## 4th EURADOS Winter School

## "Radiological emergencies – Internal exposures"

### 3 February 2010

### Aula Pocchiari – Istituto Superiore di Sanità

## ABSTRACTS

| 4th EURADOS Winter School<br>"Radiological Emergencies – Internal exposures"<br>Wednesday, 3 February 2010 | | |
|---|---|---|
| Time | Speaker | Title |
| 09:00-09:40 | L. Prosser (HPA, UK) | Scenarios and preparedness on Radiological Emergency |
| 09:40-10:20 | W. Weiss (BfS, DE) | Application of the ICRP recommendations for the protection of people in emergency exposure situations |
| 10:20-10:50 | G. Etherington (HPA, UK) | Monitoring for dose assessment |
| 10:50-11:20 | *coffee break* | |
| 11:20-11:50 | A. Hodgson (HPA, UK) | Rapid application of models in internal dosimetry, from monitoring data to dose |
| 11:50-12:20 | J.R. Jourdain (IRSN, FR) | Medical management and treatment of contaminated patients: strategy for individuals versus mass casualties |
| 12:20-12:50 | W. Raskob (FZK, DE) | Emergency and post accidental management: Lessons learned from the European project EURANOS |
| 12.20-14:00 | *lunch* | |
| 14:00-14:30 | E. Kroeger (BfS, DE) | The Litvinenko Polonium-210 case – German experiences |
| 14:30-15:10 | I. Galatas (AGH Athens, GR) | Emergency preparedness in biological/chemical emergencies |

**Radiation Emergencies: Scenarios, Consequences and Preparedness**

Lesley Prosser

Health Protection Agency, UK

There are potentially a wide range of emergency scenarios involving radioactive materials that could lead to radiation exposure of individuals or populations through internal exposure, external exposure or a combination of pathways. These scenarios include accidental events such as an accident at an operating nuclear power reactor to a range of potential scenarios where individuals might utilise radioactive materials for malicious purposes.

An overview of some potential scenarios is presented. These are not based on any current risk or threat assessments and utilise information already present in the public domain.

Such scenarios can have wide-ranging consequences both in the short and longer-term. A key component of developing effective emergency preparedness arrangements is to apply lessons from past events involving radioactivity in addition to drawing on the extensive arrangements in place to deal with accidental events. Some past events are examined.

From a radiation protection perspective the objectives set and procedures used to protect the public are largely independent of whether the radiation exposure arises from an accidental or malicious origin. This is discussed. The essential elements of planning an effective response to whatever scenario are also considered.

## Application of the ICRP recommendations for the protection of people in emergency exposure situations

Wolfgang Weiss

Federal Office for Radiation Protection and ICRP; Committee 4

ICRP publication 109 (2009) describes the application of the new advice of ICRP for the system of protection (ICRP publication 103), and explains how the previous advice (ICRP publications 60; 63) fits into the new overall system of protection. Where the Commission's advice is unchanged from its previous recommendations, or issues are discussed thoroughly in publications by other international organisations (IAEA BSS, DS 44), appropriate references are given and no detailed discussion is provided.

Key elements of the new system of protection (ICRP publication 103) are the

- Introduction of *REFERENCE LEVELs* which represent the level of dose or risk, above which it is judged to be inappropriate to plan to allow exposures to occur. It is recommended that national authorities set (a) reference level(s) between, typically, 20 mSv and 100 mSv effective dose (acute or annual, as applicable).
- Consideration of *ALL exposure pathways* and *ALL* relevant protection options when deciding on the optimum course of action to be taken.
- Justification of the full protective *STRATEGY*, resulting in more good than harm.

Important aspects during *PLANNING* are the identification of the *dominant exposure pathways*, the *times* over which components of the dose will be received, and the *potential effectiveness* of individual protective measures. ICRP recommends that *plans* are prepared for all types of possible emergency exposure situation. To the extent possible, the overall strategy and its constituent individual protective measures should be worked through and agreed with all those potentially exposed or affected (*stakeholder* involvement). Once the protection strategy has been optimised, *triggers* for initiating the emergency response plan shall be developed. Triggers are expressed in terms of any observable circumstances or directly *measurable quantities*, such as dose rates, reactor core temperatures, wind direction.

