Topic: "Technological foundations of radiation therapy. Radiation therapy of malignant tumors. The body's response to radiation treatment.

Purpose of the lesson : To have an idea about the specialized radiological department, the device of radiation technology, the features of the pre -radiation period. Radiation control.

Specific objectives of the lesson:

Know:

1. The device of radiation technology.
2. Classification of radiation therapy by type of radiation and methods of implementation.
3. Radiation therapy planning.
4. The body's response to therapeutic radiation exposure.

Be able to:

1. Build a remote exposure plan.
   (X- ray therapy , tele -gamma therapy)
2. Correctly determine the method of contact irradiation.
3. Preparing the patient for treatment.
4. Prevention of radiation reaction.
5. Treatment of radiation damage.

The base for conducting and material support of the lesson:

1. Study room.
2. Cabinet of gamma therapy of the department of radiation therapy of the ROD.
3. Test cards.
4. Study tables.
5. Video films, multimedia presentations.
6. Case histories, radiographs of patients served by the gamma room.

Content of independent work:

1. test control of knowledge.
2. Tasks in radiotherapy planning.
3. study of literature on the specified topic.

Literature:

1. » Kishkovsky A.N., Dudarev A.L. "Radiation therapy of non-tumor diseases". M, 1977.
2. Zetgenidze G.A. "Clinical radiology". M.1985
3. Lindenbraten L.D., Korolyuk I.P., "Medical radiology and radiology", M. "Medicine", 2000

4.G.E. Trufanov "Radiation diagnostics and radiation therapy", St. Petersburg, 2005.
5. "Radial diagnostics". A textbook for universities. Under the editorship of prof. Trufanov G.E. M, 2007

Information block:

Radiation therapy is one of the main, and often the only method of treating patients with malignant diseases. To increase the effectiveness of radiation therapy, topometric preparation of patients for radiation is necessary. The effectiveness of radiation therapy depends not only on the radioactivity of the tumor, but also on the ratio of doses of ionizing radiation received by the tumor and the surrounding, especially healthy organs and tissues that are critical to ionizing radiation.

The first principle of clinical topometry is strictly individual preparation.

The second principle is strict adherence to the rule - to examine the patient in a body position that is identical to the position during the planned irradiation.

The third principle of clinical topometry is the maximum approximation of the physiological state of the patient during the study to the state during irradiation.

So, from the whole mass of means and methods, one should choose not burdensome for the patient and not difficult for the attendants, but the most necessary and providing sufficient information.

For over 75 years, X-ray therapy has been widely used in oncological, gynecological, therapeutic, surgical practice as one of the active biological factors. This method is one of the most common methods of radiation therapy, which is used both in large medical institutions and in district hospitals to treat not only tumors, but also various inflammatory processes. Most often, domestic devices are used.

X-rays are generated under various technical conditions. In the X-ray tube of the apparatus, beams of different penetrating power are generated, therefore, during radiation treatment, filters are used to obtain beam uniformity. So for close-focus therapy, aluminum filters are used, and for deep X-ray therapy, copper and aluminum filters are used.

Close-focus X-ray therapy, in which the maximum absorbed dose is achieved essentially in the skin, can be used to treat small tumors of the skin of the lips, oral mucosa, vulva, and epithelial skin neoplasms. Close-focus X-ray therapy can be used in outpatient and inpatient settings as an independent method or in combination with other types of radiation therapy, in particular with remote gamma therapy or deep X-ray therapy. In all cases of malignant tumor diseases, close-focus X-ray therapy is carried out as a course of treatment, which consists of daily sessions of single irradiation at doses from 100 to 500 r . The use of large doses of single exposure is a positive feature of close-focus X-ray therapy and is allowed only because the effect of radiation extends exclusively to tumor tissues.

Long-focus radiotherapy is radiation treatment with x-rays generated at a voltage of 180-250 volts. Filters made of materials with a high specific gravity are used (not only aluminum, but also copper filters). In addition, long distances are used, the source is the skin (30- 60 см). Under such conditions, a greater uniformity of the radiation of the working beam is achieved. Gamma radiotherapy is carried out as a course of self-treatment, consisting of 3-4 (in the treatment of inflammatory diseases) or 20-30 (in the treatment of tumors) daily procedures in the form of combined treatment with previous or subsequent surgical removal of the tumor, as well as in the form of combined treatment, for example, with close-focus X-ray therapy, with application gamma therapy, etc.

In the process of remote X-ray therapy for malignant tumors, a single single dose is 200-250 r for each field. More often, irradiation is carried out from several fields, and each is irradiated every other day. With this rhythm of irradiation, erythema on the skin develops in 12-15 days, i.e. after reaching a total surface dose of 1200-1400 r on the field. At a total dose of about 3000 r , small bubbles appear on the skin, which merge with each other, open, and a weeping surface is formed. Therefore, skin irradiation at a dose of more than 3000 rad is not allowed due to possible severe radiation damage. However, in the treatment of deep-seated tumors, to create the necessary focal dose to the tumor, irradiation at a dose greater than 3000 rad is required. For this purpose, special devices were introduced into the practice of remote gamma therapy - rasters or lead gratings. Lead gratings are introduced into ordinary tubes, while irradiation is carried out not with one working beam with a cross-sectional area equal to the size of the irradiation field, but with several radiation fluxes with a small cross-sectional area.

According to its purpose, remote gamma therapy corresponds to long-focus X-ray therapy, however, compared to the latter, it has a number of advantages:

1. In gamma devices, radiation sources with a long half-life are used, so that the activity of the drug, and, consequently, the intensity of the radiation, change very little from day to day. In this regard, the dose rate of gamma units is more stable than that of X-ray therapy devices, and the error in dosing in the process of remote gamma therapy is less than with X-ray therapy.

2. Gamma radiation is relatively less absorbed in the skin than X-rays, and therefore the permissible value of the exposure dose of skin radiation is greater and amounts to 4000 r .

3. The radiation of remote gamma units is characterized by a much smaller dose drop at depth compared to X-rays, therefore, the relative depth dose will be greater, which is very important in the treatment of deep-seated malignant tumors.

4. The absorption of gamma rays in soft tissues and bones is more or less uniform than with conventional X-ray therapy, which is very important for reducing radiation exposure to the bones, and in particular when irradiating head tumors.

The peculiarities of the radiation dose distribution of gamma units make it possible to use remote gamma therapy in almost all localizations of malignant tumors and even in cases where conventional X-ray therapy is ineffective. For the destruction of metastatic tumors, it is required to irradiate them only due to remote therapy at a dose of about 5000 rads. Such a massive exposure to X-rays of the skin would lead to its necrosis, while gamma therapy is carried out without the development of severe radiation injuries. Remote gamma therapy is carried out in the same way as X-ray therapy in the form of a course of treatment lasting 1-2 months, from the 1st or 2 or more fields in doses of 200-300 glad for each. Irradiation is carried out according to special schemes used in deep X-ray therapy.

