Lecture

# Topical issues of radiation hygiene.
# Issues of bioethics and biosafety in the application of ionizing radiation.

Radiation as adverse physical production factor.

Radioactive radiation is widely applied in the atomic power station, the industry, in medicine for medical and diagnostic procedures.

Feature action of this factor on organism is pathological changes even at small levels of influence that demands especially strict observance hygienic requirements, norms of radiating safety (NRS) and careful survey of working.

Concept "Radio-activity".

Radio-activity is ability of substances to spontaneous disintegration (transformation nucleus of atoms of one elements into others) with allocation of energy as particles or radiation.

The characteristic kinds of ionization radiation:

1. Corpuscular radiation:

- Alpha radiation is a stream of alpha-particles (nucleus of helium). This is basically from natural isotopes. Ionization ability is forming 6000 pairs ions in 1 $mm^3$, penetrating ability is run in air 11 mm, in fabrics 1/6 mm running. they penetrate only into a superficial layer of skin. Protection is by clothes, by aluminum foil. The basic danger is at internal hit in an organism with water, food;
- Beta radiation - a stream of beta-particles (electrons or positrons). Ionization forms 6 pairs ions in 1 ml, penetrating ability is up to 1m in air, in tissues it makes up to 1 cm. Protection can used any materials, except lead (formation braking X-ray radiation).
- Neutron radiation is a stream of neutrons. Ionization is 400 pairs ions in 1 ml, run in air is hundreds m, in tissues it makes up to 10m. Protection against fast neutrons is substances with a small serial number (hydrogen) - water, paraffin, polymer materials. Slow neutrons are absorbed by borum, cadmium.

2. Electromagnetic radiation:

X-ray and gamma - radiation. Ionization forms 0,1 pairs ions in 1 ml, run in air makes up hundred m, in tissues it makes up some m (depends on rigidity of radiation - from length of a wave). Gamma - radiation is more rigid.

Protection is materials with high density - lead, concrete.

ACTION of RADIATION ON the ORGANISM

The basic stages of development of radiation injuries:

1. Formation of ionized and excited atoms and molecules which cooperate among themselves and various molecular systems, forming biologically active substances, also they are possible breaks of intermolecular connections (initial or starting processes);
2. Action of biologically active formed substances (free radicals, ions etc.) on biological structures of a cells in organism. It is destruction of biosubstances and formation new substances unusual for an organism;
3. Violation of metabolism of biological systems with changes appropriate functions.

The major biological reactions organism at action of radiation.

All consequences of radiation action on organism can be conditionally divided on SOMATIC effects and REMOVAL effects. Somatic effects are ones at the irradiated organism, removal effects are ones appeared after long time or at future generations.

All radiating effects divide on:

STOCHASTIC - it is no threshold of harmful action, have probable character - estimated on possible risk - the cancerogenic, mutagen action, hereditary effects, it is difficult investigate in experimental research, it is impossible to establish threshold of harmful action precisely. These effects are basically shown at action of small dozes (when the professional and natural irradiation for life does not exceed 100 BER)

NOT STOCHASTIC (threshold) effects. Weight of defeat depends on doze and it is possible to establish threshold of harmful action and to determine safe levels influence of radiation. All norms of radiation are based on the prevention of these effects. Not stochastic effects are concerned:

1 Sharp radiation sickness is possible at dozes of irradiation at once more than 100 BER (100-200 - easy degree; 200-300 - average; 300-500 -heavy and from above 500 BER - the heaviest). Dozes 500-600 BER at a unitary irradiation are absolutely fatal.

2. Chronic radiation sickness is possible at long irradiation in a doze less than 100 BER.

3. Beam burns on the skin are possible reaction of 1 degree - at doze up to 500 BER; 2 degrees - up to 800; 3 - up to 1200; 4 - from above 1200 BER.

4. Beam cataract makes up at doze of radiation more than 30 BER per one year.

It is showed, that somatic effects do not arise at observance established hygienic specifications. However if there are not threshold of stochastic and hereditary effects, hygienic specifications can not guarantee their absence.

