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Ways to Optimize Measures to Reduce Post-Radiation Reactions in Cancer Patients Under Radiation Therapy

[1]Akhmadalieva Nigora Odilovna, [2]Salomova Feruza Ibodullaevna, [3]Sharipova Sazhida Akhmetjanovna, [4]Sherkuzieva Guzal Fakhritdinovna, [5]Muyassarova Mukhabbat Mukhammadievna, [6]Mirsagatova Mavluda Rikhsillayevna
Tashkent medical academy, Uzbekistan

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Abstract
The article is devoted to one of the problems of modern medical radiology - to ensure radiation protection of cancer patients during radiation therapy and improve the quality of their future life, based on a comprehensive assessment of the actual state of radiation protection of patients during the period of radiation therapy in oncological hospitals. The features of the characteristic signs of damage after radiation therapy of cancer patients are presented. Recommendations are presented to improve the quality of life of patients undergoing radiation therapy, it is necessary to use a differentiated approach and use a wider range of recommendations aimed mainly at reducing the severity of general body reactions.

Oncological diseases are considered diseases, the timely detection and proper treatment of which creates the prerequisites for a very favorable prognosis. In the treatment of these diseases, as well as in the diagnosis, a large role belongs to radiation methods based on the use of the damaging effect on cells of ionizing radiation (IR).

Radiation therapy (RT) is one of the most important methods of cancer treatment. However, in addition to other side effects, RT can cause post-radiation reactions (PCR), which can lead to a significant deterioration in the quality of life of patients. Therefore, the optimization of measures to reduce PLR is a very important task in oncological practice and is a priority and relevant.

One of the main factors influencing the risk of developing PCR is the individual patient's sensitivity to radiation therapy. Therefore, the use of an individual approach to treatment is an important measure to reduce the risk of PCR. This includes a preliminary assessment of the patient's sensitivity to radiotherapy and determining the optimal dose of radiotherapy for each patient. You should also take into account the age, health status, anthropometric parameters of the patient, and other factors that may affect the sensitivity to radiotherapy.

At a sufficiently high level of exposure, any living object can be killed by this radiation, but it turned out that living organisms respond to any level of exposure to these radiation. The nature of the effects that arise in a living organism depends on many factors: the type of irradiation, its energy, dose, duration of irradiation, the irradiated tissue (organ), individual sensitivity, and others.

Despite the great importance of post-radiation reactions and complications, in recent years, one can note a slight decrease in the attention of researchers to this problem: very rare works characterizing the frequency of such reactions in patients exposed to radiation, their quality of life in the post-radiation period, clinical efficacy and the nature of drugs that increase radioresistance of healthy tissues and used in clinical practice. There are practically no works considering the possibilities of protecting patients during radiation therapy. These circumstances became the basis for the present work.

The aim of the study was to scientifically substantiate the need to use an extended range of measures to ensure radiation protection of cancer patients during radiation therapy and improve the quality of their future life, based on a comprehensive assessment of the actual state of radiation protection of patients during the period of radiation therapy in oncological hospitals.

Methods and objects of research. To identify the need to use an expanded range of measures to ensure the radiation protection of cancer patients during

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radiation therapy in our republic and improve the quality of the patients' later life, a comprehensive assessment of the actual state of radiation protection of patients during the period of radiation therapy was carried out in one of the leading oncological institutions of the republic - the Republican Oncology scientific center (ROSC). The methods of radiation therapy used were studied, organizational measures were assessed in preparing patients for irradiation, and the doses of irradiation of patients were analyzed from the standpoint of generally accepted recommendations. The procedure for conducting irradiation sessions in 50 cancer patients was studied, and their assessment from the point of view of the nature and sufficiency of measures to protect parts of the body and organs not involved in the pathological process, radioprotective measures used before irradiation, during the irradiation sessions, and at the end were identified irradiation. During the research, the analytical method, the method of observation, and the socio-hygienic method were used.

Research results.