During emergency *RESPONSE* the reference level is used as a *benchmark* against which the results of implementing an optimised protection strategy are assessed, and for guiding the development and implementation of further protective measures if necessary. Furthermore, the reference level will be an important input when deciding whether or not to terminate protective measures.

There are *no pre-determined temporal or geographic boundaries* that delineate the transition from an emergency exposure situation to an existing exposure situation. Governments and/or regulatory authorities will, at some point, identify a new reference level, typically between 1 and 20 mSv in a year, which can be used to judge optimisation of protection strategies in the longer term, i.e. for existing exposure situations. ICRP will provide advise on the "Application of the Commission's system to the Protection of People Living in Long Term Contaminated Territories after a Nuclear Accident or a Radiation Emergency" in ICRP publication 111 (2010).

**Monitoring for Dose Assessment**

George Etherington

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In the event of a radiological emergency, individual monitoring for internal contamination may be required for very large numbers of people. One of the main tasks would be to differentiate between those whose exposures could result in adverse effects on health and those with insignificant exposures. This issue is one of the main differences between monitoring for occupational exposures and monitoring after a radiological emergency. This lecture describes how objectives and strategies for individual internal contamination monitoring may be defined to meet this need. Techniques and equipment are described, distinguishing between the needs for screening and more accurate internal dose assessment. The specification of a monitoring strategy is discussed, including the choice of appropriate monitoring methods (whole body monitoring, lung monitoring, urine sample analysis, etc.), the definition of action levels that can be compared with the results of screening measurements, and the corresponding follow-up actions. The assessment of absorbed doses to organs in cases of very high internal exposures is discussed, and iAEA’s scheme of generic reference levels for RBE-weighted absorbed doses is described. The methods described in TMT Handbook for the assessment of committed effective dose are described, and the limitations of simple approaches to internal dose assessment discussed. Finally, selected information resources that are likely to be of assistance in planning and organising the monitoring response to a radiological emergency are briefly described.

## Rapid application of models in internal dosimetry, from monitoring data to dose

Alan Hodgson

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The accidental or deliberate dispersal of radioactive aerosols into the public environment will require urgent decisions to be made on whether the public can be reassured that radiation doses are acceptably low or whether treatment should be implemented. A treatment regime may include the use of lung lavage or the administration of chelating, blocking, dilution or purging agents to enhance the elimination of the radionuclide. However, such decisions are likely to be difficult due to lack of information on the chemical form and particle size distribution of the aerosol, the biokinetic and retention characteristics of the radionuclide in the body and the likely efficacy of any treatment.

A procedure is described to simplify the decision making process for public reassurance, and possibly treatment issues, based on a simple dose assessment. Account is taken of the potential range in particle size and biokinetic behaviour of potentially important radionuclides. For action level doses of 1, 20 and 200 mSv, the relationship between the activity in the body and/or tissues and excreta and the time after acute intake are expressed graphically.

The graphs can be used to deduce whether:

- doses are acceptably low
- treatment should be considered or is unnecessary
- the monitoring procedure considered is optimal
- the minimum detectable amount (MDA) of the radionuclide by the preferred monitoring procedure is sufficiently low to assess the specified dose
- the uncertainty in the assessed dose using a particular monitoring procedure is acceptable;
- measurement times can be reduced compared with those used routinely

This approach is considered appropriate for rapid decisions on medical management or public reassurance when potentially large numbers of people are involved. It is not intended as a substitute for individual dose assessment.