## GROUPS CRITICAL BODIES. LAW of BERGANIE.

Law of French scientist Berganie is: radio sensitivity of tissues is directly proportional to its ability to division and inversely proportional to degree of its differentiation. Thus, than more intensively in a fabric or body there are processes of duplication of cells and the less a fabric is differential, the more sensitively it is to radiation. According to this law ail bodies share on 3 groups of critical bodies:

1 - all body, gonads, bodies of blood formation (red bone brain);
2 - all internal organs,
3 - skin, bones.

Based on possible consequences of irradiation the following categories of irradiated people are determined:

**Category A.** It includes medical staff (professionals) and people, who work with sources of ionizing radiation directly regularly or temporarily.

**Category B.** It includes people, who do not work directly with sources of ionizing radiation, but their working places are located so, that they can be exposed to the influence of radionuclides and other sources of radiation, used in the establishments.

**Category C** is population in the whole that is the population of a district, a region or a country**.**

## HYGIENIC NORMATIVES of RADIATION

For protection working and the population from radiation there are established the following norms. On influence on critical bodies maximum permissible doses (MPD) radiation are established at external irradiation:

Category A - the persons professionally contacting to radiation -
MPD 2 BER / year (0,2 Zivert / year) or 40 miliBER in week.
Category B - people which are taking place near with sources of
radiation - MPD - 0,2 BER (0,02 Zv / year).

Category C - other population - MPD - 0,1 BER (0,01 Zv / year).

In hygiene all sources of radiation share on CLOSED and OPEN:

- CLOSED source is as radiation acts only in environment (example - X-ray tube);
- OPEN source is in environment can act both radiation, and particles (example - radioactive isotopes).

Principles of radiation safety at work with the closed sources of radiation.

CLOSED SOURCE allocates in environment only electromagnetic radiation such as X-ray or gamma - radiation. Basis protective measures are rules of transmission of radiation:

a) The doze of external irradiation is proportional to intensity and time of action;
b) Intensity of radiation is inversely proportional to a distance;
c) Intensity of radiation decreases depending on thickness of screens.

4 principles of protection from radiation are: 1) protection by amount of doze, 2) by distance, 3) by time, 4) by screens.

There are 5 kinds of screens for protection from radiation:

- Protective containers for storage radioisotopes;
- Screens for the equipment;
- Mobile screens;
- Screens in building designs (walls, ceilings, doors, floors);
- Screens individual means of protection - lead gloves, aprons, etc.

Principles of radiating safety at work with open sources of radiation.

OPEN SOURCE allocates in environment not only x-ray and gamma - radiation, but also streams of radioactive particles (alpha, beta-particles and neutrons). Main principles of protection are:

- Use principles of protection at work with the closed sources;
- Hermetic sealing, automation of the equipment, isolating suits, special boxes and exhaust devices for work with isotopes;
- Special not adsorbing coverings of surfaces, often cleaning surfaces of radioactive pollution;
- The special equipment of ventilation (exhaust ventilation is equipped with filters), water drains (in special sediment bowls), sufficient water supply;
- Special lay-out of premises with the built protective designs; a lay-out of a site - distance radiological laboratories from residential buildings, branches etc. depending on their class (4 classes by annual amount used radioactive substances);
- Careful radiating and medical control personnel;
- Observance personal hygiene and requirements to overalls.

Problems of radiating ecology.

Natural radiating background (NRB)

Natural radiating background - a natural level of radio-activity in the given district, basically dependent on natural factors. On the average makes about 100 miliBER / year, but can test significant fluctuations in view of the natural and anthropogen reasons. In Crimea it is 6-30 miliRoentgen / hour (it is more - in the mountain part of Crimea -radioactivity of the granite masses, containing uranium).

Structure NRB:

- Space radiation (25-40 %) - (2 filters protection from it - EMF of the Earth and ozone cloud) it varies in connection with fluctuations of solar activity and interplanetary EMF, on the average the person on the Earth by it receives 28 mBER/year;
- Natural radio-activity of ground (granite), air, water;

- Food stuffs - about 25 % NRB

Thus, in NRB the external irradiation makes 75 %, internal 25 %.