As a result of the research, it was revealed that the leading oncological institution of the republic - ROSC - uses a fairly narrow range of radiation therapy methods, which, nevertheless, are modern, using appropriate equipment: remote irradiation - in 50-82% of cases, contact radiation therapy – from 20% to 50% of cases. Organizational measures in preparing patients for irradiation (taking into account the form and stage of the disease, choosing the method of irradiation, calculating the dose and its fractionation, and preparing patients for irradiation sessions) correspond to the generally accepted procedure for pre-radiation preparation of cancer patients. The radiation doses of patients used in the ROSC mostly correspond to generally accepted recommendations and average 50-75 Gr; only when irradiated with RGM does the radiation dose reach 80-85 Gr. During direct sessions of irradiation of patients, radiation protection of parts of the body and organs not involved in the pathological process is carried out, however, no radioprotective measures are taken before irradiation. In the vast majority of patients (from 71 to 100%), after 1-2 sessions of irradiation, a complex of negative reactions is noted, the nature of which to a certain extent depends on the type of irradiated tumor and the radiation dose. 2-3 weeks after the end of exposure, the variability of post-radiation reactions increases, but their frequency in some forms of the disease (esophageal cancer) decreases somewhat. At the end of irradiation, to improve the quality of life of patients, all of them are recommended measures aimed at reducing the frequency and severity of post-radiation reactions, however, these recommendations are the same for all patients and do not take into account either the radiation dose, or the type of cancer, or the nature of post-radiation reactions. It is concluded that to improve the quality of life of patients undergoing radiation therapy, it is necessary to use a differentiated approach and use a wider range of recommendations aimed mainly at reducing the severity of general body reactions. As practical recommendations, suggestions are given on the use of additional measures both during the irradiation sessions and after the end of radiation therapy.

Therefore, careful monitoring of the patient's condition before, on time, and after irradiation, and the implementation of appropriate measures can improve the well-being of patients, and increase the survival time. For the prevention and treatment of post-radiation complications, primary attention should be paid to the skin and mucous membranes, because. under any type of irradiation, these organs are necessarily involved in the number of irradiated tissues. In the occurrence of post-radiation injuries, the values of single and total absorbed doses, and intervals between irradiation sessions are of decisive importance. Tolerant doses that cause wet epidermis without subsequent necrosis are 2000-7000 rad (20-70 Gr) [55].

Discussion.

The methods of radiation therapy for cancer are constantly being improved, and the technologies and sources of ionizing radiation used are expanding, which makes radiation therapy more effective. At the same time, during radiation therapy, not only the tumor is exposed to radiation, but, to some extent, the entire body of the patient. Without taking into account this danger, the patient's quality of life can be significantly reduced, even if the underlying disease is successfully treated. The issues of quality of life in irradiated oncological patients in our republic have so far been only the subject of characterization of certain aspects of post-radiation reactions, without their systematic study. All this makes it possible to consider the problem of ensuring radiation protection of cancer patients during radiation therapy as a rather relevant, humane aspect of sociopathology therapy, which

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allows not only prolongs the life of such patients but also improves its quality.

To identify the need to use an expanded range of measures to ensure the radiation protection of cancer patients during radiation therapy in our republic and improve the quality of the patients' later life, a comprehensive assessment of the actual state of radiation protection of patients during the period of radiation therapy was carried out in one of the leading oncological institutions of the republic - the Republican Oncology scientific center (ROSC). The methods of radiation therapy used were studied, organizational measures were assessed in preparing patients for irradiation, and the doses of irradiation of patients were analyzed from the standpoint of generally accepted recommendations. The procedure for conducting irradiation sessions for oncological patients was studied, and their assessment from the point of view of the nature and sufficiency of measures to protect body parts and organs not involved in the pathological process, radioprotective measures used before irradiation, during irradiation sessions and after irradiation were identified. During the research, the analytical method, the method of observation, and the socio-hygienic method were used.

Many researchers believe (Ivanitskaya V.I. et al., 1989; Gorbunova V.A. et al., 2000; Moskvina N.A., 2004; Tkachev S.I. et al., 2011; Panshin G.A. ., 2012) that reactions occurring immediately after irradiation resolve spontaneously within the next 1-2 weeks. Our research revealed a slightly different picture. After 2-3 weeks after the end of the entire course of irradiation, we noted an increase in the number and nature of post-radiation reactions.

