Contribution of IRSN in the management of radiological accidents

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Abstract:
IRSN is a key partner for IAEA in the field of preparedness and response to radiation emergencies and is involved in the medical management of radiological accidents since more than a decade by deploying expert on the fields, and facilitating treatment of victims. This paper summarizes the developments of rapid tools used for dose assessment and the improvement made on diagnosis and treatment strategies of radiation injuries.

1 INTRODUCTION

Until recently, radiation accident management was designed to deal with accidents in known sites where the risks are clear and likely to involve a limited number of victims. However, given the growing threat of suicide terrorist attacks that seek to cause massive human losses at unpredictable locations, the strategies for radiation or nuclear accident management should be reformulated. In situations caused by terrorist attack, the number of victims will depend on the configuration of the accident, but could range in the case of a dirty bomb or the malevolent dispersion of an orphan source from several tens or hundreds of victims to thousands or hundreds of thousands of victims in the case of improvised nuclear device. Thus, terrorist attacks could lead to a very large number of victims requiring emergency hospital admission and treatment. At present, the medical teams that would be involved in the initial management of these patients are generally not adequately trained in the handling of patients suffering from severe acute radiation syndrome (ARS). This means that in the event of a terrorist attack, without appropriate preparation for such an unfamiliar situation, the medical system would come under enormous pressure to define appropriate responses and treatment options. To help medical teams make the right decisions in such extraordinary situations, it is essential that appropriate Europe-wide standard protocols for treating mass accidental radiation exposure are formulated. At present, a number of valuable treatment and accident management options to deal with such events have been proposed. However, a more coherent and systematic plan for treating mass radiation accidents in Europe is needed.

IRSN is a key partner for IAEA in the field of preparedness and response to radiation emergencies. IRSN staff responded to a number of radiological accidents this last decade by deploying expert on the fields, and facilitating treatment of victims in French hospital. In emergency situations, such as nuclear or radiological accident, IRSN experts, with support of Percy hospital have provided technical advice and consultation on the matters related to public health, medical response, dose reconstruction, biological dosimetry as necessary. IRSN was involved in the management of different accidents following IAEA request, including the accident of Georgia-1996-97 (4 victims), Georgia-1998 (85 suspicion), Panama-2000, Georgia-2002 (3 victims), Poland (2002, 1 victim), Chile-2005 (1 victim), Tunisia-2008 (1 victim), Ecuator-2009 (1 victim). Moreover, IRSN managed the accidents of Belgium-2006

(1 victim), Senegal-2006 (3 victims and 60 suspicion), Epinal-France-2006 (24 patients), Toulouse-France-2007 (145 patients). Research and development of rapid tools of dose assessment, diagnosis and treatment strategies of radiation injuries are conducted since more than 10 years by IRSN and make IRSN one of the “operational” experts in the field of radiological emergency.

2 DOSE RECONSTRUCTION USING PHYSIQUE TECHNIQUES

In most cases of radiological accidents caused by an external source, the irradiation is heterogeneous, even for a whole body irradiation. Therefore, more than a whole body dose, estimating the dose distribution in the victim's organism is essential to assess biological damages. This dose distribution can be obtained using physical dosimetric reconstruction methods. Techniques based on experimental and numerical dose reconstruction and retrospective dosimetry by electron spin resonance (ESR) are set up in order to assess as accurately as possible and as quickly as possible the dose received and especially its distribution throughout the organism [1]. These data, in addition to the biological and clinical ones, are very useful for the physicians to tune their diagnosis and to define the most suitable therapeutic strategy.

2.1 Experimental dose reconstruction

An experimental dose reconstruction consists in irradiating a tissue-equivalent anthropomorphic dummy equipped with dosemeters in conditions as close as possible to those of the accident. Such a dummy is made up of sections with locations provided for inserting dosemeters, thus enabling the distribution of the dose in the organism to be mapped. Depending on the radiation source, different types of dosemeters can be used.For irradiations localised at hand, mouldings of victim’s hand can be also performed.

