonic reactivity tends to increase (I – 26.41% and III – 41.02%); a similar, yet statistically valid rise is manifested by the subgroups of the 4th-year students (2 – 11.53% and 6 – 38.43%, $P < 0.05$). No such relationship is manifested by the 1st-year students. There are valid differences in the numbers between the 1st and 4th-year students manifesting the asympathicotonic reactivity when the dose of endogenous accumulation is below 25 Bq/kg (1 – 40.70% and 2 – 11.53%, $P < 0.05$) (Table 4.5).

Thus, the subgroups of students who came to live in Gomel about two years ago manifest pronounced and statistically valid variations of the numbers of asympathicotonias as a function of the accumulated dose, those permanently residing in the radiation

Table 4.5

Analysis of the results of cardiointervalography in subgroups. Vegetative reactivity

	< 25 Bq/kg	26–45 Bq/kg	> 45 Bq/kg
4th-year subgroups	2	4	6
Asympathicotonia	3 (11.53%)	11 (27.50%)	12* (38.48%)
Normotonia	15 (57.69%)	18 (45.00%)	13(41.93%)
Hypersympathicotonia	8 (30.78%)	11 (27.50%)	6(19.35%)
1st-year subgroups	1	3	5
Asympathicotonia	11 (40.74%)	32 (45.07%)	20 (42.55%)
Normotonia	13 (48.14%)	26 (36.61%)	19 (40.42%)
Hypersympathicotonia	3 (11.12%)	13 (18.32%)	8 (17.03%)

Note. * – $p < 0.05$.

contaminated areas manifest no such relationship. In our view it is a reflection of the processes of adaptation of the organism to incorporation of radiation.

Evaluation of the metabolic status has indicated that among the students in the groups in which the dose of endogenous accumulation is higher, the cortisol concentration in the blood serum tends to increase: group I – 837.27±44.14 nMol/l and group III – 871.26±50.30. This tendency is more pronounced in the subgroups of the 4th-year students (856.44±74.49 nMol/l in the 2nd subgroup and 1035.89±43.31 nMol/l in the 5th subgroup).

There is a statistically valid difference in the concentration of cortisol within the discriminated subgroups: while the accumulated dose is 26–45 Bq/kg: 750.03 ± 36.27 nMol/l among the 1st-year students, it is 982.09 ± 68.45 nMol/l among the 4th-year students (P < 0.02); when the dose of accumulation is below 25 Bq/kg there is no valid difference in the cortisol concentration in the blood serum: I – 843.39±50.93 nMol/l and IV – 856.44±74.49 nMol/l (P > 0.1) (Table 4.6).

Thus, there are pronounced differences in the cortisol concentrations in the blood serum of the 4th-year students compared

Table 4.6

Concentration of hormones in the blood serum in the subgroups

	< 25 Bq/kg		26–45 Bq/kg		> 45 Bq/kg	
Subgroups	1	2	3	4	5	6
Cortisol	843.39± 50.93	856.00± 74.49*	750.03± 36.27*	982.09± 68.45	761.34± 43.31**	1035.89 ±103.25
Ttriiodine thyronin (T3)	1.42± 0.05**	1.91± 0.10	1.50± 0.04*	1.70± 0.07	1.45± 0.04	1.57± 0.06*
Thyroxin (T4)	93.28± 4.12**	119.45± 7.89	91.95± 4.93*	110.17± 9.59	91.74± 4.95	106.99± 9.74

Note. * – $p < 0.05$; ** – $p < 0.02$.

with the 1st-year students in the subgroups in which the doses of endogenous accumulation of radiation increase. In our view, the obtained data reflect the adaptation of the 4th-year students to the living conditions when their organisms are exposed to endogenous incorporation of radiation.

Analysis of the concentration of triiodine thyronin in the blood serum manifests its statistically valid (P < 0.05) reduction in the groups with larger accumulated doses: I – 1.66 ± 0.06 nMol/l and III – 1.50±0.03 nMol/l. A similar statistically valid reduction is manifested by the 4th-year students in the subgroups from 1.91±0.10 nMol/l – subgroup 2 to 1.57±0.06 nMol/l – subgroup 6 (P < 0.05) and absence of such variations among the 1st-year students. The concentration of T3 in the blood serum of the 4th-year students is higher in all three subgroups compared with the 1st-year students, these differences being statistically valid in the subgroups below 25 Bq/kg: 2 – 1.91 ± 01.10 nMol/l and 1 – 1.42 ± 0.05 nMol/l (P < 0.02); 4 – 1.70 ± 0.07 nMol/l and 3 – 1.50 ± 004 nMol/l (P < 0.05); 6 – 1.57 ± 0.06 nMol/l and 5 – 1.45 ± 0.03 nMol/l (P > 0.05) (Table 4.6).

Analysis of the concentration of thyroxin (T4) in the groups indicates that it tends to reduce as the dose of endogenous accumulation of ^{137}Cs reduces from 104.92±6.21 nMol/l – I to 97.10±4.48 nMol/l – III. A similar, yet a more pronounced tendency is manifested by the 4th-year students in the subgroups from 119.45±7.89 nMol/l subgroup 2 to 106.99 ± 9.74 - subgroup 6. No such relationship has been observed among the 1st-year students in their subgroups.

The concentration of T4 in the blood serum in the subgroups among the 4th-year students is higher than among the 1st-year students, this difference is statistically valid in the subgroups below 25 Bq/kg and 26–45 Bq/kg and amounts to:

2 – 119.45 ± 7.89 nMol/l and 1 – 93.28 ± 4.12 nMol/l ($P < 0.02$);
4 – 110.17 ± 9.59 nMol/l and 3 – 91.95 ± 4.93 nMol/l ($P < 0.05$);
6 – 106.99 ± 9.74 nMol/l and 5 – 91.74 ± 4.95 nMol/l ($P > 0.05$) (Table 4.6).

Thus, the concentration of hormones of the thyroid gland in the blood serum of the 4th-year students is a function of the accumulated dose of radiation and it may reflect the processes of adaptation of their organisms to exposure to radiation and specifically the impairment of metabolic processes in the myocardium.

The analysis of the concentration of enzymes in the blood serum in the students' groups, both cholinesterase and gamma glutamil transpeptidase, manifests that it tends to increase as the dose of endogenous accumulation of radioisotopes rises. The same, but a more pronounced tendency is manifested by the individuals permanently living in Gomel (the 1st-year students) among which the concentration of cholinesterase rises from 7416.07±294.32 U/L – subgroup 1 to 7879.16±311.15 U/L – subgroup 5; γ-glutamin transferase from 12.08±1.87 U/L – subgroup 1 to 17.95 ± 1.96 U/L – subgroup 5, meanwhile the 4th-year students who had come to live in Gomel two years before manifest an opposite tendency of the reduction of concentrations of the above enzymes in the subgroups. Moreover, the ALT and AST among the 4th-year students tend to increase in the subgroups with a larger dose of endogenous accumulation: ALT from 16.20±1.35 IU/l – subgroup 2 to

19.64±1.89 IU/l – subgroup 6; AST from 22.16±2.04 IU/l – subgroup 2 to 25.16±2.11 IU/l – subgroup 6.

Thus, a higher concentration of the CE and GGTP enzymes among the 1st-year students evidences a more profound disorder of metabolic processes on the part of the liver and the heart compared with the 4th-year students who arrived from 'cleaner' areas.

The accomplished study has revealed a specific vulnerability of young individuals to the incorporation of radiation; the organisms in the stage of adaptation are specifically vulnerable to such incorporation. A whole combination of modifications evolves evidencing both direct effects of endogenous incorporation of radioisotopes (^{137}Cs) upon the myocardium and indirect effects through the organs and system controlling the functions of the cardiovascular system.

Hence, it is a crucial problem to create utmost safe conditions of living in the areas contaminated with radiation and to reduce its incorporation by developing organisms as well as to elaborate actions to improve metabolic process in the myocardium

CONCLUSIONS

1. The 1st and 4th-year students of the Gomel Medical Institute aged between 17 and 20 years and living in the areas where the soil is contaminated with radiation, primarily with ^{137}Cs with the concnetration 1–5 Ci/km^2, manifest registerable electrophysiological modifications of the cardiovascular system in the following forms: (1) arrhythmias and blockades of various degrees of expression; (2) disorders of the metabolic processes in the myocardium; (3) manifestations of the effects of the vegetative nervous system upon the cardiac functions.

2. The incidence of the above pathological modifications among the 4th-year students directly depends upon the concentration of radiation (primarily ^{137}Cs) incorporated by the organism,

meanwhile the 1st-year students manifest just a pronounced tendency.

3. Modifications of the intraventricular conduction along the right pes of the His bundle are the most frequent disorders of the cardiac functions among these two cohorts of students.

4. Disorders of the cardiac functions relate to the modifications of the vegetative reactivity in the direction of the growing incidence of asympathicotonias as the dose of incorporated radiation increases, it is specifically typical for the 4th-year students who arrived to Gomel from 'cleaner' areas of Belarus.

5. Variations of the concentrations of the hormones of the thyroid gland and the adrenal cortex, the reactivity of cholinesterase and gamma glutamin transpeptidase in the blood serum depend upon the dose of endogenous accumulation of radiation in these two cohorts of students and they reflect the processes of adaptation of young organisms to the exposure to radiation.

6. The obtained results may be useful to elaborate actions of prevention and treatment of the cardiovascular functions among the individuals living in the areas contaminated with radiation.

The accomplished studies allow also to outline actions aimed at preventing the evolution of pathological modifications in the cardiovascular system and at facilitating the processes of adaptation of young organisms to the effects of small doses of ionizing radiation.

In our view these actions can be the following:

1. Strict monitoring of radiation levels incorporated by organisms with food.

2. The level of concentrations of radioisotopes among younger individuals should be considered as a marker of potential evolution of cardiovascular pathologies.

3. Younger individuals should undergo regular prophylactic examinations in the areas contaminated with radiation in order to identify risk groups.

4. Preparations should be developed and introduced which accelerate excretion of incorporated radioisotopes from the organism (enterosorbents).

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Chapter 5

IMMUNO-HEMATOLOGICAL ASPECTS OF THE JUVENILE ORGANISM UNDER THE EFFECT OF INCORPORATED RADIOISOTOPES

The Chernobyl disaster has provoked a variety of medical and biological problems, the most essential being the problem of preserving health of the affected population and future generations.