The article presents the features of the characteristic signs of damage after radiation therapy in cancer patients and also presents recommendations for improving the quality of life of patients undergoing radiation therapy, it is necessary to use a differentiated approach and use a wider range of recommendations aimed mainly at reducing the severity of general body reactions. As practical recommendations for specialists in this field of medicine, suggestions are given on the use of additional measures both during irradiation sessions and at the end of radiation therapy.

Irradiation conditions for the studied group of patients. To solve the tasks set, a survey interview of 50 adult patients who received radiation therapy (RT) at the Republican Scientific Cancer Center (RSCC) was conducted.

The statistics of oncological diseases show that the main part of these diseases is registered at the age of 35-60 years. In this regard, the contingent of patients selected by us corresponded to this age - 77.1% of the studied patients had an age of 36 to 56 years (Fig. 1)

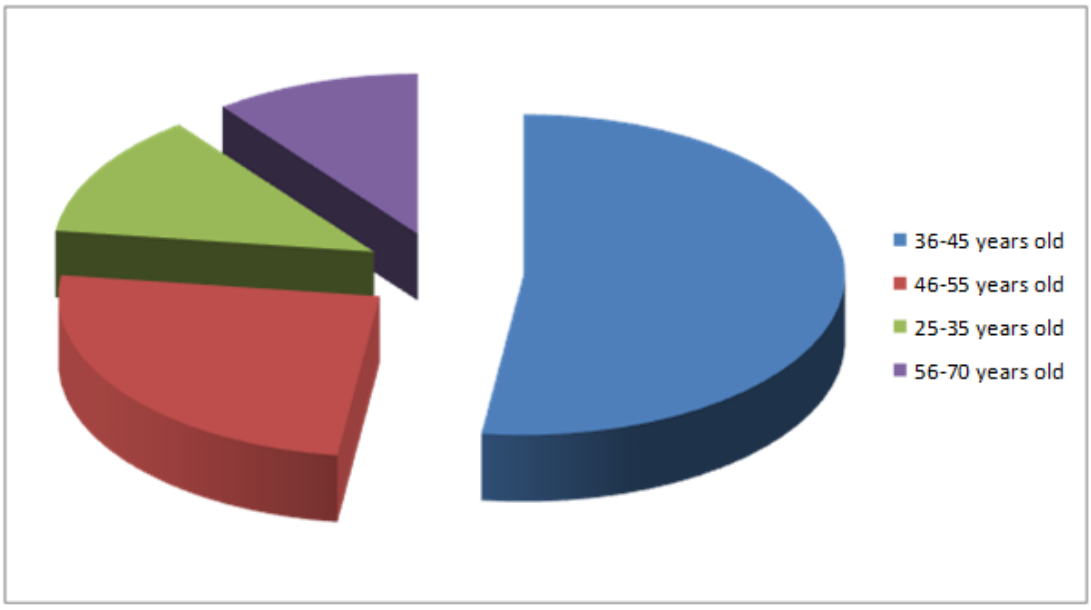

Fig.1. Age of the examined patients, %

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The study included patients with 4 forms of pathology: breast cancer (BC), cervical cancer (CC), brain cancer (BC), and esophageal cancer (EC). The choice of three forms of pathology - breast cancer, cervical cancer, and EP - was because these types of malignant neoplasms (MNs) occupy leading positions in the structure of sociopathology. The choice of patients with RGM is because, for this form of pathology, radiation therapy is one of the main types of medical procedures. Of the studied patients, 31.2% were patients with RP, 27.1% - breast cancer, 22.9% - breast cancer, and 18.8% - cervical cancer.

Depending on the type of cancer and the stage of development of the disease, it is planned to use the conditions for conducting radiation therapy. It was revealed that the planning of conditions for the irradiation of patients in a given institution is determined based on a consultation in each specific case.

