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Forensic Medical Aspects of Radiation Accidents Investigation

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Radiation accidents with fatal and non-fatal outcomes are hard to investigate.

Results of forensic medical analyses are important and sometimes crucial to establish details of the accident. Based on them, the experts can substantially assist in the investigation: help to formulate possible versions and determine further investigative leads.

In case of internal irradiation the following aspects should be taken into account within such forensic medical analyses.

There are several pathways of intake of radionuclides: inhalation, ingestion or intake through intact or injured skin.

In case of inhalation of radioisotopes degree and nature of lesions of respiratory organs depend primarily on absorbability of them across the air-blood barrier. Hardly soluble radioactive substances are partly removed from the airways with mucus. The rest is retained in pulmonary tissue and has mainly local effect.

In cases of intake of radioactive substances through the gastrointestinal tract well-absorbed radioisotopes (15-20%) are transferred into the blood and then uniformly distributed throughout the body or selectively concentrated in organs and tissues of main deposition.

In case of contact with intact skin radioactive substances might cause local injuries. The rate of their development and severity depends on the absorbed dose and the rate of absorption of radioactive material (e.g. 90% of the radioactive strontium is deposited in bones, causing even in the early days deep distortion and suppression of normal physiological bone formation, which does not occur in case of acute radiation syndrome due to external exposure).

If external irradiation of victims in combination with intake of radioactive substances is suspected, it is important to confirm this information using spectrometric (radiometric) and radiochemical analyses in order to determine pattern of distribution of radionuclides through tissues and organs of corpse and level of radioactivity.

In case of external exposure different conditions of irradiation have different effects on clinical history and anatomical characteristics of radiation injury. This is due either to a different degree of severity of pathologic changes or specific localization of the most pronounced effects. It is important to consider qualitative and quantitative characteristics of pathological processes in order to help assessing the full range of different conditions which could cause the prior fatal lesion.

There are unlimited variants of non-uniform exposure with a primary direct effect of ionizing radiation on a particular part of the body. So, it is important to identify the basic scenarios where the absorbed dose to head, chest, abdomen or limbs is maximal.

In cases of non-uniform external radiation exposure a pathologist should take into account that an isolated or predominant exposure of head to large dose leads to lesion of its skin, mucous membranes of mouth and nose, eyes and brain. Irradiation of chest results in lesion of lungs, heart muscle, spine (with peripheral spinal disorders), bone marrow of sternum and vertebrae. Irradiation of abdomen and pelvis results in lesions of small intestine up to development of ulcero-necrotic changes and peritonitis. Sometimes it may result in lesion of colon and other internal organs, e.g. kidneys. Irradiation of limbs results in lesions of skin and skeletal muscles.

Macroscopic and especially microscopic examination of hemopoietic organs of a deceased is of particular importance in order to establish presence / absence of significant differences in condition of bone marrow, taken from different parts of the body, as well as the discrepancy between severity of suppression of hematopoiesis and characteristics of peripheral blood.

Period of time passed after radiation injury can be assessed on the basis of morphological characteristics of bone marrow. Under doses at which the hematopoietic form of radiation syndrome takes place, the stromal elements and plasma cells dominate in cellular composition in the first 2-3 weeks of the disease. Later, after 4 weeks, granular lymphocytes appear. Then morphological signs of early recovery can be observed: the number of hematopoietic stem cells and mitosis increase.

Using immunomorphological methods of staining of bone marrow sections an expert can make a rough estimation of radiation injury severity. Under the doses within “marrow failure” range (1-10 Gy) the number of dying cells is low - an average of 4-5 in a field of view of a microscope. Under higher doses (“intestinal” and “cerebral” forms of radiation syndrome) - cell death exceeds 50%.

Thus, a lot of questions traditionally asked experts by investigating authorities can be answered on the basis of the assessment of nature and severity of lesions observed on corpse or body of survivor including 1) diagnostics of radiation injuries and making decision on possibility or impossibility of development of such lesions under conditions specified in a case files; 2) determination of period of time passed after radiation accident and mechanism of radiation injury development in order to reconstruct circumstances of a case; 3) determination of radiation characteristics; 4) assessment of dose and exposure duration.

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