Disorders of the immunity and hemopoietic systems are known to play a significant role in the evolution of immediate and remote consequences of exposure to ionizing radiation. Modifications of the immunity and hematological parameters belong to the early manifestations of pathological responses due to strong vulnerability of lymphoid and hemopoietic tissues [5, 9]. These modifications lead to the inhibition of resistance of juvenile organisms in the contaminated areas. The rise of the incidence of acute respiratory viral infections [3], chronic infections among children and adolescents [2], appearance of allergic and autoimmune diseases [7] are the evidence.

Virtually, the problem of the effects of external and internal irradiation upon the juvenile organism has not been fully understood. In particular, comparative data are lacking about the modifications of the immunity and hemopoietic systems in response to the doses of internal accumulation of radiation among the children living in the contaminated areas. Therefore, screening studies of the immunity and hematological status of the children in the areas with different levels of radioactive contamination caused by the Chernobyl fallout have great practical significance.

For investigation of the status of the immunity and hemopoietic systems, 2070 children aged between 3 and 8 years who attended nurseries were examined manifesting a high incidence of disorders of the cardio-vascular, endocrine, digestive systems and organs of vision.

The children were divided into 7 groups:

group *1* – Gomel children (the concentration of ^{137}Cs in the soil is 1–5 Ci/km^2);

group *2* – children in Svetlogorsk who had been evacuated two years before the study from the areas with the concentration of ^{137}Cs in the soil over 40 Ci/km^2;

group *3* are children in Zhlobin ((the concentration of ^{137}Cs in the soil is below 1 Ki/km^2);

group *4* of children from Vetka (the concentration of ^{137}Cs in the soil is 15–40 Ci/km^2);

group *5* are the children from Stolbun (the concentration of ^{137}Cs in the soil is 5–15 Ci/km^2);

group *6* are children from Svetilovichi (the concentration of ^{137}Cs in the soil is 15–40 Ci/km^2);

group *7* is control from Grodno (the concentration of ^{137}Cs in the soil is below 1 Ci/km^2).

Based on their age the children were divided into 2 subgroups in each group: a) from 3 to 6 years; b) from 6 to 8 years (Table 5.1).

The following blood parameters were determined among the children: absolute erythrocyte count, total concentration of hemoglobin and determination of the color indicator (CI), absolute leukocyte and thrombocyte count, relative concentration of cell elements in the blood smear, erythrocyte precipitation rate (EPR).

The Medical and radiological monitoring MODULE (MRM) served to

measure the doses of internal accumulation of radioisotopes after laboratory tests among the children from Gomel (group *1*), Vetka (group *4*), from Stolbun (group *5*), Svetilovichi (group *6*),

Table 5.1

Distribution of children based on the age and place of living

Group	Community	^{137}Cs concentration in the soil (Ci/km^2)	Age	
			3–6	6–8
1	Gomel	1–5	176	59
2	Svetlogorsk	<1	34	53
3	Zhlobin	<1	574	250
4	Vetka	15–40	178	389
5	Stolbun	5–15	28	69
6	Svetilovichi	15–40	57	90
7	Grodno	<1	93	20
Total			1140	930

Grodno group 7). To evaluate the functions of the hemopoietic system 19 male rats of the 'Vistar' line with the body weight 250-320 were kept on a standard diet of 35 grams of grain a day during 10 days. The experimental and the control groups of the animals received grain with the concentration of ^{137}Cs 445.7 Bq/kg, ^{90}Sr 15.5 Bq/kg, the grain for the control group contained 44.2 Bq/kg of ^{137}Cs and 1.7 Bq/kg of ^{90}Sr. Based on the rations the experimental animals daily received with oats 16 Bq of ^{137}Cs, $54 \cdot 10^{-2}$ Bq of ^{90}Sr, the control animals daily received 10^{-2} Bq of 137Cs and $6 \cdot 10^{-2}$ of ^{90}Sr. Therefore, the radioactivity of the grain was primarily determined by ^{137}Cs.

The following investigation methods have been employed:

1. Determination of the erythrocyte count, concentrations of hemoglobin, leukocytes and thrombocytes, the leukocytary formula, the erythrocyte precipitation rate using standard techniques.
2. Common techniques served to determine the leukocyte and erythrocyte count, concentration of hemoglobin, the leukocytary formula among the 'Vistar' line rats.
3. Internal accumulated doses of isotopes were determined using the medical and radiological monitoring MODULE (MRM).

Table 5.2

Concentration of radioisotopes in the organisms of children (Bq/kg)

Community (group)				
Gomel (group 1)	Vetka (group 4)	Stolbun (group 5)	Svetilovichi (group 6)	Grodno (group 7)
30.32±0.66	70.53±8.86**	80.07±6.82**	106.54±31.29*	29.74±0.67

Note. * – $p < 0.02$; ** – $p < 0.001$ – valid differences versus group 7.

A γ-radiometer-92 served to measure the concentrations of ^{137}Cs in the organisms of the laboratory animals.

The obtained results were processed statistically using the Student criterion.

The average concentrations of the radioactive elements in the organisms of the main groups significantly exceeded the concentrations among the control children (Table 5.2).

Compared with the control, the analysis of the erythrocytary condition has manifested a valid reduction of the erythrocyte count in the blood among the children of all age groups living in the areas where soil contamination with ^{137}Cs exceeds 5 Ci/km^2 (Fig. 5.1), meanwhile the concentration of hemoglobin has manifested a valid rise (Fig. 5.2). The erythrocyte count among the children evacuated from the areas contaminated with ^{137}Cs in excess of 40 Ci/km^2 (Svetlogorsk) manifested significantly higher numbers of erythrocytes (the children aged between 3 and 6 years) or the numbers (the children aged between 6 and 8 years) correlated with the parameter in the control group.

Clinical and laboratory examinations of the children are corroborated by the results of studies of the erythrocytary condition among the laboratory animals kept on the diet with a significant concentration of ^{137}Cs. For example, the absolute erythrocyte count in the experimental group amounted to $8.49 \pm 0.13 \cdot 10^{12}$/l, it is validly less than $9.69 \pm 0.11 \cdot 10^{12}$/l in the control ($p < 0.001$). Yet, the concentration of hemoglobin has demonstrated an opposite

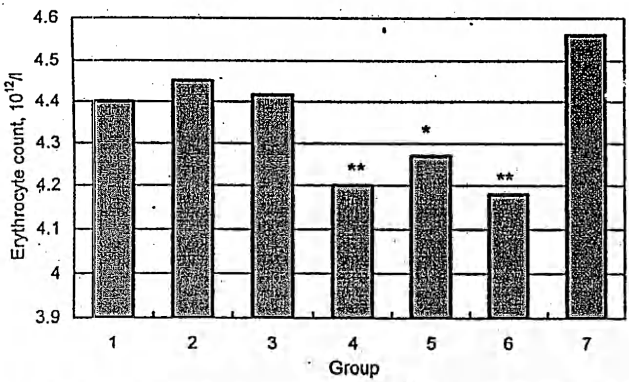

Fig. 5.1. Erythrocyte count among children aged 6–8 years. * $P < 0.05$, ** $P < 0.001$

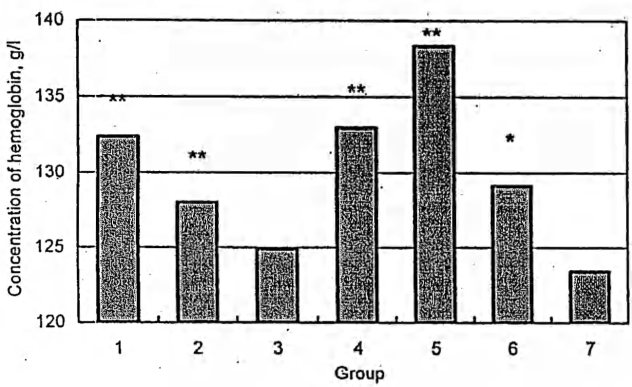

Fig. 5.2. Concentration of hemoglobin among children aged 6–8 years * P< 0.05, ** P< 0.001. *1* – Gomel, *2* – Svetlogorsk, *3* – Zhlobin, *4* – Vetka, *5* – Stolbun, *6* – Svetilovichi, *7* – Grodno

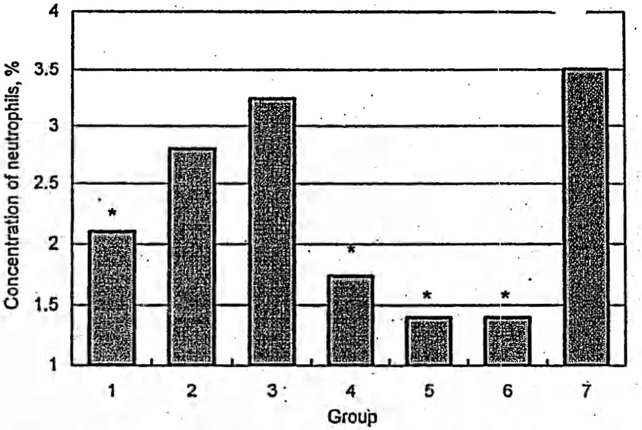

Fig. 5.3. Concentration of stab nuclear neutrophils among children aged 3 - 6 years ** $P < 0.001$

relationship; it amounted to 165.75 ± 3.41 g/l in the experiment and to 155.27 ± 3.43 g/l in the control, Hence, the children exposed to external and internal radiation manifest inhibition of the proliferative function of the hemopoietic system. The fact is corroborated by a number of reported studies [5, 8].

The process of saturation of the organism with iron has undergone substantial modifications. The children in the areas with adverse radiation conditions have manifested a valid reduction of the leukocyte count (6.50±0.08·10^9/l in Vetka and 6.40±0.17·10^9/l in Svetilovichi in the age group 6 – 8 years ($P < 0.05$). The relative concentration of form elements tended also to modify shoeing the reduction of stub stem neutrophils in each age group in Gomel, Vetka, Stolbun and Svetilovichi (Fig. 5.3).

The experimental animals after a significant incorporated dose of ^{137}Cs (62.76 ± 3.84 Bq/kg in the experiment, 9.76 ± 1.77

Bq/kg in the control) did not demonstrate any valid variations. Still, the relative count of stab nuclear neutrophils validly reduced in the experiment (1.30 ± 0.43)% versus (4.18 ± 0.89)% in the control ($P < 0.01$).

A statistically significant reduction of the relative monocyte count has been registered among the children in the areas of ^{137}Cs contamination over 15 Ci/km^2. These parameters were 4.15 ± 0.18 % in Vetka, 4.59 ± 0.32 % in Svetilovichi in the age group 3 – 6 years and 5.15 ± 0.16 % and 4.07 ± 0.28 % in the age group 6 – 8 years ($P < 0.05$). The relative lymphocyte count increased among 3 – 6 year-old children in Zhlobin (42.73 ± 0.44 %) in Vetka (46.92 ± 0.69 %), in Svetilovichi (46.67 ± 1.30 %), ($P < 0.05$), versus the control Grodno group.