## Medical Management and Treatment of Contaminated Patients: Strategy for Individuals *versus* Mass Casualties

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### Rationale

The presentation will give comprehensive information about the principles governing and mechanisms behind the use of drugs administered to patients contaminated with radioactive material. It is also anticipated to provide the participants with the well-managed healthcare organization, as well as decision-making elements allowing them to make the most appropriate decision to the situation they will be facing. Tables summarizing practical information about every treatment (time and pathway for administration, quantity of drug to be used, side effects, etc.), which will be given to casualties contaminated with radionuclides of maximum concern. Finally, a special attention will be paid to the difference in procedure to be applied as a function of the number of casualties to be treated, recognizing that the management of mass casualties needs the implementation of specific procedures different than those usually applied when healthcare providers will be dealing with a few number of patients.

### Introduction

Emergency personnel are rarely familiar with the topics of radiation exposure and/or radioactive contamination, and few emergency physicians have experience in managing a case of acute radiation syndrome or local radiation injury. Although many emergency personnel have had training regarding procedures for handling the patient contaminated with radioactive materials, most training has focused on the more likely situation of handling only one or two accident patients. Sadly, today's international environment is such that the real possibility exists that emergency department personnel might have to deal with not just one or two victims of a radiation accident, but overwhelming numbers injured in a malevolent act. Triage and distribution of patients to distant hospitals would be a necessity should such a malevolent act occur. Victims could be irradiated, contaminated with radioactive materials and injured by the heat and force of explosions.

### Irradiation *versus* Contamination

Irradiation (sometimes called "exposure") occurs when a person is exposed to penetrating radiation (gamma rays, neutrons, x-rays) from a source external to the body. The total body or a large portion of it can be irradiated in an incident, or a small, localized area can be affected. Time, distance, and shielding can reduce exposure from a source. Once the source of penetrating radiation is removed, or the victim is moved away from the source, no further exposure will occur. On-scene triage should be based on the severity of conventional injuries, while triage during the first 24 hours of hospitalization should include consideration of exposure to penetrating radiation. Although irradiation does not cause early, life-threatening symptoms, it can, in time, cause serious or life-threatening illness if the radiation dose is high. If irradiation is combined with trauma, recovery is threatened. Triage and subsequent early treatment decisions are based on the signs and symptoms evident in the first 24 to 48 hours and on the results of laboratory tests completed during that time.

External contamination occurs when radioactive materials are deposited on the external surface of the body. Internal contamination occurs when radioactive materials are ingested, inhaled, or absorbed through skin or wounds, or when neutron irradiation occurs. If radioactive atoms enter cells, they are said to be "incorporated." As long as radioactive materials are on or in a person, the person is being irradiated. Contamination does not cause symptoms, unless the contaminants are corrosive, toxic, or thermally hot. Caregivers should use strict isolation precautions (including wearing cap, mask, gown, shoe covers, and double gloves) when handling contaminated victims, and gloves should be changed frequently to avoid cross contamination.

Radioactive material may be inhaled, either as gases or particulates. Inhaled radioactive gases have varying amounts of absorption into the blood. Inhaled particulates that are not coughed out or swept out by cilia can be gradually solubilised to some extent, and then absorbed, or deposited eventually in the tracheobronchial lymph nodes, where they stay indefinitely. Radioactive material that is swallowed, from mouth contamination, ciliary movement in the bronchial system that movers particulates to the mouth, or the eating or drinking of contaminated food, can be absorbed to some extent, depending upon what it is, and unabsorbed radioactive material is excreted in stool. Of material that is absorbed, some may be deposited in a variety of organs, and some may be excreted in urine. In addition, radioactive shrapnel from the destruction of a sealed source of radioactive material can become embedded in a wound.

Incorporation is a time-dependent, physiological phenomenon related to both the physical and chemical natures of the contaminant. Incorporation can be quite rapid, occurring in minutes, or it can take days to months. Thus, time can be critical and prevention of uptake is urgent. Several methods of preventing uptake might be applicable and can be prescribed by a physician. Some of the medications or preparations used in decorporation might not be available locally and should be stocked when a decontamination station is being planned and equipped. If internal contamination is suspected or has occurred, the physician or radiation safety officer should request samples of urine, faeces, vomitus, wound secretion, etc. Whole-body counting and bioassay can help evaluate the magnitude of the problem and the effect of any treatment. The contaminated patient admitted with an airway or endotracheal tube must be considered to be internally contaminated.

