Medical experience lessons of the assistance of radiation accident victims

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Introduction

The existence of national and international registries on human radiation injuries induced by radiation accidents gives not only the ability to prepare databases on many reference data useful in case of new incidents but also to generalize these materials.

One of perspective goals of such generalization consists in the separation of accident types with the following specific features: character of damaging factors, rate and structure of clinical signs found in victims and rationalized scope of protective diagnosis and therapeutic measures.

Such working classification of the accident will give the future opportunity to optimize the organization of medical assistance and to consider the previous experience critically.

The present report is the attempt to do such generalization using the significant original experience of author and her colleagues in Russia [1] as well as to include the literature reference data [1-3, 6].

Methods of analysis, Materials and Results

The following sources of data were selected from the whole library according to their completeness:

I - 19 criticality accidents;
II - 18 accidents happened when doing unscheduled manipulations at nuclear reactors;
III – incidents of transportable and stationary sources of radiation [3,4].

First two types of accidents were most specific (in all countries) to the start-up period of the atomic industry of military purposes and criticality assembly experiments. After the long pause the occasional large-scale accident at the Chernobyl Nuclear Power plant (1986) has produced about 1/3 of the whole totality of clinical observations and 1/2 of all lethal outcomes (28 cases) within 50 years of the operation of atomic industry. Within recent 10-20 years the severe cases of ARS and LRI (grade III) including these of lethal outcome (15 fatalities) are related to the situation of contact with radiation source of poor control (121 situations), which sources have been circulated in the environment or (more rarely) situated in the stationary installations of different purposes [1].

General information on threshold doses inducing acute radiation sickness and local radiation injuries as well as the classifications of radiation injuries in accordance to their severity and pathogenesis are provided by a number of publications [2,3].

The only indication given here consists in the fact that the application of etiopathogenetical principle originated from our work [2] rather than very unsuccessful enumeration of all radiation injuries given by ICD 9-10; the etiopathogenetical principle provides the classification of damage peculiarities for different types of accidents [4].

Criticality accidents are specific to the following features:

a) complex energy spectrum of ionizing radiation together with peculiarities of the exposure geometry which cause very heterogeneous dose distribution inside the body;
b) usually small number (1-10 persons) of the victims and people involved in the accident;

c) significant differences of the character of whole body damage and local injuries found in victims of the same accident;
d) negligible small importance of radionuclide environmental contamination and body intake;
e) specific importance and complexity of the evaluation of dose distribution inside the body using dosimetry assessments and clinical laboratory tests, which determines the selection of therapy measures (including indications to bone marrow transplantation, recovery of cardiorespiratory system function, amputation and plastic surgery of local defects). The analysis of observations done in the former USSR and Russia (1957, 1959, 1971, 1997 etc.; [5]), Mol [6], and Vincha [7] as well as the recent situation in Tokaimura (30.09.1997; [12]) demonstrates the large possibility to evaluate, particularly, the presence of sources of hemopoiesis self-recovery (local biopsy and modified cytogenetic tests), which possibility was not completely used; the timely elaborated necrectomy is also the major subject of therapy for the accidents of such type [2, 4, 5-8, 12].

The importance of urgent high-qualified medical assistance of such victims provided by radiation medicine specialists of combustiology and hematology profiles is completely obvious to support all phases of therapy including urgent resuscitation, microsurgical plastic surgery and hemopoietic cell transplantation etc. [9].

Accident group II is specific to the importance of so-called “human factor” (the sequence of operator mistakes or the violation of approved standard of work) as well as the accidental group I. However, some technological defects were obvious essentially for the start-up period of the industrial nuclear reactor exploration.

The specific features of the situation in addition to these listed above are the following:
a) the presence of local component of the neutron beam exposure (together with gamma radiation);
b) possibility of contact (hands, more frequently) with exposed elements of the reactor construction or with
subjects moved out from the technological channels (gamma&beta injuries);
c) environmental release of the industrial aerosols and gases, which is specifically essential to form
gamma&beta radiation fields in case of massive destruction of the reactor core (Windscale accident, 1951; Chernobyl accident, 1986);
d) relatively low input of the internal exposure in case of the inhalation radionuclide intake (alternatively to
equal input in case of combined skin injuries found for two victims of the Chernobyl accident);
e) the predominance of victims among the people involved in the accident [4, 6].

