

Barth I, Rimpler A, Nikula T, Schilp M, Buck O, Wengenmair H, Leissner G, Kopp J, Sciuk J

**Strahlenexposition des Personals bei der endovaskulären Brachytherapie (EVBT) mit Re-188 nach PTA im peripheren Stromgebiet
Radiation Exposure of Staff During Endovascular Brachytherapy with Re-188 after PTA in the Peripheral Blood Stream**

Zeitschrift für medizinische Physik 19 (2009), 193-199,
doi:10.1016/j.zemedi.2009.01.006

Endovascular brachytherapy using a balloon catheter filled with Re-188 solution is a promising method for the prophylaxis of restenosis in peripheral blood circulation after percutaneous transluminal angioplasty (PTA) treatments. Thereby about 20 GBq Re-188 with a specific activity of about 5 GBq/ml are used. The high ionisation density of the beta radiation with high energy leads to selective irradiation of the blood vessel wall near the catheter, whereas the surrounding tissue remains almost unaffected. However the hospital staff has to carry out some work steps within close range to the high activity during preparation and therapy, causing a high risk of skin exposure, in particular at the hands. Estimations and measurements of the maximal local skin dose were made with thin-layered thermoluminescence dosimeters. It was assessed that the annual dose limit for skin of 500 mSv may be exceeded considerably when using conventional procedures and considering the expected number of 75 treatments per annum. By using the newly developed rhenium-188 application device "FlowMedical Application System" the exposure risk for the staff could be reduced drastically. The maximum skin dose of 76 mSv for the radiologist and of 50 mSv for the physicist was decreased to 2 mSv per treatment for both of them. Consequently, from the radiation protection point of view, the itm Rhenium-PTA® is a safe method. Any exceeding of the dose limit can be prevented.

Berg HP, Winter Ch

Analysis of external flooding and tsunamis for nuclear power plants at tidal rivers.

Kerntechnik, 74, No 3; 132-139, 2009

The German regulatory body has issued technical documents on methods and data for probabilistic safety assessment, elaborated for a comprehensive integrated safety review of all nuclear power plants in operation. These documents contain, among others, a graded approach for the probabilistic assessment of external flooding. Main aspects are explained such as the underlying probabilistic considerations and the mathematical procedures for the calculation of exceedance frequencies for nuclear power plants at tidal rivers in Germany. Moreover, extreme events such as tsunami waves have been investigated.

Berg HP

Overview on the different applications of probabilistic safety assessment for nuclear power plants.

Kerntechnik, 74, No 3; 106-110, 2009

Worldwide it can be recognised that the use of probabilistic safety assessment (PSA) in regulatory as well as operational decision-making is state of the art and seen as a successful development. Therefore, in most cases the regulator encourages the performance of PSAs to provide information to complement and support the defence in depth philosophy as well as operational configuration decisions. The main application of the PSA is still as part of integrated safety reviews, in particular in the frame of comprehensive (periodic) safety reviews. Other more specific applications areas of PSA are, among others, design evaluation, event analysis with aid of PSA, evaluation of technical specifications; risk-informed in-service inspection, risk monitoring and accident management. The extent of these applications vary from country to country but has been increasing during the last years.

Berg HP

Experience with quantitative safety targets on international level.

Kerntechnik, 74, No 3; 159-164, 2009

Internationally, probabilistic safety analyses represent the state of the art in the licensing process for new industrial facilities, but increasingly also for evaluating the safety level of older industrial plants, e. g. as part of periodic safety reviews of nuclear power plants. Quantitative safety goals have not yet reached the same level of acceptance. However, this depends on the type of industry. Most of the countries consider those criteria as safety targets rather than as sharply defined boundary values. The Netherlands and the United Kingdom are exceptions, they require demonstration of compliance with legally binding safety goals in the licensing procedure.

Blakely W, Carr Z, Chin-May Chu M, Dayal-Drager R, Fujimoto K, Hopmei M.; Kulka U, Lillis-Hearne P.; Livingston G, Lloyd D, Maznyk N, Del Rosario Perez M, Romm H, Takashima Y., Voisin P, Wilkins R., Yoshida M

Meeting Report - WHO 1st Consultation on the Development of a Global Biodosimetry Laboratories Network for Radiation Emergencies (BioDoseNet)