Installations for carrying out gamma therapy.

Methods of static distance therapy. Recently, betatrons have been used for remote beam therapy, in which the electron beam is not immediately decelerated, as in conventional X-ray tubes, but after preliminary acceleration of electrons in a vacuum chamber under the influence of powerful electromagnets. In the process of acceleration, electrons acquire colossal energy, which reaches up to 30 Mev and more in medical betatrons . The steep drop in dose rate at a certain depth suggests that the use of the betatron beam is the most effective method of remote therapy for tumors of superficial localization.

Remote gamma therapy can also be carried out using mobile radiation sources, by rotational pendulum, convergent, and rotational irradiation at a controlled speed. The main advantage of mobile methods is the concentration of radiation energy in the tumor area with a simultaneous steep drop in dose in the surrounding healthy tissues and a significant reduction in radiation exposure to the skin. However, the clinical use of mobile irradiation is limited not by the skin reaction, but by possible radiation changes in individual internal organs and the blood system, since a larger volume of tissues is irradiated. Irradiation can be carried out on the domestic installation "ROKUS", "AGAT-R".

The device of this apparatus allows the use of rotation angles from 0 to 360 ^{0} . In cases where the radiation source during treatment is in close proximity to the tumor or in its tissue, irradiation is called <u>contact irradiation.</u>

Contact methods of radiation therapy include: *intracavitary, interstitial, radiosurgical, application* , *selective accumulation of isotopes in tissues and close-focus radiotherapy* . As is known, the application of a method is determined by its dosimetric characteristics. Contact methods of radiation therapy are characterized by a sharp drop in the dose value at the closest distances from the source. Hence, contact irradiation alone can be used only for small tumors not exceeding 1.5 2 смin diameter. In other cases, contact methods are combined with one of the remote therapy methods.

In malignant neoplasms of the esophagus, bladder, cervix, rectum and other abdominal organs, radioactive drugs can be applied directly to the tumor. This method of irradiation is called <u>intracavitary.</u>

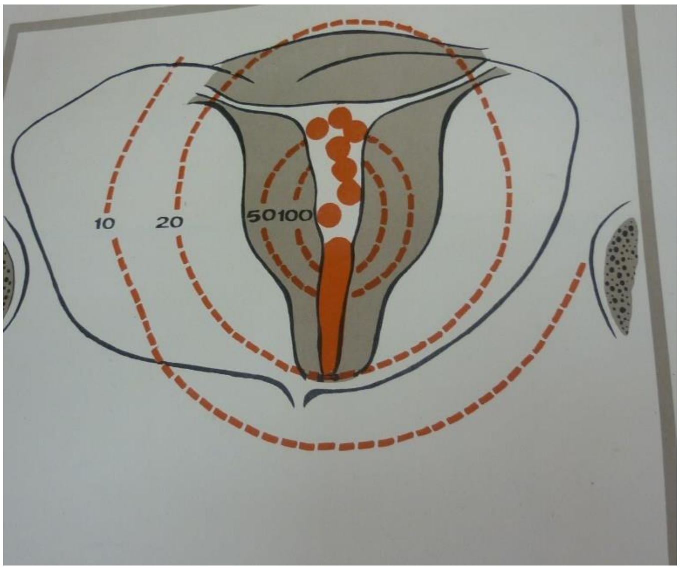
Intracavitary gamma therapy uses Ra ^{226} , Co ^{60} , cesium in the form of linear and volumetric radiation sources. The line source can be made from cylindrical preparations of Ra , Co , or ball-shaped sources of beads from Co and Cs . Preparations or beads are arranged in one line in a solid rubber probe. In order to reduce the dose rate on the mucous membrane, the radiation source must be 0.5- 2 см. To do this, on the outer side of the probe at the level of preparations there is a thin rubber balloon, into which, after the introduction of the probe, air is injected, creating a distance between the source and the tumor. The total activity of the radiation source is 50-60 microcuries . The active length of the source is set depending on the size of the tumor and must exceed it 2 смfrom the upper and lower edges. A linear radiation source is used for intracavitary gamma therapy for cancer of the esophagus, rectum, and cervix.

Applicators for intracavitary irradiation

With intracavitary β-therapy, colloidal solutions of Au ^{198} and J ^{90} are used . Unfortunately, the low penetrating power of β particles limits the indication for the use of these isotopes. Colloidal solutions can be injected into the bladder, into the abdominal cavity and into the pleural cavity. For intracavitary β-therapy, an Au solution with a particle size of 20 to 200 microcuries and a gold content of about 0.01 g per 1 cm ^{3} is used . Subject to protective measures, the solution is injected through the catheter into the bladder and after 3.5-4 hours the catheter is removed.

In the abdominal cavity, the solution is glad. Au is introduced for prophylactic purposes to influence possible dissemination after gastric resection or gastrectomy for cancer, after resection for cancer of the small and large intestines, after surgery for ovarian cancer. In addition, the solution of Au ^{198} is used for cancerous ascites with a palliative purpose. Contraindications to the introduction of a radioactive solution into the abdominal cavity are persistent leukopenia and thrombocytopenia, severe general condition, and the presence of postoperative complications. A short half-life (2.7 days or 65 hours) allows, without the risk of side radiation exposure, to create a source of radiation of the required intensity in the lesion.

Intracavitary radiotherapy.



The method of radiation therapy, in which the radioactive substance is located inside the tumor tissue during treatment, is called interstitial . Depending on the radiation used, a distinction is made between gamma therapy and β-therapy.

Interstitial gamma therapy is indicated for well-circumscribed small tumors whose volume can be determined quite accurately. It is especially advisable to use interstitial treatment for tumors of mobile organs (cancer of the lower lip, tongue, breast, external genital organs) or for tumors that require local irradiation (cancer of the inner corner of the eye, eyelid). For interstitial gamma therapy, radioactive gamma-emitting preparations Ra , Co , Cs are used in the form of needles, pieces of wire, cylinders or granules. The needles have a stainless steel sheath that serves as a filter, the outer diameter of the needle is 1,8 мм. The introduction of radioactive needles into the tumor tissue is carried out in the operating room with the obligatory observance of the rules of asepsis and antisepsis, as well as the protection of personnel from radiation. Local anesthesia of the tissues around the tumor is mandatory; novocaine is not injected into the tumor tissue. The introduction of the needle is introduced with special tools, immersed in the eye, and the thread inserted into the eye is fixed to the skin. During the entire time of interstitial irradiation, the patient is in a special active ward. Upon reaching the required focal dose, radioactive needles are removed by pulling on the threads.