According to these features the clinical peculiarities of radiation damage are reflected in:

a) significant rate of local injuries (working hand, eye lens) combined with mild signs of general symptoms
of radiation sickness;
b) small number of direct participants of the accident, who was sometimes involved due to the repeated
manipulations in different accidental areas, which caused the fractionating of dose of heterogeneous dose
rates followed to change of the clinical dynamics and, correspondingly, diagnosis and prognosis value of
separate symptoms;
c) necessity to separate persons of real contact with radiation among large group of surrounding people;
d) incompleteness of dosimetric characteristics even if the modern techniques (ESR, LAS) are applied; such
techniques does not take into account the heterogeneity of dose distribution in time and in body, which
significantly modifies dose-effect ratio. Usual simplification is based upon the total dose averaged in
body/body segment (or on its major fraction). Therapy measures are determined by the clinical syndrome
taking into account this simplification.

In case of the Chernobyl accident the same actions were taken too [10]. At the relatively early terms the
neutron exposure was excluded from the exposure factor spectrum as well as the significant importance of the
internal exposure due to the inhalation radionuclide intake. The ratio of number of victims to the number of
people involved was properly assessed (1:1,000).

Due to the movement of 134 victims inside gamma&beta radiation fields the exposure was accepted to
be relatively homogeneous in the body (which was indirectly confirmed by the character of cytogenetic shifts).
Biological criteria of dose indication were also based upon the extrapolations (curves of the dynamics of
granulocytes, thrombocytes and lymphocytes) to the cases of single short-time exposure to ionizing radiation.
However, some deviations of symptoms specific to such dose have been attracted by researchers [9, 10].

The heterogeneity of dose distribution for beta radiation both in the surface and in the depth of the body
(56 patients from the total number of 134 ARS patients) was also completely obvious [11]. Having the high
importance for the disease outcome the severe local beta damages did not cause very significant modification of
general clinical manifestations of radiation sickness caused by gamma radiation for most significant prognosis
signs at early terms after the irradiation [7, 10].

Only two cases of combination of radiation damage with thermal burn (vapor burn) were observed. In
these cases the wound intake of radionuclides has increased the input of internal exposure dose accumulated to
the end of observation period. However, the major criteria of severity (and dose) applied to biological parameters
have corresponded to known regularities specific to the single exposure to gamma radiation of the assessed dose
range.

Only two incidences of early laboratory hypothyreosis were observed in ARS patients, which
disturbance was successfully treated by corrective therapy.

Radionuclide body burdens and internal doses in all other organs evaluated in patients died at acute
period have confirmed that their importance is negligible in case of short-time inhalation [10].

Group III of radiation incidents and accidents is specific to the last quarter of 20th century for all
countries. Our data library can be used to identify about 200 cases from 120 situations of such type. The specific
features of these situations are:

a) increasing amount of source types and kinds of radiation exposed (with predominance of
gamma&beta sources of different purpose);
b) wide range of doses from practically negligible to severely damaging;
c) obvious predominance of local exposure versus whole body exposure excluding
accidents at powerful stationary irradiators;
d) typical localizations (hand, thigh, clothes projection on the body trunk);
e) difficulties of dose estimates using direct data and predominance of its calculation
reconstruction in the injury focus on separate parameters (ESR of clothes, shoes,
tooth, etc.) [11].

Clinical manifestations and their peculiarities are as follows:

1. At the initial phase these manifestations can be detected by anamnesis only, because of late admittance
of patients;  
2. Prognosis criteria are very complex, which make the influence in the selection of adequate terms and scope of surgery;  
3. Duration, severity and expressiveness of residual signs and LRI consequences (ulcers, scars, amputation defects etc.) are often large and make persistent disability of patients;  
4. Etiological diagnosis is complex for late patient admittance essentially and it requires qualified expertise of radiation medicine specialists.  
5. At recent years the specific progress of the repeated application of some paraclinical examination techniques (USI, CT) providing more objective assessment of dynamics localization and character of the process (edema, destruction), which can optimize therapy;  
6. Wide application of radiation sources in different branches of industry, agriculture and medicine actualizes the training of general medical practitioners for this group of accidents and injuries induced.

Group IV: When analyzing the library one can confirm again the very rare incidence (single cases) of the induction of acute effects by internal exposure sources (Americium, Tritium, Cobalt-60, Polonium, Cesium-134, 137, Iodine radioisotopes). In the past the works with Radium and Thorium were the origin of accidents of such type [2].