**Treatment of External and Internal Contamination**

***External Contamination***

In most cases, external contamination can be readily detected with survey instruments and readily removed. Decontamination (removal of contaminants) can be accomplished by removal of the victim's clothing and thorough, careful washing with warm water, in which specific agents for radionuclide decorporation could be used (e.g. DTPA in case of presence of actinides) and soap, followed by a radiation survey to determine if the washing procedure was sufficiently effective. Except for victims of serious trauma, decontamination can be accomplished prior to admission to hospital emergency care. Uninjured individuals do not require hospitalization unless they are vomiting, have diarrhea, or have conventional reasons for seeking emergency care.

In case of radioactive material embedded in a wound, the treatment of radioactive shrapnel is its surgical removal, as quickly as possible. The shrapnel should only be touched with instruments, not fingers, and should be placed in a lead container for shielding purposes. The bed of the wound will be carefully washed with water and specific agents for radionuclide decorporation whether their administration is relevant with regards to the content of the radionuclide mixture.

***Internal Contamination***

A variety of rather simple pharmacologic concepts are exploited in order to rid the body of radioactive contamination (radionuclide decorporation).

If radionuclides are in the gastrointestinal tract, speeding up intestinal transit will favour excretion in the stool rather than absorption. A simple laxative thus becomes a radionuclide decorporation drug. Certain drugs will bind radionuclides in the gastrointestinal tract, making the radionuclides unavailable for absorption. Prussian blue, an unabsorbable dye, works this way for cesium and thallium, including radioactive isotopes of these elements. Flooding the gastrointestinal tract with stable counterparts of the radioactive material will compete with the radioactive material for absorption, and thereby cut down on the absorption of radionuclide.

Once the radionuclide enters the blood, one can try to block uptake in the target organ, such as by using non-radioactive potassium iodide to block radioiodide incorporation into thyroid hormone and subsequent storage in the thyroid gland. One can also use propylthiouracil to block the thyroid from taking up radioactive *or* non-radioactive iodide. One can change the chemical state to one that is less toxic, such as by alkalinizing the urine after uranium ingestion with sodium bicarbonate. This produces uranium bicarbonate, which is less nephrotoxic than other forms of uranium. Sometimes diuretics can be used to promote urinary excretion, such as after tritium (H-3) contamination. Chelating agents such as Ca-DTPA and Zn-DTPA may be intravenously administered to chelate a number of radioactive metals and promote their urinary excretion.

However, it is necessary to draw attention to the large number of existing documents and recommendations concerning the treatment of internal radioactive material contamination by radioactive. Thus, participants will also learn to make the difference between drugs that have shown a true efficacy, from molecules although often mentioned, for which their administration is not based on any serious scientific basis so far. Finally, the speaker will provide an overview of on-going research aiming at improving existing treatment protocols. Widely published recommendations, which should not be considered because of the lack of evidence in terms of efficacy, will also be clearly mentioned.

**Emergency and post accidental management: Lessons learned from the European project EURANOS**

Wolfgang Raskob

Karlsruhe Institute of Technology, Institut für Kern- und Energietechnik, Eggenstein-Leopoldshafen, Germany

In June 2009, the 5-year multi-national project EURANOS, funded by the European Commission in its 6th Framework Programme, reached its end, achieving most of the objectives addressed in the work programme. Partners from 23 European countries integrating 17 national emergency management organisations with 33 research institutes, aimed to enhance the preparedness for Europe's response to any radiation emergency and long term contamination. Three handbooks to assist national and local authorities in the management of contaminated food production systems, inhabited areas and contaminated drinking water resources in Europe were developed in conjunction with a wide range of European stakeholders. Further guidance was prepared to support the decision making team in the lifting of early phase countermeasures A governance framework for the sustainable rehabilitation of long term contaminated territories was developed and tested in France and in Norway. Considerable progress was made in developing a consistent set of models for calculating the best estimate of the current radiological situation in both contaminated agricultural and inhabited areas. These models were integrated in both the ARGOS and the RODOS decision support systems. Decision aiding components were improved to support the selection of management options with the help of multi criteria decision analysis procedures.

