Types of radiation mass casualties and their management

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Summary. Management of radiation mass casualty exposure that may occur as a result of nuclear or radiation accident will depend on the type of accident, and of the knowledge about the actual radiation exposure situation for those who might be involved. Management of the public after an accident in a nuclear or radiation installation will follow existing specific emergency plans, and will take advantage of existing radiation monitoring systems. In other radiation mass casualty exposures, whenever accidental or malevolent use of radiation, there will be a requirement to employ screening programs for indentifying and sorting out exposed people (radiological triage), who will need medical treatment and/or other assistance like decontamination and individual dose assessment. In the later stage after the accident the monitoring for dose assessment purposes for those who will need medical or public health assistance will be required. Demand for dose assessment for large groups of individuals may create the need for international assistance. Prompt and credible public information is vital in all radiation emergencies, and it would be even more important in situations when radiation mass casualties result from exposures to nuclear or radiological material out of regulatory control. In such situations unpredictability of the event creates increase in the risk perception and public communication activities of the authorities will be the key element to prevent unnecessary fear and panic, and the measure to reassure the populace.

Key words: radiological triage, monitoring, dose assessment, public information.

Riassunto *(Tipi di incidenti da radiazioni e gestione delle vittime)*. La gestione delle vittime di un'esposizione a radiazioni ionizzanti risultante da un incidente radiologico o nucleare dipende dal tipo di incidente e dalla conoscenza della reale situazione di esposizione per le persone potenzialmente coinvolte. In seguito a un incidente avvenuto in un'installazione nucleare o radiologica la gestione del pubblico deve seguire gli specifici piani di emergenza esistenti e utilizzare i sistemi esistenti di monitoraggio delle radiazioni. Al contrario, in altre situazioni di esposizione alle radiazioni che coinvolgano vittime e causate da un uso accidentale o ostile delle radiazioni, sarà necessario ricorrere a programmi di screening per identificare e selezionare (*triage* radiologico) le persone esposte che necessitano di trattamento medico e/o altra assistenza, come la decontaminazione e la valutazione della dose individuale. Nell'ultimo stadio dopo l'incidente, si richiederà il monitoraggio per la valutazione della dose per coloro che avranno bisogno di assistenza medica o sanitaria. La valutazione della dose in larghi gruppi di individui potrebbe rendere necessario valersi dell'assistenza internazionale. Un'informazione al pubblico rapida e credibile è cruciale in tutte le emergenze con radiazioni e sarebbe ancora più importante in situazioni in cui le vittime risultino da esposizioni a materiale radiologico o nucleare fuori dal controllo di legge. In queste situazioni la non prevedibilità dell'evento crea un aumento nella percezione del rischio e l'attività di comunicazione al pubblico da parte delle autorità è l'elemento chiave per prevenire paura e panico non necessari e per riassicurare la popolazione.

Parole chiave: triage radiologico, monitoraggio, valutazione di dose, informazione al pubblico.

INTRODUCTION

Approximately ten years ago the common focus regarding mass casualty scenarios connected with the use of radioactive material and/or radiation was related to accidents at nuclear power plants and casualties resulting from nuclear detonations. The common feature of these scenarios is that information about the source term (*i.e.* type of the radiation source, strength and other characteristics) and the time when the exposure started/took place is available and the implication is therefore that the possibility exists to calculate approximate doses for large groups of people using the information about the source and data from environmental monitoring. Individual dose estimations in such cases are usually limited to smaller groups.

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Moreover, in many actual cases, persons that were suspected of having been exposed to radiation levels that resulted, or may have resulted in considerable doses, were radiation workers wearing personal dosimeters at the time of exposure.

There have been other accidental incidents that were caused by insufficient safety and security measures and control of sealed radioactive sources in the 1960 and 1970's, but these typically involved a limited number of exposed persons. National and international efforts to improve legislation and control of radioactive sources used in industry, medicine and research as well as increased security for storage and disposal facilities has improved the situation and the number and severity of such accidents has decreased [1].

RADIATION INCIDENTS AND ACCIDENTS WITH THE POTENTIAL FOR MASS CASUALTIES

Casualties from nuclear explosions

Nuclear explosions which may result from attacks on nuclear installations, nuclear weapons explosion or the use of Improvised Nuclear Device's (IND's) are the incidents which constitute the greatest potential for a mass casualty situation.

The management of casualties from accidents at nuclear installations is typically covered by nuclear emergency plans [2]. Management of the casualties from an attack with an IND will probably overwhelm current public health and medical response capabilities and will be adversely influenced by loss of command and control capability. In such cases mass casualties will have to be handled in a rather unorganised way as the normal medical and public health infrastructure will most probably be compromised [3]. The WHO document "Health protection guidance in the event of a nuclear weapons explosion" may be a document worthy of consideration in such situations [4].