At the same time such situations require the constant readiness because the prognosis criteria of such situations at the initial terms are based upon the sophisticated dosimetry data and on few clinical examples given in literature rather than on the clinical data [2, 6].

It follows to the presence of brief divisions devoted to this subject to be included in internal medicine manuals, disciplines of toxicology, labor medicine and hygiene because the outcome of such patients strongly depends on the qualified actions applied urgently. These very first phases are dealt with general medical practitioners i.e. there is a small chance to change the radionuclide body metabolism at late terms.

Discussion and Conclusions

Thus, the specific algorithm can be built for the action sequence incase of radiation accident to determine and to minimize its health sequelae.  
1. The accidental causal source determined at first minutes will make the exact orientation of the type of situation occurred even the accuracy of such determination is not high;  
A) criticality accident (research institutions, atomic industry, nuclear weapon conversion and works with nuclear weapons and nuclear fuel);  
B) accidents of massive stationary source of radiation (destruction of the reactor core fragments, malfunction of the safety system of powerful gamma irradiator);  
C) accidents with transportable “orphan” sources;  
D) accidents accompanied by unsealing of radiation source and environmental radionuclide release.  
2. The determination of accidental scenario typical for each variant of accident with consequent adjustment of general regularities to the real circumstances of the accident on the major parameters of the exposure and on possible clinical manifestations with the assessments of:  
2.1 Character and type of radiation exposure;  
2.1.1 external±internal exposure (inhalation, ingestion, skin application, wound contamination);  
2.1.2 radiation spectrum and the degree of homogeneity of dose distribution in the time, space and body surface;  
2.1.3 possible number of people involved, really exposed and injured;  
2.1.4 basic clinical manifestations and outcome prognosis;  
2.1.5 principal directions of actions, place of the assistance and resource reserving for repeated therapeutic and prophylactic measures as well as the rational number and qualifications of recovery operation workers;  
2.1.6 other unfavorable factors of the accident.  
3. Scope of the information required for different categories of people involved in the accident including:  
3.1 victims and their relatives;  
3.2 administrators and governing bodies;  
3.3 mass media and general public of region and nation depending upon the scale of accident and terms of the accident occurrence;  
3.4 registration and documentation forms.  
4. Final phase of the accident consequence analysis and total harm inflicted evaluation require:  
4.1 perspective plan for the return to the normal living conditions (for patient, agency, region and public);  
4.2 information providing to scientific community and international organizations;  
4.3 recommendations for the rational dynamic system of social economical decisions and legislation optimization.
Chernobyl accident lessons

The Chernobyl accident situation can be arranged to the following algorithm:

1. Massive external source of the relatively uniform gamma radiation and heterogeneous source of beta radiation with the absence of neutron radiation and significant internal radionuclide intake in personnel (position B above);
2. The ratio of people involved/really exposed/injured is 1,000:100:1;
3. Basic clinical manifestations include: ARS of different severity grades, which ARS was frequently aggravated by disseminated beta dermatitis requiring the urgent hospitalization in specialized hospital. Other people have to be registered and provided with possible individual dose reconstruction and predominant out-patient examination using general principles (which was not realized completely for the Chernobyl accident).
4. The large importance of the unfavorable global and local social psychological and economical factors accompanied the accident and influenced in health and risk precipitation.
5. The information was provided to the victims more properly than that to their relatives and world scientific community, when it was frequently provided in late terms and incorrect way.
6. Unsuccessful legislation of the former USSR, which legislation has enforced the discredit to the adopted medical measures with consequent complications of social and psychological rehabilitation in recovery operation workers, essentially.

The national level contradictories in information given on the final effects of the accident are also reflected by ineffectiveness of rehabilitation measures as a whole.

The large usefulness and realistic assessment of international organizations stress the importance of international cooperation of competent specialists of different countries in case of large scale radiation accident. Finally, I would like to express deepest appreciation to my native colleagues and researchers of different countries, who has given valuable advises and experience used to analyze the origin observations accumulated within 50 years of work on the problem. I consider the present report as the general summary of many years of physician work, which can be useful not only to the specific discipline of radiation medicine, but also to medical assistance in any other industry of potentially unsafe technology as well as to the science of medicine as a whole.

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