Analysis of the materials of copying of case histories and individual exposure maps of patients showed that various methods of radiation therapy were used to treat the studied group of patients (Table 1)

Table 1. Methods of radiation therapy of the studied patients, %

Treatment methods used	Form of MN			
	breast cancer	cervical cancer	Brain cancer	esophageal cancer
Radiation therapy as an independent type of treatment	49	19	75	18
Radiation therapy in combination with chemotherapy, including:	51	81	25	82
-preoperative radiotherapy	5	40	-	41
- postoperative radiotherapy	46	41	25	41

As evidenced by the data presented in Table 1, the main method used in the ROSC is complex therapy, including RT and chemotherapy, and in the treatment of breast cancer and EP, postoperative RT for CC is mainly used - both pre-and postoperative RT, brain cancer - LT as an independent method of treatment.

The main type of RT used in the ROSC is remote RT used in the study group of patients in 82.5% of cases. Contact intracavitary therapy (17.5% of all patients) was used in 50% of patients with cervical cancer and 30% of patients with EP.

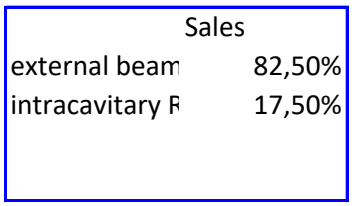

Fig 2. Types of radiation therapy used, %

When conducting RT, several devices are used – “Teraton Primus”, “Gamma-Honey Plus”, “CyberKnife”, and “Gamma Knife”.

The main part of patients receives irradiation sessions on the first two types of devices: 45.9% of the studied patients received radiation on the Teraton-Primus device, and 35.4% - on the Gamma-Plus device.

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"Cyber Knife", or "Gamma Knife" is used only to irradiate brain tumors; in this case, the radiation is assembled into one beam, which acts pointwise on the tumor during one or two procedures.

Irradiation doses are determined during the planning of irradiation and depend on the form of the disease, its stage, and the intended methods of irradiation. For the studied group of patients, the radiation doses were (Table 2):

Table 2 Radiation doses used

The nature of the radiation dose	Dose for different forms of malignant neoplasm, Gr			
	breast cancer	cervical cancer	Brain cancer	EP
total radiation dose, Gr	50 to 70	70-76	50-60	83-85
dose fractionation (number of exposure sessions)	25-28	15-20	2-3	17-20
radiation dose per session, Gr	2-2,5	2-5	20	3-5

As can be seen from the data presented, the highest doses of radiation are used in radiotherapy of RC - up to 85 Gr, and a single dose reaches 6 Gr with up to 20 sessions. Irradiation doses for breast cancer and cervical cancer are at the level of generally accepted doses with fractionation by 2-5 Gr. When irradiating brain cancer, doses of 50-60 Gr are used, but since a special irradiation technology is used - “gamma knife”, then during 1 session the radiation dose is 20 Gr. Radiation therapy requires mandatory pre-radiation preparation, which includes individual identification of the anatomical and topographic features of the tumor, marking the irradiation field on the patient's body, and computerized irradiation planning.

When conducting computer planning with the participation of a radiologist and a physicist, the energy of the radiation used, the size, and the number of radiation beams with the radiation dose for each beam are outlined. It also planned the need to use and the nature of protective blocks and other elements to reduce radiation exposure to adjacent healthy tissues.

Upon completion of the irradiation planning, the irradiation process is simulated: the patient is placed on a table (couch), and the irradiation field is marked on his body, after which the irradiation is simulated within the marked field and time.

During irradiation, the size and configuration of the tumor change, so the irradiation conditions are periodically adjusted.

The study of pre-radiation preparation of the studied group of patients showed that each patient undergoes such preparation (Table 3).

After pre-beam preparation, direct irradiation sessions are scheduled. The radiologist conducting irradiation is guided by the record of the irradiation plan in the patient's chart (area and field of exposure, total dose, a dose of each fraction, number of fractional doses, etc.)

During each irradiation session, the patient is placed on a table or couch as it was done during the simulation, the patient’s body is fixed so that it does not move, the patient’s body is surrounded by protective blocks or plates of lead rubber around the intended irradiation field, after which direct irradiation begins.