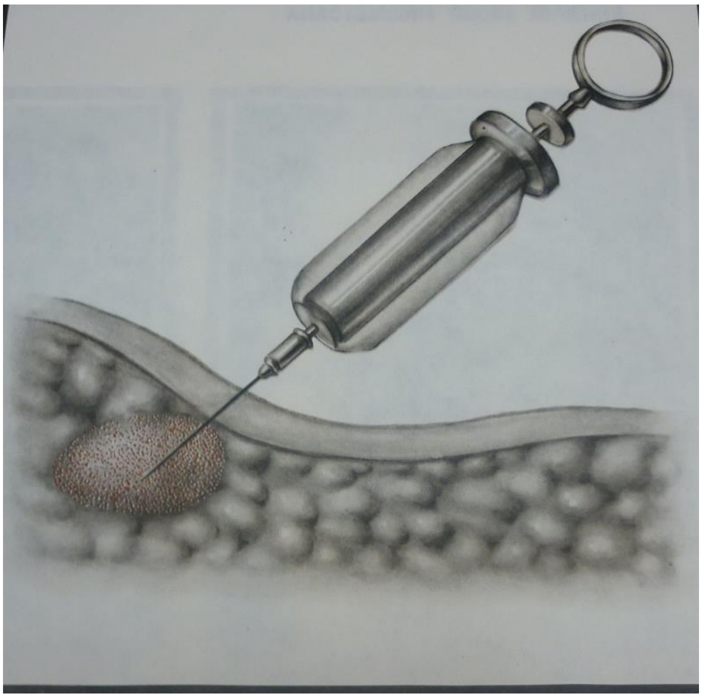
Interstitial gamma needle therapy is not without drawbacks. In addition to the trauma of this procedure, a necrotic channel appears in the tissues around the needle due to a high dose, as a result of which the radiation source can shift and even fall out. Improvement and search for new forms of preparations led to the use of radioactive cobalt granules in nylon tubes for interstitial gamma therapy. Nylon tubes have a smaller outer diameter, minimally injure surrounding tissues and significantly reduce the time of personnel contact with radioactive material. Due to the flexibility and elasticity, the radiation source can be shaped to approximate the configuration of the tumor.

With interstitial gamma therapy, the optimal dose over time, i.e. dose rate is 35-40 rad/hour. This dose rate allows for 6-7 days to bring to the tumor 6000-6500 rad. and cause radical damage to the tumor.

A variation of interstitial irradiation is the radiosurgical method . The essence of the method lies in the formation of access to the tumor and the impact on it with radioactive drugs or in the irradiation of the tumor bed with radioactive substances after its removal. The radiosurgical method can be used for various localizations of the tumor process of stage I and II , as well as for tumors that are on the borderline of inoperability , but without the presence of distant metastases. This method is indicated for metastases of cancer of the oral cavity, lips, larynx, in the submandibular and cervical lymph nodes, with soft tissue sarcomas, cancer of the external genitalia.

In the radiosurgical method of treatment, both gamma and β emitters are used. The form of a radioactive preparation can be very diverse. Needles, nylon tubes with cobalt granules, Au granules , tantalum wire, colloidal radioactive solutions, as well as absorbable threads impregnated with them are used.

Au Colloidal Solution Method ^{198} with intradermal metastases



In the treatment of certain inflammatory processes and malignant neoplasms of the skin and mucous membranes, radioactive preparations can be placed either directly on the surface of the pathological focus, or at a distance of no more than 0.5- 1,5 см. This method of irradiation is called application. Depending on the size and depth of the lesion, gamma-emitting radioactive preparations are used.

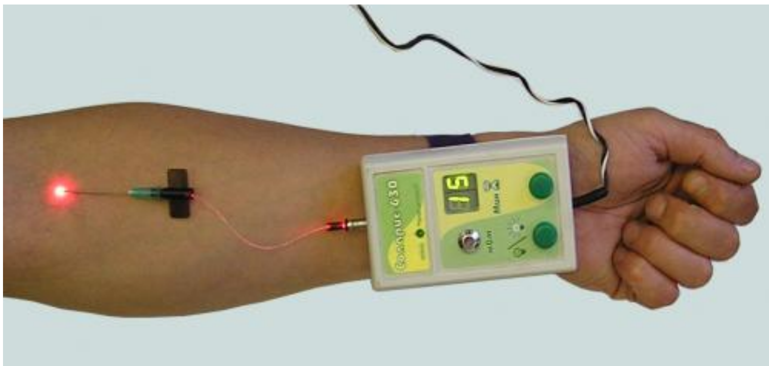
Application β-therapy is used in the treatment of processes that spread in the surface layers (up to 4 мм) of the skin and mucous membranes (capillary angiomas, hyperkeratosis, leukoplakia, neurodermatitis, erosion). β-radiation P , intrium , waist, promethium, strontium, xenon act on the pathological focus without irradiating the underlying tissues. Plates of various sizes with a radioactive substance ranging from 0,1 ммto thick are 0,35 ммcovered with a thin polyethylene or thermine film.

Treatment of patients with capillary angiomas is carried out in the form of a course consisting of 6-9 daily irradiation sessions. The daily dose is 300-500 rad, and the total for the entire course is 2000-3000 rad. The results of treatment in children are usually better than in adults. For eczema, application of β-therapy is used only when other methods fail. As a result of treatment, the inflammatory process, skin infiltration usually decreases, itching weakens and disappears.

Application gamma therapy is used in cases where the process is located at a depth of more 4 ммand is indicated for tumors of the skin and mucous membranes, relapses and metastases in the skin and subcutaneous tissue. In application gamma therapy, radioactive preparations are placed in special masks-models that simulate the shape of the irradiated surface. The model is made from a mixture of wax and paraffin. A plate of this mass with a thickness of 0.5 1,0 смis heated in hot water (up to 40 ^{0}) and, when it becomes soft, is superimposed on the surface to be irradiated. In order for the radiation surface to exactly correspond to the pathological focus, it is outlined with fuchsin, after which an imprint of the contours of the area to be irradiated remains on the model. Inside this circuit, radioactive preparations are placed. To obtain a uniform dose field, it is necessary to follow certain rules for the location of preparations. More often, preparations are arranged in the form of a rectangle or circle, but always in such a way that the irradiation area exceeds the visible size of the pathological focus. Application gamma therapy can be carried out by continuous or fractional irradiation.

Finally, it is necessary to note one more method of radiation therapy, based on the selective absorption by tissues or organs of certain radioactive drugs, called internal irradiation . Radioactive drugs are administered per . os , in / in, intra -arterially .

Internal exposure method



Currently, colloidal solutions P , J , Au are used for intra-arterial therapy .

Radioactive Au ^{198} is used in the treatment of leukemia. The colloidal solution is administered intravenously at the rate of 0.5-1 microcuries per 1 кg patient's weight, with a total dose of 5 microcuries . If necessary, a second course is carried out after 4-6 months, and 1/2 or 1/3 of the initial dose is administered.

