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MCI FORUM
FORUM FOR DISASTER & MILITARY MEDICINE

MEDICAL CORPS INTERNATIONAL FORUM

19th Nuclear Medical Defence Conference 2011
May 16th to 19th, Munich, Germany

Abstracts

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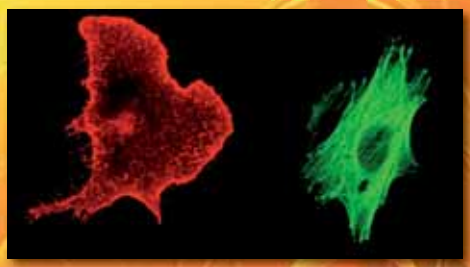
German Society of Military Medicine and Pharmacy (GSMMP/DGWMP)

Bundeswehr Institute of Radiobiology affiliated to the University of Ulm



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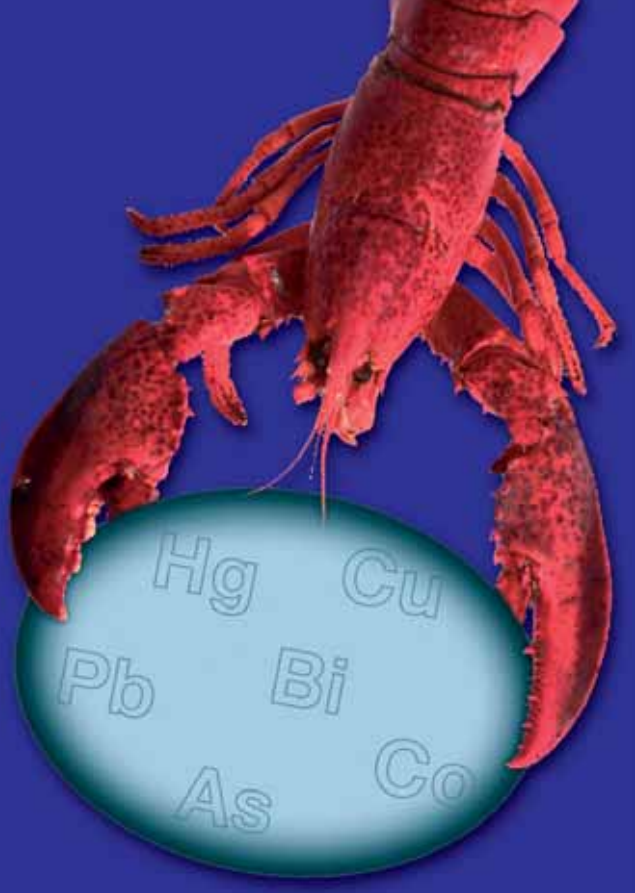

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19th Nuclear Medical Defence Conference 2011
May 16th to 19th, Munich, Germany

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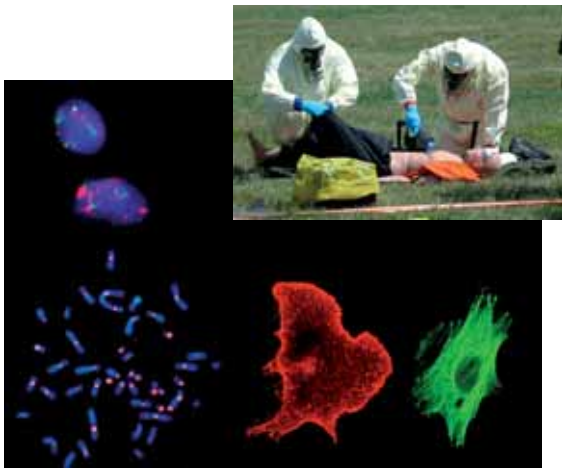

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Editor-in-chief:
Major General MC (ret.) Gianpiero A. Lupi, MD
E-mail: gianpiero.lupi@mci-forum.com

Managing Editor:
Colonel MC (ret.) Hans-Eberhard Bosse, MD
E-mail: hans-eberhard.bosse@mci-forum.com

Co-Editor:
Colonel Prof. Dr. Viktor Meineke
Director Bundeswehr Institute of Radiobiology affiliated to the University of Ulm
Neuherbergstr. 11, 80937 Munich/Germany
E-mail: viktormeineke@bundeswehr.org

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Welcoming address by the Conference Chairperson and Secretary

Dear Colleagues

It is a pleasure for us to welcome you to the 19th Nuclear Medical Defence Conference from May 16th to 19th, 2011 in Munich!
As in earlier years this conference will be held by the Bundeswehr Institute of Radiobiology affiliated to the University of Ulm. For the first time the conference will be presented in a new "Update" format. New research findings and insights in the fields of medical radiation protection, radiobiology and radiation medicine will be the key topics. Special attendance is addressed to the fact that these aspects will be presented in a comprehensive form for a broader audience in relation to the idea of continuous education. A program has been scheduled with six plenary sessions, "Risk Perception and General Aspects", "Effects of Electromagnetic Fields and Low Dose Ionizing Radiation", "Radiation Accident Management", "Radiation Accident and Countermeasures", "Biological Dosimetry and Dose Reconstruction" and "Radiobiology and Radiation Medicine".
Another "change of format" applies to the period of the conference. We decided to extend this year's conference for an additional day dedicated to the current dramatic events in Fukushima, Japan. Therefore, the first day of the conference will be covering the topic "The Radiation Accident in Fukushima, Japan - Consequences for National and International Radiation Accident Management". Measures in the field of radiation accident management and radiation protection on various national and international levels will be the key topic.

For the first time the German Society for Military Medicine will organize an industrial exhibition that accompanies the conference. There, companies will present the latest products and technologies in the field of radiation protection and laboratory equipment for radiation research.
More than 200 participants from 31 nations are expected to attend the conference this year. This fact underlines the unique international aspect of our conference format and offers plenty of opportunities for extensive discussions after the oral presentations, the poster sessions or at the social events. The conference dinner will take place in the Schlossrestaurant located at the shores of Lake Tegernsee.

We hope that you will enjoy your stay in Munich and we wish you an exciting conference as well as interesting new contacts. Please also enjoy the beautiful town of Munich and its surroundings.

Colonel Prof. Dr. Viktor Meineke
Chair, 19th Nuclear Medical Defence Conference
Director Bundeswehr Institute of Radiobiology
affiliated to the University of Ulm

Master Sergeant Claudia Biendl
Conference Secretary

Greetings by the President of the GSMMP/DGWMP

Dear participants of the Nuclear Medical Defence Conference 2011

I should like to extend a warm welcome to you all here in Munich on behalf of the German Society of Military Medicine and Pharmacy (Deutsche Gesellschaft für Wehrmedizin und Wehrpharmazie, DGWMP). It is gratifying to see that so many scientists and experts have once more found the opportunity to come here to the Medical Academy of the Bundeswehr to discuss topical and fundamental themes at the Nuclear Medical Defence Conference.

Arrangement of the programme for this regular conference was again in the reliable hands of the Bundeswehr Institute of Radiobiology. Working in close collaboration with the DGWMP, which has provided for the administrative side of things, the conference organisers have thus created an outstanding platform for the exchange of specialist ideas.

The recent emergencies at Japanese nuclear power plants as a result of earthquake damage have given the two subject complexes “Radiobiology” and “Nuclear protection” a particular immediacy. While the debate about nuclear energy and the potential risks associated with radiation has become excessively impassioned in Germany, it is being conducted in a far more restrained and rational manner in other countries. Although the on-going events in Japan are undoubtedly dreadful and traumatic for those directly affected, it cannot be ignored that these occurrences will provide us with a wealth of options and research opportunities from which we can learn for the benefit of the future of mankind. In view of the seriousness of what is happening, there can be no doubt that a profusion of new and prospectively valuable data will be obtained.

It was not so very long ago that the closure of the Bundeswehr Institute of Radiobiology was being proposed as part of the plans to reduce the size of the Bundeswehr and its medical services. Fortunately, this proposal came to nothing. What we need to bear in mind for the future is that the significance of an event is not determined alone by the frequency with which it occurs, but also by the extent of its effects. No country can assume that the repercussions of radiological disasters will simply remain confined to a particular locality. Over the long or short term, these will always assume a global dimension.

Sincerely

Dr. Christoph Veit, M.D.
Brigadier General (ret.)

Welcome letter

Dear participants

MEDICAL CORPS INTERNATIONAL FORUM – MCIF would also like to take the opportunity to welcome you to the Nuclear Medical Defence Conference here in Munich.

It was on the occasion of the 2009 Medical Biodefence Conference that we, working in collaboration with Prof. Zöller, began publishing the papers given at that year's conference in a special MCIF supplement.

We are pleased to announce that we will be following this up again this year with a further MEDICAL CORPS INTERNATIONAL FORUM – MCIF supplement that will contain abstracts of the conference papers and displayed posters.

Articles on the subjects of field, disaster and combat medicine regularly appear in MEDICAL CORPS INTERNATIONAL FORUM – MCIF and our objective is to provide a forum through which the military medical services worldwide can exchange information and ideas and maintain close contact.

In addition to MCIF, we also produce other specialist publications dedicated to aspects of the work of the military medical services, including our leading German language periodical, WEHRMEDIZIN UND WEHRPHARMAZIE.

A member of the Beta publishing group is **bsbb**; bsbb has been commissioned by the Deutsche Gesellschaft für Wehrmedizin und Wehrpharmazie **(German Society for Military Medicine and Military Pharmacy)** to organise the trade exhibition accompanying the Nuclear Medical Defence Conference. As a congress and seminar management concern, bsbb is also responsible for the organisation of numerous conferences on military medical themes and has for many years been coordinating the German-Chinese Symposium on Military Medicine that will also be taking place here in Munich this June.

We wish the conference all success!

Heike Lange
Managing Director Beta Publishing

Johann-Henrik Winner
Managing Director bsbb

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- German Society for Military Medicine and Pharmacy, GSMMP/DGWMP (Deutsche Gesellschaft für Wehrmedizin und Wehrpharmazie e.V. - Vereinigung deutscher Sanitätsoffiziere (VdSO))

bio Safety Security Defence
International Congress 2011
APAC'S Practices, Challenges, and Strategies

Conference: 18 – 20 July 2011
Exhibition: 19 – 20 July 2011
Putra World Trade Centre, Kuala Lumpur

Introduction

The threat of disease comes from natural, accidental and deliberate causes. We try to deal with natural disease by public health measures, with accidental disease by biosafety measures and with deliberate disease by biosecurity and biodefense both in the laboratory and beyond the laboratory (see New Approaches to Biological Risk Assessment, Royal Society, London, 2009).

However, it is clear that improvements in each of these areas are likely to help us deal with the others: thus improvements in public health can help deal with natural, accidental and deliberate outbreaks of disease. Our Congress Programme whilst concentrating on biosafety, biosecurity and biodefense also necessarily covers aspects of public health.

The Congress comes at an opportune time between the Preparatory Committee meeting for the 7th Five-Year Review Conference of the Biological and Toxin Weapons Convention (BTWC) and the full Review Conference at the end of the year. It is to be hoped that the fruitful discussions in the annual meetings of the BTWC State Parties in the Inter Sessional Process since 2006 can be turned into effective decisions on actions to strengthen the barriers against biological warfare and biological terrorism at the review, and that our Congress can assist in achieving that objective.

Dr Malcolm Dando
Professor of International Security
Dep. of Peace Studies, Bradford Univ., UK.

Basic Information

The Malaysian government namely the Ministry of Defense, Ministry of Health, Ministry of Agriculture, Ministry of Natural Resources and Environment, and National Security Council of Malaysia in collaboration with PROTEMP and beta congress are organizing this International Congress focusing on Asia Pacific's Practices, Challenges, and Strategies of biosafety, biosecurity, and biodefense. As a follow-up of the successful Biosafety and Biosecurity Asia Conference 2007, the Congress brings wide-known experts with Asia Pacific's knowledge and experience to discuss pertinent issues that need to be addressed by regional and international communities on biosafety, biosecurity and biodefense.

The more than 1,500 expected delegates will come from Ministries of Defense, Ministries of Health, Ministries of Agriculture, Disaster Preparedness Centers, Disaster Recovery Agencies, Health Services, Lab Managers including Quarantine Labs, Medical & Healthcare Professionals, Veterinarians, Technicians, Universities and Research Institutes, WHO, FAO, and other related UN Agencies.

Bioscience and biomedical laboratories around the world are actively involved in research and development, medical diagnosis, biotechnology or educational activities. These activities require handling infectious biological materials, living microorganisms or their genomes as well as manipulations with these materials. Scientists have a special responsibility to the environment and public to follow safe working practices (biosafety) and keep their work and materials secure (biosecurity) so that they do not expose the community and environment with these materials. The issues of biosafety and biosecurity and obligations of scientists has now become an urgent responsibility for both the scientific community and to policy makers and regulators.

Trade Exhibition

For the first time the congress in 2011 will be accompanied by an industry exhibition of biological and chemical safety, security and defense equipment and services. The exhibition offers a good opportunity for the congress participants to make themselves acquainted with commercially available state-of-the-art equipment in the field of safety.

bio Safety Security Defence

International Congress & Exhibition 2011

18 - 20 July 2011

Putra World Trade Centre • Kuala Lumpur

www.biossdcongress.com

Workshops 18 July • **Conference** & **Exhibition** 19 - 20 July

The International Congress on Biosafety, Biosecurity and Biodefence will be addressing pertinent global issues with special attention to the roles of international organizations, biological weapons convention, biorisk management, bioterrorism, and emerging infectious threats.

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Why you should be part of the BioSSD 2011 Congress

There is an urgent need for industry professionals and members of academia to gather and discuss preventive measures against current trends that leaves the world community open to serious biosafety threats.

29 internationally renowned experts will be presenting their findings and assessments at the conference on appropriate measures that should be undertaken to face current global biosafety challenges. Be part of this initiative and benefit from the wealth of information available while exchanging analysis and observations with industry professionals and members of academia.

The BioSSD 2011 Trade Exhibition

The Trade Exhibition will expose you to a vast array of biosafety, biosecurity and biodefence technology from the Asia Pacific, the Middle East, Europe, and North America. Exhibits will range from laboratory, medical, and protective equipments; detection and reconnaissance systems; decontamination systems; vaccinations; therapeutics; software systems and so much more.

