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Second Announcement

Joint ICRP-RERF-JHPS Workshop on

Recent Progress in Radiation Dosimetry for Epidemiology and Radiological Protection

The University of Tokyo

Saturday, December 2, 2017

Organised by the International Commission on Radiological Protection (ICRP), Radiation Effect Research Foundation (RERF), and Japan Health Physics Society (JHPS)

Co-organised by Japanese Society of Radiation Safety Management (JRSM)

Objectives

Radiation dosimetry plays an important role in radiological protection and epidemiological studies. In this joint ICRP-RERF-JHPS workshop co-organised by JRSM, recent developments on radiation dosimetry will be discussed. Additionally, recent studies on atomic bomb survivors as well as the challenges in environmental remediation after medical incidents and the Fukushima nuclear accident will be also reported.

Registration

Advance registration is required for the preparation of presentation materials. The registration fees to be paid onsite are 2,000 JPY for official members of JHPS and/or JRSM, 1,000 JPY for student members, and 4,000 JPY for non-members. Please send your name, affiliation, and e-mail address to the Secretary of Japan Health Physics Society at exec.off@jhps.or.jp by 30 November 2017.

Venue

Room number 221, Faculty of Engineering Build. 2, Hongo Campus, The University of Tokyo
Access: http://www.t.u-tokyo.ac.jp/foee/access.html

Program

13:30 – 13:40: Opening Address

by Hiroko Yoshida (JHPS)

13:40 – 16:50: Scientific Session

Chair: John Harrison (ICRP), Michiaki Kai (JHPS/ICRP)

Speaker:

1. Harry Cullings (RERF)
   DS02R1: new dose estimates in use for the latest LSS studies

2. Wesley Bolch (ICRP)
   Modern phantoms and their applications

3. John Harrison (ICRP)
   Dosimetric quantities and risk

(15:10 – 15:20: Coffee break)

4. Daiki Satoh (ICRP)
   External doses to the public from contaminated land

5. Yusuke Koba (JHPS)
   CT dosimetric calculator

6. Kentaro Manabe (JHPS)
   Modeling of internal dose from an insoluble cesium

16:50 – 17:00: Closing Remarks

by John Harrison (ICRP)

Abstracts

(1) DS02R1: new dose estimates in use for the latest RERF studies

H.M. Cullings

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Abstract–The dose estimates for the atomic bomb survivors followed by RERF have been calculated by a series of "dosimetry systems" created over the years by outside scientific groups, of which the most recent is Dosimetry System 2002 (DS02). DS02 calculates the source terms of prompt and delayed neutrons and gamma rays emanating from the bombs as fluences: numbers of radiations per unit cross-sectional area, in categories of direction and energy. Based on calculations of transport through the atmosphere in an air-over-flat-ground model, these are converted to kerma in air at 1 m above ground at various distances ("free-in-air kerma") from the bomb hypocenters. In addition the transported fluences are used with detailed tabulations of results from Monte Carlo calculations to calculate shielding by terrain and structures ("shielded kerma" at the survivor's shielded location) and organ dose (absorbed dose to a particular organ, accounting for the body's self-shielding). RERF recently introduced a new set of dose estimates, DS02R1, based on several years' intensive work on improving survivors' input data on location and shielding by vetting original source documents, using a Geographical Information System (GIS) to correct for distortions in the 1945 US Army maps that were used to record locations in map coordinates, providing more universal and accurate terrain shielding input data from contemporary high resolution digital terrain elevation data, and correcting a number of other specific sources of inaccuracy. The systematic differences between DS02 and DS02R1 are relatively modest, but there are more substantial differences for individual survivors that are thought to reduce random errors. This talk will describe the development of DS02R1 and show the differences in dose estimates as well as the corresponding differences in risk estimates for a set of recent cancer mortality data.

(2) Modern phantoms and their applications

W. Bolch

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Abstract–Medical imaging of the infant, child, and adolescent plays an extremely important role in the overall medical management of this critical component of the medical patient population. The vast majority of medical images are acquired via use of ionizing radiations (photons) and thus careful optimization of patient radiation dose and image quality must be undertaken. Organ doses from medical imaging of the pediatric patient population are difficult to ascertain via experimental measurement, and thus one typically employs computational anatomic models coupled to Monte Carlo radiation transport simulations. In this present, we will review the development of reference phantoms for the ICRP pediatric series – newborn, 1-year-old, 5-year-old, 10-year-old, and 15-year-old male and female, as well as series of pregnant female models. We will also review the use of phantom libraries that cover a broad range patient body morphometries such as those of the UF/NCI phantom series, which permit more detailed and patient-specific estimates of organ dose. The presentation will review techniques for organ dose assessment in three key areas of medical imaging – computed tomography, fluoroscopy (both diagnostic and interventional), and nuclear medical. We will discuss various studies which seek to quantity the accuracy by which reference phantoms and phantom libraries can provide patient-specific values of internal organ dose.

