Case Report: Iridium 192 - Health Effects during 20 Years after Irradiation

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This Case Report has presented health effects of high level of irradiation with gamma rays from Ir¹⁹²m on the patient M. L. during 21 years after the accident. The main purpose of this investigation was to analyze long time consequences of partial high-level irradiation on human health. Locally, short-term irradiation, with high deadly dose, caused acute radiation syndrome with reversible disorder function of the individual, most exposed, organs. Frequency of chromosomal aberrations (dicentric), characteristic for direct irradiation, was increased. However, dicentric analyzes did not give expected result for an acute radioactivity illness. Radio dermatitis had begun already after the incident, while changes on the heart began not earlier than six months and gradually have been increased up to two years after the incident. Irradiated parts of the patient skin have been replaced with auto-transplanted skin and appropriate therapy had been taken. More than two decades after the irradiation, system (leukemia) nor solitary tumor on near organs (liver, heart, lungs, bones) have not been appeared. Radiation illness did not happen in spite of very large dose, because impacts had been local and body was unlikely irradiated. Also, an appropriate therapy was organized and other potential illnesses did not appear.

Iridium-192 (Ir¹⁹²m) is a meta-stable isotope of Iridium that emitting gamma radiation with a low level of Linear Energy Transfer (LET) and high penetration in human body. This isotope frequently has been used for industrial radiography (7).

Usually, workers daily engaged with Ir¹⁹²m for a long time period can be injured by radiation and level of tissue damage depends on doses and period of radiation (3).

Consequences of industrial radiography gamma rays accidents (greater than 20Gy) are skin necrosis in various parts of the body (1). Two up to three decades after irradiation exposure malignant disease could be developed (4). Myeloid leukemia, associated with exposition to gamma rays, can be found in clean-up workers 10 years after the accident (2, 6).

Dose equivalents up to 20-30Sv exposed on the fingertips of workers can cause progressive tissue deterioration and successive amputations of the fingers (7). Health risks could arise in a case of environmental pollution with the radioactive isotope Ir¹⁹²m if it has been lost.

This article has reviewed long-term health consequences of an accidental overexposure from Ir¹⁹²m radiography source on a human being.
INCIDENT

Patient M. L. was 53 years old porter in a car factory, when he took a lost source of Ir$^{192m}$ with an initial power of 296 GBq in a factory courtyard on August 14th, 1982. This Ir$^{192m}$ was used for industrial gamma-radiography and when incident had happened starting power was 275 GBq (7.43 Ci). Patient M. L. carried this gamma source three days in the left upper pocket of the worker blouse, and after that he put it in the table where he had worked one up to two hours per day in next 19 days, when the source was detected and removed.

METHODOLOGY

Monitoring of health effects after the irradiation with high level of radiation started three weeks after the accident and has been continued after three, six, and twelve months, as well as later on after two and half and eleven years.

Mentioned monitoring included: clinical symptoms; clinical and laboratory indicators; skin changes; blood changes; chromosomal changes in the karyotype of lymphocytes; changes on the heart, liver, eye lens; in fact all radiosensitive cells and tissues, as well as parts of the body or organs that had been closely to the source of Ir$^{192m}$. Exposure and absorbed doses on the patient body had been calculated taking into the consideration source power, time of exposure, and distance from the source (9, 10, 11).

RESULTS

Assessment of absorbed dose. Approximately calculated dose was about 22.50 Gy up to 42 Gy for the distance of seven up to five centimeters. Frequency of chromosomal aberrations (dicentrics) confirmed that absorbed dose of gamma rays was high.

Clinical symptoms and signs. Patient M. L. first time was hospitalized on September 3rd, 1982 in the Institute of Occupational Medicine and Radiological Protection in Belgrade with symptoms of acute radio-dermatitis on the parts of body that have been in the contacts with the radioactive source. The most intensive skin changes were on the upper part of right thigh side, front wall of left thoracic girdle (figure 1), on the front side of left thigh, and also on the part of right and left hands joint. Except the insomnia and fast wearing radiation syndrome was not followed with other difficulties or objective findings.

Frequency of chromosomal aberrations was increased. There were dicentric end ring forms; many cells contained both of them (multiple chromosomal aberrations). However, dicentric analyzes, reevaluated few times in short period intervals, did not give expected result for an acute radioactivity illness. Frequencies improperly have varied in the function of time, so that they had increased, contrary to the expectance that it should decrease. Obtained values of absorbed doses on the patient body by this method have been improperly distributed so that it was not possible to implement them for an assessment of biological effect. Probably, it was result of an uneven distribution resulting that lymphocytes from the parts of the body had been closer to the source of radiation were un-proportionally more damaged than those further from the source.