Radiation research 171: 127-139, 2009

The World Health Organization (WHO) held a consultation meeting at WHO Headquarters, Geneva, Switzerland, December 17-18, 2007, to develop the framework for a global biodosimetry network. The WHO network is envisioned to enable dose assessment using multiple methods [cytogenetics, electron paramagnetic resonance (EPR), radionuclide bioassays, etc.]; however, the initial discussion focused on the cytogenetic bioassay (i.e., metaphase-spread dicentric assay). Few regional cytogenetic biodosimetry networks have been established so far. The roles and resources available from United Nations (UN) agencies that provide international cooperation in biological dosimetry after radiological emergencies were reviewed. In addition, extensive reliance on the use of the relevant International Standards Organization (ISO) standards was emphasized. The results of a WHO survey of global cytogenetic biological dosimetry capability were reported, and while the survey indicates robust

global capability, there was also a clear lack of global leadership and coordination. The expert group, which had a concentrated focus on cytogenetic biodosimetry, formulated the general scope and concept of operations for the development of a WHO global biodosimetry laboratory network for radiation emergencies (BioDose-Net). Follow-on meetings are planned to further develop technical details for this network.

Brix G, Zwick S, Kiessling F, Griebel J

Pharmacokinetic Analysis of Tissue Microcirculation Using Nested Models: Multimodel Inference and Parameter Identifiability

Medical Physics 36 (2009), 2923-2933

It was the aim of this study to evaluate the identifiability of physiological tissue parameters by pharmacokinetic modeling of concentration-time curves from dynamic-contrast enhanced (DCE) imaging and to assess the information-theoretic approach of multimodel inference using nested models. Tissue curves were simulated by an established reference model for different physiological scenarios and analyzed by a two-compartment model as well as by two reduced models. The competing models were ranked according to Akaike's information criterion. To utilize the information available from all three models, model-averaged parameters were estimated using Akaike weights that quantify the relative strength of evidence in favor of each model. As compared to the full model, the reduced models yielded equivalent or even superior AIC values for scenarios where the structural information in the tissue curves was limited. Multimodel inference substantially improved the precision of the estimated tissue parameters. The presented concept of pharmacokinetic analysis of DCE data using three nested models under an information-theoretic paradigm offers promising prospects for the non-invasive quantification of physiological tissue parameters.

Brix G, Nissen-Meyer S, Lechel U, Nissen-Meyer J, Griebel J, Nekolla E, Becker C Reiser M

Radiation Exposures of Cancer Patients from Medical X-Rays: How Relevant are they for Individual Patients and Population Exposure?

European Journal of Radiology 72 (2009), 342-347

X-ray procedures have a substantial impact not only on patient care but also on man-made radiation exposure. Since a reliable risk-benefit analysis of medical X-rays can only be performed for diagnosis-related groups of patients, we determined specific exposure data for patients with the ten most common types of cancer. For all patients with the considered cancers undergoing medical X-ray procedures in a maximum-care hospital between 2000 and 2005, patient- and examination-specific data, in particular the cumulative 5-year effective dose and the mean annual effective dose per patient, were analyzed. In total, 151,439 radiographic, fluoroscopic, and CT procedures, carried out in 15,866 cancer patients (age, 62 ± 13 years), were evaluated. The mean 5-year cumulative dose varied between 8.6 mSv (prostate cancer) and 68.8 mSv (pancreas cancer). Due to an increasing use of CT scans, the mean annual effective dose per patient increased from 13.6 to 18.2 mSv during the six-year period. Combining the results obtained in this study for a particular hospital with cancer incidence data for Germany, we estimated that cancer patients having X-ray studies constitute at least 1 % of the population but receive more than 10 % of the total effective dose related to all medical X-ray procedures performed nationwide per

year. A large fraction of this dose is radiobiologically ineffective due to the reduced life expectancy of cancer patients.

Brix G, Nekolla E, Noßke D, Griebel J

Risks and Safety Aspects Related to PET/MR Examinations

European Journal of Nuclear Medicine and Molecular Imaging 36 (2009), 132-138

The introduction of PET/MR systems into medical practice in the foreseeable future may not only lead to a gain in clinical diagnosis as compared to PET/CT imaging due to the superior soft-tissue contrast of the MR technology but can also substantially reduce exposure of patients to ionizing radiation. On the other hand, there are also risks and health effects associated with the use of diagnostic MR devices that have to be considered carefully. This review summarizes biophysical and biological aspects which are of relevance for the assessment of serious health effects related to the exposure of patients to both ionizing radiation in PET and (electro)magnetic fields in MR. On this basis, some considerations concerning the justification and optimization of PET/MR examination are presented – as far as this is possible at this very early stage. It should be noted, however, that current safety standards do not take into account possible synergistic effects of ionizing radiation and (electro)magnetic fields. In the light of the developing PET/MR technology there is thus an urgent need to investigate this aspect in more detail for exposure levels that will occur at PET/MR systems.