For more information log on to www.biossdcongress.com

For Congress enquiries:

ASIA / PACIFIC

Ms Ashikin Hassan (conference)

ash@protempgroup.com

Ms Karen Dass (exhibition & sponsorship)

karendass@protempgroup.com

Tel : +603 6140 6666 • Fax : +603 6140 8833

EUROPE / AMERICAS

Mr Johann-Henrik Winner

Johann-Henrik.Winner@bsbb.de

Tel : +49 228 919137-37 • Fax : +49 228 250535

Oral Presentations

Tuesday-Sessions 17.05.2011

1. The Radiation Accident in Fukushima, Japan – Consequences for National and International Radiation Accident Management

The Radiation Accident in Fukushima Japan March 2011 - Overview

H. Thielen
Gesellschaft für Anlagen und Reaktorsicherheit, Köln, Germany

The Fukushima Dai-ichi nuclear accident on 11 March 2011 was a consequence of the 9.0 magnitude Tōhoku earthquake and the following tsunami. A series of on-going equipment failures in several blocks of the power plant led to releases of radioactive material into the atmosphere and the seawater. Based on these emissions the accident was rated level 7 (major accident) of the international nuclear and radiological event scale (INES). The emissions caused significant values of radiation and isotope concentrations measured by involved institutions in the environment and especially in different media like soil, water and foodstuff. Based on these monitoring data the authorities in Japan implemented emergency measures to protect the population of the region. These measures are for example evacuation of people from the zone with high gamma dose rates or ban of contaminated foodstuff with respect to existing limit values. Also in Europe the direct and indirect effects of the releases in Japan can be observed but the measured values are far below those values which could affect human health.

Real-time health decisions during a nuclear crisis - need for a "scientist-clinician"

C. N. Coleman
*Office of the Assistant Secretary for Preparedness and Response (ASPR), Dept of Health and Human Services (HHS) and National Cancer Institute (NCI), Washington, DC and Bethesda, MD (on behalf of the HHS team: Steve Simon (NCI), Mike Noska (FDA), Jana Telfer and Thomas Bowman (CDC)) *The contents in this abstract and presentation are from the HHS team and do not represent U.S. Government policy or opinion*

The March 2011 disaster in Japan was the result of unprecedented circumstances, which had been thought to be extremely unlikely to occur: a massive earthquake and tsunami destroyed the regional power and transportation infrastructure following which redundant backup systems could not function leading to potential failure of six nuclear reactors and three spent-fuel pools. Approximately 30,000 people died or were missing and many more were displaced. The Japanese mustered a remarkable response, evacuating the destroyed area as well as a 10 km zone around the nuclear power plant (NPP) facility. Experts from Japan and other countries worked to understand the situation of the reactors and to mitigate health and medical consequences. HHS sent a 5 person team including a clinician, communications expert, medical countermeasure distribution expert and 2 health physicists- 1 with expertise in radiation epidemiology studies and another on radionuclide cycle in food and water.

The challenges included dealing with the uncertainty of the conditions at the NPP and effect on Japan, the public's fear of radiation and its effects, the need for potassium iodide and the confusing array of radiation units and protective action guidelines. Our response included assisting with situational awareness and the possible consequences, communicating this in a timely and effective manner, overcoming the understandable fear, including the dire reports from various news sources and experts and working with the Japanese to develop appropriate research studies. Previous and ongoing collaboration that had been fostered by the Global Health Security Action Group were extraordinarily helpful. Managing the response in the face of partial information required scientists to be part of "triage decision-making" familiar to clinicians, hence the need for "scientist-clinicians".

Capability profile of the Medical Defense Task Force Team of the Bundeswehr Institute of Radiobiology

J. Hartmann, T. Knie, V. Meineke
Bundeswehr Institute of Radiobiology affiliated to the University of Ulm, Munich, Germany

Affiliated to the University of Ulm, the Nuclear Medical Defense Task Force Team (TF) of the Bundeswehr Institute of Radiobiology represents a singular national resource for the medical management of radiation accidents.

In fact, the ability of the Bundeswehr to take immediate nuclear medical defense action at any time is provided by two TF Troops, ensuring 24/7 readiness. The key capabilities and tasks of the TF are recording medical history and clinical examination, medical sampling, and the immediate introduction of therapeutic measures in patients who have been potentially exposed to radiation. Radionuclide analysis and verification of the decontamination status with the use of various measuring devices provide a basis for evaluating the health hazard potential in patients who have been exposed to radiation.

Another important task is the coordination and supervision of medical measures aimed at restoring the health of exposed patients. Amongst other things, this involves the provision of technical support for medical evacuation measures and, most importantly, immediate expert advice for military decision makers at the scene. Reach-back capability for the TF is provided by the Bundeswehr Institute of Radiobiology at all times. The TF is deployed in close cooperation with the NBC Medical Defense Task Force, Division IX, of the Bundeswehr Medical Office.

The purpose of keeping available or deploying the TF of the Bundeswehr Institute of Radiobiology is to ensure that all Bundeswehr physicians at home and abroad can receive at all times the professional advice and support they need as part of their responsibility to diagnose and provide treatment for health disorders following exposure to ionizing radiation.

Radioecological Aspects of the Radiation Accident in Fukushima

R. Michel
Institut für Radioökolgie und Strahlenschutz
Leibniz University, Hannover, Germany

The radioecological aspects of the Fukushima accident are discussed as observed during the deliberations of the Crisis Management Group of the German Commission on Radiological Protection (SSK). According to

its statute the SSK advises the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) on issues involving the protection against dangers of ionizing and non-ionizing radiation. The SSK Crisis Management Group substitutes the SSK in case of a nuclear or radiological emergency. The group was convoked by BMU after the accident at Fukushima Dai-ichi and is working since on various consulting mandates posed by BMU. The permanent mandate is to follow-up the course of events and to interpret it with respect to the possible radiological consequences. Aside from this, several practical aspects of the management of the Fukushima consequences under German and European viewpoints were dealt with.

Starting with the general problem to understand the Fukushima accident and to initially estimate its consequences on the basis of incomplete information, the course of events is shortly looked at. Then the local and global dispersion of radionuclides in the atmosphere and the contamination of the environment are dealt with. The crucial points were the weather conditions which turned out - except for short periods – to spare widely the Japanese mainland from heavy fallout and led most of the releases over the Pacific. The first measurements of ambient dose rates in the vicinity of Fukushima Dai-ichi and other places were extremely helpful to assess the radiological situation in Japan, since they allowed even a long-term forecast of the radiological consequences. Radioactivity in drinking water, vegetables, and fish was of concern, but turned out to be of minor importance, since only few foodstuffs exceeded the Japanese limits which are in accordance with a one Millisievert per year exposure. Sparse information on Sr-90 and Plutonium isotopes exists, but this information points to these radionuclides being of minor relevance even in the vicinity of the Fukushima nuclear power plant.

Due to the long course of accidental events and an initially unforeseeable development of the Fukushima plant, it was hard to predict the radiological consequences. However, with relatively well agreeing estimates of the source term of the atmospheric releases from French and Japanese authorities, the potential radiation exposure (external and total) can be estimated with some confidence, provided that the situation at the plant remains stable. It also allowed for a comparison between the accident of Fukushima with those of Chernobyl and TMI, demonstrating that the radiological impact of the Fukushima accident will be much lower than that of the Chernobyl accident, but widely exceeding that of TMI.

A special mandate of the SSK Crisis Management Group was to develop a communicable rationale for regulations on contaminations of foodstuff, goods, vehicles and people in Germany and Europe. Considering that the Fukushima accident did not cause an emergency in Europe and based on the recommendations of ICRP 103 for an existing situation, the SSK Crisis Management Group recommended a reference level of one Millisievert per year as the basis of further regulations. Since the Japanese limits for radioactivity in foodstuff were in line with this reference value and in view of the need for international harmonization of radioactivity limits, it was recommended and finally adopted by the European Commission to apply the Japanese limits internationally. The reference value recommended also allowed for a consistent treatment of other consulting mandates with respect to practical radiation protection.

Wednesday-Sessions 18.05.2011

2. Risk Perception and General Aspects

The Israeli perspective on Terrorism – Past, Present and Future

Y. Barneis, I. Ostfeld
Medical Corps, IDF, Israel

Terror has been threatening Israeli citizens ever since the state was founded. Often, those threats aren't unique and are a part of a global trend. However, Israel serves as a model for it social and military reaction, as well as for its medical response to terror.

Past: Terror against Israeli citizens has been going through constant change. Initial threats were mainly of ambushes on civilians, along rural areas, after which came the threat of hostage abduction. This usually didn't represent a risk for mass casualty events (MCE). Medical response was based both on military and civilian medical teams and indicated the development of "Tactical Medicine" and "Special-Operation Medicine" within the IDF.

Present: Suicide terrorism (ST) isn't a new phenomenon in history, and its modern manifestation imposed global fundamental challenges. ST in Israel has two major patterns: shooting attacks, which are usually limited in their medical outcomes and bombing attacks, which may create MCE. This current trend changed the pre-hospital approach to MCE in the urban setting in Israel, especially by eliminating the "Field Triage" and emphasizing the concepts of "Scoop and Run". Missile, rockets and mortar bombing on Israeli cities is considered as another form of terror. As also known from worldwide experience, bombarding civilians has only limited medical impact, but huge mental health significance.

Future: The cruelty, decisiveness, disregard for human life and especially the fanatic, fundamental ideology of ST, emphasizes the possible catastrophic outcome should terrorists gain accesses to non-conventional weapons. Unfortunately, initial attempts have already been made.

International Consensus on Management of Acute Radiation Syndrome (ARS) in Hospitals: Recommendations Based on Quality of Evidence – Results of a WHO Consultation

N. Dainiak
Bridgeport Hospital, New Haven, USA

Diverse clinical practices have been used to manage individuals with acute injury from ionizing radiation. The WHO convened a panel of experts to rank the evidence for medical countermeasures for management of ARS in a hypothetical scenario involving the hospitalization of 100-200 victims. English-language articles were identified in MEDLINE and PUBMED. Reference lists of retrieved articles were distributed to consultants prior to and updated during the meeting. Studies included case series and case reports of ARS, randomized controlled trials (RCTs) of relevant interventions used to treat non-irradiated individuals, reports of well controlled studies in irradiated animals, and prior recommendations of subject matter experts. Studies addressing treatment of the hematopoietic syndrome (HS) were extracted, using the Grading of Recommendations Assessment Development and Evaluation (GRADE) system. In cases of HS where data were imited or incomplete, and in cases of ARS affecting non-hematopoietic organ systems, a narrative review of the observations was made. The panel assessed the quality of evidence and classified recommendations as strong or weak.

No RCTs of medical countermeasures have been completed for individuals with ARS. The use of GRADE analysis of countermeasures for injury of hematopoietic tissue was restricted by the lack of comparator groups in man. For the HS, reliance on data generated in non-irradiated humans and in experimental animals was necessary. Based upon GRADE analysis and narrative review of HS, a strong recommendation is made for administration of G-CSF or GM-CSF, and a weak recommenda-

tion is made for the use of erythropoesis-stimulating agents or hematopoietic stem cell transplantation.

A consensus on hospital management of ARS affecting non-hematopoietic organ systems was achieved by assessment of data generated in non-irradiated humans and in experimental animals. A strong recommendation is made for: administration of a serotonin receptor antagonists prophylactically when the suspected exposure is >2 Gy and of topical steroids, antibiotics and antihistamines for radiation burns, ulcers or blisters; excision and grafting of radiation ulcers or necrosis of the skin with intractable pain; provision of supportive care to individuals with neurovascular syndrome; and administration of electrolyte replacement therapy and sedatives to individuals with significant burns, hypovolemia and/or shock. A strong recommendation is made against the use of systemic steroids in the absence of a specific indication. A weak recommendation is made for the use of fluoroquinolones, bowel decontamination, loperamide and enteral nutrition; and for selective oropharyngeal/digestive decontamination, blood glucose maintenance and stress ulcer prophylaxis in critically ill patients.

In summary, few methodologically robust studies of irradiated human individuals are available and, due to ethical concerns with the conduct of controlled studies in humans, such studies are unlikely to emerge in the near future. Nevertheless, consensus is achieved for the management of ARS affecting the hematopoietic and non-hematopoietic organ systems.

MASS Casualties and Health Care following the Release of Toxic Chemicals and Radioactive Material – THE MASH PROJECT

Å. Sellström[1], A. Göransson Nyberg[1,2], D. Baker[3,4], V. Murray[4], S. Mobbs[4], V. Meineke[5], J. Legarda[6], L. Stenke[7].

[1] *The European CBRNE center, affiliated with the University of Umeå - established in Sweden,*

[2] *Swedish Defense Research Agency, FOI, Sweden,*

[3] *Assistance Publique des Hôpitaux de Paris, SAMU, France,*

[4] *Health Protection Agency, HPA, London, United Kingdom,*

[5] *Bundeswehr Institute of Radiobiology affiliated to the University of Ulm, Munich, Germany,*

[6] *Centro de Estudios e Investigaciones Técnicas de Gipuzkoa, CEIT, San Sebastian, Spain,*

[7] *Karolinska Institutet, KI, Sweden.*

Exposures to toxic chemicals or to radioactive materials following mass emergencies may develop at a rate and reach a magnitude sufficient to create a major crisis. The MASH project, supported by DG Health, addresses the problem of mass casualties and adheres to the idea expressed by the Commission that generic preparedness planning and interoperability are key elements in mitigating the impact of mass emergencies

MASH has been using scenario-derived discussions, surveys, interviews, reviews, systems analysis, forecasting and critical seminars. Specifically MASH has sought to define the level of knowledge, preparedness and treatment in the Member States. MASH contained the following work packages:

- CR(E) Scenarios
- Best practice of today - C mass casualties
- Best practice of today - R mass casualties
- Contribution of modern bio-technology
- Contribution of modern Information and Communication Technology
- Foresight into needs, possibilities and knowledge gaps in the future

Each of the work packages has produced its own in-depth study, which will be shortly described and commented on.

In the foresight format, MASH reported on future needs, possibilities and knowledge gaps and placed these on a time line in a 3 yr 10 yr and 20 yr perspective.

The MASH report stresses the holistic approach to preparation. Furthermore, MASH high-lights the strategic value to include and use the available developments in information and communication technology as well as biotechnology in order to improve effectiveness of response and casualty management. MASH also addresses the little motivation and interest from end users for preparedness issues, although these are given high priority at the political level.

3. Effects of EMF and Low Dose Ionizing Radiation

Risk of electromagnetic exposure: Evidence and comparison

N. Leitgeb

Institute of Health Care Engineering, Graz University of Technology, Graz, Austria

Comparative health risk assessment of electromagnetic fields (EMF) has been performed in their entire frequency range from static fields until ionizing radiation. Due to considerable change of physical and biological interaction and the nature of potential adverse health effects comparison was based on the carcinogenic potential of environmental EMF exposure levels. There was a need for more sophisticated discrimination of levels of evidence as well as the quality of the available database. Conclusions were based on a synoptic view to results of different scientific approaches such as theoretical and biological interaction modelling, evidence for accumulative effects, in vitro and in vivo investigations and epidemiologic studies. The comparative assessment revealed significant differences of objective results and public risk perception, and puts EMF risks into perspective. Unfortunately, ambient exposure levels are highest at frequency ranges with highest health risk potential. As a consequence, in these frequency ranges health protection is hardly reached by setting legal limits but requires individual's responsible behavior based on adequate risk perception.

