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LUNG DOSE CALCULATIONS FOR INHALED ALPHA EMITTERS USING PERSONAL COMPUTERS

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Lung dosimetry of inhaled alpha-emitters is performed with complex models in scientific research work, while calculations for practical applications in radiation protection are use equations with simple multiplicative factors. Because of the many parameters involved in lung dose calculations and the variation of exposure conditions the use of such factors is not an appropriate way to get reliable information about radiation risks. The wide spread of computer systems and the fact that computers are very powerful nowadays makes it possible to do more sophisticated calculations with a computersystem. Basic requirements for practical applications of dosimetric models is the simplicity in handling and performing the calculations. The use of a computer system allows to do calculations with a preprogrammed model by defining and adapting only the relevant parameters. The structure of the model and the implementation on small computers as well as the parameters involved in lung dosimetry are discussed in this paper.

Introduction

The basis of dosimetry in radiation protection is the quantitative assessment of dose from radiation exposure. This relation is considered to be linear and thus can be calculated with simple equations using multiplicative factors. This concept is reasonable for external radiation but not for dosimetry of inhaled radionuclides. The dose of inhaled alphaemitting radionuclides depends on many processes and factors like deposition, clearance and have to be calculated for a specific target.

Many models of deposition, translocation and dosimetry are discussed in the literature [2,3,4,5,6]. Most of them describe detailed analysis of specific problems or only selected parts of the dose calculations. They are not used in practical radiation protection. The ICRP Task Group II [1,2] discussed the features and adequacy of the Working Level concept for inhaled radon decay products as a physical correlative of the absorbed lung dose. This concept does not consider modifying factors like particle size, unattached fraction or morphological and physiological parameters. The effective dose equivalent is assumed to be 0.01 Sv/WLM and is used as a multiplying factor in practical radiation protection. For practical dosimetry it is very important to have an easy to handle tool for calculations of different problems.

The idea of this paper is to use a more sophisticated dose model as a program package on a small computer and to give the health physicist the advantage to adapt the parameters to the specific problems. So the health physicist has not to worry about the inner structure of the model and has access to the model by changing parameters. The model is based on scientific concepts and can be modified if new scientific results become available.

The application of the model is not restricted to the use in health physics. It can be applied to epidemiological problems as well. Epidemiological data are as good as the dose calculations are. Applying only factors to dose calculations leads to a loss of information. So the use of a refined computer model gives much more detailed information about individual or collective doses.

Dose models

Dose calculations of inhaled alpha-emitting radionuclides yield radiation doses in different organs and tissues, particulary in the respiratory tract. For the calculations we can distinguish different processes like deposition, translocation and energy deposition in a specific target. For practical use it is necessary to define the relevant parameters for all the processes and to allow the user to change these parameters interactively.

Dose calculations are usually performed on three levels:

1. Organ doses are calculated with simple relationships to the exposure. The calculations require only a simple electronic calculator and do not consider variations of exposure conditions.
2. Organ doses are calculated by the use of a more complex model considering physiological, morphological and aerosol characteristics. The calculations on this level give the doses for the same target as in level 1, but contain more specific information about individual data. The application of this concept is not restricted to the calculation of individual doses but can also be applied to population doses using statistical parameters or parameter distributions. The basis of the calculations is a program package on a computer system with the possibility to change parameters. The internal organisation and structure of the program package (model) does not influence the use of the program.
3. Doses are calculated for specific targets (tissues, lung generations, cells) also considering physiological, morphological and aerosol characteristics. This model gives the most detailed dose information using the same input data as in level 2. These calculations can also be performed on a small computer system.

The characteristics of the calculations on level 2 and 3 are the use of a model with a program package on a small computer.

The different processes of deposition, translocation and local dose delivery can be treated as program moduls. The technique of structured programming allows to change modules or to use different modules for one process. This feature is important for deposition calculation and for the calculation of local doses. Here we find many different models describing the same process, which can be implemented to the computer code.

Definition of parameters

The selection of parameters is one of the options of the computer dose model on levels 2 and 3. To make the model easy to handle it is necessary to find the relevant parameters for dose calculations. Considering the three parts of the model, deposition, translocation and local dose, relevant parameters are given in Table I.

Table I

Parameters for lung dose calculations

Aerosol	particle size (AMD or particle size distribution)
	nuclide concentration
	nuclide characteristics
	(half life, decay chain, alpha particle energy)
	unattached fraction
	solubility
	transfer rates between compartments
Morphology	tidal volume
	respiratory minute volume
	lung volume
	scaling factor (airway diameter/length)
	body weight
Physiology	cycle time
	breathing cycle
	mucus transit time
	compartment transition times
Target	volume
	tissue density
	surrounding tissue

For practical use most of the parameters will be fixed and the parameter description can be called from libraries (e.g. library for "aerosol characteristics of radon decay products in dwellings" or "morphology and physiology of reference man").

The computer model should also allow the calculation of population doses or the dose to specific population groups. This option needs the definition of aerosol and morphological/physiological parameter distributions. The results of the calculations give a dose distribution for a given population. This is very important also for radiation protection because this distribution gives also information about the percentage of people with higher doses than the mean dose. Incorporating this information into epidemiological studies could lead to better understanding of dose-effect relations.

Conclusions

Lung dose calculations for radiation protection purposes usually do not consider different exposure conditions or morphological and physiological differences. With the help of a computer program package these calculation can be done conveniently and give more detailed information about doses or dose distributions. The most important feature for practical applications is to develop a system with an easy to handle data input allowing to adapt the relevant parameters in dosimetrical calculations to a specific problem. The use of small computers and a predefined computer model with libraries for different applications improves the dose calculations and permits practical usage. The comparison of radiation protection calculatios can be realized by distributing the proper software using mass storage devices.

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