Eder H, Geschwentner D, Hofmann P, Liesenkötter B, Matthes R

Elektrische und Magnetische Felder von Kompaktleuchtstofflampen – Ermittlung und Bewertung

Electric and Magnetic Fields of Compact Fluorescent Lamps – Assessment and Evaluation

Strahlenschutzpraxis 15 (2009), Nr.3, 59-67

The electric and magnetic field strength close to common compact fluorescent lamps (CFL) have been measured and evaluated in relation to international recommended reference levels. In addition, body-internal current densities have been estimated and compared to the respective basic restrictions. In distances of 30 cm and more, all tested CFLs comply with the reference values for electric field strength. Magnetic field strengths were found altogether very low. Also the estimated current densities indicate, that all investigated CFLs can be deemed to comply to the respective limit in distances of common use. Therefore, based on current scientific evidence adverse health effects can be ruled out.

Greve B, Dreffke K, Rickinger A, Könemann S, Fritz E, Eckardt-Schupp F, Amler S, Sauerland C, Braselmann H, Sauter W, Illig T, Schmezer P, Gomolka M, Willich N, Bölling T

Multicentric Investigation of Ionising Radiation-induced Cell Death as a Predictive Parameter of Individual Radiosensitivity.

Apoptosis, Vol. 14, No. 2, Februar 2009

In the present study, the predictive value of ionising radiation (IR)-induced cell death was tested in peripheral blood lymphocytes (PBLs) and their corresponding Epstein-Barr virus-transformed cell lines in an interlaboratory comparison. PBLs and their corresponding LCLs were derived from 15 tumour patients, which were considered clinically radiosensitive based on acute side-effects, and matched controls. All participating laboratories detected a dose-dependent increase of apoptosis and necrosis in lymphocytes of individual samples with the Annexin V-assay, to a very similar extent. For LCLs the test did not work in the investigated dose range. However, comparing the mean values of apoptotic and necrotic levels derived from the radio-sensitive cohort with the mean values of the control cohort did not reveal a significant difference. Nor were hypersensitive samples unambiguously and independently identified by all three participating laboratories. The value to predict clinical radiosensitivity by this assay as previously reported is thus highly questionable.

Grosche B, Jung T, Weiss W

**Häufigkeit von Krebs bei Kindern in der Umgebung von Kernkraftwerken
Incidence of Childhood Cancer in the Vicinity of Nuclear Power Plants**

In: Umweltmedizinischer Informationsdienst (2009), Nr.1, S. 17-21

The Federal Office for Radiation Protection funded a case-control study which was conducted by the German Childhood Cancer Registry and of which the results were published in late 2007. Study subject was the risk of cancer among children below the age of 5 living near nuclear power stations in Germany. According to the study's main hypothesis an increasing risk with increasing proximity to a nuclear site was shown. This is mainly based on leukaemias. Within 5 km around the sites the risk was roughly twice that in more distant areas. In spite of the study's size the number of newly diagnosed cases in the close vicinity of the sites is small. The radioactive discharges from the nuclear power plants are too low by a factor of at least 1,000 to explain the study findings. The Federal Office for Radiation Protection does not see a reason for immediate action. Notwithstanding that further research is warranted into the causes of leukaemia. Little is known on that, and the questions the study raised can only be answered if more is known on the pathogenesis of childhood leukaemias.

Häusler U, Czarwinski R, Brix G

Radiation Exposure of Medical Staff from Interventional X-ray Procedures: a Multicentre Study

Eur Radiol 19: 2000–2008, 2009

The purpose of the study was to analyse the radiation exposure of medical staff from interventional X-ray procedures. Partial-body dose measurements were performed with thermoluminescent dosimeters (TLD) in 39 physicians and nine assistants conducting 73 interventional procedures of nine different types in 14 hospitals in

Germany. Fluoroscopy time and the dose–area product (DAP) were recorded too. The median (maximum) equivalent body dose per procedure was 16 (2,500) μSv for an unshielded person; the partial-body dose per procedure was 2.8 (240) μSv to the eye lens, 4.1 (730) μSv to the thyroid, 44 (1,800) μSv to one of the feet and 75 (13,000) μSv to one of the hands. A weak correlation between fluoroscopy time or DAP and the mean TLD dose was observed. Generally, the doses were within an acceptable range from a radiation hygiene point of view. However, relatively high exposures were measured to the hand in some cases and could cause a partial-body dose above the annual dose limit of 500 mSv. Thus, the use of finger dosimeters is strongly recommended.