It highlights the necessity for individual's responsible behavior in terms of prudent avoidance supported by information. The comparison indicates where risk awareness might merit priority. This is not restricted to the UV frequency range but includes also other exposures such as to nocturnal light or to infrared radiation within cabins. In comparison, exposures to nonionizing EMF attract disproportionate attention.

Exposures from electromagnetic fields. Results from a long term epidemiological study in a Belgium cohort of former RADAR operators

E. Degrave

Belgian Defence, Brussels, Belgium

There is still some concern about long-term carcinogenic effect of exposure to high frequency electromagnetic fields. Few studies have been published with decades of follow-up. Since military radars have been extensively used since the mid-50's especially during the cold war, military radar operators form a useful focus group for epidemiological studies. The Unit of Epidemiology and Biostatistics of the Belgian Defence has achieved a wide study about the possible link between electromagnetic exposure and health problems, essentially cancers by the operators of Hawk radar sites.

The all-cause mortality of 27,671 Belgian militaries (professional and conscripts) who served from 1963 until 1994 in battalions equipped with radars for anti-aircraft defence was studied over the period 1968–2004. A control group was formed by 16,128 militaries who served during the same period in the same military area but who were never exposed to radars. We found no increase in all-cause mortality in Belgian militaries who were in close contact with radar equipments of anti-aircraft defence battalions compared to the military control group.

A second study focused on the 4417 professional militaries radar operators (and 2932 professional militaries in the control group) investigated the cause specific mortality. Age-adjusted rate ratio (RR) and (95% confidence intervals) were derived from a Poisson regression model. RRs were 1.22 (1.03-1.47) for neoplasms and 3.51 (1.19-10.3) for symptoms, signs and ill defined conditions. RRs for other causes of death were not significantly different from 1.00. Among deaths from neoplasms, RR for hemo-lymphatic cancer was 7.22 (1.09-47.9). RRs for other causes of cancer deaths were not significantly different from 1.00. In conclusion, exposure of professional military personnel to anti-aircraft radars that existed in Western Europe from the 1960s until the 1990s may have resulted in an increase in the incidence of hemolymphatic cancers. It remains to be established whether this increase is due to microwaves generated by radars or ionizing radiation produced by electronic devices producing the microwaves. This study investigating health effects on military radar operators was conducted inside the Belgian Military Defence. Precautionary principles taken to assess the credibility of the study and its scientific value are also discussed.

Hazards of electromagnetic radiations in the military settlement and operations: an overview of research programs developed in the French army

J.C. Debouzy, D. Crouzier, V. Dabouis, C. Bachelet, A. Perrin
Institut de Recherche Biomédicale des Armées – Antenne de La Tronche – CRSSA, La Tronche, France

Military uses of electromagnetic fields (EMF) have dramatically increased since Word War II, thus covering an extremely wide field of applications, e.g. communications, electronic war, warfare targeting, detection, non lethal weapons… Increased attention have been progressively paid to possible biological effects of EMF, both under the terms of professional exposure and/or to deal with possible overexposure hazards encountered in accidental or operational conditions on the battlefield. This led DoD Health Service to develop researches on biological effects of EMF, some of them are presented as listed below :

- Radars : Biological effects of radar radiation (pulsed and CW) in the LSX bands in vitro (cell apoptosis and co-genotoxicity, ROS production…) an in vivo (immunity and Nervous system studies in rodents)
- Epidemiology : A 25-year cohort study on health effects of occupational radar exposure in the French Navy (lethality and cancer morbidity)
- Jammers : Effects of operational Jammers exposure on people bearing medical metallic implants. (implanted osteosynthesis implants, vascular clips, stents…), and possible medico- legal implications ?
- Consequences of chronic radar exposure on the eyes after refractive keratomy. Evaluation of the consequences of chronic Radar (10GHz) exposure on the eyes after refractive keratotomy in rabbits.
- Less lethal Weapons (ADS) and millimetric waves (W band). Consequences on skin and eyes, cellular stress and ROS production; genic expression, and immunity in rodents.

Starting studies:

- Biological effects of UWB. (ultra wide band) : extensive jamming « all frequencies » by unique extremely powerful pulse (100 MHz – 1.5 GHz).
- Biological effects of simultaneous exposure to HF EMF and Carbon nanoparticles-possible organism penetration, cell membrane crossing and oxydative stress and inflammation properties, protein or DNA binding…
- specific electrical properties : half conductors, vibration and motion in EMR, vectorization.

Environmental and Health Risks Posed by Combat Uses of Depleted Uranium

W. Dekant
University of Würzburg, Würzburg, Germany

Depleted uranium (DU) is a by-product of uranium (U) enrichment. DU is less radioactive than U, but retains the chemical properties of natural U. DU is defined as U with a percentage fraction by weight of U-235 of less then 0.711%. The radioactivity of DU is only about 60% the radioactivity of natural U as DU has less of the more radioactive isotopes U-234 and U-235 per mass unit then natural U. Due to its pyrophoric properties and the capacity for penetration through armor plates, DU is intensively used in "penetrators" in armor-piercing ammunitions. Since such munitions have been intensively used in combat, health risk assessment for this application have been performed by several organizations. Exposure monitoring in combatants in several recent conflicts and in residents of areas where DU-ammunition was used by ICP-MS analysis of urine samples (permits a sensitive detection of DU exposure due to different isotope pattern as compared to natural U) did not detect exposures to DU in many cases; if detected, the concentrations of DU in urine were low and significantly below the concentrations of natural U isotopes.

All U isotopes emit alpha particles; due to the low penetration capacity of alpha particles, a health hazard is only expected when U or DU are ingested or inhaled. Detailed assessments of the radiological risks of DU use have concluded that effective radiation doses will be well below accepted dose-rate limits derived for radiation protection when using realistic exposure scenarios. The chemical toxicity of U is considered more relevant for risk assessment. In all scenarios, the intake of DU will also remain well below the intake of natural uranium. Since exposures to DU both in soldiers and in residents in areas with military use of DU could not be detected or was very low with exposures well below thresholds for chemical toxicity or accepted limits for radiological protection of the general population, human health risks due to the chemical and radiological toxicity of DU are not expected. Environmental monitoring in areas with DU use in combat included soil, drinking water and biota and is adequate to conclude that, except very close to destroyed vehicles and penetrators, DU contamination in these areas is also low. Due to the low exposures, possible risks for terrestrial and aquatic ecosystems are considered as very low.

Development of a CBRN – Dispersion Model for Infrastructure Buildings

G. Sdouz
Austrian Institute of Technology, Seibersdorf, Austria

One of the big threats in complex critical infrastructure buildings as hospitals, airports or train stations is the dispersion of CBRN agents (Chemical Biological Radiological Nuclear) which can be caused accidentally or controlled in the case of a terror attack. To support risk studies, the decisions of first responders in the case of emergency and in training situations, and to mitigate the consequences of such a dispersion a prognosis model has been developed. For outdoor situations several useful models are available. However, the supply of models to predict the dispersion in complex buildings is very limited and detailed models for aerosol behaviour and air condition systems are lacking completely.

As a basis for the development of such a model the German reactor containment code COCOSYS was selected. This code has been tested

sufficiently and is used in the international reactor safety community. In addition it contains physical models for the behaviour of aerosols and radionuclides. For the application in complex buildings models for air condition systems and different boundary conditions according to different environments were developed. The extended code was tested with several scenarios in a large hospital. The first simulations provided very reasonable results which are useful for the task of the first responders. Among the next steps are the validation of the new models and the selection of critical scenarios.

Implications for Human and Environmental Health of Low Doses of Radiation

C. Mothersill, C. Seymour
Department of Medical Physics and Applied Radiation Sciences, McMaster University, Hamilton, Ontario, Canada

Our understanding of the biological effects of low dose exposure has undergone a major paradigm shift. We now possess technologies which can detect very subtle changes in cells due to small exposures to radiation or other pollutants. We also understand much more now about cell communication, systems biology and the need to consider effects of low dose exposure at different hierarchical levels of organization from molecules up to and including ecosystems. We understand at least in part, some of the mechanisms which drive low dose effects and which perpetuate these not only in the exposed organism but also in its progeny and even its kin. ICRP (International Commission on Radiation Protection) and all national radiation and environmental protection organisations have always accepted a theoretical risk of low doses and have applied the precautionary principle and the LNT (linear-non-threshold) model which basically says that there is no safe dose of radiation. Therefore even in the absence of visible effects, exposure of people to radiation is strictly limited. However recent advances in our understanding of the mechanisms underlying the biological effects of low dose effects of ionizing radiation have also revealed that similar mechanisms can be induced by chemicals in the environment. Therefore interactions between radiation and chemicals are likely and that the outcomes following mixed exposures to radiation and chemicals may not be predictable for human or environmental health, by consideration of single agent effects. This means that previously held views about safe doses or lack of harmful effects cannot be sustained and we need to consider the possibility that in fact discontinuous dose responses could occur leading to uncertainties in low dose response. This chapter will consider the history of the new discoveries and will consider among other things, evidence for emergent effects after mixed exposures to combined stressors which include ionizing radiation. The implications for regulation of low dose exposures to protect human health and environmental security will be discussed.

4. Radiation Accident Management

Medical Implications of Enhanced Radiation Weapons

G. I. Reeves
Defence Threat Reduction Agency & USSTRATCOM Center for Combating WMD, Lorton, USA

During the 1960s through 1980s the United States and several other nations developed, and considered deploying, enhanced-radiation warheads (ERW). The major difference in the effects of ERW (sometimes called “neutron bombs”), as compared to other types of nuclear weapons, is due to the significant increase in the ratio of prompt radiation output to blast and thermal energy output. The hazards from fission product fallout are relatively decreased, which affects models guiding those making population evacuation vs. shelter decisions. However, the creation of increased activation products will pose a greater risk to first responders, affecting where and for how long they access casualties. Initial triage of casualties, distribution of patterns of injury, and medical management of ERW will also be shown to significantly differ from that of fission weapons. The possibility of treatment of cases of radiation-induced incapacitation becomes more realistic as well. There will be a need for neutron dosimetry in addition to photon and electron dosimetry capabilities. Emergency response planners and medical personnel, civilian or military, must be aware of these differences in order to reduce the horrible consequences of ERW usage and appropriately protect and treat casualties.

Evaluation of Demographic Factors that Influence Acute Radiation Response

D. Stricklin, D. Oldson, T. Pellmar, K. Millage
Applied Research Associates, Arlington, USA

Casualty estimation tools are critical in planning for nuclear event scenarios. Current consequence assessment models based on healthy adult males may not adequately represent the population. The literature was surveyed to identify key demographic, genetic, and environmental factors affecting acute radiation response. Information on in utero exposures, gender, age, and co-morbidity status was collected using data from Japan, radiation accidents, animal experiments, and clinical oncology. Burn and trauma studies were also examined for surrogate acute injury data. Fetal radiation sensitivity is well documented; increased mortality or malformations are observed depending on gestational age. Gender differences in response to acute radiation have been observed; 10% greater incidence of radiation syndrome was observed among male A-bomb survivors. Trauma data show increased mortality in males, apparently due to immunological differences between genders. Limited data suggest vulnerability in the very young and old due to immunological status and co-morbidities, respectively. Certain genetically susceptible sub-populations demonstrate marked increased sensitivity to radiation exposure. Persons with heritable mutations such as ataxia telangiectasia have dramatically increased mortality after radiation therapy. Interaction of radiation and co-morbid conditions has not been well studied; however, burn and trauma data indicate that co-morbidities negatively impact response to acute injury. The key factors evaluated together with their prevalence indicate the importance of modeling demographic variability in casualty estimations, can help identify vulnerable subpopulations, and provide insight on treatment requirements.

Emergency Care Centres – An Efficient Method for Mitigation of Consequences after a Dirty Bomb Attack

H. Miska
Civil Protection Commission with the Federal Ministry of the Interior, Klein-Winternheim, Germany

The concept of Emergency Care Centres has been developed by the Commission for Radiological Protection to care for a large number of people affected by a nuclear accident. The main objectives of these centres are information of arriving people, registration, contamination control, decontamination, if needed, dose assessment and finally medical as well as social support. By experience from many exercises, the concept has been developed further on and has proven feasibility and a capacity to care for about 2,000 individuals within 24 hours.

Apart from operation after a major nuclear accident, the method may also be very efficient after an attack with a Radiological Dispersal Device (RDD) or "Dirty Bomb". Radioactive contamination is easily detectable; the dose assessment would be different from that after a nuclear power plant accident but, on the other hand, dose by external radiation would not be a major path of irradiation. Even after an attack with chemicals, the concept could be used to care for affected people, although, in this case, other methods need to be implied for contamination control.

The contribution will elucidate the concept of Emergency Care Centres, not well known outside of Germany and will describe experiences and problems in its implementation and adaptation for response to NRC attacks.

Simulation and GIS-Systems: tools to support decisions of radiological countermeasures

W. Scheuermann, A. Piater, A. Lurk
Institute of Nuclear Technology and Energy Systems University of Stuttgart, Germany

In case of a radiological accident to decide the right countermeasures tools are needed to manage the complexity of such a situation with many people involved.

This paper describes how a system like ABR which simulates the dispersion of radioactive particles in combination with a GIS system can be used to assist decision makers in case of radioactive particle release.

The simulation system ABR was developed in the scope of an environmental monitoring system called Kernreaktorfernüberwachung Baden-Württemberg. The model uses as main input parameter the weather conditions, including rain, the topography and the source term. The system simulates the release and transport of radioactive particles providing as results the dose rates for different age groups and organs based on cloud radiation and radiation of deposited nuclides on the ground.

The main requirements for such a tool are its ease of use in stressful situations and the delivery of reliable results. Providing values for the exposure of the public is one thing to help decision makers to find the right countermeasures but there are a lot more of data which has to be taken into account. For example the location of hospitals, places to distribute iodine tablets, or important roads which can be used to evacuate people, etc.

To be able to make right decisions, tools are required which allow the integration of simulation results describing the radiological situation and the points of interest (POI). Geographical information systems (GIS) can be the clue to bring both types of information together.

Radiation Accidents in Bulgaria (1980–2000), Lessons Learned

J. Djounova
National Centre of Radiobiology and Radiation Protection of Bulgaria, Sofia, Bulgaria

The issue of emergency exposure is striking in recent years in concern to the possible terroristic use of radiation sources.