2.2 Numerical-anatomical dose reconstruction

The principle of dosimetric reconstruction of a radiological accident using numerical simulations is firstly, to model the person exposed to radiation using a numerical anthropomorphic phantom in the accident environment and secondly, to calculate the doses absorbed in the organism using a radiation-material interaction Monte Carlo computer code. The victim can be modelled by a standard mathematical anthropomorphic phantom made up of simple geometric elements or by a so-called voxel phantom. For global irradiation, a mathematical anthropomorphic phantom is generally used whereas for localised irradiations voxel phantoms are used. A voxel phantom is generated from computed tomography or magnetic resonance imaging (MRI) images of the victim and provide a very realistic description of the human anatomy.

2.3 ESR measurements

The Electronic Spin Resonance (ESR) is used to quantify the free radicals created by the irradiation in some materials. The quantity of radio-induced free radicals is proportional to the dose delivered in the material. ESR is capable of measuring a wide range of materials and numerous materials from the victim (tooth enamel, bone tissue, hair, nails) or found in his environment can be used (sugars, glasses, plastics…). In practice, this technique is currently used in ex-vivo for bone tissue and tooth enamel.

3 MEDICAL MANAGEMENT

3.1 Medical management of the Acute Radiation Syndrome

An European consensus concerning the medical management of mass radiation exposure was obtained in 2005 during a conference held by the European group for Blood and Bone Marrow Transplantation, the Institute of Radioprotection and Nuclear Safety, and the University of Ulm [2]. At the conference, a two-step triage strategy to deal with large masses of radiation-exposed patients was designed. The first step of this strategy concerns the first 48 hours and involves scoring the patients exclusively on the basis of their clinical symptoms and biological data. This allows the non-irradiated bystanders and outpatient candidates to be identified. The remaining patients are hospitalised and diagnosis is confirmed after the first 48 hours period according to the METREPOL (Medical Treatment Protocols for radiation accident victims) scale. This grades the patients according to the severity of their symptoms. It was also agreed that in the case of ARS, emergency HSC transplantation is not necessary. Instead, cytokines that promote haematological reconstruction should be administered as early as possible for 14-21 days. Crucial tests for determining whether the patient has residual haematopoiesis are physical dose reconstructions combined with daily blood count analyses. It was agreed that HSC transplantation should only be considered if severe aplasia persists after cytokine treatment. Two recent cases of accidental radiation exposure (accident of Fleurus-Belgium, 2006 and accident of Dakar-Senegal, 2006) were managed successfully by following and improving the European consensus. Thus, a European standard for the evaluation and treatment of acute radiation syndrome victims is now available. This standard may be suitable for application around the world.

3.2 Medical management of radiological burns combining stem cell therapy and surgery

Treatment of severe radiation burns remains a difficult medical challenge. The response of the skin to ionizing radiation results in a range of clinical manifestations. The most severe manifestations are highly invalidating. Although several therapeutic strategies (excision, skin grafting, skin or muscle flaps) have been used with some success, none have proven entirely satisfying. The concept that stem cell injections could be used for reducing normal tissue injury has been discussed for a number of years. Mesenchymal Stem Cells (MSC) therapy may be a promising therapeutic approach to improve radiation-induced skin and muscle damages [3]. Pre-clinical and clinical benefit of MSC injection for ulcerated skin and muscle restoration after high dose radiation exposure has been successfully demonstrated. Four patients (Chile-2005, Senegal-2006, Tunisia-2008, Ecuator-2009) suffering from severe radiological syndrome were successfully treated in France based on combined autologuous human grade MSC injection to plastic surgery. Stem cell therapy had to be improved to the point that hospitals can put safe, efficient and reliable clinical protocols into practice.

4 CONCLUSION

IRSN is a key partner for IAEA and WHO in the field of preparedness and response to radiation emergencies. IRSN staff responded to a number of radiological accidents this last decade following request of IAEA by deploying expert on the fields, and facilitating treatment of victims in French hospital. Research and development of rapid tools of dose assessment, diagnosis and treatment strategies of radiation injuries are conducted since more than 10 years by IRSN and make IRSN one of the “operational” experts in the field of radiological emergency.

5 REFERENCES

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