Having in mind that source of radiation was closely to the lymph axillaries nodes additional analyses of lymphocytes karyotype had been carried out. Those analyses have identified significant increase of dicentrics frequency in the long time period after the accident, while in a case of proportional irradiation of the body it could be expected its gradual disappearance.

One year after the accident patient complained on occasional pains in the heart area and increased perspiration during the night. Ulcerous-necrotic changed parts of the skin, breasts
and thigh had been changed with the auto-transplanted skin that had been taken from the inside of the right thigh (figure 2). Skin closely around the auto-transplant, as well as the skin in the area of right hand joint was marble-sided, with telangiectasis, de-pigmented and black pot usual for chronic radio dermatitis.

Two years after the accident necrosis on the hand joint pro graduated in radiation ulcers, so excision had happened and radio dermatitis chronics ulcers non-specific was confirmed by path-histological (PH) analyses, without the morphological elements for malignity (Table 1). Radiological signs of osteoradionecrosis had not been identified. Twelve years after the accident skin was dark-red on the areas of earlier necrosis, partly edematous and atrophied, without the signs of malignant alterations. Eye lens stay transparent and radiation cataract was not developed.

<table>
<thead>
<tr>
<th>Year of examinations</th>
<th>Skin disease</th>
<th>Path-Histological (PH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>Radio dermatitis acute grades II</td>
<td>Auto transplantation cutis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dermatitis ulcerous – necrotic</td>
</tr>
<tr>
<td>1984</td>
<td>Radio necrosis (Ulcers radiation)</td>
<td>Excision (Tierschu method)</td>
</tr>
<tr>
<td></td>
<td>Dermatitis chronic ulcerous non specifics</td>
<td></td>
</tr>
<tr>
<td>1993 – 2003</td>
<td>Radio dermatitis chronics</td>
<td>Atrophic, Oedema</td>
</tr>
</tbody>
</table>

**Clinical-laboratory findings.** Presence of the thrombocytopenia and leucocytopenia in the blood had been identified. The liver was increased 2 cm. Bilirubin in serum had been increased, liver enzymes and factors of coagulation and fibrinolysis were disturbed, in fact factors of pro-thrombus complex. Blood cells count and factors of coagulation completely have been normalized after two years of irradiation. Lymphatic glands had not been increased.

In 1993, eleven years after the accident all elements of haematopoiesis, as well as all liver functions, have been within the physiological framework. By the cytology genetic analyzes of karyotype, chromosome aberrations have been excluded and 14 micronucleus per 1,000 of cells were usual, similarly as in a no exposed population.
Electrocardiography findings (ECG) closely after the incident were without changes. After six months, in February 1983, appearances of ECG were evident, negative T-cog in D1, D2, AVF, and in pre-cordial drain V2-V6.

Such findings had not been followed with subjective difficulties or objective findings on the hearth (Table 2).

Table 2. Cardiac injuries during 10 years after irradiations years

<table>
<thead>
<tr>
<th>Year of examinations</th>
<th>Duration of time from exposure</th>
<th>Electrocardiograph changes</th>
<th>Ergo-metric test</th>
<th>Echocardiogram</th>
<th>Blood pressure</th>
<th>Clinical signs and symptoms</th>
<th>Cardiac disease Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>3 weeks</td>
<td>Normal</td>
<td></td>
<td></td>
<td>Hypotensions</td>
<td>F100/min Nausea</td>
<td>Acute radiations syndrome</td>
</tr>
<tr>
<td>1983</td>
<td>6 months</td>
<td>T negative in D1, D2, AVF and V2 - V6</td>
<td>Normal</td>
<td>Normal</td>
<td>Hypotensions</td>
<td>F 75/min</td>
<td>Myocardial ischemia</td>
</tr>
<tr>
<td>1983</td>
<td>9 months</td>
<td>T negative in D1, D2, AVF and V2 - V6 Elevation ST</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>F 70/min</td>
<td>Ischemic myocardium sub-epicardial</td>
</tr>
<tr>
<td>1983</td>
<td>15 months</td>
<td>T negative in D1, D2, AVF and V2 - V6</td>
<td>Negative</td>
<td>Normal</td>
<td>Normal</td>
<td>F 68/min</td>
<td>Ischemic myocardium post irradiation</td>
</tr>
<tr>
<td>1984</td>
<td>21 months</td>
<td>T negative from V3 to V6</td>
<td>Negative</td>
<td>Pericardial adhesion</td>
<td>Normal</td>
<td>Stenocardio</td>
<td>Pericarditis</td>
</tr>
<tr>
<td>1984</td>
<td>24 months</td>
<td>T negative from V5 to V6</td>
<td>Pericardial adhesion</td>
<td>Hyper tensions</td>
<td>Brest pain</td>
<td>Chronic Radiations Myopericarditis</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>10,5 years</td>
<td>Normal</td>
<td>Hyper tensions</td>
<td>Vertigo F 65/min Anorexia</td>
<td>Chronic Radiations Syndrome</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Findings did not regress on the coronal-dilatators therapy and maintain balance until 1984, and echocardiogram did not point out pathological changes. On the end of 1984, ergo-metric test did not result of reduced coronary reserves and after patient got tired, even decrease of ST level has happened. Repeated echocardiogram showed a pericardial adhesion.