This paper provides an overview of the radiation accidents in Bulgaria for a period of 20 years. Nine accidents are analyzed with 46 persons involved. The most common incidents are in industrial radiography and incidents with "orphan sources".

The doses of exposure are below 0.5Gy TBI. The results from the medical management of the accidentally exposed persons are presented.

5. Radiation Accidents and Countermeasures

Evaluating the Evidence for Current Guidelines to Triage a Large Population Following a Major Radiation Event

A. B. Flood[1], E. Demidenko[1], R. J. Nicolalde[1], A. Shapiro[2], A. L. Wiley, Jr.[3],
B. B. Williams[1], L. Zubkoff[1],4, H. M. Swartz[1]
[1] *Dartmouth Medical School (DMS), Hanover, USA*
[2] *Food and Drug Administration (FDA), Rockville, USA*
[3] *Oak Ridge Institute for Science and Education (ORISE), Oak Ridge, USA*
[4] *Department of Veterans Affairs, White River Junction, USA*

Background: Planning medical care in a major radiation disaster requires dosimetry for rapid triage, assuming a resource-compromised medical system. Current guidelines focus on clinical measures based on a consensus of experts and experiences with small-scale radiation accidents. Neither current nor developing methods have been evaluated by modeling the circumstances of triaging a large population exposed during a terrorist event.

Methods: We propose a framework to evaluate individual-level dosimetry for triage of large numbers of people following a radiation event and apply this framework to current guidelines. We considered four common guidelines for dosimetry: time-to-emesis, lymphocyte depletion rate (LDR), dicentric chromosome aberrations (DCA), and clinical symptoms. We modified clinically-based scientific and regulatory criteria for evaluating screening methods to take into account needs for the specified circumstances, assuming the need is to identify exposures >2 Gray. Criteria include *data quality* (accuracy and completeness of data, generalizability to the likely circumstances for exposure) and statistical quality (accuracy of dose estimates including minimized false negatives). *New* criteria include *feasibility* (available facilities, equipment or expertise; elapsed time before results are available) and *ease of obtaining results* under the specified conditions (invasive sampling, standardizability of information, transportation requirements for samples, difficulty of communicating results to decision-makers and patients).

Results: LDR and DCA as currently carried out are inadequate for initial triage because of the time and expertise needed to complete the assays, and severe limitations on capacity. Time-to-emesis avoids these limitations, but poor data quality and missing information undermine its sensitivity and specificity for effective triage.

Internal contamination by actinides after wounding: a robust rodent model for assessment of local and distant actinide retention and decorporation efficacy

N.M. Griffiths[1], A. Van der Meeren[1], J.C. Wilk[1], M.C. Abram[1], N. Helfer[2], C. Guichet[3]
[1] *Laboratoire de RadioToxicologie*
[2] *Service de Santé au Travail et*
[3] *Laboratoire d'Analyses de Biologie et Médicale, Arpajon, France*

Introduction: Internal contamination by actinides following wounding may occur in nuclear fuel industry workers or subsequent to terrorist activities causing dissemination of radioactive elements. Contamination by actinides can result in pathological effects, either local or distant from the site of entry, stemming from alpha particle irradiation.

Objectives: To develop a robust experimental approach in the rat of internal contamination by actinides following wounding with rupture of dermal and vascular barriers.

Methods: Anesthetized rats were contaminated with Mixed Oxide (U,PuO2) or plutonium nitrate following wounding by deep incision of the hind leg muscle. Urinary excretion of actinides was measured and after euthanasia tissue samples evaluated for actinides and histological changes. A simple rapid technique was assessed using humid swabs in order to have a preliminary idea of contamination levels.

Results: For insoluble MOX most of the contaminant was retained at the wound site even given overt rupture of different barriers in comparison to Pu nitrate where less was found at the wound site. DTPA (30 µmol/kg i.v.) increased urinary excretion of α activity of MOX which for the most part was accounted for by americium. A superior efficacy of DTPA was observed after Pu nitrate indicated by higher urinary excretion and greater reduction in bone and liver Pu retention. The use of swabs for an initial estimate of contaminant activity provided a useful, simple adjunct to more complex external counting.

Conclusion: This model could be applied to other situations involving contamination following wounding including rupture of the dermal and vascular barriers.

Quality Assurance in Military Medical Research and Medical Radiation Accident Management

M. Hotz, V. Meineke

Bundeswehr Institute of Radiobiology affiliated to the University of Ulm, Munich, Germany

In order to handle quality assurance aim-oriented and effectively, a continual enhancing in efficiency is necessary on the basis of (internationally) recognized standards. This applies accordingly for military medical research or medical radiation accident management. Because of its holistic approach the internationally recognized DIN EN ISO 9001:2008 offers an excellent basis to design a quality management system. A quality management system according to DIN EN ISO 9001:2008 increases the effort of continual improvement of the offered product (or service) and produces transparency. Regarding transparency an organization has to define, design quantifiable, measure, evaluate and verify all essential processes. This process approach is characteristic of the DIN EN ISO 9001:2008. For reference laboratories, medical laboratories or medical devices these requirements are not sufficient, here the "measuring bar" should be raised. But standards with requirements to DIN EN ISO/IEC 17025:2005 (specifies the general requirements for the competence to carry out tests and/or calibrations, including sampling) or DIN EN ISO 15189:2007 (specifies requirements for quality and competence particular to medical laboratories) were derived from the 9000 ISO family and compromise an extensive conformity. In the case of risk management, DIN ISO 31000:2009 (provides principles and generic guidelines on risk management) similar conditions are valid. Additionally the component "uncertainty" is implemented in the quality management system. On closer considerations, whether a Task Force is ordered in contaminated area or whether the necessity for a certain therapy with potential radiation accident victims is given, the DIN ISO 31000 can play a role.

We postulate that DIN EN ISO 9001:2008 is a solid basis for the development of a quality management system in the most directions. Justifying a quality management system in medical research facilities or in the scope of medical radiation accident management the further development and optimization of an existing quality management system is quite simple. Distinct organizational structures are necessary if accreditation of individual laboratory groups according to different standards is scheduled, for example in special diagnostics with goal to compare test results in the context of external quality assurance.

Thursday-Sessions 19.05.2011

6. Biological Dosimetry and Dose Reconstruction

Phytoceuticals and Dietary Supplements for Radioprotection

C. K. K. Nair

Amala Cancer Research Centre, Trichur, India

Radiation protecting drugs and compounds are of great importance owing to their potential application during planned radiation exposures such as radiotherapy, diagnostic scanning, undertaking cleanup operations in nuclear accidents, space expeditions etc and unplanned radiation exposures such as accidents in nuclear industry, nuclear terrorism, natural background radiation etc. Free radicals and reactive oxygen species generated as a result of exposure of living systems to ionizing radiation have been implicated in the deleterious consequences and health hazards due to exposures to ionizing radiations. The oxidative free radicals cause a variety of damages to DNA, membranes etc. The radiation induced lesions in the cellular DNA are mainly strand breaks, damage to sugar moiety, alterations and elimination of bases, cross links of the intra and inter strand type and cross links to proteins while peroxidation of the lipids and oxidation of proteins constitute the major lesions in the membranes. The substances capable of inhibiting formation and spread of free radicals and their damage have been shown to prevent or inhibit or delay the manifestation of the deleterious consequences of radiation exposure and offer protection to mammalian organisms. Radioprotectors might reduce the cancer risk to populations exposed to radiations. They can reduce the normal tissue injury during radiotherapy of cancer. Many of the compounds developed for radioprotection, though showed promising results in laboratory studies were of limited human application due to several factors such as toxicity, difficulties in administering required amounts, limited availability etc.

The use of dietary antioxidants, supplements, vitamin derivatives and phytoceuticals such as extracts of medicinal plants, fungus and pure compounds found in the extracts to prevent gamma-radiation induced cellular DNA damage under *ex vivo* and *in vivo* conditions were investigated in mammalian system using single cell gel electrophoresis or comet assay. The dietary supplements, such as curcumin and vitamin C, Poly MVA, the extract of the medicinal mushroom- *Ganoderma lucidum*, extracts of medicinal plants such as *Acorus calamus, Centella asiatica*, etc, phytochemicals such as asiaticoside, alpha asarone, ferrulic acid, gallic acid, sesamol, glyzyrrhizic acid etc and derivatives of vitamin E have been shown to reduce mortality induced by whole-body gamma-radiation in mice and prevent radiation-induced damages in cellular DNA under *ex vivo* and *in vivo* conditions in mammalian system. Also, it was found that these enhance cellular DNA repair process upon administration following radiation exposure. Some of these non toxic agents could be of use in human applications for protecting against ionizing-radiation induced damages. The talk will present an overview of the ongoing work in the author's laboratory on radioprotection in mammalian systems by some of the nontoxic nutraceuticals and phytoceuticals.

Biological Indication and Dosimetry of Chronic Exposure

T. V. Azizova[1], V. Rybkina[1],V. Meineke[2]
[1] *Southern Urals Biophysics Institute (SUBI), Ozyorsk, Chelyabinsk Region, Russia;*
[2] *Bundeswehr Institute of Radiobiology, Munich, Germany*

From practical experience, there are a lot of situations, when physically measured doses are not available or dose verification is required, especially for non-uniform exposure. In this context, biological indication and dosimetry are of great importance. The major objective of a joint research project between the Southern Urals Biophysics Institute (Ozyorsk, Russia) and the Bundeswehr Institute of Radiobiology (Munich, Germany) is identification of biological markers of chronic external and/or internal exposure and development of the dosimetry system for dose assessment based on biological parameters. The study cohort includes nuclear workers, first employed at one of the main facilities (reactors, radiochemical, and plutonium production facilities) of the Mayak PA in 1948-1972, who were exposed to chronic external and/or internal exposure over a wide dose range (0.1 up to 4.6 Gy). For the identification of biological markers, a complex of methods was applied, including cytogenetic, molecular genetic ones, ELISA, and flow cytofluorometry for analyses of protein and gene expression, structural genomic disturbances. The research findings will be demonstrated in the presentation.

MULTIBIODOSE: multi-disciplinary biodosimetric tools to manage high scale radiological casualties

A. Wojcik[1], A. Bajinskis[1], H. Romm[2], U. Oestreicher[2], H. Thierens[3], A. Vral[3], K. Rothkamm$_4$, E. Ainsbury[4], M. Bendertitter[5], P. Fattibene[6], A. Jaworska[7], C. Lindholm[8], C. Whitehouse[9], F. Barquinero[10], S. Sommer[11], K. Woda[12], H. Scherthan[13], B. Vojnovic[14], F. Trompier[15].
[1] *Stockholms University, Stockholm, Sweden*
[2] *Federal Office for Radiation Protection, Munich, Germany*
[3] *University Gent, Belgium*
[4] *Health Protection Agency, London, United Kingdom*
[5] *Institute of Radioprotection of safety Nuclear, Grenoble, France*
[6] *National Institute of Health, Rom, Italy*
[7] *Norwegian Radiation Protection Autority, Norway*
[8] *Radiation and Nuclear Safety Autority, Helsinki, Finland*
[9] *Westlakes Scientific Consulting, West Cumbria, United Kingdom*
[10] *Autonomas University of Barcelona, Spain*
[11] *Institute of Nuclear Chemistry and Technologie, Poland*
[12] *German Research Center for Environmental Health, Munich, Germany*
[13] *University of Ulm, Germany*
[14] *University of Oxford, United Kingdom*
[15] *European Radiation Dosimetry Group, Braunschweig, Germany*

In the event of a large scale radiological emergency biological dosimetry is an essential tool that can provide timely assessment of radiation exposure to the general population and enable the identification of those exposed people, who should receive immediate medical treatment. A number of biodosimetric tools are potentially available, but they must be adapted and tested for a large-scale emergency scenario. These methods differ in their specificity and sensitivity to radiation, the stability of signal and speed of performance. A large scale radiological emergency can take different forms. Based on the emergency scenario different biodosimetric tools should be applied so that the dosimetric information can be made available with optimal speed and precision.

The aim of this multi-disciplinary collaborative project is to analyse a variety of biodosimetric tools and adapt them to different mass casualty scenarios. The following biodosimetric tools will be established, improved and/or validated: the dicentric assay, the micronucleus assay, the gamma-H2AX assay, the skin speckle assay and the blood serum protein expression assay. In addition EPR/OSL dosimetry in components of pocket electronic devises will also be investigated. The assays were chosen because they complement each other with respect to sensitivity, specificity to radiation and the exposure scenario as well as speed of performance.

The project will involve the key European players with extensive experience in biological dosimetry. Training will be carried out and automation and commercialisation pursued. An operational guide will be developed and disseminated among emergency preparedness and radiation protection organisations.

The final deliverable of this project will be establishment of a biodosimetric network that is fully functional and ready to respond in case of a mass casualty situation. Thus, the project will strengthen the European security capabilities by achieving tangible results.

The project is funded by the FP7 Security program. URL: http://www.multibiodose.eu.

DNA Damage Foci - Potent Indicators of External and Internal Radiation Exposure

H. Scherthan[1], D. Gassen[1], R. Zabold[1], M. Lassmann[2], V. Meineke[1]
[1] *Bundeswehr Institute of Radiobiology affiliated to the University of Ulm, Munich, Germany*
[2] *Department of Nuclear Medicine, University Würzburg, Germany.*

Ionizing radiation (IR) can damage tissues and cells and provoke cellular responses, among which the DNA damage response seeks to repair DNA double strand breaks (DSBs) that are a severe threat to a cell's survival and genomic integrity. At and around the site of the DNA break DSB recognition, signalling and effector/repair proteins accumulate. One significant IR-induced alteration is the extensive phosphorylation of histone H2A.X around the DSB, creating γ-H2AX foci that can be visualized by immunofluorescence and enumerated as fluorescent foci in the nucleus. Similarly the 53BP1 protein accumulates at DSBs. IR-induced γH2AX and 53BP1 foci correlate closely with the expected amount of DSBs and the loss of foci with DNA repair kinetics [1]. Some tissues like testis, exhibit endogenous γH2AX formation (e.g. testis) and stalled replication forks also can also lead to focus formation. However, in non-cycling peripheral blood lymphocytes γ–H2AX and 53BP1 focus formation is low and a valid bio-indicator of radiation exposure. Setting up the focus assay requires special care and highly specific antibodies. An SOP format is advisory for reliable performance of the assay. Using a standardized protocol we report on IR-induced γ–H2AX and 53BP1 focus formation in in vitro photon-irradiated peripheral blood leukocytes, and in leukocytes retrieved from differentiated thyroid carcinoma (DTC) patients before and after ~3.5 GBq I-131 incorporation in the course of DTC treatment. Our analysis was facilitated by a transport protocol that involves storage or shipping of ethanol-fixed samples. This is important for field scenarios, since transportation at room temperature may result in >50% foci loss after 24h at RT rendering dose reconstruction based on foci yields difficult and unreliable. Comparison of focus yields in blood samples of 25 patients diagnosed with DTC and treated with radioiodine (mean administered activity: 3.5±0.6 GBq I-131) with the values derived by physical dosimetry was possible for samples between 2h and 144h after administration of I-131. The mean absorbed dose to the blood of DTC patients was 0.39±0.40 Gy (Min: 0.17 Gy, Max: 2.2 Gy). After 24h the daily mean dose increment was less than 0.05 Gy. The focus assay revealed mean numbers of radiation-induced γ-H2AX foci per nucleus that matched those of 53BP1 foci and increased from a baseline value of 0.008±0.007 to a maximum of 0.267±0.189 foci 2h after I-131 uptake. An elevated number of excess foci per cell (0.040±0.024) could still be detected 120-144h after therapy. Overall, there was a time-dependent decrease of induced foci with hardly any change between 24h and 96h, while the 120-44h values were still significantly elevated above baseline. A significant inter-individual variation between patients prevented a global correlation between absorbed dose (rates) and the number of induced foci [2].