Distribution of thrombocytes in the blood is worthwhile to be noted for both scientific and practical purposes. In particular, it has been proven that the lability of the thrombocyte generation process is an adverse precursor of the hemopoietic system condition among children. The children in the main groups have manifested rise of thrombocyte count, specifically it is pronounced in the age group 3 – 6 years (Fig. 5.4).

Clinical and laboratory evaluation of the hematological status of the juvenile organism has revealed a number of interrelated modifications determined by the degree of the effect of radioactive elements upon the organism.

Modifications in the hemopoietic system among children in the areas of contaminated with isotopes are reflected by the reduction of the relative numbers of erythrocytes and leukocytes in the peripheral blood, relative numbers of stub nuclear leukocytes and monocytes, by the relative rise of the numbers of lymphocytes and the absolute numbers of thrombocytes.

The obtained data correlate with the results yielded by the analysis of a huge bank of data from the hematological register of the Medical Radiological Center of the Russian Academy of Medical Sciences, Obninsk [5, 8].

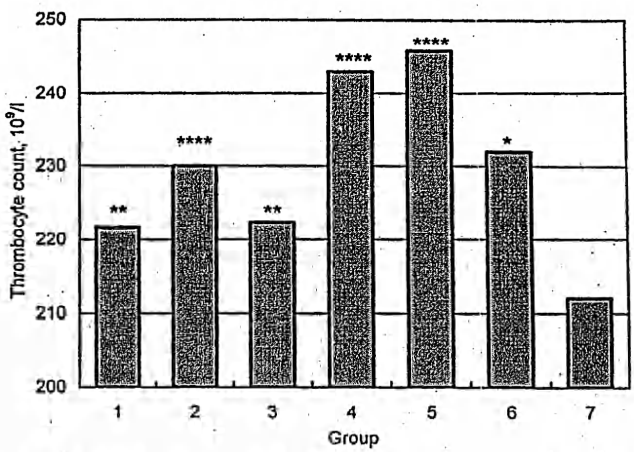

Fig. 5.4. Thrombocyte count among children aged 3 – 6 years: * $P < 0.05$, ** $P < 0.002$, *** $P < 0.01$, **** $P < 0.001$

The degree of expression of these modifications is in direct proportion to the expression of extra- incorporeal effect of radioisotopes, primarily ^{137}Cs, upon the juvenile organism.

After accumulation of ^{137}Cs in the amount 62.76 ± 3.84 Bq/kg the experimental rats of the Vistar line in the test group, versus 9.76 ± 1.77 Bq/kg in the control group, manifest reduction of the absolute erythrocyte count and the relative count of stab nuclear neutrophil leukocytes, while the lymphocyte count remains unchanged.

The children evacuated from the areas contaminated with ^{137}Cs in excess of 40 Ci/km^2 into the 'clean zone' manifest restoration of the physiological state of the myelocytary process.

The obtained data can be useful for projecting actions of prevention and treatment of pathological conditions of the hemopoietic and immunity system produced by the effects of internal and external irradiation of juvenile organisms.

Our previous publications reported the data about modifications of a number of parameters of the immune system under the effect of incorporated radioisotopes [1].

The present publication deals with the investigation of correlations between the concentrations of immunoglobulins of the most frequent classes M, J, A in the blood and the most essential biological substances. It is primarily significant for identification of the role of the immune system in the pathogenesis of structural and functional disorders of a number of vital organs and systems under the effect of radiation. Two groups of children from Gomel, as the main group (the ^{137}Cs contamination level in residential areas is 1 – 5 Ci/km^2) and from Grodno, as the control group (the ^{137}Cs contamination level in residential areas is below 1 Ci/km^2). The concentrations of immunoglobulins of M, J and A classes, thyroxin, triiodine thyronin, cortisol, billirubin, urea, creatinin, cholesterin, uric acid, total protein, albumins, glucose. calcium, phosphorus, triglycerides, alkaline phosphatase, lactate dehydrogenase, cholinesterase, amilase, alanin aminotransferase, aspartate aminotransferase, gamma glutamin transpeptidase reactivities were determined in the blood serum of the children.

The medical radiological monitoring system has served to determine the accumulation of radioisotopes from gamma-sources (primarily ^{137}Cs and ^{134}Cs).

The children in the main group have manifested a directly proportional correlation between the concentration of IgJ and T3, IgJ and glucose in the serum in response to the variations of concentrations of the radioisotopes in the organism. A similar relationship has been demonstrate by the concentrations of IgM and cortisol, IgM, IgA ad total protein in the blood.

The control children have manifested an inversely proportional correlation between the concentrations of IgJ and T3 and a directly proportional correlation between IgA and T4 in the blood.

The above parameters have manifested no correlation with the humoral immunity parameters.

These correlations evidence a close functional link between the immune and endocrine system. It becomes specifically clear considering the reported data about the potential of immunoglobulins of various classes (M, J, A) to bind thyroxin and triiodine thyronin [6].

When the metabolic chain loses the above hormones the functions of the hypophysis-thyroid system become upset releasing significant quantities of the thyreotropic hormone which stimulates the thyroid gland. It causes both structural modification of the thyroid gland and increases generation of T3 and T4 and their release into the blood.

They produce a pronounced effect upon a variety of vital organs and systems, specifically the cardiovascular and reproductive systems.

When IgJ and thyroid hormones are combined, it may evolve based on the previous specific autoimmunization caused by the effect of radioactive elements upon both the immune and endocrine systems.

This hypothesis is confirmed by the fact that the children in the main group manifest both correlation between the concentration of IgJ and T3 and between IgJ and glucose.

Considering the antigen affinity between the thyroid and pancreatic glands [4], the obtained data can be explained by specific immunological responses to the antigens of the same type by these two organs.

Meanwhile the children in the areas with the ^{137}Cs contamination below 1 Ci/km^2 manifest no such phenomena.

Thus, the accomplished study has revealed that the children in the areas contaminated with radioisotopes manifest typical metabolic modifications reflected by a close correlation between the number of immunoglobulins and hormones. It should by all means be remembered when investigating the pathogenesis of a number of disorders of endocrine organs, primarily, the endocrine and pancreatic glands.

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Chapter 6

CONDITION OF THE ORGANS OF VISION AMONG THE CHILDREN LIVING IN THE AREAS CONTAMINATED WITH RADIOSOTOPES

The organ of vision belongs to the organs most vulnerable to ionizing radiation [3]. Yet, little is known so far what structural modifications occur in the eyes of the children exposed to the effects of external and incorporated radiation. There are single reports about the pathologies of eyes among the individuals who suffered from the Chernobyl accident [2]. Experimentally it has been manifested that external irradiation causes abnormalities of the development of the optic nerve and the retina among laboratory animals [1]. A minimal cataract-inducing dose is 3–5 Gy [3] producing a significant opacity of the lens.

Proceeding from the reported data the objective has been to investigate the condition of the organs of vision among school-age children (7–16 years) living in the areas with different levels of radioactive contamination and in response to its accumulation in the organism.

To achieve the objective the ophthalmologic examinations were accomplished in 1996: *vision measurements* or determination of the sharpness of vision; *skiascopy* or determination of refraction; determination of the potentials of absolute accommodation; biomicroscopy; inverse ophthalmoscopy. The examinations covered 561 children living in the following communities of the Vetka district: in Vetka (the concentration of ^{137}Cs in the area amounts to 15–40 Ci/km^2); in Svetilovichi (the concentration of ^{137}Cs in the area amounts to 15–40 Ci/km^2); in Stolbun (the concentration of ^{137}Cs in the area amounts to 5–15 Ci/km^2). The control group included 103 children living in Gomel (the concentration of ^{137}Cs in the area amounts to 15–40 Ci/km^2). Examinations in 1997 covered 728 children in the same areas using the above ophthalmologic techniques (Table 6.6). The radiation monitoring networks has been employed to evaluate the accumulation of ^{137}Cs and other gamma-sources. The obtained results were processed statistically.

The examinations in 1996 revealed the most frequent pathological modifications of the organs of vision among the children living in the areas with ^{137}Cs contamination 15-40 Ci/km^2, meanwhile they are not as frequent among the children in the 'cleaner' areas and much less frequent in Gomel (Table 6.1). Each area included into the study manifested its own features (Table 6.2). In particular, cataracts are much more frequent among the children in Svetilovichi (49.2%), meanwhile destruction of the vitreous body dominates among the children in Vetka (26.2%). Examinations in 1997 revealed a similar pattern, yet with a somewhat lesser incidence of pathological conditions (Table 6.3, 6.4).

Based on the doses of incorporated radiation the children in main groups were divided into 3 subgroups – 0–20 Bq/kg, 21–50 Bq/kg and over 50 Bq/kg (Table 6.5). It is noteworthy that that number of the children with the accumulated ^{137}Cs doses in excess of 50 Bq/kg has reduced in 1997 significantly compared with 1996 (Table 6.6).

Analysis of the incidence of pathological modifications in the areas of the study allows to identify generally their forms, it has been observed that the incidence is directly proportional to the concentration of incorporated radioisotopes. This proportionality is specifically manifest in relation to cataracts (Table 6.7, 6.8).

A similar 'dose' relationship has been registered in individual areas in 1996 both in respect to the frequency of all pathological conditions (Svetilovichi and Stolbun) and their separate forms: cataracts among the children in Vetka, Svetilovichi; cyclastenias among the children in Svetilovichi and Stolbun; destruction of the vitreous body among the children in Stolbun; combined cataracts and destruction of the vitreous body among the children in Svetilovichi (Table 6.9).

