EDUCATIONAL ESTABLISHMENT
BELARUSIAN STATE MEDICAL UNIVERSITY

Exam

Discipline:
«Radiation medicine and ecology»

Specialty:
1-79 01 01 “General medicine”

APPROVED
Head of the Department

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16.11.2023

Exam program

“Ecological medicine” section

1.1. Basics of environmental medicine. Environmental factors.

Environmental medicine (ecological medicine): concept, goals, objectives, methods. Contribution of heredity, nutritional status and free radical stress into environmental diseases occurrence. Features of the approach to diagnosing and treatment from the perspective of environmental medicine. Examples of the environmental diseases.

Biosphere: concept, characteristics of the major components. Ecosystem: concept, components (ecotope and biocenosis), profiles. Ecosystems classification considering accessibility of energy sources, examples and features of ecosystems. The city as an ecosystem, main characteristics and distinctive features affecting the public health.

1.2. The effect of physical factors on the human body and health.

Environmental factors: concept, classification. Chronobiology and chronomedicine. Effect of visible light and illumination on humans. Biological clock: the diurnal cycle control mechanism. “Seasonal affective disorder” (winter depression): causes, pathogenesis, clinical signs, approaches to treatment, preventive measures. Ultraviolet radiation (UV radiation): concept, profile, mechanism of detrimental effect. Innate human protective mechanisms against adverse effects of UV radiation. Algorithm for calculation of the safe sunbathing time. Minimal erythema dose (MED), UV index. Types of the human skin sensitivity to UV radiation. Human health implications of exposure to UV radiation. Modification of human body sensitivity to UV radiation. Prevention of adverse effects of the skin exposure to UV radiation.

Geomagnetic factors. Mechanism of the geomagnetic storm. Mechanisms of influence on the human body. Oxidative stress and principles to prevent its arising in a cell. Optimization of the exposure of geomagnetic factors on the human body. Meteorological sensitivity: concept, classification accounting for severity of clinical manifestations and types of meteopathic reactions.

1.3. The effect of chemical factors on human health

Alien chemicals (xenobiotics): concept, common classification. Properties of xenobiotics attributing to their toxicity. Mechanisms of toxic action. Toxicokinetics of xenobiotics: absorption, distribution in the body. metabolism, excretion. Effectors of the endocrine system (EES, *syn. endocrine disruptors*): concept, classification, characteristic, metabolism and action mechanism, human health expected effects of a long-term exposure.

Multiple chemical sensitivity: concept, causes for its occurrence and progression, clinical manifestations, approaches in diagnosing and cure. Ecotoxicology.

1.4. Effects of biological factors on human health.

Pathogenic mechanisms of effects of biological factors on human body, examples of the influence. Molds, *Candida albicans* and their role in human pathology. Exorphins. Insulin dependent diabetes mellitus. Hypersensitive pneumonia and Legionnaires' disease.

1.5. Heredity and variation.

The role of genetic factors in the occurrence of the environment-dependent health disorders in humans. Mechanisms of genotoxicity of xenobiotics. The mutation frequency. Chromosomal mutations. The significancy of genome instability in the occurrence of diseases in humans. Somatic mutations and neoplasms, the role of oncogenes and tumor-suppressor genes. Processes of the Deoxyribonucleic acid (DNA) repair. Determination of mutation spectra – screening for genotoxic environmental xenobiotics.

1.6. Environmental and health implications of atmosphere pollution.

Environmental and health implications of atmosphere pollution. Factors and sources of atmosphere pollution. Features of the influence of atmosphere pollutants on the human body. Features of pulmonary toxicity and hemotoxicity of xenobiotics.

Carbon oxides: profile, sources of emission into atmosphere, mechanism of toxic effect in humans. "Greenhouse" effect, chain of changes to the biosphere induced by global warming, expected environmental and health effects of global warming. Nitrogen oxides: profile, sources of emission into atmosphere, mechanism of toxic effect in humans. Photochemical smog: concept, conditions required for the setting of photochemical smog, its major components, including occurrence of products of photochemical reactions, human health effects. Sulfur oxides. Chemical transformations of air pollutants: chemical smog and acidic atmospheric precipitation, potential environmental and health effects.

Stratospheric ozone: characteristics, mechanism of forming, the typical concentration and distribution in atmosphere. Mechanism of ozone layer depletion. “Ozone hole” concept. Factors affecting ozone accumulation in the stratosphere, biological and health effects of ozone layer depletion.