IR-induced DSB focus formation may serve as a potent indicator of radiation exposure, especially in incorporation scenarios. Foci numbers correlate linearly in a dose range of a few mGy up to 1Gy when cell isolation and immunostaining is done shortly (<2h) after exposure. In low dose and dose rate scenarios, such as after incorporation of radionuclides, focus estimation is well suited for the detection of radiation exposure, even when the absorbed dose to the blood is less than 20 mGy. However, individual dose reconstruction remains difficult due to a large inter-individual variation and rapid repair-associated focus loss. Elevated foci numbers detected even 24h post external or internal irradiation can serve as indicators of a significant exposure and support clinical decisions. Finally, an automated format of the repair focus assay may be useful for triage of exposed versus non-exposed in radiological and nuclear events.

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Usefulness and limits of FISH-based translocation analysis for retrospective radiation biodosimetry

C. Beinke, V. Meineke
Bundeswehr Institute of Radiobiology affiliated to the University of Ulm, Munich, Germany

Due to the high stability and accumulation over time translocations are currently the cytogenetic marker of choice for radiation dose estimation following protracted radiation overexposures or overexposures which occurred up to several decades in the past (environmental / occupational / medical exposures). In the course of this, particular intention is focused on the quantification of low doses (<< 1.0 Gy) for the purpose of evaluating potential associations between different radiation-induced chromosomal aberrations and future health impairments, usually cancer. However, existing limitations of FISH-based translocation analysis give occasion to further improve this technique. In order to further elucidate the characteristics of radiation induced cancer, like radiation and radiation quality specificity or total dose and dose rate dependencies, more accurate and reliable individual dosimetry within extensive epidemiologic studies are essential. Unfortunately, the individual dose assessment in the very low dose range is actually still impeded by the limited knowledge of the frequency of spontaneous translocations due to several already determined and potentially not yet known confounders. Therefore, extensive studies encompassing a considerable number of different collectives with regard to translocation frequencies in unexposed individuals have to be performed. Furthermore, practical limitations of translocation analysis are the tremendous workload and costs of huge approaches. This could be overcome by standardizing and automating translocation scoring to allow sharing of future work and planning of more extensive studies.

Reliable and sample saving gene expression analysis approach to develop diagnostic tools applicable for radiation exposure scenarios

M. Port[1], C. Seidl[2], C. Ruf[3], A. Riecke[4], V. Meineke[5] ,M. Abend[5]
[1] *Department of Hematology, Hemostasis, Oncology, and Stem Cell Transplantation, Medical School, Hannover, Germany*
[2] *Department of Nuclear Medicine, Technical University Munich, Munich, Germany*
[3] *Department of Urology, Federal Armed Forces Hospital, Hamburg, Germany*
[4] *Department of Internal Medicine, Federal Armed Forces Ulm, Ulm, Germany*
[5] *Bundeswehr Institute of Radiobiology, Munich, Germany*

Purpose: Is it necessary hybridizing individual instead of pooled RNA samples on microarrays for screening gene targets suitable as diagnostic tools for radiation exposure scenarios, but meeting comparable microarray quality criteria?

Material and Methods: For developing new clinical diagnostic tools, we employed a two stage study design in five projects. At first, pooled and not individual RNA samples were hybridized on microarrays for screening purposes. Potential gene candidates were selected based on their fold-change only. This was followed by a validation/quantification step but using individual RNA samples and quantitative RT-PCR. Quality criteria from the screening approach with pooled RNA samples were compared with published data from the MicroArray Quality Control (MAQC) consortium who hybridized each reference RNA separately and established quality criteria for microarrays.

Results: When comparing both approaches, we found insignificant differences for quality criteria such as false positives, sensitivity, specificity and overall agreement. However, material, costs and time were drastically reduced when hybridizing pooled RNA and gene targets applicable for clinical diagnostic purposes could be successfully selected.

Conclusion: When searching for new diagnostic tools the two stage study design using either pooled or individual RNA samples on microarrays shows comparable quality criteria, but the RNA pooling approach saves unique material, costs and efforts, and successfully selects gene targets which can be used for the desired diagnostic purposes.

Electron Paramagnetic Resonance (EPR) Dosimetry for response to a large-scale radiation incident

H. Swartz, A.B. Flood, B. Williams, R. Dong, J. Gui, X. He, P. Lesniewski, M. Kmiec, J. LaRiviere, T. Mathews, T. Raynolds, O. Grinberg, I. Salikhov, E. Demidenko, J. Nicolalde, D. Wilcox
Dartmouth Medical School, Hanover, USA

The potential exposure of large numbers of individuals to levels of radiation that could lead to acute clinical effects has become a major concern with the advent of terrorism, along with the continuing concerns about radiation accidents. In order to cope medically with such an event, it is essential to be able to identify those individuals who probably have had clinically significant exposures so that they can be entered into the medical system and to identify those who do not need medical intervention so that the response system is not overwhelmed by them. The capabilities of EPR to measure radiation-induced paramagnetic species along with the persistence of such species in certain tissues (teeth, finger & toenails, bone, and hair) has led to EPR becoming a prominent methods for making the measurements in potentially affected individuals. The technical requirements for developing these capabilities into practical tools that could be applied effectively in such an event are daunting but remarkable progress has been made. Consequently, EPR dosimetry is increasingly recognized as a major component of response plans. Developments using EPR tooth dosimetry based on measurements of the upper incisors have matured sufficiently so that negotiations are underway with a USA federal agency for its development as an FDA approved and manufacturable device (to be carried out in collaboration with General Electric). EPR using nails has also made significant progress, with the emergence of methods to measure nails in situ under point-of-care/field conditions and to measure clipped nails transported to specialized laboratories.

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Study of the stability of EPR signals after irradiation of fingernail samples

R. A. Reyes[1], F. Trompier[2], A. Romanyukha[3]
[1] *Uniformed Services University of the Health Sciences, Bethesda, USA*
[2] *Institut de Radioprotection et de Sûreté Nucléaire, Fontenay-aux-Roses, France*
[3] *Naval Dosimetry Center, Bethesda, USA*

Our recent studies have suggested that the electron paramagnetic resonance in fingernails can be used to measure received doses as result of radiation accidents [1-4]. Use of fingernails as an emergency dosimeter has benefits of easy non-invasive sampling, fast dose measurements (~10 min) potentially in field conditions and almost immediately after exposure event. This study represents a next step in the development of EPR fingernail dosimetry, e.g. evaluation of the stability of radiation-induced signal (RIS) at different storage and irradiation conditions. RIS fading during storage in both stressed (untreated) and unstressed (soaked in water) samples (n=20) were studied at two temperature conditions: freezing (temp ≈ -20 °C) and room temperature (20-24 °C). Fingernail samples with the same clipping size and number irradiated to 15 and 20 Gy were measured for over 200 days and those irradiated to 100 and 200 Gy were measured for 114 days. The other group of samples irradiated to 1, 3, 8, and 20 Gy was followed for 25 month storage. Our study demonstrated that all samples that were kept at low freezing temperatures showed a stable RIS with no significant fading. All samples that were kept at room temperatures showed an initial fading of the signal with a slow rise of the EPR signal after irradiation with time to a saturation level. Obtained results allow to make recommendation on appropriate storage conditions of fingernails for EPR dosimetry use.

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Dose assessment after nuclear emergencies and radiological terrorism using personal objects and environmental dosimeters

C. Woda, J. C. Kaiser

Helmholtz Center, German Research Center for Environmental Health, Institute of Radiation Protection, Munich, Germany

The increasing risk of a mass casualty scenario following a large scale radiological accident or attack necessitates the development of appropriate dosimetric tools for emergency response. Here we report on two complementary approaches using either personal objects as fortuitous dosimeters or area dosimeters, which are placed at pre-selected positions of high importance (i.e. public squares). For personal objects, we show that certain type of chip cards (e.g. credit cards, debit cards and SIM cards) and portable electronic devices (e.g. mobile phones) have high potential to be used as individual dosimeters for rapid assessment of the radiation exposure. The wide variety of usable objects ensures that a large part of the general population is equipped with at least one fortuitous dosimeter. The dose information is read out using optically stimulated luminescence (OSL) on specific radiation sensitive components. We will give a comprehensive overview of the main dosimetric properties of these materials and of open questions that still need to be resolved.

For area dosimeters, we employ passive BeO-based OSL detectors as inexpensive, environmentally stable dosimeters with highly favourable luminescence properties. High resolution maps of the radioactive contamination in the urban environment are then produced from the localized dose measurements using either plume model fitting methods or geo-statistical interpolation. For the latter, the Inhabited Areas Monitoring Module (IAMM) is applied, which is an operational module of the European decision support systems RODOS and ARGOS. Our complementary approaches are demonstrated in a hypothetical scenario based on the explosion of a radioactive dispersion device.

7. Radiobiology and Radiation Medicine

Three-dimensional thermal tomography as a predictor for radiation-induced skin injuries

J. Chu

Rush University Medical Centre, Chicago, USA

Objective: To develop a 3D thermal tomography (3DTT) based system that can rapidly identify the individuals who are at risk of developing clinically important acute skin injury during a radiological/nuclear event.

Materials/methods: Eleven hairless mice were exposed to a single dose of 40 Gy to the dorsal surface of the left hind thigh using an Ir-192 source via a 1 cm high dose rate brachytherapy Leipzig applicator. An infrared camera captured a series of images of each mouse immediately after a brief (2.5 ms) photographic flash for about 6 seconds (a total of 3000 frames). These data were then used to compute and present cross-sectional images based on the object's thermal effusivity at the voxel level.

Results: Six mice developed moist desquamation (the high-grade group) and five did not (the low-grade group). Effusivity tended to decrease beginning a day or more after irradiation. This effect was measured by the relative average effusivity difference (RAED) between the treated and control sides over 0.3-0.6 mm depth. RAED increased earlier in the high-grade group, leading to a distinct separation of the values during days 2 through 5 after irradiation. The difference between the groups with respect to RAED was statistically significant by univariable logistic regression on days 4 ($p = 0.035$) and 5 ($p < 0.001$) after irradiation.

Conclusion: 3DTT is a relatively new thermal imaging technology. Our data strongly suggest that it predicts radiation-induced moist desquamation by several days and may provide an effective tool for patient triage at radiological attacks.

X-ray Fluorescence Microscopy and the Bionanoprobe

G. E. Woloschak, T. Paunesku, S. Vogt

Northwestern University, Chicago,USA

Argonne National Laboratory, Argonne, USA

X-ray Fluorescence Microscopy (XFM) is one method that can be used to induce elemental X-ray fluorescence; hard X-rays are focused onto a specimen and induce characteristic X-ray fluorescence in the samples, which can be used to localize and quantitate different elements in cells and tissues. Detection of most elements on the periodic table is possible including actinides like Pu and U, cellular constituents

such as Zn and P, and environmental contaminants such as Hg, and others; examples of these will be shown. XFM can be used for detection of such elements in tissues, cells and even subcellular sites. The Bionanoprobe being constructed at the Advanced Photon Source will considerably improve the achievable spatial resolution on soft materials, such that precise elemental maps can be acquired even in small organelles, rapidly, and in 3D. X-ray phase contrast methods, will simultaneously provide the ultrastructural context so that it is possible to identify specific cellular organelles.

Mesenchymal Stem Cells as a new cell drug to mitigate cutaneous radiation syndrome

D. Agay[1], H. Scherthan[2], F. Forcheron[1], D. Riccobono[1], F. Hérodin [1], V. Meineke [2], M. Drouet[1].

[1] *Institut de Recherche Biomédicale des Armées - Antenne de La Tronche – CRSSA, La Tronche, France*

[2] *Bundeswehr Institute of Radiobiology affiliated to the University of Ulm, Munich, Germany*

Cutaneous radiation syndrome (CRS) is the delayed consequence of localized skin exposure to high doses of ionizing radiation (IR). New therapeutic management of IR–burned patients has suggested the benefit of local cellular therapy using mesenchymal stem cell (MSC) injections in favour of wound healing and pain control. Here we examined in a large animal model the therapeutic potential of autologous bone marrow- or adipose tissue-derived stem cells (BM-MSCs or ASCs) to prevent or cure CRS.

Göttingen minipigs were locally irradiated using a 60Co gamma source at the dose of 50 Gy and grafted with autologous BM-MSCs (n=3) / ASCs (n=5) or PBS injected (n=8). Multipotent adult stem cells were cultured in MEMα with 10% fetal calf serum and basic fibroblast growth factor (2ng.mL-1) and then were intradermally injected four times from days 25 to 95 (50x106 MSCs each time). All controls exhibited a clinical evolution similar to human after a latency phase of several weeks: early erythema, hair loss, dry and moist desquamation, leading to final necrosis (81-222 days post IR). Immunohistology revealed severe skin damages and severe rhabdomyolysis in the muscle tissue below the entry area. In BM-MSC grafted minipigs, the CRS occurrence was delayed in comparison with the controls. In ASC-grafted minipigs, an ultimate wound healing was observed in four out of five grafted animals (day 130 ±28, complete in two of them). Histologically, the cleaning of the damaged epidermis appeared earlier than in non-grafted controls and immunohistological analysis of cytokeratin expression showed a final strong hyperproliferative activity of the keratinocytes leading to surnumerous cell layers in the entry area. Q-dot labelling confirmed that grafted ASCs accumulated at the dermis/subcutis barrier in which they attracted numerous immune cells correlated with an earlier and increased CD3 and λ light chain labelling. A transient increase in local vasculature was observed in one pig and Q-RT PCR analysis showed that in vitro irradiated (25Gy gamma) cutaneous fibroblasts incubated with ASC-conditioned media secreted proangiogenic factors (increased VEGF mRNA levels).