Jacob P, Rühm W, Walsh L, Blettner M, Hammer G, Zeeb H

Cancer Risk of Radiation Workers Larger than Expected?

Occupational and environmental medicine Vol. 66 Nr.12: 789-796, 2009

Background: Occupational exposures to ionizing radiation mainly occur at low dose rates and may accumulate effective doses of up to several hundred milligray. It is presently assumed that the cancer risk per dose after such exposures is smaller than for acute, high-dose exposures.

Objective: To evaluate the evidence of cancer risks from low-dose-rate, moderate-dose (LDRMD) exposures to ionizing radiation.

Methods: A literature search for primary epidemiological studies on cancer incidence and mortality risks from LDRMD exposures included publications from 2002 to 2007, and an update of the UK National Registry for Radiation Workers study. The analysis was restricted to studies reporting excess relative risk (ERR) estimates per dose for all or large groups of cancers. For each study we calculated the risk for the same types of cancer among the atomic bomb survivors with the same gender proportion and matched quantities for dose, mean age-attained and mean age-at exposure. A combined estimator of the ratio of the ERR per dose from the LDRMD to the corresponding value for the atomic bomb survivors was calculated.

Results: Generally, the ERR per dose was larger than or similar to the corresponding estimate for the atomic bomb survivors. Overall, the ratio of the ERR per dose in the LDRMD studies to the corresponding quantity in the atomic bomb survivors was 1.21 (90% CI: 0.51; 1.90).

Conclusions: The present analysis does not confirm that the cancer risk per dose for LDRMD exposures is lower than for acute, high-dose exposures. Although the individual epidemiological studies all have methodological and statistical limitations, the results of the present analysis challenge the cancer risk values currently assumed for occupational exposures. This particularly applies to the use of a dose and dose-rate effectiveness factor (DDREF) for low-dose-rate exposures.

Kirchner G, Strebl F, Bossew P, Ehlken S, Gerzabek M

Vertical migration of radionuclides in undisturbed grassland soils

Journal of environmental radioactivity 100 (2009), 716-720

Literature data on numerical values obtained for the parameters of the two most popular models for simulating the migration of radionuclides in undisturbed soils have been compiled and evaluated statistically. Due to restrictions on the applicability of

compartmental models, the convection-dispersion equation and its parameter values should be preferred. For radiocaesium, recommended values are derived for its effective convection velocity and dispersion coefficient. Data deficiencies still exist for radionuclides other than caesium and for soils of non-temperate environments.

Kirchner G, Steiner M, Zähringer M

A new approach to estimate nuclide ratios from measurements with activities close to background

Journal of environmental radioactivity 100 (2009), 484-488

Measurements of low-level radioactivity often give results of the order of the detection limit. For many applications, interest is not only in estimating activity concentrations of a single radioactive isotope, but focuses on multi-isotope analyses, which often enable inference on the source of the activity detected (e.g. from activity ratios). Obviously, such conclusions become questionable if the measurement merely gives a detection limit for a specific isotope. This is particularly relevant if the presence of an isotope, which shows a low signal only (e.g. due to a short half-life or a small transition probability), is crucial for gaining the information of interest.

This paper discusses a new approach which has the potential to solve these problems. Using Bayesian statistics, a method is presented which allows statistical inference on nuclide ratios taking into account both prior knowledge and all information collected from the measurements. It is shown that our method allows quantitative conclusion to be drawn if counts of single isotopes are low or become even negative after background subtraction. Differences to the traditional statistical approach of specifying decision thresholds or detection limits are highlighted.

Application of this new approach is illustrated by a number of examples of environmental low-level radioactivity measurements. The capabilities of our approach for spectrum interpretation and source identification are demonstrated with real spectra from air filters, sewage sludge and soil samples.