Table 6.1

Incidence of pathologies of the organ of vision among children in the Vetka district in 1996

Community	Contamination with ^{137}Cs (Ci/km^2)	Number of examined children	Incidence of pathologies of the organ of vision	
			absolute	%
Vetka	15–40	294	276	93.9
Svetilovichi	15–40	130	123	94.6
Stolbun	5–15	137	79	57.7
Gomel	1–5	103	71	68.9

Table 6.2

Incidence of individual pathological conditions among the children examined in 1996

Pathological conditions of the organ of vision	Vetka		Svetilovichi		Stolbun		Gomel	
	absolute	percent of the total	absolute	percent of the total	absolute	percent of the total	absolute	percent of the total
Cyclastenia	62	21.1	23	17.7	15	10.9	29	28.1
Cataract	34	11.6	64	49.2	16	11.7	6	5.8
Destruction of the vitreous body	77	26.2	3	2.3	24	17.5	18	17.5
Abnormal refraction	61	20.8	11	8.5	18	13.1	18	17.5
Cataract and destruction of the vitreous body	39	13.3	9	6.9	6	4.4	–	–
Embryogenesis disorders	–	–	13	10.0	–	–	–	–
Others	1	0.3	–	–	–	–	–	–

Table 6.3

Incidence of pathologies of the organ of vision among the children in the Vetka district in 1997

Community	Contamination with ^{137}Cs (Ci/km^2)	Number of examined children	Incidence of pathologies of the organ of vision	
			absolute	%
Vetka	15–40	529	261	49.3
Svetilovichi	15–40	91	81	89.0
Stolbun	5–15	108	44	40.7

Table 6.4

Incidence of pathologies of the organ of vision among the children in the Vetka district in 1997

Pathological conditions of the organ of vision	Vetka		Svetilovichi		Stolbun	
	absolute	percent of the total	absolute	percent of the total	absolute	percent of the total
Cyclastenia	45	8.5	12	13.2	–	–
Cataract	51	9.6	40	44.0	9	8.3
Destruction of the vitreous body	15	2.8	3	3.3	–	–
Abnormal refraction	86	16.3	9	9.9	21	19.4
Cataract and destruction of the vitreous body	58	11	4	4.4	14	13.0
Embryogenesis disorders	–	–	13	14.3	–	–
Others	6	1.1	–	–	–	–

Table 6.5

Distribution of the children from main groups based on the incorporated dose of radiation in 1996

Incorporated dose, Bq/kg	Numbers of examined children							
	Total		Vetka		Svetilovichi		Stolbun	
	abs.	%	abs.	%	abs.	%	abs.	%
0–20	19	3.4	15	5.1	–	–	4	2.9
21–50	181	32.3	79	26.9	45	34.6	57	41.6
over 50	361	64.4	200	68.0	85	65.4	76	55.5

Table 6.6

Distribution of the children from main groups based on the incorporated dose of radiation in 1997

Incorporated dose, Bq/kg	Numbers of examined children							
	Total		Vetka		Svetilovichi		Stolbun	
	abs.	%	abs.	%	abs.	%	abs.	%
0–20	60	8.2	55	10.4	1	1.1	4	3.7
21–50	505	69.4	413	78.1	29	31.9	63	58.3
over 50	163	22.4	61	11.5	61	67.0	41	38.0

Table 6.7

Incidence of individual pathologies in response to the incorporated dose of radiation among the children in the Vetka district in 1996

Incorpo-rated dose, Bq/kg	Total numbers of pathologies		Cataract		Cyclastenia		Destruction of the vitre-ous body		Cataract and destruction of the vitre-ous body	
	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%
0–20	13	68.4	1	5.3	4	21.1	5	26.3	3	15.8
21–50	100	55.3	35	19.3	22	12.2	33	18.2	10	5.5
over 50	258	71.5	78	21.6	74	20.5	66	18.3	40	11.1

Table 6.8

Incidence of individual pathologies in response to the incorporated dose of radiation among the children in the Vetka district in 1997

Incorporated dose, Bq/kg	Total numbers of pathologies		Cataract		Cyclastenia		Destruction of the vitreous body		Cataract and destruction of the vitreous body	
	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%
0–20	25	41.7	7	11.7	2	3.3	8	13.3	1	1.7
21–50	250	49.5	57	11.3	39	7.7	82	16.2	11	2.2
over 50	111	68.1	36	22.1	16	9.8	26	15.9	6	3.7

Table 6.9

Incidence of individual pathologies in response to the incorporated dose of radiation among the children in 1996

Incorporated dose, Bq/kg	Total numbers of pathologies		Cataract		Cyclastenia		Destruction of the vitreous body		Cataract and destruction of the vitreous body	
	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%
Vetka										
0–20	12	80.0	1	6.7	4	26.7	5	33.3	2	13.3
21–50	51	64.6	6	7.6	13	16.5	25	31.7	7	8.9
over 50	149	74.5	27	13.5	45	22.5	47	23.5	30	15.0
Svetilovichi										
0–20	–	–	–	–	–	–	–	–	–	–
21–50	30	66.7	22	48.9	5	11.1	1	2.2	2	4.4
over 50	69	81.2	42	49.4	18	21.2	2	2.4	7	8.2
Stolbun										
0–20	1	25.0	–	–	–	–	–	–	1	25.0
21–50	19	33.3	7	12.3	4	7.0	7	12.3	1	1.8
over 50	41	54.0	9	11.8	11	14.5	17	22.4	4	5.3

Table 6.10

Incidence of individual pathologies in response to the incorporated dose of radiation among the children in 1997

Incorporated dose, Bq/kg	Total numbers of pathologies		Cataract		Cyclastenia		Destruction of the vitreous body		Cataract and destruction of the vitreous body	
	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%
Vetka										
0–20	23	41.7	6	10.9	2	3.6	7	12.7	1	1.8
21–50	201	48.7	40	9.7	37	9.0	69	16.7	11	2.7
over 50	37	60.7	5	8.2	6	9.8	10	16.45	3	4.9
Svetilovichi										
0–20	–	–	–	–	–	–	–	–	–	–
21–50	28	96.55	15	51.7	2	6.9	2	6.9	–	–
over 50	53	86.9	25	41.0	10	16.4	7	11.5	3	4.9
Stolbun										
0–20	2	50	1	25.0	–	–	1	25.0	–	–
21–50	21	33.4	2	3.2	–	–	11	17.5	–	–
over 50	21	51.15	6	14.6	–	–	9	21.95	–	–

A similar relationship has been clearly traced in respect to the incidence of all pathological conditions in Vetka and Stolbun (Table 6.10) in addition to the destruction of the vitreous body, yet the latter pathology is less frequent than in 1996.

Studies accomplished in 1996 have revealed that the children living in the areas contaminated with radiation manifest a higher incidence of pathological modifications of the organs of vision with their direct proportional relation to the concentration of ^{137}Cs. In a number of communities the registered frequency of pathological forms depends upon the radiation dose incorporated by organisms. The same situation was revealed by consecutive examinations of the children. Still, reduction of the accumulated doses of radiation from gamma-sources in the organisms of the children and the declining frequency of a number of pathological forms should be emphasized.

The study evidences a close relationship between the appearance of pathological modifications of the organ of vision and the amount of accumulated radiation in the organism, with cataracts and the vitreous body destruction manifesting a directly proportional dependence.

Therefore, elimination of radiation from the organisms of children and reduction of the radiation burden should be top-priority actions of treating pathologies of the organ of vision.

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Chapter 7

THE MOTHER–PLACENTA–FETUS SYSTEM UNDER THE EFFECT OF INCORPORATED RADIOISOTOPES

The current ecological situation is aggravated by the factors of contamination of the environment with radiation affecting negatively public health. As a result of the Chernobyl disaster in 1986 the Gomel region was contaminated with the products of decay of ^{134}Cs, ^{137}Cs. Contamination of the soil, plants and food with radioactive isotopes has made man exposed to a continuos effect of small doses of ionizing radiation and its accumulation in the organism.

The placenta is one of the most actively functioning organs in the organism of a gravid and the radioisotopes it accumulates inevitably affect the functions of the fetus-placenta complex. The placenta is the organ which maintains the formation, development and growth of the fetus [9]. Its role is extremely significant both for the physiological evolution of pregnancy and in case of adverse conditions of intrauterine fetus development. The placenta implements various functions of nutrition and gas exchange of the fetus, excretion of the products of metabolism, formation of the immunity status. In pregnancy the placenta, performing the functions of a hema encephalitic barrier when the fetus is lacking protection of the nervous centers and of the whole organism against pathogenic factors. The fetoplacentary complex generates the same hormones the endocrine female glands do without pregnancy, yet in the quantities 10-100 times exceeding the daily output of the classic endocrine glands [2, 7]. Such intensive biosynthesis of hormones by the fetoplacentary complex controls the process of gestation.

When radioactive substances penetrate into the mother's organism they may initially penetrate through the placentary barrier directly into the fetus causing disorders of the fetus development and simultaneously producing modifications in the mother's organism.

The potential of various radioactive substances to penetrate through the placenta has been evidenced in numerous studies [1]. Still, no data have been basically reported about accumulation of radioisotopes in the placenta and the features of functioning of the fetoplacentary complex in such conditions. Hence, investigation of these factors is absolutely worthwhile both for scientific and practical purposes.

The objective of the present study has been to investigate the morphological and functional characteristics of the mother-placenta-fetus links in response to the dose of accumulation of radioisotopes (primarily ^{137}Cs) in the placenta.

The tasks have been the following:

1. To investigate the relationship between the level of accumulation of radioactive substances in the placenta and the age, the blood type and the Rh-factor, the body weight, accompanying obstetric, gynecological and extragenital pathologies.

2. To evaluate the hormonal status of the mother and the fetus at various doses of accumulation of radioisotopes.

3. To identify structural modifications of the placenta in response to the concentration of radioisotopes.

4. To perform a clinical analysis of the evolution of labors, the postnatal and early neonatal periods with the account of the accumulated doses of radiation in the placenta.

The study at a maternity hospital from 1994 to 1996 has covered 210 deliveries among women who permanently live in the areas with the density of radioactive fallout 1–5 Ci/km^2.

The placentas were sampled among women after preterm deliveries, after deliveries via natural paths or after intervention, with the consideration of age, social status, the parities of deliveries,

Table 7.1

Distribution of new-born mothers among the groups based on the dose of accumulated radioisotopes

Group	Specific radioactivity, Bq/kg	Numbers of mothers	%
Control	0	19	9.05
1st	1–99	97	46.19
2nd	100–199	53	25.24
3rd	200 and over	41	19.52

obstetric and extragenital pathologies.

A gamma-counter PYT-90 served for measurements of concentrations of radioisotopes in the placenta, the results were computer-processes and converted into Bq/kg. The accumulated doses were within the range 0–1250 Bq/kg. No radiation was detected in 19 placentas which were included into the control group. The remaining placentas were divided into three groups based on the doses of radioisotopes shown in Table 7.1.

The pregnancy evolution, labors, postnatal and early neonatal periods based on records, files and histories of development of newly born infants were analyzed clinically in each case.

Blood was sampled among 74 out of 210 women from the ulnar vein and the funicle placentary end immediately after parturition. The vein was squeezed after the first inhalation of the neonate. The following hormones were determined in the serum using a radioimmunological method with a set of standard local-made reagents: estradiol, progesterone, testosterone, triiodine thyronin, thyroxin and prolactin.