Casualties from accidents with abandoned or orphan sources and legacy facilities

Generally speaking, the control of radioactive sources has improved in the western countries, but during the 1990's, changes in political systems and the deterioration of old agreements, including those relating to the control of radioactive sources in some regions of the world, resulted in several events with the potential for mass casualties. There have been, and are, many international initiatives regarding abandoned and orphan sources and legacy facilities (such as the projects dealing with the Russian nuclear legacy and that of other countries, and international efforts to replace Radioisotope Thermo-Electric Generators, RTG's), in addition to national and international measures to handle old medical and industrial facilities and to control the illicit trafficking of sources. Within the context of profit as a motive for the theft or dismantlement of a radiological source, as evidenced by last incidents in Argentina, Dakar and Russia, there are probably many sources that are not under control and which may be insufficiently protected against such activities [5].

The accident in Goiânia in 1987 [6] provided the first evidence that situations involving abandoned and orphan radioactive sources can lead to a mass casualty. Such accidents will probably not result in many fatalities but the numbers of potentially exposed individuals requiring monitoring and treatment could overwhelm the management capacity of a single country.

Casualties from malevolent use of radiation (different from IND)

Other possible situations where radiation mass casualties may arise are criminal acts and attempts towards the malevolent use of radiation [7-10]. To date, the best known incident of such use of radioactivity has been the Litvinienko Polonium-210 poisoning case of 2006. Polonium-210 is an alpha emitter used in very small quantities in industrial applications such as the elimination of static charges on the surfaces, but it is not readily available in the quantities used in this incident. The peculiarity of this incident was that the purpose of act was to harm a single individual, and it was not foreseen that the incident would require measures for the management of thousands of people, and moreover that it would have an international radiation emergency impact.

Malevolent use of radioactivity or radiation sources in public places such as urban commercial and business centres, transport systems, large sport and entertainment arrangements or political demonstrations can lead to radiation mass casualty situations.

The use of a Radiological Dispersal Device (RDD), the so-called "dirty bomb", attack on transports of radioactive material or the unannounced dispersal of radioactive substances (including contamination of food and water resources) may cause contamination of large numbers of people. However, most people would be exposed to relatively small doses of radiation [8]. Nevertheless, such situations will require tremendous efforts to triage the possibly hundreds of thousands or several tens of thousands of people potentially exposed just to find those actually exposed and especially those who may need dedicated medical treatment. This was clearly demonstrated by the Goiânia accident [6]. Moreover, the dispersal of radioactivity will result in contamination of the human environment (homes, workplaces offices etc.) and will demand expensive action for decontamination of dwellings, workplaces and other infrastructure.

The placement of strong radiation sources, termed Radiological Exposure Device's (RED's) in public places such as public transport systems or crowded urban centres have the potential to affect quite high numbers of people, especially in situations where the source is hidden and can not be detected promptly. In such situations it can be expected that there is the potential for both a considerable number of people to develop an acute radiation syndrome as well as some fatalities. Quite a large number of individuals might be exposed to subclinical doses.

In such emergencies the time between the placing of the source and the time when the source is subsequently discovered can be considerable and sometimes it is not possible to determine this period during management of the incident. This last point influences both the number of possible victims involved and the number of concerned potential victims. Research has shown that the lack of predictability in time, place and magnitude, which are the general characteristics of radiation accidents, magnify the psychological and psychosomatic impact of such events [11]. Radiation protection authorities will be under a tremendous pressure to detect, as early as possible, the radiation hazard, to identify the source of exposure and to initiate and conduct prompt actions to control the spread of contamination, as well as actions to establish a program for both environmental and personal monitoring.

MANAGEMENT OF MASS CASUALTIES

The management of the populace and casualties in the event of mass radiation exposure will depend on the availability of information about the radiation source involved. The management of the populace and casualties in radiation emergencies occurring at permanent nuclear installations will follow pre-prepared emergency response plans. Situations such as those involving the malevolent use of radiation or exposure to stolen or orphan sources, will require modified, more general emergency plans where the specific nuclear emergency plans are not applicable or need to be modified [7].

The medical triage (trauma triage) of radiation casualties would generally rely on the occurrence and timing of clinical signs and symptoms such as nausea and vomiting or blood counts. Information about the timing and the mode of exposure or contamination is important to support both medical and public health measures. However, if the exposure is not severe the symptoms may manifest themselves some time later. Moreover, if the timing of exposure is not determined it is difficult to identify those exposed to moderate or relatively low doses in the first days.