Additional anthropogenic sources of increase NRB for the population:

- Regions of the atomic power station and consequences of their failures and nuclear explosions;

- Diagnostic x-ray procedures (at roentgenoscopia the patient receives 1 BER at once); (it is important to reduce unnecessary diagnostic x-ray procedures). - TV-sets - at see color TV for 4 hours in day person receives 50 mBER per year (it is especially important for children).

Dynamics (changes) NRB.

It is investigated since 50th years. Rise of it was in 50th years (reason -mass tests of the nuclear weapon), than - decrease to 70th years (convention about interdiction nuclear tests in 3 environments -now permissible only underground explosions), growth since 70th years (development atomic power stations).

# HYGIENIC REQUIREMENTS TO TREATMENT-AND-PROPHYLACTIC ESTABLISHMENTS.

Treatment establishments (hospitals) is build for creation treatment-guarding mode

The treatment-guarding mode and it main components.

The treatment-guarding mode is the complex of treatment -diagnostic, hygienic, administrative and economic actions, directed on he fastest restoration of work capacity or health of the person.

*Treatment-diagnostic actions:*

- Diagnostic and medical procedures. They are the main factor, but without performance other measures of treatment-guarding mode their efficiency is reduced.

*Hygienic actions:*

- Optimum choice site of hospital, observance requirements to hospital site and its functional zones,
- Creation sanitary-antyepidemic mode in hospitals, prevention intra hospital infections (II),
- Creation optimum hygienic conditions of accommodation, lay-out, solation and functional connection premises in hospital,
- Maintenance hygienic requirements to microclimate, bacterial impurity of the hospital environment, illumination, ventilation, water supply, heating of hospital premises,
- Maintenance rational and dietetic feeding patients, prevention food poisonings,
- Observance personal hygiene by patients and the personnel,
- Creation optimum working conditions for medical staff and prevention occupational diseases in personnel.

*Administrative actions:*

- Establishment the schedule and mode of operation of hospital and polyclinic,
- Management states of the personnel,
- Analysis effectiveness work of the personnel etc.

*Economic actions:*

Supply with medicines, linen and the equipment, foodstuffs transport supply of hospital.

HYGIENIC REQUIREMENTS for the HOSPITAL SITE

At choice place for site of hospital of the <u>common structure</u> (central region hospital city hospital with polyclinic etc) 2 basic requirements are showed:

1) Creation optimum hygienic conditions in the place of location - is better behind city.

2) Availability to the served population (radius service of polyclinic in city 3-5 kms) - hospital must be in city center where it is bad hygienic conditions.

It is difficult enough to combine both these requirements since they are inconsistent. Now the problem is solved by construction hospital on surburb, and polyclinics - in city center.

For the <u>specialized hospitals</u> (phtysiatric, oncological, psycho-neurologic, infectious, venerologic) the first requirement is priority, second is not need.

<u>The important criterion of hospital site is its area.</u>

The sizes of the ground areas for hospitals of all types are regulated Sanitary norms and depend on capacity of hospital at capacity hospital up to 50 cots - 300 $m^2$ for 1 cot, up to 100 cots - 200 $m^2$, from 200 up to 400 cots - 140-100 $m^2$, from 400 up to 800 cots - 100 - 80 $m^2$, from 800 up to 1000 cots - 80 - 60 $m^2$.

For the specialized hospitals in suburb the area is increased for infectious and oncological hospitals on 15 %, for phtysiatric and psychiatric - on 25 %, for pediatric on 40 % The area site of maternity hospital makes 0,7 from norms for usual hospital.

HYGIENIC REQUIREMENTS FOR THE LAYOUT of the HOSPITAL SITE.

The hospital site should be the rectangular form with a ratio of the sides as 1:2 or 3:4 for convenience functional zones.

The density building of site of hospital should not exceed 15 %. Green plantings should occupy not less than 60 % of the area of a site. On perimeter the protective green strip not less than 15 meters is arranged.

Functional zones on hospital site:

1 Zone medical buildings (infectious and not infectious). Infectious branch place in depth of a site.

2 The landscape gardening zone - includes green plantmgs on perimeter of a site, between buildings.

3 The zone pathological anatomical branch should settle down outside of their visibility from windows of medical cases.

4 Zone polyclinic. The polyclinic should be placed on distance 30-50 m from medical cases and have a separate entrance on a hospital site, or to be closer to a main entrance on a hospital site.