Table 3 Preradiation preparation of patients and its correction

Elements of pre-beam preparation	Percentage of patients subjected to pre-radiation preparation			
	cervical cancer	breast cancer	brain cancer	esophageal cancer
preparation of anatomical and topographic data on the tumor and adjacent structures	100	100	100	100
irradiation field marking	100	100	100	100
computer planning of irradiation conditions	100	100	100	100
irradiation simulation	100	100	100	100
periodic correction of irradiation conditions	100	100	100	100

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Irradiation time depends on the planned dose, it is individual, but, as a rule, a direct irradiation session to obtain a fractionated dose is 5-6 minutes, and the total session time is 15-20 minutes unless any difficulties or unforeseen situations need to be eliminated.

Thus, the study of the conditions of irradiation of the study group of patients showed that, in general, these conditions correspond to all the principles of radiation therapy accepted in world practice.

Post-radiation reactions in patients and measures to mitigate them.

When conducting a survey of patients subjected to radiation therapy, immediately after 1-2 sessions of irradiation, we recorded numerous and varied reactions in most patients. The frequency of such reactions in women is characterized by Table 4.

Table 4 Reactions registered in women after 1-2 irradiation sessions, %

Registered reactions	Frequency of registered reactions, % of the number of patients							
total number of patients who had some kind of reaction	breast cancer, n = 13		cervical cancer, n = 9		brain cancer, n = 4		esophageal cancer, n = 7	
	abc.	%	ABC.	%	abc.	%	abc.	%
total patients who had reactions, including:	10	76,9	7	77,8	4	100	5	71,4
redness of the skin or mucous membranes	9	69,3	4	44,4	2	50,0	5	71,4
itching	6	46,2	7	77,8	3	75,0	5	71,4
weakness	8	61,5	6	66,7	2	50,0	5	71,4
headache	10	76,9	5	55,6	4	100,0	3	42,8
nausea	7	53,8	6	66,7	2	50,0	3	42,8
vomit	7	53,8	5	55,6	-	-	3	42,8
swallowing disorder	3	23,1	-	-	-	-	4	57,1

When irradiating women with breast cancer after 2 sessions of irradiation, adverse reactions were noted in 76.9% of patients. Headache, redness of the skin, and weakness were most often noted, nausea, vomiting, and itching of the irradiation site were less common, and in three cases there was a reflex violation of swallowing.

When irradiated with cervical cancer, radiation reactions after 1-2 sessions were detected in 77.8% of patients. Most often, itching, weakness, and nausea were recorded, vomiting and headache were noted in half of the patients, and redness of the vaginal mucosa was observed in 44.4% of cases.

During irradiation of sick women with RGM, certain reactions after 1 irradiation session were noted in all patients: all women had a headache, in 75% of cases - itching of the scalp at the site of irradiation, in half of the exposed women redness of the skin, nausea and weakness were registered .|

When irradiating women with RP after 1-2 sessions of irradiation, reactions were noted in 85.7% of cases. These were redness, itching, weakness, and almost half of the irradiated patients had headache, nausea, vomiting, and swallowing disorders. The observed men had two forms of pathology - brain cancer (7 cases) and cancer of the esophagus (9 cases). After 1-2 sessions of irradiation with RGM, as in women, post-radiation reactions were observed in 100% of cases: headache (100%), redness and itching of the scalp (71.4 and 85.7%, respectively), weakness (71 .4%), nausea and vomiting (57.0% each).

During irradiation of men with RP, post-radiation reactions after 1-2 irradiation sessions were observed with approximately the same frequency as in women - 88.9%. Swallowing disorders persisted in all men, weakness was noted in 77.8%, nausea and vomiting in 66.7%, itching in 55.6%, and headache in 44.5% of cases.

Many researchers believe that the reactions that occur immediately after irradiation disappear on their own within the next 1-2 weeks.

Our research revealed a slightly different picture. After 2-3 weeks after the end of the entire course of irradiation, we noted an increase in the number and nature of post-radiation reactions (Table 5).