(3) Dosimetric quantities and risk

J.D. Harrison

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Abstract–The dosimetric quantities used in radiological protection are absorbed dose (D), with the special name of gray (Gy), and equivalent dose (H) and effective dose (E), both with the special name of sievert (Sv). D is the primary scientific quantity from which E is calculated and is the most appropriate quantity for use in setting limits on organ/tissue doses to prevent tissue reactions (deterministic effects). H to organs and tissues is obtained by multiplying organ/tissue absorbed doses by radiation weighting factors (w_R) to account for the relative effectiveness of different radiation types in causing stochastic effects at low levels of exposure, and can be seen as an intermediate step in the calculation of E. It is argued that the current use of H to set limits to prevent tissue reactions should be discontinued. E is calculated as the sum of organ/tissue equivalent doses multiplied by tissue weighting factors (w_T) which provide a simplified representation of fractional contributions to total stochastic detriment from cancer and hereditary effects, expressed as sex-, age-, and population- averaged values of detriment-adjusted risk (Sv^{-1}). E was originally developed by ICRP for use in the radiological protection of workers and the public. In these applications, it is used as a risk-adjusted dosimetric quantity to manage protection against stochastic effects, comparing planned or received doses with dose limits, dose constraints, and reference levels expressed in the same quantity. Its use allows all radiation exposures from external and internal sources to be considered together and summed, relying on the assumptions of a linear non-threshold dose-response relationship, equivalence of acute and chronic exposures at low doses or low dose-rates, and equivalence of external and internal exposures. While age- sex-, and population- related differences in risks per Sv are recognised, the use of constraints and reference levels that apply to all workers and all members of the public, together with optimisation, provides a pragmatic and workable system of protection that does not distinguish on an individual basis. In medical applications, estimates of E are used for comparing doses from different diagnostic and interventional imaging modalities (e.g. CT and nuclear medicine) and exposure techniques that give different spatial distributions of radiation within the body tissues. E is used to provide a generic indicator for classifying different types of medical procedure into broad risk categories for the purpose of communicating risks to clinicians and patients. E is also used to inform decisions on justification of patient diagnostic and interventional procedures, planning requirements in research studies, and evaluation of unintended exposures. Bearing in mind the uncertainties associated with risk projection to low doses or dose-rates, it is considered reasonable to use E as an approximate indicator of possible risk in such applications, with the additional consideration of variation in risk with age, sex and population group. For medical procedures or other situations in which a single radiosensitive organ receives the majority of the dose, such as the breast in mammography, or the thyroid from therapeutic administration of iodine, mean absorbed doses to the tissues of interest should be used rather than effective dose. The use of E as an approximate indicator of possible risk is not a substitute for risk analysis using best estimates of organ/tissue doses, appropriate information on the relative effectiveness of different radiation types, and age- sex- and population- specific risk factors, with consideration of uncertainties. Collective effective dose is a valuable tool in the optimisation of protection, particularly for occupational exposures. However, its use to predict possible health effects should be treated with great caution, and judged in relation to background incidence rates.

(4) External doses to the public from contaminated land

D. Satoh

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Abstract–A significant amount of radioactive material was released into the environment by the accident at the Fukushima Daiichi Nuclear Power Plant (Fukushima I NPP) of the Tokyo Electric Power Company Holdings, Inc., which was caused by the Great East-Japan Earthquake and tsunami that struck Japan on 11 March 2011. The radioactive materials were widely deposited on the ground around the Fukushima I NPP, where they elevated the radiation dose. To protect the public from radiation exposure, the effective doses in the environment contaminated with radionuclides need to be determined. In particular, because of the relatively long half-lives of cesium and high energies of radiated photons, radioactive cesium (^{134}Cs and ^{137}Cs) deposited on the ground after the accident is one of the most important nuclides for estimating medium-term to long-term doses resulting from external exposure in Fukushima. Effective doses are usually estimated on the basis of measurable quantities by using conversion coefficients that are calculated for a particular situation of each exposure. The International Commission on Radiological Protection (ICRP) provided a database of conversion coefficients to convert particle fluence or air kerma to effective dose under idealized irradiation situations in the ICRP *Publication 116*. However, for estimating the external doses to the public from contaminated land, directly applying the data of the *Publication 116* is difficult because the radionuclides are distributed in the soil and isotropically emit radiation. In addition, the effective doses need to be estimated from the activity concentration, personal dose equivalent Hp(10), or ambient dose equivalent H*(10) that have been measured in Fukushima. In this work, a database of conversion coefficients to convert the activity concentration to the effective dose rate for various ages that represent general population has been constructed for external exposure to radioactive cesium distributed in the soil, and the relationships between the personal dose equivalent rate, ambient dose equivalent rate, and effective dose rate have been analyzed. The age-dependent conversion coefficients were calculated for planar sources of radioactive cesium at source depth of 0.0, 0.5, 2.5, 5.0, 10.0 and 50.0 g/cm^2 in the soil by incorporating the ICRP reference phantoms for newborns; 1-, 5-, 10-, and 15-year-old children; and adults into the Particle and Heavy Ion Transport Code System (PHITS), which is a Monte-Carlo simulation package. The definition of the effective dose given in the ICRP 2007 Recommendations was applied to the dose estimation not only for adults but also for children and babies here. The personal dose equivalent rate monitored by a personal dosimeter worn on the bodies of the public and the ambient dose equivalent rate were calculated in the same environmental radiation fields, and were compared with the effective dose rates. From the results, it was found that the personal dose equivalent provides a good estimate regarding the effective dose in the contaminated environment and does not exceed the ambient dose equivalent value at a height of 100 cm above the ground, while the effective doses for younger people are higher than those for adults. This means that the radiation exposure of the public in Fukushima can be controlled adequately by monitoring the personal dose equivalent using a dosimeter. In addition, the activities of the ICRP Task Group 90 for developing age-dependent conversion coefficients for external exposure to various radionuclides in air, soil and water are also introduced in the workshop.