102 placentas out of 210 were subjected to pathoanatomical studies for determination of weight, thickness, the placentary-fetus factor. Sections of the tissues about 2 cm wide from the central, paracentral and macroscopically modified sites fixed with formalin and cast into paraffin were subjected to microscopic studies. After dying with hematoxylin-eosin the preparations with sections 4–8

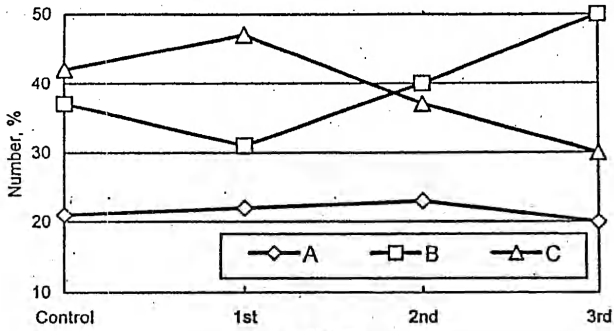

Fig. 7.1. Distribution of mothers (%) on age at the moment of Chernobyl disaster in 1996. *A* – 11 years and younger; *B* – 12–14 years old; *B* – 15 years and older

μm thick were studied with the help of an illuminating microscope.

The obtained data were processed statistically using variational techniques, the variations were validated using the *t*-criterion of Student. Groups *1, 2, 3* were compared with the results in the control group manifesting statistically valid variations ($p < 0.05$) marked in the text, in the Tables and graphs with '*' sign.

The accomplished studies have revealed that mothers after parturition who were 11-year old (the prepuberty period) and younger at the moment of the Chernobyl disaster numbered approximately the same in all the groups – 21–24.5%. The number of mothers who were 12–14 years in 1986 was gradually increasing together with the accumulated doses of radioisotopes in placentas (the control group – 36.8%, groups *1* – 30.9%; *2* – 39.6%; *3* – 51.2%), while the number of mothers in the post-puberty period during the disaster manifested an opposite tendency (the control group – 42.2%; groups *1* – 46.42%; *2* – 35.9%; *3* – 29.3%). Hence, accumulation of radioisotopes in placentas was more inten-

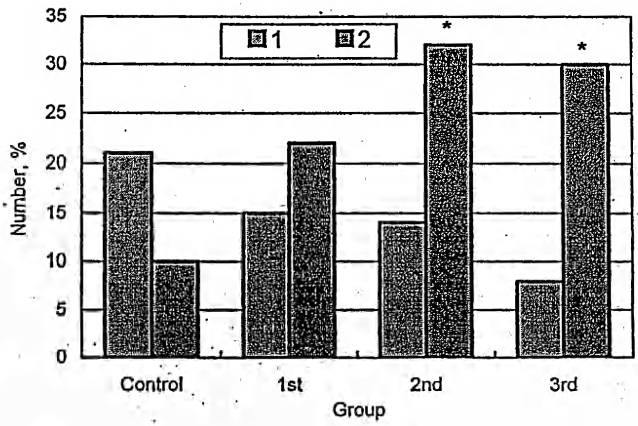

Fig. 7.2. Results of gynecological analysis (%). *1* – menarche in 15 years and older; *2* – pathologies of the ovaries

sive during the disaster among the women at the stage of inception of menstrual functions (Fig. 7.1).

The anamnetic data have manifested the effect of the menstrual function upon the concentration of radioisotopes in the placenta. The delayed menarche (15 years and older) occurred among 21.05% of new mothers in the control group, among 15% in the first and the second groups and just among 7.3% in the third group. Before conception the accumulation of radioisotopes in the placenta is stimulated by various pathologies of the ovaries, such as chronic adnexitis (the control group – 5.26%; groups *1* – 0%; *2* and *3* – 24.5%), dysfunction, aldodysmenorrhea, primary infertility, apoplexy. Generally the following data have been obtained: the control group – 10.52%; groups *1* – 21.64%; *2* – 32.06%; *3* – 29.85%* (Fig. 7.2).

The accompanying extragenital pathologies have manifested

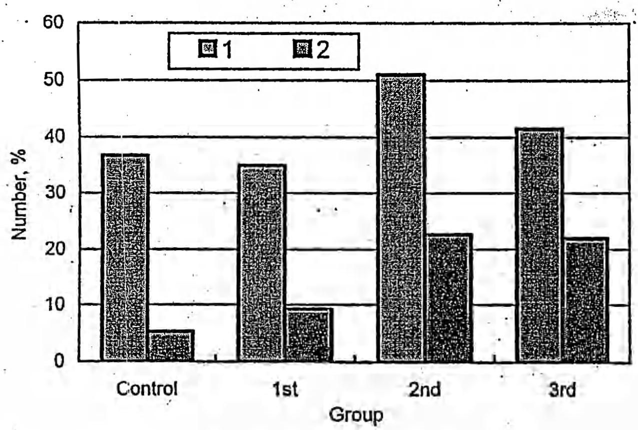

Fig. 7.3. Pregnancy evolution with risk of interuption (%). *1* – during all pregnancy; *2* – in 1[st] three-month period

a direct relationship between the accumulated radiation dose in the placenta and the pathologies of the cardiovascular system relating primarily to its functions: the control group – 10.52%; groups *1* – 16.49%; *2* – 17.01%; *3* – 30.22%. The data obtained during the follow-up of pregnancy evolution evidence that the condition of formation of the placenta influences the accumulation of radiation. The risk of pregnancy interruption during the initial three months was the following: the control group – 5.26%; *1* – 9.27%; *2* – 22.64%; *3* – 21.95%.

No relationship has been observed between the risk of pregnancy interruption and the accumulated dose in the placenta during the second and the third three-month periods. In general, pregnancy evolution with the risk of interruption occurred among 36.84% in the control group, among 35.05% in the first, 50.94% in the second and 41 46% in third groups (Fig. 7.3).

No relationship has been established between the numbers of preceding induced or spontaneous abortions and the dose of radioisotopes in the placenta.

The dose of accumulation of radioactive substances among gravidas pregnant for the first time was 146.52 ± 151.48 Bq/kg, among the gravidas pregnant for the second time 90.97 ± 89.3 Bq/kg. The overwhelming majority of mothers delivering for the first time were in the puberty period (12–14 years) during the disaster in 1986.

Studies of the effect of the blood type and Rh-factor upon the accumulation of radioisotopes by the placentas have yielded the following results. Placentas of Rh-negative women validly accumulate less radiation 88.76 ± 79.19 Bq/kg on the average, the Rh-positive accumulate 137.53 ± 168.74 Bq/kg ($P < 0.01$). The Rh-negative in the control group were 36.84% compared with 18.56% in the first, 22.64% in the second and 9.75% in the third groups. Also, a direct relationship has been established between the numbers of mothers with B (III) blood types and the dose of accumulation of radioisotopes in the placenta and an inverse relationship among the mothers with the A (II) blood type. The data are shown in Fig. 7.4.

Since the ^{137}Cs dose in the placenta is governed both by the incorporation of radioisotopes and their migration, it can be assumed that radioactive cesium becomes bound by protein antigens in the blood on the surfaces of erythrocytes and it is thus transported from the gastric tract to other organs. This assumption is corroborated by the studies among the students of the Gomel Medical Institute. The average dose of accumulation of radioisotopes by Rh-negative students amounts to 18.09 ± 3.88 Bq/kg, by the Rh-positive students 23.81 ± 8.22 Bq/kg ($p < 0.01$). Thus, a definite relationship is traced between the accumulation of radioisotopes in the organism and protein antigen determinants on the surfaces of erythrocytes which make up the Rh-factor.

The body weight, among other factors affecting the accumu-

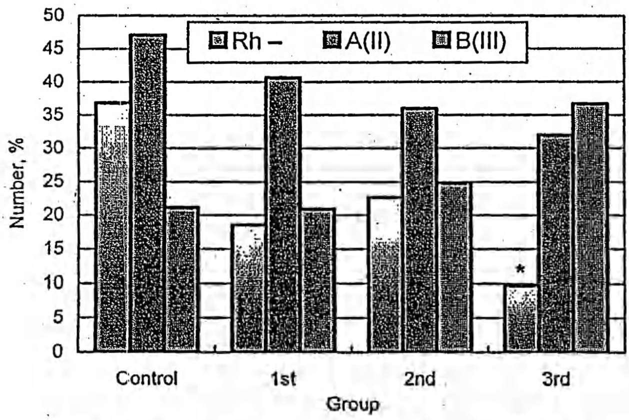

Fig. 7.4. Distribution of mothers on the blood groups and *Rh*-factor (%)

lation of radioactive substances in the placenta, has significance. The numbers of women with normal body weight reduces as the dose of accumulation increases, while the numbers of women with different degrees of obesity demonstrate a more pronounced expression (Fig. 7.5).

Evaluation of the hormonal status of 74 mothers and fetuses has allowed to divide them into the following groups: the control group , the first group – 25 cases, the second group 18 cases and the third group 22 cases. Tables 7.2 and 7.3 list the concentrations of steroid and thyreoid hormones in the blood of mothers and fetuses.

Estradiol concentration in mothers' blood in all the groups amounted to about 20.44 nMol/l on the average, the lowermost normal concentration during the first three months was 30 nMol/l. The concentration of testosterone in all the groups was 10.16 nMol/l on the average exceeding the maximum normal limit by 5

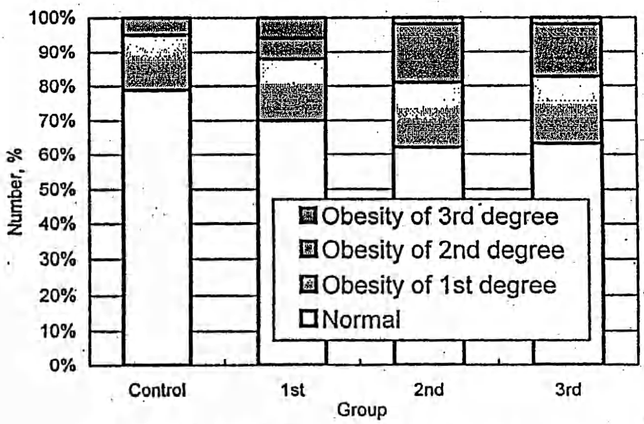

Fig. 7.5. Distribution of mothers on the body weight (%)

nMol/l. The number of new mothers with the testosterone concentration above normal was 33% in the control group, 48% in the first, 61% in the second and 73% in the third groups.

Estradiol concentration in the blood of fetuses validly reduces as the dose of radioisotopes in the placenta increases. Unlike estradiol, the concentration of testosterone validly increases (Figs. 7.6–7.8).