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Table 5 Comparative frequency of post-radiation reactions in women after 1-2 irradiation sessions and 2-3 weeks after its completion, %

The nature of post-radiation reactions	breast cancer		cervical cancer		brain cancer		esophageal cancer	
	After 1-2 sessions	In 3 weeks	After 1-2 sessions	In 3 weeks	After 1-2 sessions	In 3 weeks	After 1-2 sessions	In 3 weeks
fatigue, weakness	61,5	92,3	66,7	88,9	60,0	100,0	85,7	57,1
nausea	53,8	76,9	66,7	66,7	40,0	20,0	42,8	42,8
diarrhea	-	69,2	-	88,9	-	40,0	-	42,8
dizziness	-	69,2	-	44,4	-	80,0	-	57,1
vomit	53,8	61,5	55,6	44,4	-	-	42,8	42,8
redness of the skin (mucosa)	69,2	61,5	44,4	55,6	60,0	80,0	85,7	57,1
hair loss	-	53,8	-	77,8	-	80,0	-	57,1
headache	76,9	53,8	55,6	55,6	100,0	100,0	57,1	57,1
sleep disorders	-	53,8	-	66,7	-	80,0	-	71,4
dry cough	-	30,8	-	11,1	-	-	-	42,8
peeling of the skin	-	23,1	-	11,1	-	75,0	-	28,6
skin sensitivity disorder	-	23,1	-	22,2	-	100,0	14,3	14,3
bleeding	-	7,7	-	-	-	-	-	-
long-lasting wounds	-	7,7	-	11,1	-	-	-	-
edema	-	-	-	11,1	-	20,0	-	-
itching	46,2	-	77.8	-	80,0	-	85,7	42,8
swallowing disorder	23,1	-	-	-	-	-	57,1	-
average reaction frequency	22,6±4,5	40,2±5,4	21,5±4,6	38,6±5,2	20,0±5,9	46,8±5,9	27,7±5,0	36,1±3,4
R	< 0,05		< 0,05		< 0,01		>0,05	

So, in women with breast cancer after 1-2 sessions, 7 variants of post-radiation reactions were revealed, and 2-3 weeks after the end of irradiation, a two-fold increase in various variants of negative reactions was registered. In particular, some patients developed such reactions as diarrhea, dizziness, hair loss, sleep disturbance, peeling and impaired skin sensitivity, and dry cough; there was also an increase in the frequency of some previously identified reactions - weakness and fatigue, nausea, and vomiting. A similar situation was revealed in the case of radiation therapy for cervical cancer: at the beginning of irradiation, 6 variants of negative reactions were observed, and 2 weeks after the end of irradiation, 14 types of reactions were observed with an increase in weakness, the appearance of dizziness, diarrhea, hair loss, sleep disturbances, and up to 22% of cases - occurrence of other reactions.

The condition of patients with rheumatoid arthritis changes especially significantly after the end of irradiation. If at the beginning of irradiation, they observed 5 types of post-radiation reactions, then 2-3 weeks after the end of irradiation, we registered 11 types of reactions in them, and there was also an increase in the frequency of previously recorded reactions. During radiation therapy for esophageal cancer, at the beginning of the course of irradiation, 7 types of negative reactions were detected in patients (nausea, vomiting, itching, headache, swallowing disorder, weakness), and 2-3 weeks after the end of irradiation, the number of registered reactions increases to 13 types, but these reactions are recorded not in all, but only in 50-66.7% of patients.

The negative reactions revealed by us are not specific, they rather characterize the general reaction of the organism to the effect of radiation. Nevertheless, the presence of such reactions cannot but affect the quality of life of patients, so 100% of the patients surveyed characterize their condition as "not feeling very well."

Comparison of the number of post-radiation reactions and the radiation dose of the studied patients (correlation analysis) showed that the number of these reactions has a direct positive relationship with the

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total radiation dose: when assessing reactions after 1-2 irradiation sessions, the correlation coefficient "r" was 0.74 (direct strong relationship), and 3 weeks after the end of exposure, "r" = 0.58 (direct relationship of medium degree).

Thus, despite the careful pre-radiation preparation of patients and the implementation of protective measures during irradiation sessions, we revealed a high frequency of negative general reactions during irradiation therapy, which are most pronounced 2–3 weeks after the end of irradiation sessions.