Globally this study strongly suggests that local injection of ASCs may represent a useful strategy to mitigate CRS.

ARS: Early Gastrointestinal Signs and Symptoms as Predictors of Prognosis – Database SEARCH

H. Dörr, M. Hoebbel, V. Meineke

Bundeswehr Institute of Radiobiology affiliated to the University of Ulm, Munich, Germany

The databank system SEARCH (System for Evaluation and Archiving of Radiation Accidents based on Case Histories) contains 824 clinical cases from 81 radiation accidents in 19 countries from 1945 to 2001. This exceptional collection of clinical data from accidentally radiation exposed persons are analysed regarding the clinical course and in search of parameters allowing an early prognostic estimation of the acute radiation syndrome.

To investigate the importance of radiation induced gastrointestinal signs and symptoms for the outcome of patients with acute radiation syndrome, clinical data of 283 radiation exposed persons were analysed. The main focus of this investigation was the relation of the occurrence of different signs and symptoms and their combination for the prognosis. Since most of the gastrointestinal signs and symptoms occur early and are easy to detect they can be used as early predictors of prognosis in mass casualty scenarios.

We analyzed in detail the occurrence of the following signs and symptoms in relation to the outcome of the patients: nausea, vomiting, diarrhoea, parotitis and mucositits. Some symptoms occurred more frequent (e.g. nausea 85%) than others (e.g. swelling of parotid gland 16%). Also the combination of signs and symptoms can be taken as an indicator for prognosis, since the group with more than 4 different signs and symptoms had a by far poorer outcome than the group with up to three different signs and symptoms. The number of different signs and symptoms also show a correlation to the severity of the hematopoietic syndrome. We could confirm the known relation between the occurrence of diarrhoea, especially with an early onset and a poorer prognosis. A swelling of the parotid gland was associated with the risk of over 50 % not to survive the acute phase of the acute radiation syndrome.

The early prognostic estimation for the acute radiation syndrome is of utmost importance if triage becomes necessary in case of scarce resources and mass casualties scenarios. In combination with additional clinical information gastrointestinal signs and symptoms can be used as prognostic factors of the acute radiation symptom.

Short-term sonic-hedgehog gene therapy as a new strategy to repair bone marrow niche damage and mitigate myelosuppression : preliminary evaluation in highly irradiated monkeys

M. Drouet, P. Garrigou, D. Riccobono, N. Grenier, B. Ballester, F. Forcheron, A. Peinnequin, F. Hérodin.

Institut de Recherche Biomédicale des Armées - Antenne de La Tronche – CRSSA, La Tronche, France

The Hematopoietic stem cell niche represents a complex radiosensitive compartment whose protection/repair is required for recovery from radiation-induced myelosuppression. We propose a new gene therapy strategy based on local and short term secretion of Sonic hedgehog morphogene targeting two putative tissues: (1) the bone marrow vascular niche to favour repair and crucial interactions with hematopoietic stem and progenitor cells (HSPCs) (2) HSPCs to stimulate residual hematopoiesis and shorten the periods of neutropenia and thrombocytopenia following high dose whole body irradiation. We investigated the hematopoietic response of a first pair of monkeys to a single intraosseous injection of 3.5 and 1.9 x106/kg xenogenic multipotent mesenchymal stem cells transduced with a Shh pIRES2 plasmid and grafted 2 days after a 8-Gy gamma irradiation. Thrombocytopenia (5 and 0 versus 25.4 + 7.2 ;PLTs < 20x109/L) and neutropenia (14 and 15 days versus 33.1 + 9; neutrophil <1x109/L) duration were reduced in grafted animals when compared with ungrafted controls (n=7). Areas under the curve of PLTs and ANCs between days 0 and days 30 were higher in treated animals than in controls and clonogenics returned to base-line values on day 42. Long term follow-up demonstrated a durable recovery in treated animals. This study suggests that grafting Shh-multipotent stem cells may represent a useful strategy to cure radiation-induced niche damage.

Telomeres and their role in radiation induced genomic changes

K. M. Greulich-Bode, J. Leykauf, D. Krunic, P. Boukamp

German Cancer Research Center, Heidelberg, Germany

Telomeres are specialized structures at the ends of linear chromosomes which are comprised of repetitive (TTAGGG)N DNA sequences covered with multiple proteins, forming the so-called shelterin complex. It has been postulated that in telomeric DNA radiation induced DNA damage accumulates. This can lead to dysfunction of this protective structure and therefore can give rise to telomere erosion and/or genomic instability.

Indeed, when investigating chronically irradiated (UV radiation) skin, we find areas of significantly short telomeres which in addition are positive for p53 and show damage foci co-localising with telomeres, so-called dysfunctional telomeres.

In addition, we postulate a second telomere-dependent mechanism of genomic instability. In interphase nuclei telomeres are generally organized in non-overlapping territories. This organization can, however, be disturbed. The telomeres form telomeric associations and telomeric aggregates (TAs), which are accompanied by gross changes also in the chromosomal territories and are followed by chromosomal aberrations. This mechanism is telomere length-independent.

We previously showed that c-Myc is able to induce TA formation and now provide evidence that this mechanism of genomic instability is also induced by UV-C exposure. Irradiating HaCaT-Myc cells and investigating their 3D telomeric organization (3D fluorescence in situ hybridization probing for telomeric DNA) and the chromosomal composition (karyotypes, multicolor fluorescence in situ hybridization) demonstrated that UV-C exposure induced telomeric associations and TAs within 48 to 72 hours after radiation and that this correlated with an increased number of chromosomal aberrations when investigated after several days. Therefore, TA formation may serve as an early parameter for radiation risk estimation. Potential steps of the molecular mechanism of TA formation will be discussed.

Divergent effects of radiation-induced mast cell mediators on malignant melanoma cells

K. Müller, V. Meineke

Bundeswehr Institute of Radiobiology affiliated to the University of Ulm, Munich, Germany

Mast cells are key effector cells of the immune system and accumulate around the margin of cutaneous malignancies. Our recent studies have demonstrated that dermal mast cells degranulate after ionizing radiation exposure and release various mediators. The aim of this study was to evaluate the specific effect of serotonin on malignant melanoma cells.

Irradiation of the human mast cell line HMC-1 with 5 Gy and subsequent ELISA analysis revealed serotonin as an ionizing radiation-induced mast cell secretory product. The presence of serotonin receptors 5-HT2AR, 5-HT2BR and 5-HT2CR on the human melanoma cell line IPC-298 was verified using immunofluorescence. To study the role of serotonin in the regulation of melanoma cell growth, IPC-298 cells either non-irradiated or irradiated with 5 Gy were stimulated with serotonin and subjected to proliferation assay. Our results showed that serotonin dose-dependently decreased the number of IPC-298 cells. Moreover, serotonin exerted an amplifying effect on the radiation-induced reduction in melanoma cell proliferation.

Cellular adhesion molecules play an essential role in immune and inflammatory reactions mainly by mediating cell-cell and cell-matrix interactions. Previous reports have shown that adhesion molecules are involved in the transendothelial migration of malignant melanoma cells and in melanoma metastasis. Therefore, we next aimed to determine the impact of serotonin on adhesion molecule expression by IPC-298 cells. As shown by gene array and flow cytometry, IPC-298 cells constitutively expressed a variety of adhesion molecules. Stimulation with serotonin caused a significant increase of the cell surface expression of intercellular adhesion molecule-1 (ICAM-1) and integrins beta1 (CD29), alpha2 (CD49b), alpha5 (CD49e) and alpha6 (CD49f) on melanoma cells. When IPC-298 cells were irradiated with 5 Gy following serotonin treatment, a synergistic effect of serotonin and ionizing radiation on the melanoma cell adhesion molecule expression has been observed.

Taken together, our data imply ionizing radiation-induced serotonin release by mast cells to be a crucial factor in malignant melanoma development.

Assessment of total- and partial-body irradiation in a baboon model: a kinetic multiparameter study of chromosomal aberrations and hematological, biochemical and genomic parameters. Preliminary results.

F. Hérodin[1], S. Richard[1], N. Grenier[1], C. Mouret[1], A. Peinnequin[1], S. Baugé[1], J. Denis[1], S. Gouard[1], M. Drouet[1], C. Larsson[2], H. Boulay-Greene [2], M. Abend[3], W. Blakely[4], F. Darroudi[5]

[1] *Institut de Recherche Biomédicale des Armées, La Tronche, France*

[2] *Defence R & D Canada Ottawa, Canada*

[3] *Bundeswehr Institute of Radiobiologie, Munich, Germany*

[4] *Armed Forces Radiobiology Research Institute, Bethesda, United States*

[5] *Leiden University Medical Center, Leiden, Netherlands.*

Purpose: To investigate in irradiated baboons (Papio anubis) the efficacy of a kinetic multiparameter approach both clinical, physical and biological (cytogenetic, hematological, biochemical and genomic parameters) for discriminating partial-body irradiation (PBI) from total-body irradiation (TBI). Furthermore, a dual diagnostic and prognostic goal is pursued: (1) improve the dosimetric tools to estimate the level and heterogeneity of radiation exposure (2) identify new biomarkers to assess / predict the severity of radiation injury in a non uniform exposure setting.

Materials and Methods: Anesthetized baboons placed in restraining chairs were unilaterally (front) exposed to a source of 60 Cobalt gamma-rays (dose rate 8 to 32 cGy/min) either TBI or left hemi-body irradiated (HBI; about 50% of the bone marrow was protected using a lead screen shielding the vertical right half of the collimated radiation flow), as follows: 2.5 Gy TBI (n=2), 5 Gy TBI (n=2), 5 Gy HBI (n=2) and 10 Gy HBI (n=2). Average free-in air doses were measured with an ionization chamber at the anterior iliac crest level and body dosimetry was performed using thermoluminescent or optically stimulated dosimeters. For HBI, the dose received by the left side was reduced to less than 6% relative to that received by the left side. Blood samples were collected at different times after exposure, i.e. from 1 hour until 200 days. Analysis of more than 50 parameters was performed including clinical status, blood cell count measurement, biochemical parameters measurement, genomic parameters and cytogenetic analysis (the latter at 1, 6, 24 hours, 28 days and 200 days after irradiation). Statistical analysis will be performed according to a predictive method using a non linear iterative partial least square algorithm.

Preliminary Results: Reference biodosimeters such as the dicentric chromosome assay may not distinguish PBI from TBI when equivalent whole-body doses are similar and the time of exposure is sufficient for peripheral blood homogenization. Such confounding situations need more discriminating biodosimeters / biomarkers. In our study, as expected, the shielding of 50% bone marrow prevented aplasia to happen and hematologic parameters contributed to discriminate HBI and TBI. Moreover, some parameters may be discriminant as biodosimetric markers such as neutrophils to lymphocytes ratio, creatine kinase and citrullin levels, mitochondrial DNA and others as markers of injury such as platelet counts and Flt-3 ligand levels.

Both early and more delayed assessment of clinical and biological status is required for reliable discrimination. Further work is needed, in particular through ongoing international collaborations, for comprehensive interpretation.

Poster Presentations

Wednesday 18.05.2011

Consequence modeling of an intentional radiological dispersion event on a stadium area

P. A. de Moraes Cabral, E. R. de Andrade
Brazilian Army Technology Center, Rio de Janeiro, Brazil

Mass events such as the World Cup and the Olympics are potential scenarios for terrorist attacks. Brazil will host these events in 2014 and 2016 respectively. This work aims to simulate potential consequences of an intentional release scenario where a radionuclide cesium 137 is used as the radiological agent. It is performed by calculating the probable contamination plumes and obtaining risk estimation of cancer development (as a function of age and sex) in several locations within contaminated areas. The dispersion is modeled by a Computational Fluid Dynamics (CFD) based software. To date, most of the risk assessments are conducted on Gaussian plume model basis, however some recent studies have shown the applicability of CFD models, although this tool is considered suitable only for preparedness and investigation in emergency response, due to its computational demand. Results were effective in the indication of the risk map of cancer development within the contaminated area and may provide guidance for decontamination teams. Also, results can be used to assist the authorities in managing the evacuation. Furthermore, looking after the possible time function complications such as cancer, this methodology can be helpful to scale the risk, and guide medical monitoring of the crew.

Development of multiparameter biodosimetry test for triage of casualties in a large scale radiological event

S. Sommer, A. Lankoff, M. Wojewódzka, I. Buraczewska, I. Szumiel, M. Kruszewski
Institute of Nuclear Chemistry and Technology, Warsaw, Poland

The aims of biological dosimetry have recently been undergoing significant changes. Now, it seems not to be of greatest importance to estimate the absorbed dose with high accuracy. Instead, speed and ability to perform analysis on a high number of potentially exposed people are in spotlight. The main goal is to manage a high number of casualties and be able to decide who needs urgent medical treatment and hospitalization and who can go home, because the dose received was not high enough to cause immediate danger to their health or life. The methods of biodosimetry still remain the same: dicentrics and micronucleus assays on peripheral blood lymphocytes, but they have to be adjusted using new microscopes and computer equipment for triage. Research are undertaken:

- to make the analysis of biological dosimetry endpoints half- or fully automated;
- to restrict the number of scored cells, on the one hand lowering statistical certainty, but on the other hand obtaining test results more rapidly;
- to examine the usefulness of a new potential biodosimetry tools, e.g. histone γH2AX;
- to create international, operational biodosimetric network.

At the Institute of Nuclear Chemistry and Technology (Warsaw, Poland) we meet the new challenge in the field of biodosimetry by carrying out a scientific project "Development of multiparameter biodosimetry test for triage to evaluate people irradiation in the large scale radiological event". The dicentric and micronucleus assays are being adjusted for triage mode using automated microscope Zeiss Axio Imager Z2 with Metafer 4 (Metasystems) software. The histone γH2AX assay for dosimetry is being set up and validated.

Aneuploidy of individual human chromosomes in m-FISH assay

S. Sommer[1], E. Nasonova[2,3], M. Kruszewski[1], S. Ritter[3]
[1] *Institute of Nuclear Chemistry and Technology, Warsaw, Poland;*
[2] *Joint Institute for Nuclear Research, Dubna, Russia;*
[3] *Biophysics Department, GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany;*

In analysis of chromosomal aberrations in X- or gamma-rays irradiated lymphocytes of healthy individuals the usual finding is a number of aneuploid metaphases spreads. The aneuploid cells have lower (often) or higher (rare) number of chromosomes than those with the correct karyotype. Such aneuploidy is commonly known and easy to explain: while dropping the fixed cells on the microscopic slides, some nuclear membranes may break too violently and hence, chromosomes spread over a larger area and become lost from the metaphase plates. Such phenomenon is known as caused by technical reasons and normal way to proceed is to exclude such spreads from analysis. The rationale of such procedure is to avoid underestimation of the aberration frequencies, since among the missing chromosomes may be dicentrics or rings.