Personal monitoring and individual dose assessment by biodosimetry and bioassay methods will be of great importance. The strategy for monitoring and dose assessment will depend on the type of radiation or radionuclide employed and where the incurred radiation contamination has been absorbed in the human body.

When responding to a mass casualty scenario it is important to pay attention to public health issues such as protection of the most vulnerable or radiosensitive sectors of the population (children and pregnant women) as well limitations regarding the treatment of disabled and elderly people.

Management of mass casualties when the location and time of exposure are known

There are quit a few, mostly American, guidance documents on how to manage casualties in such situations [12-16]. The output of the EU 6th Euratom Framework Programme project – TMT Handbook (Triage, Monitoring and Treatment of people exposed to ionising radiation following a malevolent act) [8] – provides a good overview, from the European perspective, regarding the management of people during such events. In chapters E to G of this handbook advice on how to proceed in the field is provided. The immediate action on the scene will be directed towards controlling the exposure, rescuing the most exposed casualties and limiting the exposure of other persons involved and the public in general. This is accomplished by establishing control zones (red and yellow), monitoring to confirm the radiation emergency, evacuation of people from the red zone, taking care of those who would require prompt medical treatment (as result of trauma triage) as well as the decontamination, registration and monitoring of people for the purpose of radiological triage (*i.e.* rapidly sorting people into groups depending on actual or potential health effects resulting from the radiation exposure) and providing advice to those who left the control zones on how to self decontaminate in contamination incidents. Chapter I of the TMT handbook provides advice on the handling of contaminated casualties and transport to hospital while chapter K elaborates on the public health response. The advice provided by the TMT handbook is rather generic and can be used in accidents other than those involving a malevolent act.

Management of mass casualties when the location and/or the time duration of exposure are unknown or impossible to determine

In a situation involving the unannounced use of radioactivity or a concealed source it may be a challenge to find and record the exposed persons and casualties, as well as manage the thousands of concerned potential casualties *i.e.* persons who really had not been in contact with the source but could claim that they were exposed and may develop sub-clinical anxiety. Some of these individuals may also develop psychosomatic symptoms that could mimic those symptoms that can be attributable to radiation exposure, like nausea and vomiting. This challenge can arise independently if the contamination or exposure was discovered fortuitously, via delayed announcement by the perpetrator or by the health system identifying symptoms of radiation exposure. The radiological triage will be a very important issue and dose assessment programs, both for screening and dose assessment purposes, will be vital. The TMT Handbook, in chapter F and H, includes practical advice on how to plan and proceed with radiological triage and dose assessment.

Those who require hospitalisation will be admitted based on the occurrence of clinical signs and symptoms [8, 15, 17]. In many countries there are specialized radiation medicine centres devoted to radiation emergency medicine. These centres will usually be responsible for treatment of those havily exposed. Other patients may be treated in referral hospitals or peripheral health centres with possible guidance from specialized centres.

Health authorities will be responsible for public health aspects and have to establish information services for the public, those potentially involved and relatives. The system for registration of the involved person and the collection of relevant personal information has to be established too. Furthermore, a network for peripheral contact and health centres should be established in order to avoid overwhelming of hospitals. Programs for screening to indentify exposed individuals and individual dose assessments have to be put in place. Such programs can be very demanding for individual countries. If a large number of individuals are exposed the involvement of international networks and assistance maybe required [8].

Management of mass casualties when there was no actual exposure

Such incident will not result in any fatalities or physically injured persons but a number of people may be affected by psychological stress and develop psychosomatic symptoms especially when credible information about the nature of the event will be delayed or not available. Prompt and commonly available information will be the most vital factor in situations when there is uncertainty about actual exposure. Media speculation regarding thousands of members of the public that might be exposed would overload the dedicated help lines, as was the case for the Polonium 210 poisoning of Litvinienko, when the media stated that 33 000 passengers of British Airlines may be at risk [11]. This last example is not, however, fully comparable in the context of this section since radioactive material was actually used in Litvinienko case.

Threat of use of radioactive material without actual use will require a credible system to reassure the authorities and the public that radiation exposure contamination did not take place. Authorities will have to employ a rapid monitoring program to confirm the absence of radiation or radioactive materials and to provide prompt information to reassure the public.

Acknowledgments

The author is very grateful to the NRPA colleagues Mark Dowdall and Eldri Naadland Holo for very useful comments and corrections during the developing of this paper.

Submitted on invitation.
Accepted on 16 June 2009.

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