Kreuzer M, Grosche B, Schnelzer M, Tschense A, Dufey F, Walsh L

Radon and Risk of Death from Cancer and Cardiovascular Diseases in the German Uranium Miners Cohort Study: Follow-up 1946-2003

Radiation Environment and Biophysics, online first: October 2009;
doi:10.1007/s00411-009-0249-5

Data from the German uranium miners' cohort study were analyzed to investigate the radon-related risk of mortality from cancer and cardiovascular diseases. The Wismut cohort includes 58,987 men who were employed from 1946 to 1989 at the former Wismut uranium mining company. By the end of 2003, a total of 3,016 lung cancer deaths, 3,355 deaths from extrapulmonary cancers, and 7,373 deaths from cardiovascular diseases were observed. Internal Poisson regression was used to estimate the excess relative risk (ERR) per unit of cumulative exposure to radon in Working Level Months (WLM) and its 95% confidence limits (CI). There was a statistically significant increase in the risk of lung cancer with increasing radon exposure (ERR/WLM=0.19%; 95% CI: 0.17%; 0.22%). A smaller, but also statistically significant excess was found for cancers of the extra-thoracic airways and trachea (ERR/WLM=0.062%; 95% CI: 0.002%; 0.121%). Most of the remaining non-respiratory cancer sites showed a positive relationship with increasing radon expo-

sure, which, however, did not reach statistical significance. No increase in risk was noted for coronary heart diseases and cerebrovascular diseases. The present data provide clear evidence of an increased radon-related risk of death from lung cancer, some evidence for an increased radon-related risk of death from cancers of the extra-thoracic airways and some other extrapulmonary cancers, and no evidence for mortality from cardiovascular diseases.

Kreuzer M, Schnelzer M, Tschense A, Walsh L, Grosche B

Cohort Profile: The German Uranium Miners Cohort Study (Wismut Cohort), 1946-2003

Int J Epidemiology, online first: Juni 2009; doi:10.1093/ije/dyp216

The publication provides a detailed description of the data of the German Uranium miners cohort study (Wismut cohort) and its results. To date the cohort is the world-wide largest study on uranium miners. It includes 59,000 male former Wismut employees. By end of 2003, 20,290 of them had died. Detailed estimates on exposure to radiation, dust and arsenic are available for all cohort members. External collaborations are welcomed by the study management committee, which comprises BfS staff members and an international advisory board. Information on how to submit a research proposal to BfS are given.

Križman M, Peter JE, Rojc J

Study on Radon Dispersion Modes from the U-mine Disposal Sites at Žirovski Vrh (Slovenia)

Radioprotection 44 (2009), Nr.5, 469-474

Long-term averages of outdoor radon levels give no information on time and spatial behaviour of dispersed radon that exhales from U-mine disposal sites. A comprehensive network of automatic stations for continuous measurements of short-lived radon decay products was installed in the early nineties at the Žirovski Vrh uranium mine. The instruments were positioned at key locations, on-site and off-site uranium mining area, and recorded EEC levels, alpha spectra, and local temperatures, all at least on hourly basis. Analyses of simultaneous records of EEC time series from several locations and analyses of corresponding alpha spectra gave more detailed information on characteristic patterns of radon behaviour and its dispersion from the sites under study. The identified modes of radon dispersion, depending on the presence and type of temperature inversion and the related major findings on the radon impact to the environment are shortly presented.

Lechel U, Becker C, Langenfeld-Jäger G, Brix G

Dose Reduction by Automatic Exposure Control in Multi-slice Computed Tomography - Comparison Between Measurement and Calculation

European radiology 19 (2009), 1027-1034

The aim of this study was to investigate the potential of dose reduction in multidetector computed tomography (MDCT) by currentmodulated automatic exposure control (AEC) and to test the reliability of the dose estimation by the conventional CT dosimetry program CT-EXPO, when an average tube current is used. Phantom measurements were performed at a CT system with 64 detector rows for four representa-

tive examination protocols, each without and with current-modulated AEC. Organ and effective doses were measured by thermoluminescence dosimeters (TLD) at an anthropomorphic Alderson phantom and compared with those given by the calculation with CT-EXPO. The application of AEC yielded dose reductions between 27 and 40% (TLD measurements). While good linearity was observed between measured and computed effective dose values both without and with AEC, the organ doses showed large deviations between measurement and calculation. The dose to patients undergoing a MDCT examination can be reduced considerably by applying a current-modulated AEC. Dosimetric algorithms using a constant current–time product provide reliable estimates of the effective dose.