5 The economic zone settles on distance 30-40 meters from other zones. Here place the central boiler-house, laundry with desinfection chamber, warehouse premises, garage, kitchen.

## THE SYSTEMS OF HOSPITAL CONSTRUCTION.

Historical types construction hospitals:

In 17-18 centuries - barracks type (one big room for all patients), then - corridor-barracks type - the big wards left in a corridor - conditions for patients and the personnel were a little improved.

The hutment type. For the first time in the world was applied by N.I. Pirogov in Crimea in 1855-1856. Patients after operations were short time in one wooden barrack, then them translated in other barrack, and old barrack burnt It made possible to lower amount of postoperative infectious complications

Pavilion type - in 19 century - the beginning 20 century. It is construction separate premises for wards in park with good airing, illumination.

Modern types construction hospitals (in 20 century):

1 Decentralized system is characterized by presence several usually one - two floor buildings, each of which is used for branch of one type (surgical, therapeutic etc). In separate buildings of hospital placed diagnostic economic and auxiliary services, management of hospital, polyclinic.

This system is now applied at construction sanatorium establishments and for building hospitals in mountain districts.

2 The centralized system is characterized accommodation all medical branches, polyclinics, administrative premises, pathological anatomical and economic branches in one multi-storey building. For example, for 900-cots hospital needs 15-floor building.

3 The mixed system building is characterized by the tendency to reduction amount of medical cases up to 2-4, centralization hospital treatment-diagnostic and auxiliary services. Infectious, children's, radiological branches and polyclinic are placed in separate buildings.

4 The centralized-block system in modern conditions is the most appropriate for large hospitals. Basic sign of centralized-block system is division all premises of hospital complex into two groups:

1) The first group of premises - for long-term, stable operation-treatment buildings with ward sections of any structure.

2) The second group of premises which functional purpose demands regular updating of the equipment, reconstruction (which realization should not stop work of hospital complex as a

whole) - operational block, premises for functional diagnostics, diagnostic laboratories, physiotherapeutic branches, polyclinic, etc.

## HYGIENIC REQUIREMENTS FOR WARD SECTION.

The basic functional element of any branch of hospital is ward section for 25 - 30 cots in some profile branches (reanimation branch). it is less. If branch is calculated for 30 cots it is equal one ward section.

The basic premises of ward section wards room of the doctor viewing buffet, bathroom hall - dining room material. There should be two 1-cot wards (for infectious patients - isolator and for agonise patients).

## HYGIENIC REQUIREMENTS TO HOSPITAL WARD.

Capacity of ward for adults and children is more senior than 1 year in hospitals should not be more than 4 cots. This parameter is optimum both in technological and in hygienic relations. The area of ward should be 7 $m^2$ on 1 cot the area in ward of intensive therapy - 13 $m^2$ on 1 cot. The microclimate temperature 18-22$^0$ C, relative humidity 40-60 %, speed movement of air 0,2-0,4 m/s. Ventilation contents $CO_2$ - 0,1 %, frequency rate of ventilation 2-3 volume of ventilation 20-80 $m^3$ in hour at 1 cot. Natural illumination: Light factor (LF) 1:5-1:6, factor natural illumination (FNI) - 1 %. Artificial illumination: common illumination in ward not less than 50 lux, local -100 lux, on duty (at night at an exit) - 3 lux. The distance between beds not less than 0 8 - 1 m and between beds and external walls is not closer than 0 9 - 1 m. Maximum permissible level of noise in ward - 25 deciBell.

## HYGIENIC REQUIREMENTS TO OPERATIONAL BLOCK.

At designing modern large hospitals rationally association several operational in a uniform complex, which should have two branches septic and aseptic with operational, auxiliary and office accommodations.

The structure operational block enter: operational, predoperative, sterilizing, narcotic, premises for storage blood and the portable equipment, a premise for surgeons and operational sisters.

Operational block shares on 4 zones on a degree of sterility:

1) Sterile (operational);
2) Strictly mode (sanitary processing for the personnel, sterilizing);
3) The limited mode (washing, rooms for the personnel);
4) Common hospital mode (cabinet chief of block, etc).