Here, we examined aneuploidy in metaphase spreads of human lymphocytes painted with a specific cocktail of fluorochrome labelled DNA-probes (m-FISH). Therefore, it was possible to independently analyse aneuploidy of each chromosome.

We found 260 events of loss or gain of chromosomes in 221 aneuploid cells, when analysed 2082 lymphocytes of healthy female donor. The data show that chromosome X is more involved in aneuploidy – 26 % of aneuploidy events than expected from it length – 5 % of whole genome. The study has been expanded to include 20 male donors with prostate cancer – 8259 cells were analysed and 855 aneuploidy events were found. In the case of prostate cancer patients, chromosomes 21 and Y are more involved in aneuploidy than other chromosomes. These results indicate that aneuploidy of individual chromosomes is not a random event.

Inter-laboratory comparison of ionising radiation dose reconstruction by the dicentric assay in Poland

S. Sommer[1], M. Kowalska[2], M. Szymańska[2], I. Buraczewska[1], M. Kruszewski[1]
[1] *Institute of Nuclear Chemistry and Technology, Warsaw, Poland;*
[2] *Central Laboratory for Radiological Protection, Warsaw, Poland;*

Biological dosimetry now tends to focus on speed of scoring and ability to perform analysis of a big number of potentially exposed individuals rather than on accuracy of dose reconstruction. Mass scale radiological event can result in too many casualties for one laboratory to manage if using currently available biodosimetry techniques. One way to adjust

biodosimetry for triage is to establish a network of laboratories on international and/or national levels which can work together on dose assessment. To initiate such a biodosimetric network in Poland, two laboratories: Center of Radiobiology and Biological Dosimetry of the Institute of Nuclear Chemistry and Technology (INTC) in Warsaw and Laboratory of Cytogenetic Dose Reconstruction of the Central Laboratory for Radiological Protection in Warsaw undertook an interlaboratory comparison of dose assessment using the dicentric assay. The main purpose of it was: 1) to check the impact of different dicentric assay protocols on dosimetry results; 2) to asses the validity of gamma-ray dose reconstruction in each laboratory; 3) to improve the dosimetric skills of each laboratory by analyzing and discussing the protocols, biodosimetry results and their statistical evaluation.

In vitro irradiation of human lymphocytes was performed in INTC using Co60 gamma-source. Three doses: low, medium and high were reconstructed at each institute, using two different calibration curves obtained in the respective laboratories. The results of dose assessment and possible explanations of deviations from the actually delivered doses will be discussed.

Investigation of Indoor Radon Level in Presumable Radon Pron Areas

K. Ivanova, V. Badulin, R. Georgieva,
National Center of Radiobiology and Radiation Protection Sofia, Bulgaria

Aim: It is well know that radon is the second cause of lung cancer in the general population, after smoking. The new international standards and publications recommend reduction of the risk from indoor radon exposure. The average equivalent dose form background per year is 2,33 mSv/a in Bulgaria and approximately 45 % is from radon exposure. The mean origin of indoor radon is soil gas and levels depend on geology, atmospheric conditions, ventilation, levels in water, so the study focuses on regions with high geologic condition – former uranium mining industries.

Methods: The cumulative (passive) method was used for the study. The measurements are carried out by E-PERM® system. Detectors are placed for approximately 6 months in randomly selected houses at different areas of the settlements with higher uranium availability - Sliven-villages area, Eleshnica and Bachkovo. The measurement in Sofia city is used as a background level.

Results: The average of the indoor concentrations of radon of the in Sofia is 25 Bq/m^3, to 250 Bq/m^3. The results for investigation villages range from 125 Bq/m^3 to 4000 Bq/m^3.

Conclusion: The results prove assumption that former uranium mining sites are radon prone areas. The level of indoor radon of residential buildings in areas with higher uranium availability is around or above the recommended reference radon levels.

Key words: Radon concentration, long-term measurement, background measurement, radon prone areas

Haematological Changes after Emergency Exposure to 60Co

J. Djounova
National Centre of Radiobiology and Radiation Protection of Bulgaria, Sofia, Bulgaria

In radiation accidents, the effects on human health depend on the specific character of the emergency itself, which complicates the process of establishing the diagnosis. To ensure adequate treatment it is necessary to assess as quickly as possible the severity of injury and the ability of haemopoetic tissue self-recovery.

In the present study the results from the medical examinations of 4 persons involved in incident with 60Co are presented. The first examinations are made at day 4th after exposure. The doses established by the biological dosimetry are below 0.5 Gy. The health status is assessed by medical specialist in radiobiology, internal medicine and neurology. Laboratory test are made and individual changes in peripheral blood cells count are analyzed and compared with unirradiated control group.

The decrease in the number of granulocytes is recorded at day 8th after the incident. The initial increase in the number of leucocytes in one of the victims could be attributed to stress reactions.

The results give the basis to develop an algorithm to specify the time when relevant hematological parameters could be examined after radiation accidents.

Analysis of Direct and Indirect Harm of Radiological Terrorism Events

O. Pavlovskiy, E. Melikhova
Nuclear Safety Institute, Russian Academy of Science, Moscow, Russia

The radiological terrorism differs from other types of terrorism not only in its radiation impact factor but also in its specific psycho-information effects, which are conditioned both by mass conscience fear of radiation and unjustifiably rigid regulation of radiation safety. Excessive perception of the radiation hazard is common to the general public, professional groups and environmental protection managerial community. An exception is the limited number of nuclear community professionals.

On the basis of analysis of some possible scenarios of radiological terrorism events (RTE) in a megapolis, direct and indirect RTE consequences are considered in three "dimensions":

- **physical** (*direct* - radioactive contamination, population radiation exposure, number and cost of demolished buildings, decontamination costs, etc.; *indirect* - by side effects, including not only lower profits received, but also a disruption of socio-economic ties, reduction of business activities, reduction of demographic potential etc.),
- **biological** (*direct* - medical consequences with the clinically proven health indicator deviations resulted from radiation exposure; *indirect* - the psychic and psychosomatic disorders resulted from a psychic trauma event or chronic distress),
- and **social** (*direct* - those associating with a real radiation impact of RTE; *indirect* – unfounded perception of non-existent radiation hazard and inadequate management of radiation risks)

A contribution of each component to economic and extra-economic losses is determined and possible ways of minimizing each contribution are discussed in the paper.

Improved combined injury casualty predictions through physiological modeling

D. Stricklin
Applied Research Associates, Arlington, USA

Accurate tools in emergency planning are critical in preparing for and minimizing the impacts of radiological events. Mathematical models based on empirical data have been developed to predict the severity of symptoms after radiation exposure. Such models have been implemented in software tools to estimate time course of symptom severity, mortality probability, and time to mortality. These tools provide guidance to planners for evaluating material and personnel requirements and help guide research by identifying critical treatment needs. Nuclear event scenarios will involve radiation combined with burn and trauma injuries. Combined injuries will exacerbate response severity and worsen outcomes; however, combined injuries have not been physiologically modeled due to data limitations. Mechanistic modeling will improve the understanding of the pathogenesis of combined injury and improve current casualty estimation tools. Translational systems biology has provided insight on the pathogenesis of acute injuries such as sepsis and trauma. We are building on this modeling foundation to help understand and predict interactions leading to increased mortality in the case of radiation combined injuries. The focus of this initial effort is on modeling radiation

combined with burn; future development will include trauma and cutaneous injury. Common target organ systems such as the hematopoietic and cutaneous systems are identified and underlying mechanistic pathways creating potential synergistic effects are described. Effects include escalated inflammation, impaired immune response, and overwhelmed repair mechanisms. Physiologically based modeling and systems biology will enable enhanced casualty prediction models. This effort also provides valuable insight into pathways for intervention and for targeting treatments.

Semi-Automation of dicentric scoring to increase throughput in case of a large scale accident

H. Romm, U. Oestreicher, U. Kulka
Federal Office for Radiation Protection, Munich, Germany

In the case of an emergency situation with a large-scale radiation accident, the first step will be to identify the radiation exposed individuals, who require medical intervention from the large population of "concerned public", not exposed. In this situation biological dosimetry may be a supporting tool in the frame of the medical triage.

Today, the most specific and most sensitive technique for biological dosimetry relies on assessing the frequency of dicentric chromosomes in peripheral blood lymphocytes. However the microscopically analysis is a time-consuming procedure. There are several approaches to cope this problem, like a new scoring strategy, analysing 20 to 50 metaphases or 30 dicentrics and establishing biological dosimetry networks to deliver fast results in a mode of mutual assistance from several cytogenetic laboratories.

Here, another strategy of increasing the throughput and optimizing the procedure is described, based on the automation of dicentric scoring by digital image processing. In this study, it was investigated, whether the software is sensitive enough to distinguish between samples irradiated with doses of 1 or 3 Gy and unirradiated controls. The results obtained so far looks very promising. A fast verification of the automatic detected dicentric candidates by a human scorer reduces the uncertainties of the obtained dicentric yields. The automation of the assay increases the throughput clearly and seems to provide homogenous results. Semi-automation of the dicentric assay may be a helpful tool for screening a large number of samples during emergency situations in the future.

Pooled Bayesian Analysis of 28 Studies on Radon Induced Lung Cancers

K. W. Fornalski[1], L. Dobrzyñski[2]
[1] *The Andrzej So³tan Institute for Nuclear Studies, Otwock-Swierk, Poland*
[2] *Faculty of Physics, University of Bia³ystok, ul. Lipowa 41,Bia³ystok, Poland*

The influence of ionizing radiation of radon-222 and its daughters on the lung cancer incidence and mortality published in 28 papers was re-analyzed, for two ranges of low annual radiation dose of below 70 mSv per year (391 Bq m-3) and 150 mSv per year (838 Bq m-3). The seven popular models of dose-effect relationship were tested. The assumption-free Bayesian statistical methods were used for all curve fittings. Also the Model Selection algorithm was used to verify the relative probability of all seven models, including the Linear No-Threshold (LNT) model.

The results of the analysis demonstrate that in this ranges of doses (below 70 and 150 mSv/year) the published data do not show the presence of a risk of lung cancer induction. The most probable dose-effect relationship is constant one (risk ratio, RR=1) in this range of dose.

The Stochastic Markov's Cells Response-to-Dose Model

K. W. Fornalski[1], L. Dobrzyñski[2]
[1] *The Andrzej So³tan Institute for Nuclear Studies, Otwock-Swierk, Poland*
[2] *Faculty of Physics, University of Bia³ystok, ul. Lipowa 41, Bia³ystok, Poland*

A new stochastic model describing the cellular response to radiation dose is described. The Markov process and stochastic tree of probabilities are used for description of the modeled group of cells. The results show that the overlap of many linear processes can result in threshold and generally non-linear response. Such phenomena are observed and reported in many papers. The presented model permits inclusion of Adaptive Response and Bystander Effects. Essentially all known biological effects can be reproduced by the model.

Retrospective Patient Dose Analysis of a Ghana's First Direct Digital Radiography System

S. Inkoom[1], J. Togobo[2], G. Emi-Reynolds[1], A. Oddoye[2], T. Ntiri[2], P. K. Gyekye[1]
[1] *Radiation Protection Institute, Ghana Atomic Energy Commission, Legon, Accra-Ghana.*
[2] *Akai House Clinic, X-ray Department, Osu, Accra-Ghana.*

The log file generated in the flat panel detector of a direct digital X-ray machine (General Electric, Haulun Medical Systems, Serial Number 8M0392) after X-ray exposure was used to acquire data regarding the entrance surface air kerma (ESAK) for some routine X-ray examinations. The data was collected for a minimum of ten patients undergoing each examination considered. The effective dose (E) was estimated from the ESAK by using appropriate entrance surface dose-to-effective dose conversion coefficients. The mean ESAK were found to be 0.26, 0.35, 0.12, 7.33, 9.76, 7.38 and 6.86 mGy for skull AP and LAT, chest AP, lumbar spine AP and LAT, pelvis AP and abdomen AP series respectively. Similarly, the mean E were found to be 0.003, 0.004, 0.012, 0.784, 0.244, 1.033 and 1.097 mSv respectively for skull AP and LAT, chest AP, lumbar spine AP and LAT, pelvis AP and abdomen AP series respectively. The mean ESAK values recorded from this study show wide variations but were below diagnostic reference levels (DRLs) of the Commission of European Communities and also compare with other studies. The comparisons of this study's dose levels with DRLs were undertaken as an approach to dose optimization. In conclusion, dose audit of digital radiography system is necessary because of the potential high doses one is likely to receive. Continuous dose evaluation in digital radiography is therefore encouraged in order to optimize doses to patients.

Radiation bio-dosimetry automation with the Metafer slide scanning platform

C. Schunck
Metasystems, Altlußheim, Germany

Bio-dosimetry is a well established procedure to assess radiation damage in humans involved in mass radiation accidents. Several assays (e.g. the analysis of dicentric chromosomes or the micronucleus assay) are available to quantify DNA damage induced by irradiation, aiming to estimate the body or partial body dose of the victims in order to apply suitable treatments.

There are generally two key requirements for any bio-dosimetry assay, which are (a) celerity to allow for rapid countermeasures, and (ii) accuracy and reproducibility. Unfortunately the assays typically involve long and tedious analyses, which are often also prone to scoring biases and lack of documentation.

Based on the microscopic slide scanning platform Metafer by MetaSystems we have developed tools to automate analysis of the chromoso-

mal aberration and dicentrics test, the micronucleus assay, the Comet assay, and the analysis of γ-H2AX foci (Schunck et al., 2004). Independent studies from France (Vaurijoux et al., 2009) and Belgium (Willems et al., 2010) have shown that, using the Metafer based system, response to radiation accidents can be performed much faster and with higher accuracy. Additionally data obtained with this method are fully documented, and can always be subject of revision. The speed of the system even allows combining a fast population triage with the complete and detailed analysis, performing both in the time frame usually scheduled for the triage only.