The concentration of estradiol among mothers versus the concentration among fetuses in all the groups amounted to 0.9 on the average (the reported data [2]) indicate it from 2 to 2.5). Testosterone among mothers versus testosterone among fetuses reduces from 1.89 in the control group to 0.49 in the third group. Also, as the accumulated dose in the placenta increases, the estradiol/testosterone ratio manifests reduction, which is more pronounced in the fetus blood. The values of the factors are listed in the Table 7.4. Due to pronounced individual variations of testosterone concentrations in the

Table 7.2

Concentrations of steroid and thyreoid hormones in the peripheral blood of mothers (nMol/l)

Hormone	Group			
	Control	1st	2nd	3rd
Estradiol	21.23±9.31	23.38±8.12	18.23±9.78	18.6±6.13
Testosterone	7.85±11.41	10.7±13.07	11.62±11.46	10.83±8.91
Progesterone	161.4±38.1	157.6±35.8	168.1±40.6	172.1±47.9
Cortisol	1884,9±757.1	1923.2±661.5	2141.7±859.8	2864.5±518.9*
Triiodine thyronin	2.03±0.41	2.67±0.81*	2.18±0.58	2.81±0.67*
Thyroxin	153.8±15.9	173.2±27.6*	182.2±52.6*	181.9±35.7*

Note. * – in reference to the control group, $p < 0.05$.

Table 7.3

Concentration of steroid and thyreoid hormones in the funicular blood of fetuses (nMol/l)

Hormone	Group			
	Control	1st	2nd	3rd
Estradiol	27.61±9.23	24.54±8.13	18.19±8.7*	20.92±6.78*
Testosterone	4.15±5.75	8.46±16.18	9.65±12.46	22.22±23.5*
Progesterone	187.5±34.7	203.0±42.6	190.7±47.2	193.3±43.6
Cortisol	1678.6±843.9	1022.1±353.4	1007.9±551.1*	1129.2±617.1
Triiodine thyronin	1.72±1.06	1.65±0.57	1.49±0.44	1.53±0.42
Thyroxin	140.4+38.3	143.6+52.2	142.2+48.9	141.7+46.5

Note. * – in reference to the control group, $p < 0.05$.

blood of mothers and fetuses the estimations of testosterone factors are relative based on average figures.

The progesterone concentration is validly higher in the blood of the fetus than in the blood of the mother: 195.05 ± 42.88 nMol/l and 164.93 ± 40.75 nMol/l, respectively ($P < 0.05$), yet the concentration of these hormones tends to increases among the mothers from the control group to the third group. The ratio between the

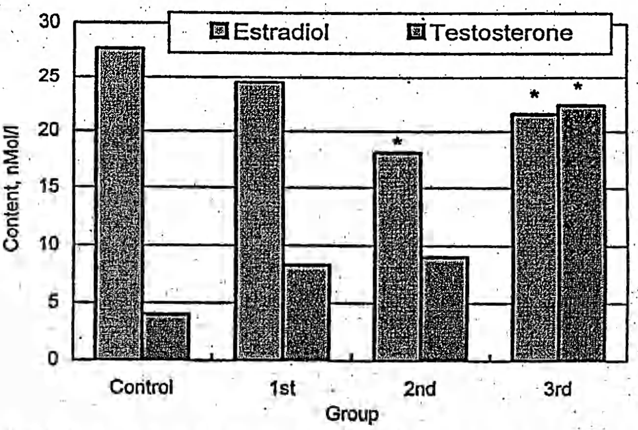

Fig. 7.6. Content of estradiol and testosterone in fetus umbilical blood (nMol/l)

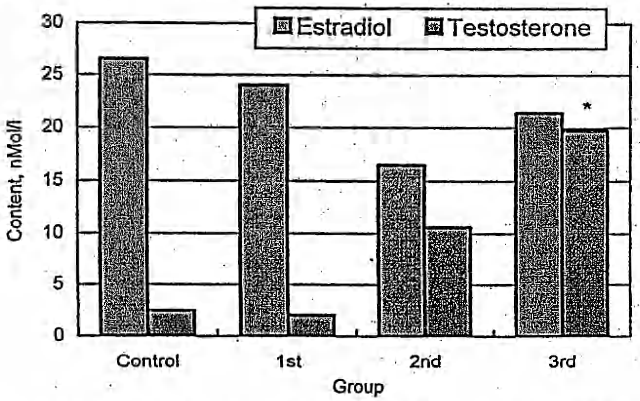

Fig. 7.7. Content of estradiol and testosterone in female fetus umbilical blood (nMol/l)

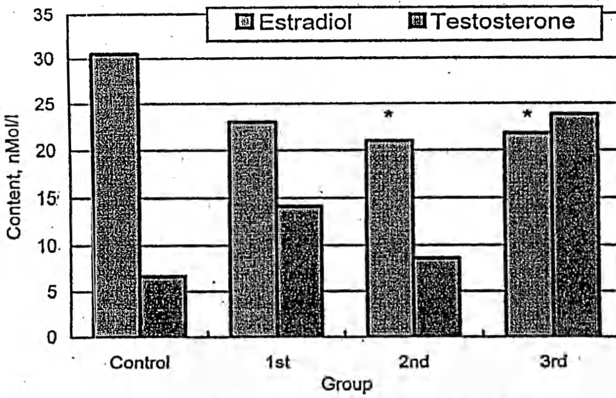

Fig. 7.8. Content of estradiol and testosterone in male fetus umbilical blood (nMol/l)

Table 7.4

Ratios of hormones in the mother (m) and fetus (f) blood

Ratios	Group			
	Control	1st	2nd	3rd
T3m/T3f	1.15±0.46	1.82±0.93*	1.65±0.73*	1.96±0.70*
T4m/T4f	1.16±0.30	1.35±0.51	1.42±0.64	1.38±0.41
Cm/Cf	1.92±1.53	2.24±1.65	2.45±1.24	3.15±1.86
Em/Ef	0.76±0.32	0.98±0.21	0.94±0.27	0.91±0.20
P/m/Pf	0.88±0.20	0.80±0.18	0.90±0.18	0.91±0.25
Tm/Tf	1.89	1.27	1.20	0.49
Em/Tf	2.70	2.18	1.57	1.71
Ef/Tf	6.65	2.90	1.88	0.94
Pm/Em	7.60	6.70	9.22	9.25
Pf/Ef	6.79	8.27	10.48	9.23

Note. * – in reference to the control group, $p < 0.05$.

mother's progesterone and the fetus' progesterone is 0.88 on the average. The reported ratio [7] between progesterone and estradiol in the mothers' blood at the moment the labors start is 1.2–2.0, our data show a significantly higher ratio from 7.6 to 9.25, which tends to increase as the concentration of radioisotopes in the placenta goes up. These hormones manifest similar ratios in the blood of fetuses.

Determination of thyreoid hormones in the mother's blood has revealed a valid rise of average thyroxin and triiodine thyronin concentrations in response to the accumulated dose of radioisotopes in the placenta, so do the coefficients of mother thyroxin / fetus thyroxin and mother triiodine thyronin/ fetus triiodine thyronin correspondingly. The fetus blood does not manifest any dynamic variations of concentrations of these hormones. In general, the concentration of triiodine thyronin (1.62 ± 0.6 nMol/l) and thyroxin (142.26 ± 47.39 nMol/l in the fetus blood is validly lower than in the mother's blood: 2.51 ± 0.74 nMol/l ($P < 0.05$) and 175.49 ± 36.86 nMol/l ($P < 0.05$), respectively.

Also, the mother's blood manifests a valid rise of the concentration of cortisol in response to the accumulated dose of radioisotopes in the placenta, the cortisol concentration in the fetus blood changes in the opposite direction (Fig. 7.9.). The mother cortisol/ fetus cortisol ratio rises from the control towards the third group. In general, the concentration of cortisol is validly higher among mothers than among fetuses: 2254.54 ± 791.25 nMol/l and 1122.5 ± 571.79 nMol/l ($P < 0.05$), respectively.

Dynamic variations of prolactin concentrations in response to the accumulated dose in the placenta have not been registered. The average prolactin concentration is validly higher in the blood of fetuses – 5321.94±2002.11 mME/l than in the blood of mothers – 4619.39±2140.17 MME/l ($P < 0.05$). The concentrations of prolactin among female fetuses and their mothers is 5906.06 ± 1874.23 MME/l and 5104.16 ± 2284.28 mME/l or validly higher

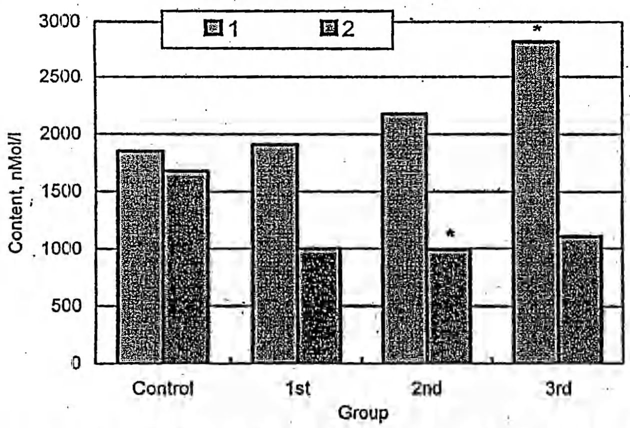

Fig. 7.9. Content of cortisol in blood of mother (*1*) and fetus (*2*) (nMol/l)

than among male fetuses and their mothers – 4673.04 ± 1955.44 (P< 0.05) and 4063.43 ± 1836.81 mME/l (P < 0.05), respectively.

The clinical analysis during parturition and the post-parturition period have yielded the following data. The numbers of delayed and induced deliveries increase as a function of the dose of radioisotopes in the placenta (Table 7.5) with the tendency to rise from the control group to the third group (Fig. 7.10).