## HYGIENIC REQUIREMENTS TO THE OPERATIONAL

Operational is designing on 1 operational table. The area operational should be not less 36 $m^2$, for difficult operations with participation the big operational brigade - 45-50 $m^2$ Common amount operational tables accept at the rate of 1 table on everyone 30 cots in branches of a surgical structure. Walls operational should be good washing, their coloring in greenish tone is preferable.

Natural illumination. Light factor – 1:2-1:4, factor natural illumination - 2-2,5 % General artificial light exposure - 300-500 lux, local - (on operational field) - 3-10 thousand lux.

Ventilation. Operational air ventilation inflow 6-multiple, extract - 5 with creation surplus of air so that microbes in air from other premises of operational block can not enter in operational. A ventilating aperture must be inflow - at a ceiling, exhaust - at a floor as pair of narcotics it is heavier than air.

Temperature of air in operational 22-25$^0$C (the patient is in a narcosis - the centers thermoregulation are switched - off), humidity up to 55 % (the prevention explosion pairs narcotics in view of high electric conductivity damp air), speed movement of air - 0,1 m/sec.

## HYGIENIC REQUIREMENTS to the RECEPTION BRANCH.

The reception is intended for registration physical examination, statement or specification of the diagnosis sanitary processing patients and in case of need - rendering emergency medical aid. At reception wards patients with the obscure diagnosis are placed.

The structure of reception includes the following premises lobby (for ixpectation), registry and help, viewing, sanitary processing (locker room, a bath, for dressing), procedural, laboratory for urgent analyses, roentgen cabinet, wards on 1-2 cot, study of the doctor on duty, toilet for the personnel.

## HYGIENIC REQUIREMENTS to INFECTIOUS BRANCH

Infectious patients act in the infectious branches not only for treatment, but also for isolation. Therefore, internal planning and sanitary mode of this branch makes for the purpose prevention intra hospital infections.

Isolation patients are carried out in boxings, half-boxings and boxing wards.

Boxing - a premise the general area 22 $m^2$ (on 1 cot) or 27 $m^2$ (on 2 cots) in which there is a ward, external entrance and tambour for receipt the patient, bathroom, internal entrance, which is connected to a hospital corridor. In boxing place patients with the obscure diagnosis and particulary danderous infections (cholera, ets ).

Half-boxing - differs from boxing only absence external entrance with tambour. Patients act in it through a hospital corridor.

Boxing wards - usual ward, cots in which are divided by partitions into height 2 - 2 5 m for the prevention contact between infectious patients. It is impossible to place here patients with air - drop infections - the general air exchange in this ward.

The Infectious branch should have two entrances: one for patients, the second - for the personnel, for delivery medicines, food etc.

Sewage from infectious branch before dump in the city water drain are disinfected (norm of residual chlorine in them - 3 mg /l).

## THE REASONS AND PROPHYLACTIC INTRA -HOSPITAL INFECTIONS. HYGIENE OF WORK MEDICAL PERSONNEL.

Intra hospital infection (II) by definition the WHO it is any clinically expressed disease microbe aetyology, amazing the patient during hospitalization or visiting medical establishments, and also medical staff during his professional work, irrespective, are shown or are lot shown symptoms of this disease during presence of the given aersons in medical establishment.

Structure activators II in 20 century:

1) Till 50th years the leading position in structure II was occupied with the sharp infectious diseases caused by pathogenic microorganisms (scarlet fever, diphtheria, chicken pox, gas gangrene, tetanus etc).

2) Original "plague" of many hospitals in 50-60-e years became a staphylococcal infection.

3) Since 70th years at first place become the gram-negative flora - proteus, esherixia, enterobacter, etc (are very stable to antibiotics).

Danger II for the patient:

- Current of the basic disease is made heavier;
- Morbidity patients at generalized form II is up to 60 %;
- There can be new illnesses during treatment in hospital.

Danger II for public health services and the state:

- Violation work of a hospital, down to time closing for desinfection;
- Increase time of stay of the patient in a hospital (on the average one case II extends term of stay of the patient in hospital for 13-17 days);

- Additional economic charges for treatment patients, work of the personnel.