Minkov V, Nekolla E, Noßke D, Griebel J, Brix G

**Nuklearmedizinische Strahlenexpositionen während der Schwangerschaft:
Risikoabschätzungen für die Leibesfrucht
Nuclear-medical Irradiation During Pregnancy
Risk Assessment for the Offspring**

Nuklearmedizin 48 (2009), 10-16

Aim: To estimate and evaluate the risks for the offspring due to the administration of radiopharmaceuticals to women during the first pregnancy weeks after conception (weeks p.c.). **Methods:** The in-utero exposition of the embryo due to diagnostic nuclear medicine procedures, for which diagnostic reference levels (DRL) are specified, as well as due to radio iodine therapy (RIT) was determined. To this end, it is assumed that the activity of the diagnostic radiopharmaceuticals administered to the mother corresponds with the DRL and amounts to 600 MBq or 4 GBq ^{131}I for RIT of benign or malignant thyroid disease, respectively. Based on these data, the radiation risk for the offspring was assessed and compared with the spontaneous risks (R_0).

Results: The dose for the offspring does not exceed 7.8 mSv for the diagnostic procedures considered, resulting in an excess risk for the offspring of less than 0.12% ($R_0 \sim 25\%$) to die from cancer during life, of less than 0.07% ($R_0 \sim 0.2\%$) to develop cancer up to the age of 15 years, and of less than 0.16% ($R_0 \sim 2\%$) for hereditary effects. RIT during the first 8 weeks p.c. results in doses for the offspring of about 100–460 mSv, resulting in an excess risk for malformations of the child of 3.4%–22% ($R_0 \sim 6\%$). **Conclusions:** The risk of stochastic radiation effects for the offspring due to a diagnostic nuclear medicine procedure of the mother during the first 8 weeks p.c. is – compared with the spontaneous risks – very small; deterministic effects are unlikely. In contrast, deterministic effects for the offspring may occur following RIT. In order to decide on a possibly indicated abortion after RIT, an individual risk assessment is mandatory.

Schlesinger D

**Der grenzüberschreitende Handel mit Altröhstoffen
Cross-border Trade with Secondary Raw Materials**
Geographische Rundschau 11 (2009), 52-58

Der Artikel gibt zunächst einen Überblick über die Bedeutung von Sekundärrohstoffen, Möglichkeiten der Abfallwirtschaft zur Gewinnung dieser (z.B. durch Recycling) sowie die Rahmenbedingungen des internationalen Handels. Anschließend werden verschiedene räumliche Fallbeispiele diskutiert. Diese sind der Einfluss von Weltmarktpreisen auf lokale Sammelsysteme für Altpapier, die Verflechtungen der wach-

senden globalen Nachfrage auf die lokale Schrottwirtschaft, der Einfluss von Kleiderspenden auf die Textilindustrie in Entwicklungsländern sowie ökologische und soziale Problemen durch die Entsorgung von Elektro- und Elektronikschrott.

The article gives in the first part an overview about the importance of secondary raw materials, recycling and waste management measures as well as the regulations of international trade. Afterwards different spatial impacts are discussed. These are the influence of world market prices on local collection systems for waste paper, the ramifications of the emerging global economy on locally situated scrap industries, the influence of donated clothes to the textile industry in developing countries as well as environmental and social problems caused by the disposal of electrical and electronic waste.

Schmid E, Wagner FM, Romm H, Walsh L, Roos H

Dose-Response Relationship of Dicentric Chromosomes in Human Lymphocytes Obtained for the Fission Neutron Therapy Facility MEDAPP at the Research Reactor FRM II.

Radiat Environ Biophys 48:67-75, 2009

The biological effectiveness of neutrons from the neutron therapy facility MEDAPP (mean neutron energy 1.9 MeV) at the new research reactor FRM II at Garching, Germany, has been analyzed, at different depths in a polyethylene phantom. Whole blood samples were exposed to the MEDAPP beam in special irradiation chambers to total doses of 0.14–3.52 Gy at 2-cm depth, and 0.18–3.04 Gy at 6-cm depth of the phantom. The neutron and γ -ray absorbed dose rates were measured to be 0.55 Gy min⁻¹ and 0.27 Gy min⁻¹ at 2-cm depth, while they were 0.28 and 0.25 Gy min⁻¹ at 6-cm depth. Although the irradiation conditions at the MEDAPP beam and the RENT beam of the former FRM I research reactor were not identical, neutrons from both facilities gave a similar linear-quadratic dose–response relationship for dicentric chromosomes at a depth of 2 cm. Different dose–response curves for dicentrics were obtained for the MEDAPP beam at 2 and 6 cm depth, suggesting a significantly lower biological effectiveness of the radiation with increasing depth. No obvious differences in the dose–response curves for dicentric chromosomes estimated under interactive or additive prediction between neutrons or γ -rays and the experimentally obtained dose–response curves could be determined. Relative to ⁶⁰Co γ -rays, the values for the relative biological effectiveness at the MEDAPP beam decrease from 5.9 at 0.14 Gy to 1.6 at 3.52 Gy at 2-cm depth, and from 4.1 at 0.18 Gy to 1.5 at 3.04 Gy at 6-cm depth. Using the best possible conditions of consistency, i.e., using blood samples from the same donor and the same measurement techniques for about two decades, avoiding the inter-individual variations in sensitivity or the differences in methodology usually associated with interlaboratory comparisons, a linear-quadratic dose–response relationship for the mixed neutron and γ -ray MEDAPP field as well as for its fission neutron part was obtained. Therefore, the debate on whether the fission-neutron induced yield of dicentric chromosomes increases linearly with dose remains open.