The numbers of deliveries with the complications of placenta separation and excretion in this period are 15.78% in the control; 30.43% in the first; 24.0% in the second; 26.71% in the third groups. Complications in the post-natal period relating to the residue of the placentary tissue and membranes, inhibited uterus involution, increase as a function of the accumulated radiation dose in the placenta (the control group – 15.78%; groups *1* – 16.3%; *2* – 20.0%; *3* – 31.7%), including the uterus subinvolution requiring administration of therotonics (the control group – 15.78%; groups

Table 7.5

Frequency of delayed and induced labors (%)

Type of complications	Group			
	Control	1st	2nd	3rd
Delayed labors	–	14.43	16.98	4.76
Induced labors	10.52	24.74	22.64	24.31

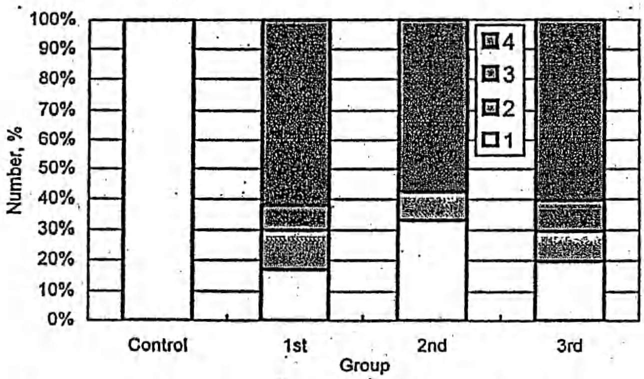

Fig. 7.10. Reasons of induced labors: *1* – belated pregnancy; *2* – late toxicosis; *3* – other reasons; *4* – premature water unburdening

1 – 11.95%; *2* – 18.0%; *3* – 29.26%). The numbers of operative interventions increase correspondingly to the numbers of pathologies during the post-delivery and placenta excretion periods and the dose of accumulated radioisotopes in the placenta (Fig. 7.11).

The rise of the average quantities of blood losses through natural paths has been manifested amounting to 242.1 ± 96.6 ml in the control group; 272.2 ± 80.1 ml in the first*; 281.2 ± 145.6 ml in the second; 267.1 ± 96.6 ml in the third groups. Variations of the proportion of different types of blood losses are demonstrated in Fig. 7.12 for each group.

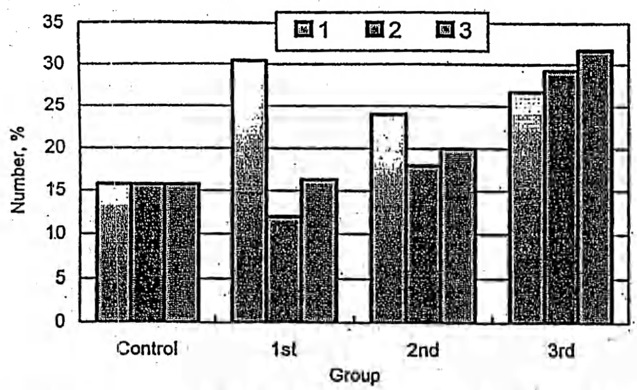

Fig. 7.11. Complications of placentar and post-natal periods (%). *1* – abnormal placenta separation; *2* – uterus subinvolution; *3* – total

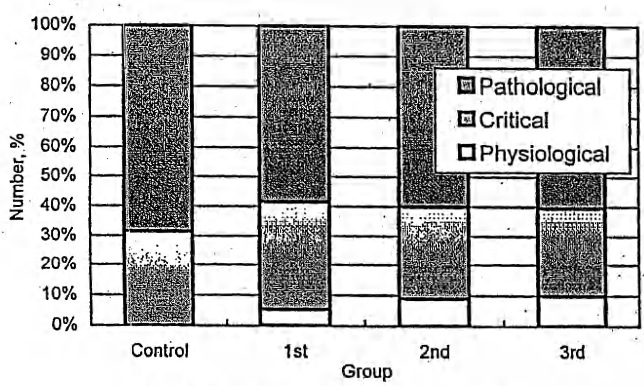

Fig. 7.12. Types of the blood losses at labor

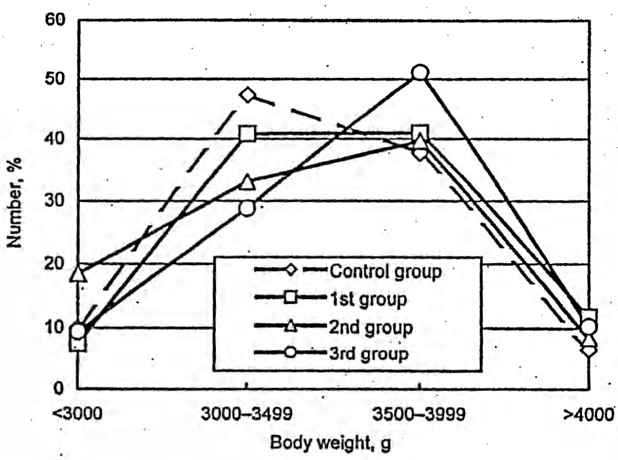

Fig. 7.13. Distribution of new-born children on the body weight (%)

The clinical analysis of the histories of development of the newly born has manifested that the doses of accumulation of radioisotopes in the placentas of female and male fetuses almost coincide amounting to 138.06 ± 157.82 Bq/kg and 142.98 ± 159.71 Bq/kg. Correlation of the body weights of the neonates and the dose of radioisotopes in the placenta has revealed domination of the neonates weighing from 3,000 g to 3,499 g in the control group (47.37%), meanwhile the majority of the neonates in the second and the third groups weigh from 3,500 to 3,999 g (39.62% and 51.21%) (Fig. 7.13). The chronic intrauterine hypoxia was detected among 10.52% of the fetuses in the control group, 18.56% in the first, 28.3%* in the second and 21.95% in the third groups, asphyxia of the neonates occurred in 9% cases, irrespective of the dose of accumulation of radioisotopes in the placenta. The total number of the neonates with pathologies in the early neonatal pe-

Table 7.6

Ratio between terminal and intermediate villuses in placentas of females of basic groups

Indicator	Group			
	Control	1st	2nd	3rd
Terminal villuses	13.43±2.39	13.79±3.08	11.5±2.44	10.73±1.16*
Intermediate villuses	4.26±0.62	4.8±0:62	4.31±0.6	4.88±0.67
Ratio between terminal and intermediate villuses	3.18±0.57	2.86±0.6	2.7±0.59	2.22±0.29*

Note. * – in reference to the control group, $p < 0.05$.

riod amounted to 15.7% in the control group, 28.86% in the first, 33.96% in the second and 29.26% in the third groups. Pathoanatomical examinations of placentas have manifested a tendency of growing weight in response for the dose of radioisotopes: 514.9 ± 109.1 g in the control group, 546.5 ± 121.1 g in the 1st, 554.9 ± 84.5 g in the 2nd and 546.5 ± 121.1 g in the 3rd groups. The placentary-fetus factor stayed within 0.156–167.

It is reported [6] that mature terminal villuses containing 5–6 capillaries and arranged over the periphery form syncyocapillary membranes in the spots where syncyotrophoblasts disappear. It is demonstrated by the placenta histologically during a physiological pregnancy evolution in all fields of vision. One membrane out of three is represented primarily by collagen fibers and a slight concentration of reticulocytes. The histological patterns of the placentas in the 2nd and 3rd groups manifest a significant number of intermediate villuses as the number of terminal villuses reduces (Table 7.6). The villuses are coated with syncyotrophoblasts, their stroma is rough with a great number of connective tissue cells which compress the fetus capillaries and displace them towards the center. In their turn, the syncyocapillary membranes reduce in the terminal villuses extending the paths of diffusion and delivery of nutritive substances, casing transition from passive transport mechanisms of the substances to active transport processes through hyperfunction of the syncyotrophoblasts and the endothelium of vessels. Individual terminal and intermediate villuses manifest significant clusters of syncyotrophoblasts evidencing intensification of the processes of generation of hormones, primarily in the median zone of the cytoplasm and around the nuclei. The above modifications are less pronounced in the placentas of the control and the first groups.

Taking into consideration the data reported in publications, it can be assumed that structural modifications of villuses, with the loss of hormonal equilibrium in the mother's and fetus' blood, can be attributed to high doses of accumulated radioisotopes in the placenta (over 100 Bq/kg). We have established that the rise of testosterone concentration against the background of estradiol concentration decline, which is stronger pronounced in the fetus blood, allows to identify more accurately the site of the damaged chain of the biosynthesis of steroid hormones in the placenta: transformation of testosterone into estradiol is arrested.

It is worthwhile to note that the concentration of triiodine thyronin, thyroxin and cortisol in the mother's blood rises from the control group towards the third group in direct proportion to the concentration of testosterone in the fetus' blood; meanwhile the latter does not manifest any variations of thyreoid hormones, while cortisol reduces. In our view, these variations are due to the stimulating effect of higher concentrations of testosterone and a milder effect of estradiol upon the hypothalamus-hypophysis system of the mother followed by stronger generation of tropic hormones. The rise of cortisol concentration in the mother's blood may inhibit the synthesis of the hormone by the fetus' adrenal glands, or accumulation of radioisotopes upsets the transport of cortisol through the placenta.

There is a number of reports [4, 8] indicating that higher doses of androgens affect the hypothalamus nervous structures and the fetus limb system modifying the brain sex differentiation in the period of sexual maturity and later during the reproductive period.

The microscopic variations we have detected in the structure of the placenta and lack of equilibrium among hormones determine complications during labors among the women of the 2nd and 3rd groups. The observed rise of delayed and induced deliveries in response to the accumulation of radioisotopes in the placenta may be attributed to the growing progesterone/estradiol ratio in the mother's blood from 7.6 to 9.25.

These modifications govern the pathologies of the post-parturition and post-natal periods compelling to resort to operative interventions with all ensuing consequences.

Summarizing the accomplished studies it can be asserted that intricate metabolic modifications in the mother-placenta-fetus system occur with specific clinical and morphological manifestations due to significant accumulation of radioisotopes. The pathogenetic mechanism revealed by us allows to project actions to prevent pathological mechanisms and pathological conditions among mothers and fetuses provoked by incorporated radioisotopes. The fact should be taken into consideration that females affected by the Chernobyl disaster in the period when the menstrual function appears have accumulated significant doses of radioisotopes. These doses cause more frequent obstetric and gynecological disorders, hence they should be referred to specific groups together with their children for close out-patient follow-up.

CONCLUSIONS

1. Females permanently living in the areas contaminated with radioactive fallout in concentrations 1–5 Ci/km^2 manifest accumulation of radioisotopes in the placenta (primarily ^{137}Cs) from 5 to 1,250 Bq/kg leading to metabolic, structural and functional modifications in the mother-placenta-fetus system with the degree of expression dependent upon the accumulated dose.

2. Accumulation of radioisotopes is directly proportion to the body weight of females, pathologies of ovaries before pregnancy,

cardiovascular disorders, evolution of the pregnancy with a risk of interruption during the first three months. Rh-positive females accumulate significantly more radioisotopes in their placentas than Rh-negative females. The majority of females with high accumulated doses in their placentas were in the pubescent period during the Chernobyl disaster in 1986.