Basic sources II:

- Initial patients, medical staff, visitors (less often);
- Secondary (objects of the intra hospital environment): tools, linen, furniture; air, food.

Categories intra hospital subjects on danger of transfer II:

1) Critical (are most dangerous, the most strict requirements to disinfection) - surgical toolkit needles, endoscopes, cateters;

2) half-critical (the equipment for inhalations and anesthesia, utensils);

3) Noncritical (linen, furniture).

The Basic ways of transfer II.

Aerosol (air - drop and air - dust);

- Contact (through tools, linen furniture);
- Injection (at introduction of medicines);
- Fecal-oral (dirty hands);
- Alimentary (through food).

Structure II:

- Infections renal ways - 15-40 %;
- Surgical infection -10-30 %;
- Infections of respiratory ways -15-20 %;
- Intestinal infections -10-20 %.

The Reasons growing II now in any countries:

- Growth among hospitalized persons from groups of the increased risk - patients with various chronic diseases (cardiovascular, oncological illnesses of blood, a diabetes), immunodepressive conditions; old patients;

- Easing natural immunity and allergization the population owing to an adverse ecological situation;

- "Urbanization" of the intra hospital environment; concentration a plenty of patients and the personnel in multi-storey buildings;

- Complication operative interventions increase their duration and traumatic, wide application endoscope equipment which are badly giving in to sterilization;

- Excessive, sometimes insufficiently proved application antibiotics, formation intra hospital kinds activators II, polyresistant to antibiotics, used in a hospital;

- Insufficiently careful disinfecting injection and other toolkit;

- Increase duration stay of the patient in a hospital, connected to many functional - diagnostic researches;

-Easing attention to strict observance hygienic and sanitary - antyepidemical modes in hospitals.

System prevention II in hospital:

1) Strict observance sanitary - antyepidemical mode:

- Good ventilation, sanitation air of premises, optimum microclimate;
- Realization medical control personnel;
- Qualitative disinfection and sterilization the equipment, linen etc.;
- Regular bacteriological control tools, linen, air, food, hands;
- Revealing and isolation infectious patients;
- Observance rules of personal hygiene by the personnel and patients.

2) Architectural actions:

- Rational accommodation and zoning hospital site;
- Interposition branches and divisions on buildings and floors for isolation ward sections,

branches, operational, studies, wards;

- Observance hygienic norms of the area, volume of hospital premises.

3) Increase resistancy patients and the personnel optimum mode of work and rest, rational balanced diet; Sufficient stay on fresh air; Scheduled and emergency immunization.

## HYGIENE of WORK MEDICAL PERSONNEL.

Between other professions, sick rate of medical personnel is rather high, especially in surgeons, anesthesiologists, infectionists, phtysiatrists (doctors, treat for tuberculosis), roentgenologists, radiologists, etc.

## HYGIENE of WORK SURGEONS and ANESTHESIOLOGISTS.

During professional work surgeons and anesthesiologists have a number of harmful factors.

- Action chemical substances (means for a narcosis),
-Adverse microclimate (hot),
- Increase concentration $C0_2$ and decrease contents $O_2$ (sterile mask on the face),
- Psycho-emotional and physical overloads with a long pressure on visual acoustical tactile analyzers,
- Compelled position of a body (long stay in vertical position),
- Contact to infectious agents (includes AIDS),
- Often violations of a mode of work and rest.

For prevention professional pathology will carry out a number of preventive actions:

- Creation good artificial microclimate (air-conditioning);
- Centralized submission $O_2$ in operational;
- Forced-air and exhaust ventilation with prevalence of inflow;
- Observance mode of work and rest (duration of a working day in operational day no more than 5 hours, alternation of one operational and two not operational days, after realization of operation - gymnastic exercises and reception soul),
- High-grade feed;
- After realization operation it is not recommended to carry out outpatient reception hours;
- Maintenance surgeons and anesthesiologists dressing from the materials providing good ventilation;
- Change dressing after four hours, mask - in 2 hours after the beginning of operation (since through this time interval sterility is lost).