Schneider U, Walsh L

Cancer Risk above 1 Gy and the Impact for Space Radiation Protection

Advances in Space Research Vol. 44, Nr.2: 202-209, 2009

Analyses of the epidemiological data on the Japanese A-bomb survivors, who were exposed to γ -rays and neutrons, provide most current information on the dose–response of radiation-induced cancer. Since the dose span of main interest is usually between 0 and 1 Gy, for radiation protection purposes, the analysis of the A-bomb survivors is often focused on this range. However, estimates of cancer risk for doses larger than 1 Gy are becoming more important for long-term manned space missions. Therefore in this work, emphasis is placed on doses larger than 1 Gy with respect to radiation-induced solid cancer and leukemia mortality. The present analysis of the A-bomb survivors data was extended by including two extra high-dose categories and applying organ-averaged dose instead of the colon weighted dose. In addition, since there are some recent indications for a high neutron dose contribution, the data were fitted separately for three different values for the relative biological effectiveness (RBE) of the neutrons (10, 35 and 100) and a variable RBE as a function of dose. The data were fitted using a linear and a linear-exponential dose–response relationship using a dose and dose-rate effectiveness factor (DDREF) of both one and two. The work presented here implies that the use of organ-averaged dose, a dose-dependent neutron RBE and the bending-over of the dose–response relationship for radiation-induced cancer could result in a reduction of radiation risk by around 50% above 1 Gy. This could impact radiation risk estimates for space crews on long-term mission above 500 days who might be exposed to doses above 1 Gy. The consequence of using a DDREF of one instead of two increases cancer risk by about 40% and would therefore balance the risk decrease described above.

Strelczyk D, Eichhorn M, Lüdemann S, Brix G, Dellian M, Berghaus A, Strieth S

Statistic Magnetic Fields Impair Angiogenesis and Growth of Solid Tumors in Vivo

Cancer Biology and Therapy 8 (2009), 1757-1763

The aim of our study was to evaluate the effects of prolonged exposure of tumors to static magnetic fields (SMFs) on angiogenesis and growth. Experiments were performed in dorsal skinfold chamber preparations of Syrian Golden Hamsters bearing syngenic A-Mel-3 melanomas. After tumor cell implantation one group of animals was immobilized and exposed to a SMF of 586 mT for 3 h. Control animals were immobilized for the same duration without SMF exposure. Using in vivo-fluorescence microscopy the field effects on tumor angiogenesis and microcirculation were analyzed for seven days. Exposure to SMFs resulted in a significant retardation of tumor growth (~30%). Furthermore, histological analysis showed an increased peri- and intratumoral edema in tumors exposed to SMFs. Analysis of microcirculatory parameters revealed a significant reduction of functional vessel density, vessel diameters and red blood cell velocity in tumors after exposure to SMFs compared to control tumors. These changes reflect retarded vessel maturation by antiangiogenesis. The increased edema after SMF exposure indicates an increased tumor microvessel leakiness possibly enhancing drug-uptake. Hence, SMF therapy appears as a promising new anticancer strategy - as an inhibitor of tumor growth and angiogenesis and as a potential sensitizer to chemotherapy.