Two years after the irradiation and twenty months after the appearance on the ST segment of ECG changes started with regression, although they had not been normalized in next few years.

From 1993 ECG findings had been totally normal. The patient M.L. had suffered from vertigo, hypertensions, nausea and anorexia irregularly, from time to time (Table 2).

On the end of 2003, 21 years after the accident, an infarct of the myocardium had happened and patient, 74 years old, died because of acute heart failure caused by coronary thrombus occlusion.
DISCUSSION

Complete, system and acute radiation illness had not happened in spite of very large dose, because impacts were local and body was uneven irradiated. Locally, short-term irradiation with high, deadly dose, caused acute radiation syndrome with reversible disorder of function of individual organs had been the most exposed. The most important changes have happened, besides the most exposed parts of the skin, on the hearth (5, 8, 9).

Closeness of lymph nodes and sternum could cause necroses in lymphatic and haematopoietic tissues, in fact fibrosis and aplasia of bone marrow (5). Changes in karyotype of lymphocytes were structural and unstable, so that they disappeared without clinical consequences (10, 11). Obviously appearance of mutations and stabile aberrations had not happened so that they could not fix themselves during the mitoses and stimulate cancer-genesis. In fact, 20 years after the irradiation, neither system (leukemia) nor solitary tumor on near organs (liver, heart, lungs, bones) had happened (2, 6). Clinical-laboratory disorders have been reversible, probably because of damage function of the parenteral organs and carry over heart system and cells membrane, and possible histological changes are repaired or their functions compensated no damaged part of the tissue (4, 7). Changes on blood cells as well as on the liver have had only reversible character because blood and liver cells have had high reparative capacity (4, 10).

Dermatitis ulcerous – necrotic has been developed as a result of high doses irradiation of 20 – 40 Gy, localized on the skin (1, 3, 7). It has been observed as a skin reaction within few weeks after the incident.

Acute radio dermatitis rarely malignly alternate (1). On the skin around the radiation ulcer (later on auto-transplants) radio dermatitis chronic had been appeared because of little smaller dose on that part of the skin, proportionally to the distance of the direct sheaf on the ulcer level. Sometimes, chronic radio-dermatitis can malignly alternate 20 – 30 years after irradiation (1, 3).

A chronic reaction to radiation can be seen starting 6 to 12 months after irradiation (3, 9, 10). Skin in nearest vicinity of excision was changed to the end with the symptoms of chronic radio dermatitis and after 21 years it was not malignancy alternate. It means that age after the incident (from 53 to 74) had impact on lower radio sensitivity (5, 8).

Chronic cardiac changes may have their onset from 6 months to several years after irradiation. The clinical symptoms may indicate chronic constrictive disease due to pericardial, myocardial, and endocardium fibrosis. Changes on the heart began gradually, not earlier than six months up to two years after the incident.

The risk of cardiac death in patients with acute myocardial infarction depends on the irradiated part of the heart and age of the patient (8, 12, 13, 14).

Symptoms of hearth function, as well as blood cells and enzymes in serum have been normalized after ten years, probably because smaller part of the heart of the old patient had been directly irradiated. Death happened because of an infarct of the myocardium and that may be connected with the changes of the heart and blood vessels, or late thrombosis occlusions (12, 14). However, classic diagnostic method (ECG) was not sufficient for monitoring late effects overdose on myocardium.

Case of the patient M. L. had pointed out that partial irradiation with high level of gamma rays from $\text{Ir}^{192m}$ may not be fatal for human beings if appropriate medical treatment has been applied.
REFERENCES