(5) CT dosimetric calculator

Y. Koba

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Abstract–Recently, X-ray CT (Computed Tomography) is very popular as helpful diagnostics. But its high exposure dose as compared with simple roentgenography should be assessed on a clinical basis as an input to the justification and the optimization. The number of CT scanners in Japan, about 13,000, has been acknowledged to be the largest over the world, as published in the reports from the OECD (Organization for Economic Co-operation and Development) in 2014. And the number of CT scanners per million populations is about 92; this is by far the largest. On the other hand, the number of CT scanners in America is the second largest and is comparable with Japan, but it per million populations is about 32. In Japan, these situations promote the dose assessment of clinical patients for justification and optimization. WAZA-ARI is the web-based open system for CT dose calculator, which has been developed by National Institute of Radiological Sciences (NIRS) and Oita University of Nursing and Health Sciences and the Japan Atomic Energy Agency (JAEA). In WAZA-ARI version 2 (WAZA-ARIv2, https://waza-ari.nirs.qst.go.jp/), can provide organ doses taking into consideration of the body type of patient using Japanese voxel phantoms developed by JAEA. And it can provide exposure dose of children using child voxel phantom developed by the university of Florida. In this system selectable CT scanners are 31 models. Number of these models account for 60% of number of CT scanner installed in Japan. We make efforts to continue increase of CT models. Furthermore, we added the database function of storing the calculation results in each facility in order to check the exposure levels of the CT examination in each medical facility in Japan. At January 2015, WAZA-ARIv2 system started, and currently over one thousand users are registered. In order to acquire more data on the actual situation of medical exposure in Japan, we plan to expand the number of users and improve functions of WAZA-ARIv2 system.

(6) Modeling of internal dose from an insoluble cesium

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Abstract–Micrometer-sized particles bearing radioactive cesium were found after the accident of Fukushima Daiichi Nuclear Power Station. The particles were insoluble with high specific activities. If the particle is incorporated into the human body, the radioactive cesium included in the particle will move as a single particulate material without being distributed throughout the body by dissolving to blood or tissue fluid. Commonly applied methods for estimation of the numbers of disintegrations in organs and tissues are designed for the average behavior (i.e. distribution in the body) of countless radioactive nuclei. Therefore, the existing methods are not applicable to the intake of the small number of cesium bearing particles. Then, we developed a method that simulates a stochastic movement of a single particle in the body. This stochastic biokinetic method used a compartment model based on appropriate biokinetic models. Each retention time of the particle is determined by a random number based on the biological half-life of the compartment. If the number of the pathways from the compartment is no less than one, a target compartment of migration of the particle is also determined by a random number based on the proportion of the transfer coefficients from the compartment. In this way, we can track the stochastic movement of the single particle in the body, and obtain the respective numbers of disintegrations of radioactive cesium in the organs and tissues. Subsequently, organ absorbed doses can be evaluated by summation of the products of the numbers of disintegrations and corresponding *S* values. Repetitive execution of this procedure makes it possible to evaluate a probability density function of exposure dose. An improved biokinetic model was also studied for micrometer-sized insoluble particles. When insoluble particles are inhaled into the respiratory tract and deposited there, they are cleared by three main routes to blood by absorption, to alimentary tract by ciliary movement, and to regional lymphatic nodes by action of macrophage. According to the preceding studies, some of the insoluble particulate matters are transferred to lymphatic nodes and retained there, and the others migrate to some organs and tissues and retained, for example, liver, spleen, thymus, and so on. Considering these pathways, we constructed a biokinetic model for the cesium bearing particles based on the experimental data. In this study, the probability density function of the absorbed dose for each target organ was evaluated by combining the stochastic biokinetic method and the biokinetic model for cesium bearing particles. In addition, the 99th percentile, arithmetic mean and median values of the distribution of doses were compared with the dose based on the existing models for inhalation type S which is generally applied to unknown chemical forms. This presentation will describe the approach to modeling of the stochastic biokinetic method and the biokinetic model for internal dosimetry of insoluble particles bearing radioactive cesium. Moreover, we will discuss the uncertainties in the lung doses from the insolubility of particles, and also the difference of doses between our constructed models and the existing cesium models.

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