Radioactive J ^{131} is used mainly for stage II and III hyperthyroidism , tumor recurrence after surgery, for thyroid cancer as an independent method of treatment, and also for prophylactic purposes as a pre- and postoperative treatment. Internal irradiation rad. J is limited by the effect of ionizing radiation on hyperplastic cells of the thyroid gland, without damaging the surrounding organs and tissues. In the treatment of thyrotoxicosis, the patient should exclude foods containing iodine from food for 1.5-2 months and not take iodine preparations. The dose of radioactive drugs depends on the degree of hyperfunction of the thyroid gland. The amount of J required for treatment can be applied simultaneously or in fractions of 1.5-2 microcuries . In thyroid cancer, in order to reduce the mitotic activity of cells, 30-45 microcuries are prescribed 2-3 weeks before surgery . After a radical operation in the early stages , J $^{131 \text{ is prescribed}}$ at 5 microcuries every three weeks, up to a total dose of 50-100 microcuries . In inoperable thyroid cancer, J is injected at 50-60 microcuries every 2-3 weeks until a therapeutic effect is obtained.

Each of the considered methods of radiation therapy has its own advantages and disadvantages. So remote irradiation does not fully provide the ratio in absorbed doses. Even, it would seem, under favorable conditions, a large volume of healthy tissues is irradiated, the regenerative capacity of which is significantly reduced.

Contact methods of irradiation create a more favorable dose ratio. However, with tumors that spread to a greater depth than 1 см, the use of contact methods will be ineffective. Therefore, for more rational irradiation, it is necessary to combine remote irradiation with one of the contact methods. This method of treatment is called the combined method of radiation therapy.

combination treatment plan , radiation therapy may be combined with *surgery* , chemotherapy, or both. The sequence of its application depends on the stage of the disease, the clinical form of the tumor, its localization and the general condition of the patient. Radiation therapy can be carried out in various versions of remote, intracavitary, interstitial irradiation with electrocoagulation, resection or extirpation of the affected organ.

From here, the following methods of radiation therapy are distinguished:

- ***Self-radiation therapy*** - radiation, or chemotherapy;
- ***Combined radiation therapy*** - remote irradiation with irradiation by one of the contact methods;
- ***Combined radiation therapy*** - radiation therapy with a surgical method;
- ***Complex radiation therapy*** - radiation and chemotherapy.

Radiotherapy planning

- *The results of scientific research allow planning doses and the number of fractions at which the level of tolerance of normal tissues will not be exceeded;*
- *Apply different fractionation modes;*
- *Strengthen the effect of ionizing radiation on the tumor;*
- *Protect surrounding tissue*

During the survey, they find out if the patient has undergone radiation treatment in the past . If it took place, then you should find out all the details (when and by what method radiation therapy was performed, which parts of the body were irradiated, in what total dose, what complications were observed).

You can not rely only on the message of the patient - you need an extract from the medical history or a written certificate from the medical institution in which he was treated.

This is extremely important, because in the treatment of tumors, a second course of irradiation can be carried out only 60-70 days after the end of the first one and taking into account the conditions of the previous irradiation.

However, it has already been noted above that the effectiveness of repeated courses is low. The first course should be as radical as possible and, if possible, the only one.

Based on the results of a comprehensive examination of the patient, an oncologist, a radiation therapist (and often a therapist and a hematologist) develop an agreed treatment strategy. It depends on the localization of the tumor, its size, histological nature and stage of development.
A small tumor can be cured with both surgery and radiation therapy.
In this case, the choice of method depends primarily on the localization of the neoplasm and the possible cosmetic consequences of the intervention.
In addition, it should be taken into account that tumors originating from different anatomical regions differ in their biological characteristics.

Tumors amenable to radical treatment (radiocurable tumors) include *cancer of the skin, lips, nasopharynx, larynx, breast, and retinoblastoma medulloblastomas , seminomas , ovarian dysgerminomas , localized lymphomas, and Hodgkin's disease.*

Radiation destruction of a large tumor encounters almost insurmountable difficulties due to radiation damage to its vessels and stroma, resulting in radiation necrosis.

In such cases, resort to *combined treatment. The combination of radiation exposure and surgery gives good results in Wilms tumor and neuroblastomas in children, cancer of the sigmoid and rectum (the so-called colorectal cancer), embryonic testicular cancer, rhabdomyosarcomas , soft tissue sarcomas.*

Surgery is very important to remove the remnant of the tumor after radiation therapy.

At the same time, radiation therapy is indicated for recurrence of a cancerous tumor after surgical or combined treatment (recurrence of cancer of the skin, lower lip, cervix), as well as for local metastases in the lymph nodes, bones, and lungs.

Prebeam period

In the *pre -radiation period* , the patient is prepared for treatment.
It should begin with psychological preparation. The patient is explained the need for radiation exposure, its effectiveness, indicate possible changes in well-being and some radiation reactions, features of the regimen and nutrition. A conversation with the patient should instill in him hope and confidence in the good results of treatment.

Further stages of preparation are enhanced nutrition with the consumption of a large amount of liquid, saturation of the body with vitamins (in particular, at least 1 g of vitamin C per day), sanitation of irradiated surfaces and cavities.

- In places to be irradiated, the skin should be clean, without abrasions and pustules.

- All physiotherapeutic procedures and medications for external use such as ointments, talkers are canceled.
- When irradiating the facial part of the head, the oral cavity is sanitized.
- Prohibit the use of alcoholic beverages and smoking. With a concomitant inflammatory process, antibiotics are prescribed, with anemia - means for its correction.

The next critical step is *clinical* ***tonometrydescribed*** above. Here, it is necessary to emphasize once again that in connection with the advent of computer and magnetic resonance imaging, fundamentally new possibilities are being created for extremely accurate focusing of radiation beams on target.

From the analysis of the location of the target on the plane, a transition is made to the volumetric perception of the tumor, from anatomical information to geometric representations, to the construction of complex dosimetric distributions provided by computer programs

- Based on the results of clinical and radiobiological analysis and topometry , such a type of radiation and such physical and technical conditions of irradiation are selected so that the intended amount of energy is absorbed in the tumor with a maximum dose reduction in the surrounding tissues.

In other words, the optimal total absorbed dose of radiation, a single dose (dose from each exposure), and the total duration of treatment are established.

Taking into account the topographic and anatomical features of the tumor and its histological structure, remote contact or combined irradiation is chosen. The irradiation technology and the type of device (apparatus) to be used are determined.

The terms of the course are agreed with the attending physician - on an outpatient basis or in a hospital.

With an engineer-physicist, a doctor, according to a dosimetric plan, outlines the optimal distribution of fields for remote irradiation.

Static irradiation can be carried out through one input field on the surface of the body ***(single- field irradiation)*** or through several fields ***(multi-field irradiation).*** If the fields are located above the irradiated area from different sides in such a way that the tumor is at the intersection of radiation beams, they speak of ***multifield cross-irradiation*** . This is the most common way. It allows you to significantly increase the focal dose compared to the dose in neighboring organs and tissues.

The main task of clinical topometry is to determine the volume of exposure based on accurate information about the location, size of the pathological focus, as well as about the surrounding healthy tissues and present all the data obtained in the form of an anatomical and topographic map (sections).