When interviewing patients and studying materials from case histories, we found that to improve the quality of life of patients, all of them are recommended measures aimed at reducing the frequency and severity of post-radiation reactions

(Table6)

Table 6 Using the doctor's recommendations to reduce post-radiation reactions

The nature of the doctor's recommendations	Percentage of coverage of patients with doctor's recommendations, %			
	breast cancer	cervical cancer	brain cancer	esophageal cancer
The use of ointments	100	-	100	-
Using Shostakovsky's balm	100	-	100	-
Taking painkillers	100	-	100	100
Periodic drip	100	100	100	100
Glucose intravenously	100	100	100	100
Reception of immunostimulants	100	100	100	100
Taking antibiotics	100	100	100	100
Taking vitamins	100	100	100	100
Walks in the open air	100	100	100	100

As can be seen from Table 6, only when using ointments and Shostakovsky's balm, the type of pathology is taken into account, obviously because with cervical cancer and RP, radiation therapy can be carried out by the contact method, in which the use of ointments, especially with RP, is impossible. In other cases, patients have standard prescriptions, including the appointment of antibiotics for all patients, which is hardly appropriate for 100% of patients. At the same time, the nature of post-radiation reactions indicates a toxic effect on the body of sick radiolysis products and requires not periodic, but daily dripping.

In addition, to reduce the number and severity of general reactions, it is necessary to use a wider range of recommendations, taking into account both the form of the disease and the radiation dose of patients.

Conclusion. The study made it possible to obtain several data of great theoretical and practical importance. In particular, the correctness of planning and pre-radiation preparation of patients in the central oncological institution of the republic, as well as their direct irradiation and compliance of radiation doses with generally accepted values, was assessed. Post-radiation reactions were revealed in patients with different forms of pathology at different times after irradiation. The analysis and evaluation of the quality of recommendations for reducing post-radiation reactions in patients was carried out.

The data obtained allow us to give an objective assessment of the actual state of radiation protection of cancer patients, identify the main gaps in this area and recommend several measures to improve the quality of life of patients undergoing radiation therapy:

1. **To increase the effectiveness of radiotherapy,** wider use of modern methods of nuclear medicine is recommended, such as stereotactic radiosurgery, the TrueBeam method (hypofractionated method), 3D-CRT - 3-dimensional conformal method, image-guided technology - IGRT, intensity modulated method - IMRT, tomotherapy, proton therapy

2. **The use of the method of hypoxic radiotherapy (**the use of a gas mixture containing 9% oxygen and 91% nitrogen), which allows the use of a higher radiation dose in radiation therapy.

3. **To reduce the severity of post-radiation reactions and improve the quality of life** of the studied cancer patients, the following additional measures are recommended among the measures used:

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Recommendations during the irradiation period:

- recommendations to patients to exclude irritating factors (smoking, spicy and hot food, dentures, alcohol, etc.)
- use of individual Cerrobend* blocks, beam modifiers, boluses**, compensating filters;
-ensuring full conformality of irradiation***
-taking into account individual sensitivity to radiation

Recommendations after the end of irradiation:

-daily skin monitoring
- exclusion of the use of heating pads, mustard plasters, compresses, diathermy, ultraviolet and infrared radiation, exposure to sunlight, irritating ointments and solutions (iodine, alcohol, turpentine)
- daily lubrication of the skin with a 20% solution of Shostakovsky's balm
- use of ointment synalar (Synalar)
- drinking plenty of green tea (tannin, vitamin B)
- good nutrition

Psychological support

Cancer treatment and radiation therapy can have a significant psychological impact on the patient. Therefore, psychological support is an equally important measure to reduce the risk of PCR. Patients should receive support and advice from psychologists and social work professionals to cope with the emotional and psychological difficulties that arise during treatment.

In conclusion, the optimization of measures to reduce PCR in cancer patients with radiation therapy is a complex and multifaceted process that requires an individual approach, comprehensive treatment, and psychological support. It is necessary to use all available methods and technologies to ensure the most effective treatment and minimize the risk of developing PCR._____

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* Cerrobend – a foam shield made from a tumor projection template and filled with an alloy of bismuth, tin, lead, and cadmium

** boluses – plates of plastic polymers, paraffin, and wet gauze placed on the irradiation area; allow the use of high doses of radiation

*** Irradiation conformity – the accuracy of matching the irradiation beam to the contours of the tumor

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