1.7. Environmental and health implications of hydrosphere pollution.

Factors and sources of hydrosphere environmental ill-being. Environmental assessment of water resources of the Republic of Belarus. Eutrophication of water

bodies: concept, causes, environmental and health effects. Characteristics and distinguished effects of waterborne xenobiotics in human body. Distinguished features of neurotoxicity and nephrotoxicity of xenobiotics.

Diseases associated with environmental status of hydrosphere. Characteristics of ecological and health aspects of waterborne xenobiotics: chlorine, volatile organic compounds, radon. Drinking water quality criteria: epidemiological safety, harmlessness in chemical composition, favorable organoleptic properties, radiation safety. Distinguished effects of waterborne xenobiotics in human body. Diseases associated with drinking of water contaminated with chemicals.

1.8. The effect of lithosphere condition and foodstuffs quality on the human health

Lithosphere, soil: concepts, characteristics. Natural and anthropogenic geochemical provinces, significance for the occurrence of endemic health disorders. The World Health Organization (WHO) recommended dietary allowance (RDA) of iodine. Endemic deficiency of iodine in the human body, conditions and factors contributing to the occurrence of endemic goiter, the effect of xenobiotics on thyroid function. Nonspecific and specific prevention of endemic goiter.

Stages of detoxification of xenobiotics. Chemical modification of xenobiotics. Microsomal oxidation system. Cytochrome P-450. The principal pathways of oxidation of hydrophobic substrates. The metabolic activation concept. The microsomal oxidation inhibitors and inducers. Conjugation of xenobiotics: concept, enzymes involved, enzymatic activity regulatory mechanisms. Elimination of xenobiotics. The major foodborne xenobiotics entering the human body. Harmful chemicals of natural origin; toxic compounds forming under certain conditions in the foodstuffs and the human body.

The genetically modified organisms and foodstuffs: concept, use, health and environmental risks, ensuring the biosafety (standardization and legal regulation).

Mercury (Hg), cadmium (Cd), strontium (Sr), lead (Pb), aluminum (A1), arsenic (As) as toxic contaminants of foodstuffs and water: characteristics, the sources of entry into water / food and human body, mechanisms of their effects and health implications. Iron (Fe), copper (Cu), zinc (Zn), selenium (Se): physiological significance for the human body, the principal sources for body penetration, human health implications of their deficient or surplus intake.

Polychlorinated biphenyls and dioxins: characteristics, sources, routes for human body penetration, patterns of distribution in the body, influence on the public health and the human environment.

Nitrites and nitrates: the major sources of entry into the human body, the transformation of nitrates in water, soil and food, regulation of the of nitrites and nitrates content in food and water, the effects of nitrites and nitrates in the human body, medical treatment of nitrites and nitrates poisoning. The N-nitroso compounds: characteristic, formation, major sources and effects in human body.

1.9. Medical aspects of human exposure to the indoor environment

Tobacco smoke: characteristic of major components, toxic effect of tobacco combustion products in the human body under various exposure variants. Characteristics of natural gas and its combustion products. Human health expected effects of the long-term exposure to natural gas and combustion products. Volatile organic compounds: concept, sources for entry into the indoor environment of residential premises, anticipated human health implications of a long-term exposure.

“Sick building” syndrome: concept, factors contributing to its occurrence, clinical presentation, strategies for prevention.

Non-ionizing electromagnetic radiation (NIEMR): concept, classification, mechanisms of biological effect accounting for NIEMR physical characteristics and exposure conditions. Effects of low-frequency electromagnetic fields on human body critical systems, strategies to reduce adverse health effects. Mobile communications: concept, distinguished features. Human health effects of a pulsed microwave electromagnetic radiation, approaches to optimize the exposure implications.

1.10. Monitoring of the environment and the public health

Biological resources: concept, classification, significance for the biosphere. Specially protected natural areas: concept, classification, significance for biosphere and humans. Recreational resources. Law of the Republic of Belarus "On specially protected natural areas". Environmental monitoring: concept, types, methods. Bioindication: concept, the mostly used test species. Socio-hygienic monitoring: concept, goals, objectives, organizational structure.

Evaluation of the human health risks, attributed to the pollution of the environment: concept, stages, models for evaluation of the body dose-dependent responses to carcinogenic and non-carcinogenic substances exposure. Algorithm for calculation of carcinogenic risk, expected count of the surplus cancer cases to be diagnosed in a causal relationship with the environment pollution. Evaluation of the risk acceptability.