The map is made in the sectional plane of the patient's body at the level of the irradiated object.

On the cut, the directions of the radiation sources during external beam radiation therapy or the location of the radiation sources during contact therapy are marked.

The choice of quantity, localization, form and size of fields is strictly individual. It depends on the type and energy of radiation, the required single and total doses, the size of the tumor, the size of the zone of its subclinical spread. Most often, two opposite fields are used, three fields (one in front or behind and two on the side), four fields with beams crossing in the focus.
With *mobile exposure, the radiation* source moves relative to the patient. The three most common methods of mobile irradiation are *rotational, sectoral, and tangential.*
With all these methods, the radiation beam is aimed at the tumor.
Radiation therapy is carried out from two opposite curly fields of complex configuration, if necessary, with the connection of a third additional field. The irradiation field includes a tumor, Mts in the lymph nodes (bronchopulmonary, root, upper and lower tracheal, paratracheal) or areas of their localization.

- After reaching the total focal dose of 45-50 Gy, it is recommended to reduce the radiation fields and increase the radiation dose to 70-80 Gy

The pre -radiation period ends with the final design of the treatment plan. A treatment plan is a set of documents for clinical radiobiological and clinical dosimetric planning, including both a map of the dose distribution in the patient's body and radiographs made through the input fields and confirming the correct aiming of the radiation beams .

hearth .

- By the beginning of the radiation period, it is necessary to <u>mark the irradiation fields</u> on the patient's body. To do this, the patient is given the position that he will occupy during therapeutic exposures. Next, the radiation beam is aimed at the tumor (of course, the installation is not turned on and irradiation is not carried out).

While laying the patient on the table of the radiotherapy apparatus, laser centralizers or light fields of radiation sources are combined with marks on the body surface.

- The central axis of the beam must pass through the center of the input field and the center of the tumor, so aiming at the focus during static irradiation is called centration .

In the case of *rotation* , irradiation is carried out around the entire perimeter of the patient's body. The advantage of the method is the concentration of the absorbed dose in the lesion with a simultaneous decrease in the dose in the surrounding tissues, especially in the skin. However, the integral absorbed dose in the patient's body is significant. It can be conditionally considered that the rotational method is the limiting variant of multifield cross-irradiation, when the number of

fields is extremely large. The method is indicated for localization of the tumor near the median axis of the body (for example, in cancer of the esophagus).
With *sector irradiation*, the source moves relative to the patient's body along an arc within the chosen angle -90°, 120°, 180° (Fig. IV.8). Such it is expedient to apply the method at an eccentric arrangement of a tumor in a body of the patient (for example, at cancer of a lung or a bladder). With *tangential* irradiation, the center of rotation of the system is located at a small depth below the surface of the body. Thus, the beam from the moving source is always directed tangentially relative to the irradiated part of the patient's body. This is beneficial when irradiating a superficially located focus of sufficient length (for example, with dissemination of cancerous nodules in the skin of the chest wall after removal of the mammary gland).

Centering can be carried out using *mechanical means:* a localizer tube, pointer arrows or rods connected to the radiation head. *Optical methods of* centering are more convenient : the light beam is thrown by the mirror in the direction of the beam of ionizing radiation and illuminates the field on the surface of the patient's body. This light field is combined with the planned field marked on the skin and light "bunnies" directed perpendicular to it from additional centralizers .
In recent years, special devices have been created **- simulators,** which designed to simulate all movements of the radiation source.
The simulator is an X-ray unit equipped with an X-ray image intensifier and a display for displaying the image. The tube can move in a circle around the patient.

Beam period - *the period of irradiation with constant medical supervision of the patient.* Clinical management of the patient in radiation and post-beam periods is extremely important, because allows you to modify the treatment plan and determine the necessary concomitant treatment.

- To irradiate each field, the patient is given a comfortable position. *Immobilization of the patient* is extremely important .
- Even a slight movement of it leads to a change in dose distribution. Immobilization is carried out using various devices.
- To fix the head and neck, fixing devices made of thermoplastic material are used. It is softened in hot water and then modeled for the respective patient, after which the material quickly hardens.
- The correctness of the beam aiming is checked using a simulator or radiography (in the latter case, radiopaque thin catheters or lead marks are placed on the edges of the intended field to get their image on the pictures).
- During the irradiation, a doctor or laboratory assistant watches the patient on the TV screen.
- The intercom provides two-way communication between the doctor and the patient. At the end of irradiation, the patient is prescribed to rest for 2 hours in the fresh air or in a well-ventilated room.
- Information about each exposure is recorded in the medical history.

Standard isodose maps show the distribution of absorbed energy in tissues, provided that the radiation beam is incident on the irradiated surface perpendicular to it. However, the real surface of the human body in most areas is rounded-convex.

In order to avoid distortion of the calculated dose distribution, compensators, or boluses made of tissue -equivalent material (for example, paraffin) are used.

- *The wedge-shaped filter* allows you to change the dose distribution in the tissues, since the absorbed dose under the narrow part of the wedge is noticeably higher than under the extended one.

- With common tumors, uneven irradiation is sometimes carried out using *lattice filters*. Such a filter is a lead plate with numerous holes. Radiation falls only on those parts of the body surface that are under the holes. Under areas covered with lead, the dose is 3-4 times less and is due only to scattered radiation.
- When irradiating irregularly shaped objects, it becomes necessary to use irradiation fields of complex configuration.
- Such ≪*curly*≫ fields can be obtained using *lead* or *tungsten shielding blocks*. They are placed on special stands, which are attached to the radiation head of the device. For the same purpose, a curly shielding diaphragm made of lead blocks is used.
- In this way, it is possible to protect organs that are especially sensitive to radiation: eyes, spinal cord, heart, gonads, etc., which may be near the radiation zone.
- Sometimes a protective lead block is placed in the central part of the working beam. It sort of splits the dose field into two halves. This is expedient, for example, when irradiating the lungs, when it is necessary to protect the spinal cord and heart from irradiation.
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Fractionated irradiation is the main method of dose adjustment in remote therapy. Irradiation is carried out in separate portions, or fractions.