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Translational Research Using Animal Radiation Models – Human Multiparameter and Integrated Biodosimetry

D.J. Sandgren, W.F. Blakely, N.I. Ossetrova

Armed Forces Radiobiology Research Institute, Uniformed Services University of the Health Sciences, Bethesda, USA

Current radiological threats dictate the requirement to identify, optimize, and validate novel diagnostic approaches to provide response capability for triage applications, field-deployable laboratories, and reference laboratories to rapidly and accurately assess radiation injury. These efforts also contribute to improvements in the biodosimetry concept of operations for response to surge demands due to mass-casualty radiological incidents. The Armed Forces Radiobiology Research Institute (AFRRI) Biodosimetry Research Group established animal (i.e., Mus musculus, Rhesus macaque) radiation models along with a human radiation response database to create a translational research platform to address these identified gaps in response capability. Animals were exposed to total-body-irradiation using 60Co γ-rays (10-60 cGy/min). Recent studies have investigated effects when comparing total-body irradiation (TBI) with partial-body irradiation (PBI) using 250 kVp x-rays with a lead-shielding apparatus. Radioresponses measured include: hematological changes, blood chemistry, and organ-specific plasma protein biomarkers. We also included various acute radiation syndrome (ARS) bioindicators in these animal radiation models, so that biomarker levels can be correlated both with exposure doses as well as ARS severity levels. Results contrasting radioresponses for clinical laboratory blood chemistry (i.e., amylase activity, acute phase proteins) and blood counts (lymphocytes, neutrophils, neutrophil to lymphocyte ratio, platelets) will be presented from these models. Efforts are underway to integrate multiparameter diagnostic indices into AFRRI's First-responder Radiological Triage (FRAT) software. Research supported by AFRRI, Biomedical Advanced Research and Development Authority (BARDA) AFR.10.064, and Defense Threat Reduction Agency (DTRA) CBM.RAD.03.10.AR.002.

Establishment of an X-Ray Dose-Response Curve for Lymphocyte Dicentric Assay

E. AlSuhaibani

King Saud University, Riyadh, Kingdom of Saudi Arabia

Cytogenetic analysis is a method for estimating the absorbed dose in case of undesired occupational or accidental irradiation exposure which may occur. Frequencies of chromosome aberrations in different populations vary depending on the variations in biological diversity, geographical location and atmospheric pollution. Therefore, each biological dosimetry laboratory should establish its own standard dose-response curve. The aim of the this study was to establish standard dose-response curve for 200 kVp X-rays as a reference in Saudi Arabia to estimate absorbed radiation doses following exposures. The conventional metaphase-spread chromosome technique was used to generate in vitro dose-response curves. Blood samples from 10 healthy male donors in each group were collected to study the effect of exposure of lymphocytes at 10 different doses of gamma ray. Yields of dicentrics and acentrics chromosomes following different radiation doses were used to establish control curves. Different types of chromosomal aberrations were scored and the frequencies were calculated. Results of this study emphasize the importance of establishing the dose response curves for different areas for their ecological varieties.

Mathematical Modeling of Radiochemical Processes: the Behavior of Water Coolant in the Transport Packaging Container

A. Barseghyan

a)"AREV" Scientific-Industrial CJSC

b) Engineering Academy of Armenia, Yerevan, Armenia

Transportation of waste is a necessary step in complete activity related with nuclear cycle; the spent fuel and high-activity waste are carried over by automobile, railway or sea transport in special containers[1]. Transportation and disposal of radioactive materials are strictly regulated to provide a high degree of safety, and the precautions regulations are in force during a greater part of the world during last decades. Nevertheless, transportation and disposal safety recommendations for many kinds of radioactive materials are still developed at the moment.

In the paper a possible conditions of origination of various hypothetic accidents are computed by mathematical modeling of radiochemical processes occurring in water-filled containers. The mathematical software is based on the theory of estimation of dynamic parameters which possesses high prognostic capacities [2-4].

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Radiological and Nuclear medical Countermeasure Advanced Research and Development at BARDA

R. Manning
Department of Health and Human Services, Washington, USA

"The BARDA mission is to ensure the availability of medical countermeasures to address public health emergencies in the United States. BARDA addresses three threat areas: (1) Chem/Bio/Rad/Nuc (CBRN), (2) Pandemic Influenza, and (3) Emerging Infectious Diseases. BARDA has a comprehensive portfolio approach to development and acquisition of products, provides a unique niche in U.S. Government biomedical R&D, is involved in mid- to late-stage product development, work with industry to move product candidates through the pipeline, and provides support staff with experience in product development and manufacturing."

Cytogenetic dosimetry techniques for radiation dose assessment

C. Beinke, V. Meineke
Bundeswehr Institute of Radiobiology affiliated to the University of Ulm, Munich, Germany

Radiation biodosimetry using cytogenetic marker allows exposure assessment and if necessary estimation of the individual absorbed dose. Dependant on the characteristics of a given scenario an appropriate technique has to be chosen: the dicentric chromosome (dic) is the most sensitive and specific marker for recent acute exposures with ionizing radiation (IR), including inhomogeneous exposure and triage dosimetry, whereas translocations (T) are usually analyzed after protracted exposures or when dosimetry is delayed up to decades after exposure. Suitable as high-throughput method is the micronucleus (MN) assay, due to time saving automated MN scoring [1]. Common to all 3 methods is the conversion of an observed frequency of the particular marker in stimulated blood lymphocytes into dose with reference to an in vitro established calibration curve [2].

Currently, cytogenetic dosimetry activities focus on standardization of methods, particularly dic and MN analysis, including validation by intercomparison studies and automation. Aim is to share the extensive workload arising during mass casualty medical management between different laboratories.

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Altered CB-Micronucleus assay significantly improves radiation dose estimates

A. Riecke[1], C.G. Ruf [2], M. Port[3], V. Meineke [4], M. Abend[4]
[1] *Department for Internal Medicine, Federal Armed Forces Hospital, Ulm, Germany*
[2] *Department for Urology, Federal Armed Forces Hospital, Hamburg, Germany*
[3] *Department of Hematology, Hemostasis, Oncology, and Stem Cell Transplantation, Hannover Medical School, Hannover, Germany.*
[4] *Bundeswehr Institute of Radiobiology affiliated to the University of Ulm, Munich, Germany*

Assessment of radiation damage after accidental exposure to ionizing radiation is based on biological dosimetry and clinical signs and symptoms. Time- and manpower requirements of established biological dosimetry approaches limit their use in the case of mass casualties. The radiation induced micronucleus frequency in peripheral blood lymphocytes has been used for biodosimetric purposes since the 80's of the last century. The task of the current project was to evaluate the impact of cell morphologies other than micronucleation to improve the CB-Micronucleus assay for biological dosimetry purposes. In addition a modification of cell staining was used to simplify the detection of cells containing micronuclei.

The Influence of Low-Dosed Ionising Radiation on the Production of Cytokines in Human Mediator-cells

M. Hotz
Bundeswehr Institute of Radiobiology affiliated to the University of Ulm, Munich, Germany

Mediator-cells, like monocytes, macrophages, dendritic cells and natural killer cells represent a key role of modulation effects in the immune system. Further investigations showed a modulating effect of low-dosed ionising radiation on the expression of adhesion molecules. However, there is less information about the tolerance of the cellular immunity in relation to radiation exposure available. The identification of bioregulators or sensitive markers of exposure could make an essential contribution during the evaluation of effects caused by radiation exposure. Even in developing procedures for triage and medical management of exposed individuals.

Human peripheral lymphocytes ex vivo are frequently used as a model system for investigations on radiation-induced chromosomal aberrations. In addition to primary blood lymphocytes different human cell lines (HL-60, THP-1, MONO-MAC-1, U-937, YT and NK-92) were used in the accomplished investigations. To examine the effect of X-ray on these cells, aberration frequency as well as the production of different pro-inflammatory cytokines (IL-1beta, IL-6 and TNF-alpha), the reactive nitric oxide (NO) and further protein markers (IL-8, IL-10, IL-12, TGF-beta, ICAM-1, Eotaxin, GM-CSF, MCP-1, CXCL1, p21, p-ATM, Bax-alpha, Flt-3 Ligand, EGF and p21) were measured after irradiation.

First results showed that low-dose ionising radiation led to no significant production of pro-inflammatory cytokines and NO 24 hours after irradiation. However, a modulating effect of X-ray on the production of TGF-beta and other protein markers could be assessed. It appears that TGF-beta plays a major role in the radiation caused immune modulation. Significant rising and persistent TGF-beta concentrations could be verified within the low-dose range 18 hours after irradiation. Besides TGF-beta the chemokine GRO-alpha (CXCL1), the cytokine Interleukin 8 and the phosphorylated ATM protein kinase are identified as protein markers among all examined cell populations. Additionally, effects could be observed at the production of the cytokine Interleukin 10 and the ICAM-1 adhesion protein in human peripheral blood lymphocytes. In the screened cell lines HL-60, U-937 and NK-92 radiation-induced level of the chemokine MCP-1 (CCL2) were measured. In the natural killer cell line NK-92 a radiation-dependent production of the cytokine Interleukin 6 and Interleukin 12 could be determined. Investigations to confirm these first results and identification of further suitable protein markers in order to complete a cluster from 8-9 potential biomarkers are the subject of current experiments.

Comparison of Applications of Gene Mutation Assay in Trad-SH cells for Monitoring Ambient Air Genotoxicity after Chernobyl and Fukushima Nuclear Power Plant Accidents

A. Panek, J. Miszczyk, A. Cebulska-Wasilewska,
Environmental and Radiation Biology Department,
The H. Niewodniczański Institute of Nuclear Physics,
Polish Academy of Science, Kraków, Poland

In order to define major contamination, its genotoxic effectiveness and to realize genetic or carcinogenic hazards, studies are necessary which yield new information on mutagenicity of complex mixtures containing potential genotoxic pollutants. The technique for screening gene muta-

tion frequency in somatic cells of the Tradescantia stamen-hairs (Trad-SH assay), have been developed many years ago specifically for radiobiological studies. Tradescantia is one of the most radiosensitive plant known. Its extremely high radiosensitivity of its hybrid clones is followed by very high sensitivity to chemical mutagens as well. This facts make Trad-SH assay particularly suitable for the environmental studies and for the detection of ambient air genotoxicity. Results of applications of the bio indicator for in situ monitoring gentoxicity of the ambient air pollution including ionizing radiation from Chernobyl Nuclear Power Plant accident are compared to recent data from monitoring the ambient air quality in the Krakow and surroundings. Following the Chernobyl accident studies were performed initially as monitoring of mutagenicity of ambient air in the period since April 29th till June 3rd 1986. Significant increase of gene mutation frequency was reported, associated with a strong expression of toxic effects. In general, mutation frequency increase due to Chernobyl fallout was corresponding to fluctuation of radioactivity in the air reported from physical measures, and to published reports about increase in chromosome aberration levels. One year later studies were repeated and mutation frequency tested at site the same as year before confirming decrease of mutation rate to the control level. Monitoring of genotoxicity of ambient air was also performed around various pollution sources (petroleum plant, heavy traffic lines) and detected gene mutation frequencies levels corresponded well either with concentrations of chemicals in ambient air or with distance from the source of pollution. Recently since 11th of March 2011, bio-indicating plants are exposed to ambient air at four different sites at the region of Krakow, and continuous screening is performed. Results will be discussed with the concern of the possible association with the physical measures of ambient air radioactivity.

Information and Communication System for Nuclear-Radiological Medical Defence

G. Goulko, V. Meineke

Bundeswehr Institute of Radiobiology affiliated to the University of Ulm, Munich, Germany

The wide use of radioactive materials in medicine and industry renders an accidental incorporation, as well as misuse it for terroristic or military purposes possible. The preparedness for such a realistic scenario includes the development of a specific Information and Communication System to assist in a rapid estimation of exposure doses for critical organs at different times and assessment of effectiveness of proposed countermeasures. It provides an effective support for the choice of countermeasures, diagnostic and therapy after incorporation.

The decision about countermeasures after incorporation of radioactive materials has to be made without delay. An indispensable condition for this is a reliable estimation of expected whole body and organ doses allowing the prognosis of health effects. These dose estimates should be based on measurements of activity in the body, organs or in excreta. The interpretation of measured values requires specific dosimetric and biokinetic models describing the metabolism of incorporated radionuclides. For this purpose a dedicated computerized support tool is helpful.

It is important to assess the amount and distribution of radio-nuclides in the body and calculate resulting radiation doses to internal organs or tissues over specific time periods. As the ionizing radiation energy deposited in a particular organ from radio-nuclides incorporated in the body cannot be measured directly, internal doses are estimated principally from in vivo or in vitro bioassay. Therefore, to make an accurate estimate of the dose, a number of parameters must be known: the chemical form of radio-nuclide, route of intake, elapsed time from intake, organs containing the material, distribution pattern, organs masses, biological half-life, particle size of the original material (for inhalation), decay scheme of the radioisotope and, of course, quantity and isotopic distribution of the material. The aim of this study is the design and implementation of a user friendly Nuclear Medical Defence-Information- and Communication-System to support decorporation measures as well as risk assessment (decision making) after incorporation of radioactive materials.

The following input information for the further calculation is needed: personal data (age, gender), incorporated radionuclides, intake scenario, bioassay data (probe type, organ, measured activity, etc.), solubility in lung or stomach (depends from intake pathway), time-characteristics (intake date and duration, measurement time). This information as well as calculated doses will be stored in the documentation table. It includes the following modules:

- Case description: personal data and accident description.
- Dosimetry: exposure conditions (time, duration, contamination, incorporation, external exposure, radionuclides composition, physical-chemical characteristics of radioactive material, etc.), bioassay data, estimated whole body and/or organ doses at measurement time and prognosis.
- Decision making: recommendation of countermeasures based on estimated actual and future exposure doses, assessment of expected effectiveness of different countermeasures, risk estimation.

As output information the following parameters will be calculated: exposure dose at the time of measurement, prognosis of future dose without countermeasures and effectiveness of proposed countermeasures in terms of averted dose.

Database SEARCH (System for Evaluation and Archiving of Radiation Accidents based on Case Histories)

H. Dörr, V. Meineke

Bundeswehr Institute of Radiobiology affiliated to the University of Ulm, Munich, Germany

The databank system SEARCH (System for Evaluation and Archiving of Radiation Accidents based on Case Histories) contains 824 clinical cases from 81 radiation accidents in 19 countries from 1945 to 2001. This exceptional collection of clinical data from accidentally radiation exposed persons allows further analysis of the clinical course, prognostic factors and multiorgan interactions of the acute radiation syndrome. SEARCH was used to develop the METREPOL-System (Medical Treatment Protocols for Radiation Accident Victims), which was an entirely new approach to manage accident victims on the basis of indicators of effect and repair considering multiorgan involvement and potential treatment options.

One example for further analysis of the clinical data from SEARCH is a systematic analysis of 110 case histories from patients with a severe form of an acute radiation syndrome to assess the type, extent and significance of multi-organ involvement. Other projects focus on skin-reactions, gastrointestinal signs and symptoms and on early prognosis in triage situations using peripheral blood cell counts. The databank system SEARCH has to be updated with new case histories of radiation exposed persons from recent radiation accidents for further analysis on a broader basis. For the further development of SEARCH, the update of existing case histories as well as including new case histories international cooperation is needed.

Authors

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