Walsh L, Jacob P, Kaiser JC

Radiation Risk Modeling of Thyroid Cancer with Special Emphasis of the Chernobyl Epidemiological Data

Radiation research 172: 509-518, 2009

Two recent studies analyzed thyroid cancer incidence in Belarus and Ukraine during the period from 1990 to 2001, for the birth cohort 1968 to 1985, and the related 1311 exposure associated with the Chernobyl accident in 1986. Contradictory age-at-exposure and time-since-exposure effect modifications of the excess relative risk (ERR) were reported. The present study identifies the choice of baseline modeling method as the reason for the conflicting results. Various quality-of-fit criteria favor a parametric baseline model to various categorical baseline models. The model with a parametric baseline results in a decrease of the ERR by a factor of about 0.2 from an age at exposure of 5 years to an age at exposure of 15 years (for a time since exposure of 12 years) and a decrease of the ERR from a time since exposure of 4 years to a time since exposure of 14 years of about 0.25 (for an age at exposure of 10 years). Central ERR estimates (of about 20 at 1 Gy for an age at exposure of 10 years and an attained age of 20 years) and their ratios for females compared to males (about 0.3) turn out to be relatively independent of the modeling. Excess absolute risk estimates are also predicted to be very similar from the different models. Risk models with parametric and categorical baselines were also applied to thyroid cancer incidence among the atomic bomb survivors. For young ages at exposure, the ERR values in the model with a parametric baseline are larger. Both data sets cover the period of 12 to 15 years since exposure. For this period, higher ERR values and a stronger age-at-exposure modification are found for the Chernobyl data set. Based on the results of the study, it is recommended to test parametric and categorical baseline models in risk analyses.

Weiss W

Towards a Coherent Conceptual Framework for Emergency Preparedness/Response and Rehabilitation - the Application of the New ICRP Recommendations Given in ICRP 103

Journal of environmental radioactivity 100 (2009), 1002-1004

In the past, most emphasis in planning for and response to an emergency situation has been placed on selected protective measures in the early phase of an emergency to keep the doses received below levels where severe deterministic health effects can be excluded and/or where the risk of stochastic effects in the population is considered "acceptable". Less emphasis has been placed on the development of comprehensive protection strategies which include considerations of the consequences of all exposure pathways and all phases, e.g. long term rehabilitation. In its new publication ICRP proposed a coherent conceptual framework for protection in all types of exposure situations including "emergency exposure situations" and "existing exposure situations". In the context of developing protection strategies for these exposure situations, the Commission recommends that national authorities set reference levels between, typically, 20 mSv and 100 mSv annual effective dose (emergency exposure situation) and 1 and 20 mSv (existing exposure situation). In order to optimise protection strategies, it is necessary to identify the dominant exposure pathways, the timescales over which the dose will be received, and the effectiveness of available protection options. The characteristics of the development and implementation of such protection strategies is described.

Willems P, August L, Slabbert J, Romm H, Oestreicher U, Thierens H, Vral A
Automated Micronucleus (MN) Scoring for Population Triage in Case of Large Scale Radiation Events

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In case of a large scale radiation accident, when hundreds of persons may be exposed, it is important to distinguish the severely exposed individuals (≥ 1 Gray), who require early medical treatment, from those less exposed. The aim of the study was to develop a quick population triage method based on automated micronucleus (MN) scoring. Automated MN scoring was performed using the MN software module developed by MetaSystems specifically for the Metafer 4 platform. Using this scoring system, about 60 blood samples can be processed in 1 day. Standard dose response curves were determined for manual and automated MN scoring. Analysis showed that the automated MN assay was closely correlated with the manual procedure and a dose of 1 Gy can be estimated with an uncertainty of 0.2 Gy. Correction for the false positives and false negatives (semi-automated analysis) did not result in an improved accuracy or reproducibility. To assess the performance of automated MN scoring in a multicenter setting, an inter-laboratory comparison was performed whereby irradiated blood samples were processed in Ghent University (Belgium) and BfS (Bundesamt fuer Strahlenschutz; Germany). Both labs obtained comparable results thus confirming the efficacy of the automated MN assay for fast population triage in case of large radiation accidents.

Wojcik A, Lloyd D, Romm H, Roy L

Biological Dosimetry for Triage of Casualties in a Large-Scale Radiological Emergency: Capacity of the EU Member States.

Radiation Protection Dosimetry, 138(4):397-401, 2010, doi:10.1093/rpd/ncp279, Dez. 2009

In recent years, a number of events have occurred that highlight the necessity of being prepared for a possible large-scale radiological event. An important question is how well are European Union (EU) Member States prepared to cope with mass radiological casualties. A survey to establish the current status of biological dosimetry across the EU was carried out with the aim of assessing capacity to perform biodosimetric triage of accident victims. Information was sought from the radiation protection authorities of the 27 Member States plus Switzerland and Norway. Biology dosimetry is established in 15 EU countries. Their total capacity for dosimetric triage is about 1500 cases per week analysed with a dicentric assay or about 800 cases analysed with a micronucleus assay. Although these numbers appear encouraging, there is not much collaboration between the laboratories and what is required is a network at the EU level.