Various dose fractionation schemes are used:

- ✓ usual (classical) fine fractionation - 1.8-2.0 Gy, depending on the histological type of tumor
- ✓ Medium fractionation - 4.0-5.0 Gy per day 3 times a week;
- ✓ Large fractionation - 8.0-12.0 Gy per day 1-2 times a week;
- ✓ Intensively concentrated irradiation - 4.0-5.0 daily for 5 days (for example, as a preoperative preparation;
- ✓ Accelerated fractionation - irradiation 2-3 times a day with conventional fractions with a decrease in the total dose for the entire course of treatment;

- ✓ Hyperfractionation , or multifractionation - splitting the daily dose into 2-3 fractions with a decrease in the dose per fraction to 1.0-1.5 Gy with an interval of 4-6 hours, while the duration of the course may not change, but the dose increases;
- ✓ Dynamic fractionation - irradiation with different fractionation schemes at individual stages of treatment;
- ✓ split-courses - an irradiation regimen with a long break for 2-4 weeks in the middle of the course or after reaching a certain dose;
- ✓ Low -dose variant of total body photon irradiation - from 0.1-0.2 to 1-2 Gy in total;
- ✓ High-dose variant of total body photon irradiation from 1-2 to 5-6 Gy in total;
- ✓ Low -dose version of photon subtotal irradiation of the body - from 1-1.5 Gy to 5-6 Gy in total;
- ✓ High-dose version of photon subtotal irradiation of the body from 1-3 to 18-20 Gy in total;
- ✓ Electronic total or subtotal irradiation of the skin in various modes in case of its tumor lesion
- ✓ The size of the dose per fraction is more important than the total time of the course of treatment. Large fractions are more effective than small fractions. Enlargement of fractions with a decrease in their number requires a decrease in the total dose, if the total course time does not change.

Thus, the main task during irradiation sessions is to ensure accurate reproduction of the planned irradiation conditions on the therapeutic unit.

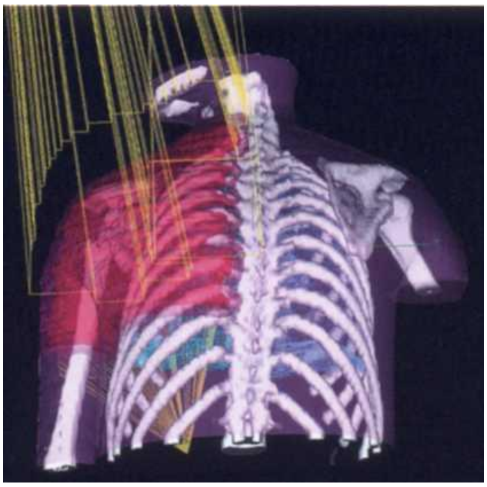
Radiation therapy: pre- or postoperative irradiation, independent.

Indications for preoperative irradiation:

- ✓ the size of the tumor is larger 3 смin diameter;
- ✓ metastases;
- ✓ fixation to the skin, skin ulceration;
- ✓ rapid tumor growth

The goal is to reduce the volume of the tumor, convert it into an operable form, destroy proliferating tumor cells, reduce the likelihood of dissemination of tumor cells during surgery.

Sarcoma of the humerus, conformal irradiation. 3D visualization of dose distribution



The modern principle of treatment: a combination of chemotherapy, radiation, surgery.
Preoperative beam. therapy in
total focal dose 45-50 Gy.
The operation is carried out after subsidence
radiation reaction.

Body reactions to therapeutic radiation exposure, post-radiation period

- Radiation therapy of tumors is accompanied by *general* and *local reactions.* With modern irradiation technology, these reactions, as a rule, do not reach a severe degree. However, the physician must be aware with their manifestations and is obliged to take all measures for their prevention and treatment.

- The general reaction is manifested in a decrease in tone, lethargy, irritability. The patient complains of lack of appetite, nausea, insomnia or drowsiness, dizziness, pain in the joints, there are violations of the cardiovascular system: shortness of breath, tachycardia, arrhythmias, lowering blood pressure; symptoms of damage to the digestive organs: increased salivation, dry mouth, bitterness, metallic taste in the mouth, flatulence, abdominal pain, diarrhea.
- A decrease in body weight is characteristic. An objective indicator of the general radiation reaction is a decrease in the number of leukocytes in the peripheral blood, so a clinical blood test should be performed every 5-7 days.
- In order to prevent symptoms of a general radiation reaction, the patient is prescribed a vitamin-rich diet with a sufficient amount of liquid; prescribe physical therapy. A complex of drugs is used, including antihistamines, antitoxic substances and hematopoietic stimulants, especially leukopoiesis .
- If necessary, they resort to transfusions of a small amount (100-150 ml) of single -group blood or leukocyte mass. In the case of the development of inflammatory processes, antibiotics are prescribed.

- Remote exposure is inevitably associated with *local radiation reactions of the skin and mucous membranes.* Skin reactions include *redness (erythema)* and *dry radiodermatitis* . Slight reddening of the skin is observed already in the first hours and days after irradiation and is explained by vasomotor disorders. Persistent erythema appears 1-2 weeks after the beginning of treatment and is accompanied by slight soreness and swelling of the skin in the irradiation zone.

After the cessation of radiation exposure, the redness of the skin decreases and its fine peeling begins. Then pigmentation is noted, which can persist for a long time.

- With more intense and prolonged irradiation, erythema is brighter, swelling is more pronounced. The epidermis thins out. Dry radiodermatitis develops . It ends with detachment of the epidermis in whole layers. The skin flakes for a long time, remains dry and pigmented.
- *Weeping (wet) radiodermatitis* using the correct radiotherapy technique should not be developed.
- When it appears, the skin infiltrated, vesicles filled with serous liquid. After the rejection of the epidermis, a weeping bright pink surface appears with a scanty discharge. It gradually epithelizes , the skin flakes off for a long time and remains unevenly pigmented.
- In order to reduce radiation reactions, the irradiation fields are sprinkled with indifferent powder. After the development of erythema, they are lubricated with fish oil or sea buckthorn oil.

With interstitial gamma therapy , skin reactions are more pronounced. The papillae of the skin lose their cover, vesicles appear with serous contents. Weeping radiodermatitis occurs . The affected area is covered with a film of fibrin. Epithelialization continues 2-3 weeks . Subsequently, the skin retains a dark color, devoid of hair. For the treatment of exudative radiodermatitis , dressings with boric liquid, prednisolone or methyluracil ointment are used.

- The reaction of the mucous membranes to radiation begins with hyperemia and swelling. The mucous membrane loses its luster, seems clouded and compacted. Then desquamation of the epithelium occurs and single erosions appear covered with necrotic plaque - a film. This is how islands of membranous radioepitheliitis arise . This is followed by the phase of confluent membranous epithelitis - on a bright red background, an eroded surface is determined, covered with a white fibrinous coating.
- After the end of the irradiation

within 10-15 days , epithelialization of erosions occurs , after which swelling and hyperemia of the mucous membrane are noted for some time.

Radiation reactions of the mucous membranes are painful. When the oral cavity is irradiated, eating is painful, when the pharynx and esophagus are irradiated, dysphagia may occur, and hoarseness is observed when the larynx is irradiated.

In order to prevent and treat radiation reactions of the mucous membranes, the irradiated cavities are sanitized, it is forbidden to eat irritating food, alcoholic beverages, and smoke.

The cavities are washed with weak disinfectant solutions and vitaminized oils (fish oil, vegetable or sea buckthorn oil, etc.) are injected into them alternately with a 1% solution of novocaine, irrigation is carried out with a 5-10% solution of dimexide .
radiation damage to various organs and tissues can occur . In practice, one has to observe *subcutaneous radiation sclerosis, necrosis, ulcers, pneumonitis , enterocolitis, rectosigmoiditis , radiation degenerative bone damage, swelling of the extremities as a result of blood and lymph circulation disorders, and also such a severe complication as radiation myelitis.*

Local radiation damage is divided into early and late.