3. Mother's blood manifests a directly proportional relationship between accumulation of radioisotopes in the placenta and concentrations of testosterone, triiodine thyronin, thyroxin, cortisol, and testosterone in the fetus blood, the latter manifests an inverse proportionality of the concentration of cortisol and estradiol.

4. Accumulation of radioisotopes in the placenta leads to its structural modifications most pronounced as a function of the accumulated dose, these modifications are accompanied by the loss of hormonal equilibrium.

5. The processes of accumulation of radioisotopes find clinical manifestations immediately after delivery and during the postnatal period due to disorders of separation of the placenta and remaining tissues, neonates show a tendency of having larger body weights, chronic intrauterine hypoxias number more in response to the rising accumulated doses.

6. The obtained data can be useful to project actions of prevention and treatment of pathological conditions caused by the effect of incorporated radioisotopes among pregnant women and infants.

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Chapter 8

EXPERIMENTAL EVALUATION OF DECORPORATING EFFECT OF PECTOPAL ENTEROSORBENT AND ITS CAPACITY TO INFLUENCE THE METABOLISM UNDER THE EFFECT OF RADIOISOTOPES

Elimination of radioisotopes from organisms of individuals living in the areas affected by the Chernobyl disaster is one the most crucial tasks. A variety of means are proposed to stimulate decorporation of radiation. Enterosorbents have a promising potential due to their simple administration and the mechanism of action among other compounds causing decorporation of radiation from the gastrointestinal tract. It is specifically meaningful when radioisotopes are incorporated enterally with food. Yet, various compounds differently absorb radioisotopes, specifically ^{137}Cs, moreover some of them strongly affect the metabolism and modify the organism internal homeostasis [1].

Research is underway for developing new compounds capable to bind isotopes and eliminate them from the gastrointestinal tract without upsetting the metabolism in the organism.

Pectopal created by the Academician V.V. Strelko with colleagues is a new compound of pectins and clay. Its predecessor is a sorbent containing 60% of modified clay and 40% of dextrin, the adsorption and metabolic behavior of the compound had been reported before [1]. However, the effect of pectopal proper upon the condition of the organism in the process of enteral incorporation of radioisotopes has not yet been studied.

The present Chapter deals with the effect of pectopal upon accumulation of ^{137}Cs in the organisms of experimental animals and ensuing metabolic modifications.

In the study 40 male common bred albino rats weighing 200–250 grams were divided into two groups – experimental and control. The first group received a daily ration of oats containing 400 Bq/kg of ^{137}Cs during 45 days. Its concentration in the oats for the control group during the same period was 40 Bq/kg.

After the 20th day of the experiment a subgroup was separated which received daily intragastrically 200 mg of pectopal. Accumulation of ^{137}Cs in the groups was registered every five days after the experiment started.

The animals from these groups were decapitated on the 46th day to evaluate the following hematological parameter: concentration of hemoglobin, erythrocyte , leukocyte counts and their varieties in the blood; the blood serum was prepared for checking the following parameters: urea, creatinin, total protein, albumins, aspartate aminotransferase, alanin amino transpeptidase using a biochemical Synchron CX-4 analyzer of the Beckman Co. The results were processed using the Student's criterion.

The results have manifested that enteral accumulation of ^{137}Cs by the organisms of male albino rats is accompanied by its progressive accumulation (Fig. 8.1), unlike the control group animals showing no such accumulation.

The intragastrinal administration of the pectopal compound during 25 days would significantly reduce the ^{137}Cs concentration in the organisms of the experimental animals. The last measurements manifested that the concentration of this radioisotope in the organisms of the experimental animals amounted to 101.95 ± 19.69 Bq/kg in contrast to 13.66 ± 3.39 after administration of the sorbent ($P < 0.01$).

Accumulation of radioisotopes in the organisms of albino rats increases the concentrations of urea, creatinin, general protein in the blood serum, compared with the control evidencing significant

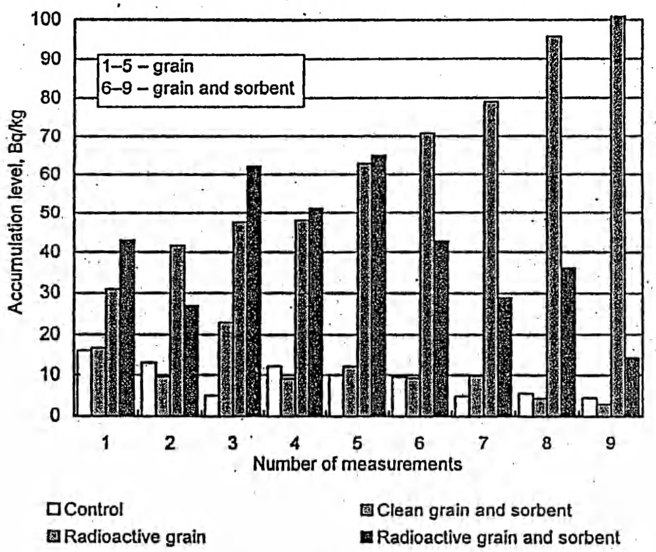

Fig. 8.1. Dynamics of accumulation of radioisotopes by control experimental rats

modifications of the protein exchange. Administration of pectopal eliminates these pathological effects (Table 8.1).

Incorporation of radioisotopes in combination with pectopal produces no substantial modifications of the major pathological parameters compared with the control.

Thus, the accomplished study has manifested that pectopal is capable to eliminate ^{137}Cs from the organisms of albino rats in the experiment when the compound is administered intragastrically. The protein exchange is restored after the upsetting effect produced by the incorporated radioisotopes. Considering this effect of pectopal it can be recommended for clinical application when radioisotopes, primarily ^{137}Cs, are incorporated via enteral paths.

Table.8.1

Variations of metabolic parameters among experimental animals

Parameters	Experimental group		Control group
	radioactive grain	radioactive grain and sorbent	clean grain
Urea, mmol/L	4.67±0.34	3.99±0.36	3.80±0.37
Creatinin, mmol/l	41.20±1.60*	37.25±2.68	33.11±2.45
Total protein, g/l	76.70±3.59*	61.38±1.95	61.11±4.35
Albumins, g/l	13.90±0.94	11.00±0.46	12.00±0.80
ALT, IU/l	43.80±4.29	33.25±2.45	40.67±5.37
AST, , IU/l	198.70±12.80	211.63±21.33	190.56±17.17

Note. * – $p < 0.05$ versus control group.

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CONCLUSION

Results of several years of studies at the Gomel Medical Institute manifest that the population in the areas affected by the Chernobyl disaster is exposed primarily to the negative influence of the radioisotopes incorporated by the organism through the food chain, ^{137}Cs, ^{134}Cs ^{90}Sr, in the first place. The degree of accumulation of some of these elements in tissues and organs is determined by a number of factors:

(1) concentration in food;
(2) age;
(3) sex;
(4) blood type and group;
(5) physical condition;
(6) action of agents upon the incorporation of radioisotopes by the gastrointestinal tract or their excretion;
(7) structural and functional features of tissues and organs.

The largest concentrations of gamma isotope sources (^{137}Cs) has been registered in the organisms of the individuals in the communities where forest mushrooms and berries are included into the diet and which are collected in the areas with the highest contamination. These radioisotopes contribute to the accumulating doses directly proportionally to age and their doses increases in the organism. Senior children have larger accumulated doses than juniors.

Experimental and clinical studies have manifested that females accumulate considerably less radioisotopes than males in the same conditions of existence. A relationship has been established between the degree of incorporation of ^{137}Cs and Rh group.

It should be emphasized that accumulation of radioisotopes in pregnancy rises sharply many times, primarily in the placenta, causing a pronounced hormonal disorder of the organisms of the mother and the fetus which is definitely to affect future development. Penetration of ^{137}Cs into the embryo is minimal among mammals and man since they have the hemochorial placenta structure evidenced by the barring action of this provisory organ.

Accumulation of radioisotopes is governed by environmental factors in many respects affecting the organism and the gastrointestinal tract primarily. Among these factors the agents capable to sorb radioisotopes and to excrete them from the organism occupy a specific place.

Such preparations or enterosorbents have different chemical structures and different sorption capabilities in respect to ^{137}Cs. Based on the data collected by the Gomel Medical Institute, clayey-pectin compounds, pectopal specifically, are the most promising ones. These preparations are capable to provide complete protection of the organism against the radioisotopes penetrating into the organism enterally.

It should be emphasized that the objective evaluation of the effect of the radioisotopes upon the human organism has become possible only after an experimental model has been created based on the studies of incorporation of radioisotopes by laboratory animals in a natural way.

Diets (grain, beef) containing ^{137}Cs and ^{90}Sr have allowed to achieve incorporation of these radioisotopes by the laboratory animals adequate to their accumulation by the population living in the contaminated areas.

Natural incorporation of radioisotopes upsets metabolic processes in the vital organs with gravest victims being the organs and tissues in which physiological conditions for proliferation of cells are insignificant or lacking. Hence, they continuously accumulate ^{137}Cs. Possibly, this radioisotope produces its negative influence primarily due toxic effects intervening with metabolic processes and damaging cell's membrane structures. The process results in functional disorders of numerous vital systems of the organism, particularly the nervous and cardiovascular systems.

Meanwhile the hemopoietic system is damaged insignificantly due to continuous proliferation and death of hemopoietic elements.

The ionizing effects of long-living radioisotopes will find their manifestation after a considerable period of time, therefore, the primary task of medical science and practice in the Chernobyl-affected areas is to create conditions for eliminating radioactive elements from the human organism.

With this in view, projected actions to accelerate decorporation of radioactive elements from the organism or to prevent their incorporation will create conditions for safe living in the areas affected by the Chernobyl disaster. Also, a continuous monitoring of the health condition is a prerequisite for early detection of diseases caused by the effect of radiation and for their successful treatment.

LIST OF ABBREVIATIONS

AP	Arterial pressure
APF	Absolute physical fitness
BWD	Body weight deficit
CIG	Cardiointervalography
CNS	Central nervous system
COT	Clinical orthostatic test
DBP	Diastolic blood pressure
EBW	Excessive body weight
FCC	Frequency of cardiac contractions
LC	Lung capacity
LP	Latent period
LPMRL	Latent period of motoric responses to light
LPMRS	Latent period of motoric responses to sound
LPSR	Latent period of sensomotoric responses
OVT	Original vegetative tone
PD	Physical development
PF	Physical fitness
RPF	Relative physical fitness
SBP	Systolic blood pressure
VNS	Vegetative nervous system
VR	Vegetative response

CONTENTS

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