The presentation will address the above mentioned topics and presents how decision support systems such as RODOS (Real-time On-line Decision Support System) can support decision making in case of a radiological or nuclear emergency.

## Experience in Real Cases: The Role and Capabilities of the Federal Office for Radiation Protection in the response to the Po-210 incident in Hamburg in 2006

Emily Kroeger

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In late 2006, Alexander Litvinenko died as a result of a poisoning with polonium-210 (Po-210) which allegedly occurred at a meeting in London. Media reports at the time linked Dimitri Kovtun to this meeting and to the German city of Hamburg. An investigation was started by Hamburg Police into Kovtun's movements during a visit to Hamburg in the week directly before the alleged poisoning.

As the presence of Po-210 at the sites visited by Kovtun in Hamburg was uncertain, Hamburg Police called on the federal defence against nuclear hazards in Germany, which includes the Federal Office for Radiation Protection (Bundesamt für Strahlenschutz, BfS).
BfS was responsible for the measurement of Po-210 at the sites visited by Kovtun, the radiological evaluation of the measurements and the radiation protection recommendations. Following a measurement for airborne contamination at the sites involved, both field and laboratory techniques (e.g., hand-held alpha detectors and grid ionisation chambers) were used to monitor the Po-210 contamination.

The traces of Po-210 found by BfS were of little radiological consequence and the radiation protection measures taken by BfS reflected this fact. However, neither the radiation protection measures taken by the emergency workers nor the reaction of the general public and press reflected the actual level of danger all of the time. The discrepancy between the actual and perceived level of danger must be taken very seriously by those responsible for giving radiation protection recommendations, as it will affect aspects of all incidents involving radioactive materials. It follows that strategies must be developed and implemented in advance to deal with both the real and the perceived threats that occur during such an incident.

**Emergency preparedness in biological/chemical emergencies**

Ioannis Galatas

Hellenic National Defense General Staff, Athens, Greece

Release of CBRN agents is the emerging threat for the modern societies and their megapolis. Medical/hospital CBRN defence represent the biggest gap in every emergency response plan worldwide. States focus on supporting operational aspects of their first response mechanisms “forgetting” that resulting mass casualties following the terrorist release of weapons of mass destruction in urban environment will be the main problem for the weeks, months or years to follow. In that way, hospitals and medical personnel is the “weak link” in each emergency plan. Doctors and nurses seem unwilling to be involved in operations of this magnitude due to lack of medical knowledge, lack of relevant specialized training, duties deriving from their main specialties and daily patient load and no visible “profit” from being involved in hospital’s defence. For the above reasons and based on the experience gained from the 2004 Athens’ Olympic Games it is proposed that “Medical CBRN Defence” to be included in the curricula of the medical/nursing schools. In this way, ALL young medical/nursing front line health professionals will have a basic knowledge regarding CBRN agents and the way they can manage future mass casualties in their own hospital environment. We must always have in mind that “disasters do not happen to places, disasters happen to people, disasters can happen to us as well!” If we continue to think that the possibility is very remote, that it will always happen to others far away from our home or working place, then the surprise will be a very unpleasant one. Besides, the basic quota in medicine is that “prevention is better than treatment!!” Hospital preparedness in CBRN emergencies is the best example of fine implementation of this very wise conclusion in daily medical life. This presentation will define the threats and targets, analyse the medical aspects of modern chemical, biological and radiological attacks in urban environment, stress certain key-points of hospital preparedness and transfer the experience of running a hospital CBRN response unit during megaevents like the Olympic Games.