- Early injuries are those that develop during radiation therapy or within 3 months after its completion. Late radiation injuries include those that occurred at any time after 3 months after radiation therapy.
- *Early damage* is observed mainly in cases where the total radiation dose is 30-50% higher than the tolerance of the irradiated tissues. If the total dose does not exceed tissue tolerance or exceeds it only slightly, then radiation damage can develop in the long term, especially under unfavorable additional circumstances (mechanical or chemical injury to the irradiation field, insolation, etc.).

Tolerant absorbed doses for human organs and tissues

Organ, tissue	**Dose Gy**
Leather	50-65
mucous membranes	30
spinal cord before20 см	57
The spinal cord is more20 см	30
Bone growing	22-30
Bone formed	80
Cartilage	59
Heart, great vessels	43
one lung	30
Both lungs	16
Esophagus	60
Stomach	35
Small intestine	35-42
Colon	45-52
Small liver volume	50
Large liver volume	30
Bladder	60
The lymph nodes	48

The level of necessary tumoricidal doses often exceeds the level of tolerance of the tissues and organs surrounding the tumor.

The main factors affecting the occurrence and severity of radiation damage include:

- the magnitude and rate of the absorbing dose

- fractional dose regimen
- volume of irradiated healthy tissue
- initial state of organs and irradiated tissues
- comorbidity

Radiation sickness

Under these conditions, violations of the vital activity of the skin contribute to the occurrence of radiation necrosis and then the formation of an ulcer.
Radiation ulcers are characterized by resistance, often surgical treatment is required for their elimination - skin grafting to the granulation surface or excision of the affected area with subsequent plastic surgery.
Treatment of local radiation damage should be comprehensive.
It consists in general strengthening therapy and local application of anti-inflammatory and absorbable drugs. With the failure of long-term conservative treatment, surgery is performed.

Strict clinical, dosimetric and radiobiological substantiation and flexible planning of radiation therapy make it possible in most cases to avoid severe complications.

- After the rehabilitation period, the patient may be in his usual domestic or industrial conditions, but follow the recommendations given to him and periodically appear for a dispensary examination.

Radiation therapy for non-cancer diseases

Radiobiological bases of radiation therapy of non-tumor diseases.

- The mechanisms of the local therapeutic action of low doses of radiation have not yet been sufficiently studied.

First , local effects were identified empirically : pronounced anti-inflammatory, decongestant, analgesic,
desensitizing. These effects led to a local improvement in tissue trophism and the elimination of various types of pathological changes.

The absence at the beginning of the 20th century of modern antibacterial therapy and the obtaining of obvious + effects during irradiation led to the widespread use of radiation therapy in the treatment of non-tumor diseases. Among the many experimental and clinical studies of that time, the works of M.I. Nemenova with employees
They studied the effect of X-rays on the nervous system, as a result of which a neuro-regular theory was created. According to this theory, the main factor in radiation exposure is the effect on the autonomic system, the pituitary -hypothalamic region, and the adrenal glands.
In the same years, the cellular-enzymatic theory began to develop, in which the main factor of local radiation action is the destruction of cells, primarily leukocytes , after which cellular decay products, including proteolytic enzymes, have a positive effect on local tissue processes. The electrochemical theory proceeds from the fact that immediately after radiation exposure, a short-term increase in acidosis occurs, which after 6-24 hours is replaced by a slowly increasing and long-lasting (8-16) alkalosis . permeability.
According to another theory - the theory of inhibition of various processes under the influence of radiation, inhibition gives rise to secondary stimulation of local processes and leads to anti-inflammatory, antispastic, antisecretory, desensitizing and other local effects of radiation. It is currently believed that therapeutic doses cause
change in capillary permeability,

- strengthening the drainage of the focus of inflammation by improving venous and lymphatic drainage ,
- swelling reduction.
- All this leads to the subsequent subsidence of pain, improvement of blood flow and local trophic processes.

In addition, the direct effect of irradiation on nerve endings with a change in the functional state of nerve centers and nodes in the direction of removing their pathological excitation has been proven.

Apparently, this leads to an analgesic effect and improved nerve conduction.

Radiation therapy of thermal lesions.

Before and after radiotherapy

The accumulated knowledge about the long-term effects of radiation, as well as the emergence of other effective methods of treatment, have narrowed the indications for radiation therapy for non-tumor diseases, however, effective treatment of patients continues in cases where other types of treatment do not help, as well as in situations where radiation has obvious advantages. In the acute period, remove the phenomena of inflammation, reduce swelling, prevent the development of granulations, excessive keloid scars.

- apply small doses of 1.5-2.0 Gy for acute and 3.0-10.0 Gy for chronic processes 3 times a week.

  single doses:

- ✓ in acute diseases - 0.2-0.3 Gy
- ✓ with chronic _ Diseases - 0.5 - 0.7 Gy

  local processes : anti-inflammatory, desensitizing, antiseptic, antisecretory effect, anesthesia, healing without keloid scars, restoration of disturbed trophic processes.

Taking into account the neuroendocrine theory, along with irradiation of the area, pathological changes and indirect irradiation, i.e., irradiation of chains of sympathetic nodes of border trunks, are substantiated.

Such irradiation improves neuromuscular conduction in post- amputation syndrome, phantom pain, syringomyelia.

Radiation safety

Protection is a set of devices and measures designed to reduce the physical dose of radiation affecting a person below the permissible dose.

The main protection factors are stationary and non-stationary devices

Stationary devices are called fixed structures - walls, ceilings, protective doors, observation windows, walls for local protection, etc. They provide protection from direct scattered radiation to all persons located in the premises adjacent to the radiation source.

Mobile protective devices - casings in which radioactive preparations or X-ray tubes are placed. The task of the casing is to completely absorb all the emitted radiation, with the exception of the working beam, which is released through the exit window and is used for research or treatment of the patient. Depending on the power of the emitter, the casings have different sizes and thicknesses. Non-stationary devices include safes for storing **radioactive** preparations and containers for their placement and transportation. To work with isotopes, there are special remote radio manipulation drains equipped with remote tools and protective screens.

Non-stationary protective devices include personal protective equipment:

- aprons made of leaded rubber

- protective skirts

- protective gloves

- protective slippers

Parts of the patient's body that should not be exposed to radiation are covered with lead rubber sheets or special lead plates.

The collar is designed to protect the thyroid gland during cranial and dental research.

perelina designed to protect the thyroid gland and internal organs during cranial and dental examinations.

apron is a reliable type of protection for X-ray dental examinations.