1.11. Regulatory and legal foundations for protection of the environment.

Environmental legislation: concept, major regulatory legal acts, basic principles of environmental law. Principal provisions of the Law of the Republic of Belarus “On Protection of the Environment”.

“Radiation medicine” section

2.1. Fundamentals of ionizing radiation action.

Radiation medicine: concept, goals, objectives, methods. Nucleon, isotope, radionuclide: concepts, principal characteristics. Ionizing radiation: concept, classification, principal characteristics. The mechanism of occurrence and characteristics of X-ray and gamma radiation, their interaction with the matter. Radioactivity: concept definition, principal features of the process. Activity as a characteristic of a source of ionizing radiation: definition of the concept, types, units of measurement, relation between systemic and non-systemic units. The Law of radioactive decay: definition, equation, graphical display, practical use to justify

measures for protection of the public in accidents at nuclear facilities (nuclear power plant).

The mechanism of origin (types of radioactive transformations of nuclei) and the interaction of charged particles with the matter. Linear energy transfer (LET): definition, unit of measurement, classification of radiation types accounting for LET value. Examples of nuclei undergoing corresponding types of radioactive transformations. Radionuclides occurring during the operation of a nuclear reactor. Features of the interaction of neutrons of different energies with the matter. Induced radioactivity.

Generic characteristics of the stages of occurrence of radiation injury. Generic pattern of oxidative stress. Radiolysis of water, key products of radiolysis. Direct and indirect effects of ionizing radiation on biomolecules. Oxygen effect: definition of the concept, relationship with LET, practical use to modify tissue radiosensitivity. Radiation biochemistry of nucleic acids, proteins, lipids. Principal types of DNA repair. The effect of ionizing radiation on the membrane structures of the cell. Types of cell responses to ionizing radiation exposure. The nowaday theory disclosing mechanisms of interphase and mitotic cell death. The chain of events in a cell leading to its autolysis.

Methods to register ionizing radiation, their description, detectors and instruments employed.

Dosimetry. Three types of dose quantities: physical, protective, operational – definition of the concepts, purpose. Doses: absorbed (including RBE - *Relative Biological Effectiveness* – weighted absorbed dose), equivalent (including ambient dose equivalent), effective – definition, formula, characteristic of weighting factors, dose units, relationship between units, requirements for use. Kerma. Air Kerma: definition, units, requirements for use.

2.2. Levels of exposure of the general public to ionizing radiation. Radiation background of the Earth

Radiation background of Earth: concept, generic framework, contribution of principal components into the yearly incurred effective dose of the members of the public.

Natural radiation background: sources of terrestrial and extraterrestrial origin, their contribution into the effective dose incurred by the members of the public. Radioactive decay chains: concept and types. Characteristic of the decay chains radionuclides. Contribution of the daughter decay products of uranium-238 and thorium-232 into the effective dose incurred by the general public. Radon and products of its decay: characteristic, members of the public exposure levels, sources, values of doses incurred by humans through exposure to radon. Optimization of the dose burden from exposure to radon and products of its decay.

Man-made radiation background: concept, components contributing to the effective dose incurred by the members of the public. Regulation of exposure of the personnel and the members of the public in a planned exposure situation. Achievements of the nuclear energetics in the Republic of Belarus. Belarusian

Nuclear Power Plant. The nuclear fuel cycle: concept, stages. Heavy nuclei fission, fission chain reaction. The Law of the Republic of Belarus “On regulation of safety in the use of nuclear energy”. Regulation of personnel and the public exposure in a situation of a planned exposure owing to operation of nuclear energy facilities.

2.3. Nature of radiation dose burden on humans in the Republic of Belarus following the Chernobyl Nuclear Plant Accident

The Chernobyl Nuclear Power Plant (NPP) accident. Pathways of exposure of the general public to radionuclides of Chernobyl release. Common patterns and characteristics of the routes for radionuclides to penetrate human body, distribution and excretion. Comparative characteristic of exposure to ingested vs inhaled radionuclides. The Law of the Republic of Belarus “On the legal status of territories exposed to radioactive contamination due to the Chernobyl accident”: use domain, classification of the areas of radioactive contamination in the Republic of Belarus, criteria for habitation on the terrains contaminated with radionuclides.

Features of the major dose causing radionuclides: I-131, Cs-137, Sr-90 – characteristic, body entry routes, distribution, excretion from the body. Dose causing radionuclides: C-14, H-3, transuranic radionuclides (Pu-239, Am-241), "hot particles” – mechanism of occurrence, characteristic, body entry pathways, distribution, excretion from the body, expected biological effects.

Radiometry: definition of the concept, types. Temporary acceptable levels, control republican levels and republican acceptable levels, reference levels of radionuclide content in food products and water. Assessment of radiometry results. Direct radiometry. Indications for measurement of radiocesium content in the body, frequency of measurements; assessment of results and calculation of the approximate dose of internal exposure.

2.4., 2.5 Health and biological implications of exposure to ionizing radiation. Radiation injuries to humans

Radiosensitivity: definition of the concept, assessment criteria, determining factors at different levels of organization of living matter. Major radiation syndromes, characteristics, relation to the dose incurred. Features of the radiation injuries arising in different age categories of the public. The effect of radiation on the embryo and fetus.

Acute radiation sickness: classification (periods, phases, severity); clinical manifestations, principles of treatment. Chronic radiation sickness (ChRS): classification; onset conditions and features of ChRS various variants; detriments in the vital body systems; treatment approaches.

2.6. Deterministic and stochastic consequences of exposure to ionizing radiation

Deterministic effects of exposure to ionizing radiation: definition of the concept, types, characteristics, dependence of the effect on the dose. Stochastic effects of exposure to ionizing radiation: definition of the concept, types, characteristics, dose-dependent effect. Comparative characteristics of deterministic vs stochastic effects of ionizing radiation. The concept of low doses of ionizing

radiation. The concepts on the effect of low doses of ionizing radiation on the human body. Radiation hormesis.

The health status of the general public in the Republic of Belarus after the Chernobyl NPP accident. Regular medical check-up of the citizens suffered the Chernobyl NPP accident and equivalent categories of the citizens: goals and objectives, primary registration groups, assessment of the quality and effectiveness of regular medical check-up.

2.7. Radiation safety control. 2.8. Reducing radiation burden to the general public.

International and national regulatory and managerial bodies in the domain of radiation safety. Law of the Republic of Belarus "On Radiation Safety": scope of application, powers of government authorities to ensure radiation safety. Principal legal documents regulating the provision of radiation safety for the personnel and the members of the public. Principles for radiation safety ensuring; categories and situations of exposure, categories of exposed individuals, restrictions imposed on the exposure of workers and members of the public to man-made sources in situations of a planned exposure. The Sanitary Standards and Regulations "Requirements to enforcement of radiation safety for the personnel and members of the public upon implementation of activities to employ nuclear energy and ionizing radiation sources": scope of application, principles of ensuring radiation safety, assessment of the radiation safety status.

Source of ionizing radiation (IRS): definition of the concept, classification by type, purpose, degree of potential radiation hazard. Organization of work with ionizing radiation sources: criteria of eligibility for employment. Organization of work with radionuclide-containing sealed IRS. Methods of protection from external exposure when operating devices generating ionizing radiation. Organization of work with radionuclide-containing unsealed IRS. Methods of protection from external and internal exposure. Radiotoxicity: definition of the concept, determining parameters. Groups of radiation hazard of radionuclides and classes of work with radionuclide-containing unsealed IRS. Regulation of medical exposure. Optimization of dose burden to patients in X-ray examination procedures. Tracking the doses incurred by patients. Individual dosimetry: definition of the concept, instrumentation; tracking the doses incurred by personnel.

Radiation accidents: definition of the concept, stages of progression, exposure doses being incurred by the general public. International Nuclear Event Scale. Regulation of emergency exposure of personnel, members of the public, first responders. Set of protective and rehabilitation measures assigned to different stages of the post-accidental period under responsibilities of state and individuals.

Skills:

1. Calculation of the annual effective dose of external and internal exposure incurred by members of the public owing to radionuclides of the Chernobyl accident release (considering the ambient dose equivalent rate, specific activity of foodstuffs), assessment of the result obtained.

2. Elaboration of a set of measures to reduce doses incurred due to external exposure.

3. Elaboration of a set of measures to reduce doses incurred due to internal exposure.

The program for exam in the “Radiation and ecological medicine” discipline for the students of the faculty for international students, the 3rd course, 1-79 01 01 “General medicine” specialty, was reviewed and approved by the meeting of the Department of Radiation Medicine and Ecology.

Minutes No. 5 dated 16 november 2023