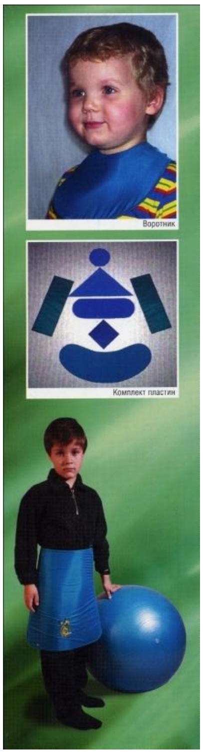
The apron (gonadal protection) is designed to protect the genitals.

X-ray protective skirt the purpose is the same, but covers the pelvic area from all sides.

A set of protective plates is designed to form the patient's irradiation field.

The staff of the radiological department is provided with clothing consisting of a gown, plastic apron with a bib, plastic sleeves, rubber gloves, slippers, shoe covers, glasses made of organic glass, respirators.

X-ray protective glasses recommended for use in angiography and urological research.



Cap to protect the head area.

The apron is unilateral convenient design on flypapers.

The double-sided apron covers the front and back of the body.

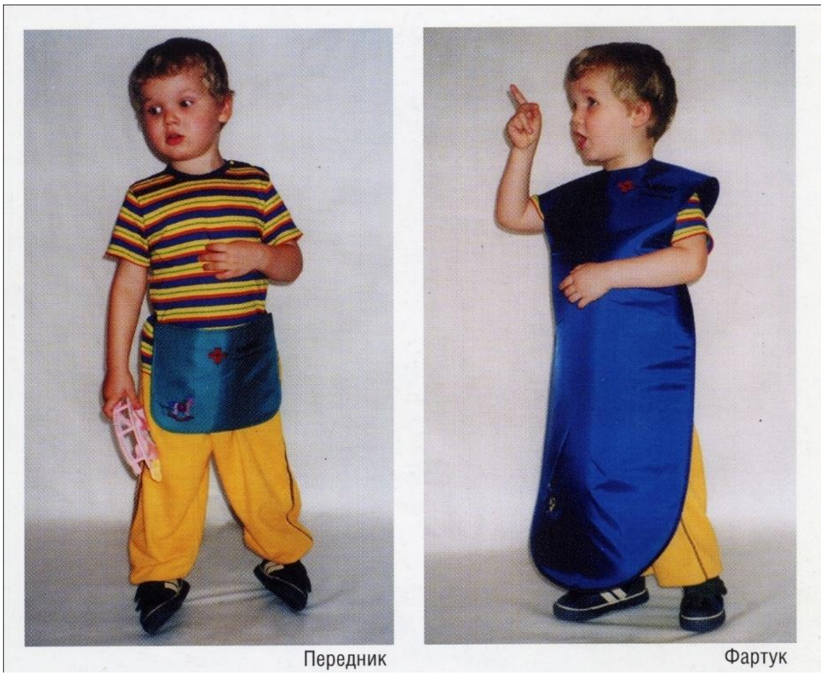
Silicone gloves with tungsten filler.

gloves are made of natural rubber. Can
used by surgeons.

A set of X-ray protective plates to protect various organs of the child in pediatric research

One-sided apron to protect the front surface of the body.
Skirt to protect the gonads.

Thyroid **Collar**



An essential factor in radiation safety is the rational arrangement of workplaces with their maximum possible distance from the radiation source.

- ***this is the so-called defense by distance*** .

Powerful radiation sources accepted

- install in large rooms and away from walls:

- in the offices, the place of work of the doctor is as far as possible from the points of the highest level of radiation.

- during X-ray diagnostic procedures, they strive for large distances between the focus of the X-ray tube and the patient.

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- during X-ray diagnostic procedures, they strive for large distances between the focus of the X-ray tube and the patient.

Dosimetry control is one of the most important health and safety factors.

- in all rooms where work with radioactive substances is carried out, it is necessary to install dosimeters that signal the excess of permissible

radiation levels.

- all employees must carry individual dosimeters with them at all times in order to determine the radiation doses they receive.

Test questions.

1. Organization of the radiological department.
2. Classification of methods of radiation therapy.
3. Electrophysical generators of ionizing radiation /medical accelerators/, their device.
4. The device of the gamma therapeutic apparatus.

5. The device of the X-ray therapeutic close-focus apparatus.
6. Radioactive preparations of open and closed type.
7. The chain of technological support of contact methods of irradiation.
8. Methods of intracavitary gamma, beta - and neuronal therapy, indications for them.
9. Methods of application radiation therapy and indications for it.
10. Production of dummies for application therapy.
11. Methods of interstitial gamma, beta and neutron therapy , indications for them.
12. Prebeam period.
13. Statistical and mobile irradiation.
14. Selection of irradiation fields, their number.
15. Beam period. Formation of the working beam and its guidance on the patient.
16. General reactions of the body to radiation.
17. Local reactions of the body to radiation.

Possible Complications of Radiation Therapy

Test tasks:

1. The threshold dose for the development of acute radiation sickness is

A . 0.5 gray

B. 1 Gr

B. 2 Gr

D .3 Gr

D .4 Gr

2. After irradiation of the male gonads, the most characteristic changes are

A . violation of sexual potency

B. hypospermia

B. hydrocele

D. hereditary diseases in children

D . decrease in blood testosterone

3 . **The clinical symptom that occurs most early in acute radiation sickness is**

A. nausea and vomiting

B. leukopenia

B. skin **erythema**

G . hair loss

4. The preferred bone marrow donor for the treatment of a patient with acute radiation sickness are

A. the patient's parents

B. siblings

V. children of the patient

D. other family members

5. The earliest changes in the clinical analysis of blood in acute radiation sickness are

A. erythrocytes

B leukocytes

V. neutrophils

G. lymphocytes

D. platelets

6. **In acute radiation sickness, clinical changes necessarily take place in the following system**

A CNS

B. cardiovascular system

B . digestive system

G. hematopoietic system

D. immune system

7. What is "interstitial radiotherapy"?

A. Oral administration of radioactive isotopes for therapeutic purposes

B. Introduction of the radiation source directly into the pathological focus.

B. Intravenous administration of a radioactive substance for therapeutic purposes.

8. What type of radiation therapy is the introduction of radioactive preparations into the cervical canal?

A. Close focus therapy.

B. To application therapy.

B. To intracavitary therapy.

9. What explains the greater radiosensitivity of malignant tumors compared to benign ones?

A. The ability to metastasize.

B. A feature to grow into the surrounding tissues.

B. A feature of rapid growth and less differentiation of their tissue.

G. Slow metabolic rate.

D. Absorption of more radiant energy.

10. What is the "standard" or "classic" mode of fine fractionation?

A. 2 Gy x 5 times a week with a break of 2 days, lasting 5-6 weeks.

B. 1 Gy x 2 times a day daily, lasting 6-8 weeks

B. 2 Gy every other day without interruption, lasting 10 weeks.

Answers :

1. **B**
2. **B**
3. **BUT**
4. **B**
5. **G.**
6. **G**
7. **B**
8. **IN**

9. IN

10. A