RESTRICTIONS FOR APPLICATION OF EFFECTIVE DOSE IN RADIATION SAFETY

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INTRODUCTION

ICRP in Publications N 26 (1) and N 30 (2) recommended to calculate the annual limit on intake (ALI) of a radionuclide as the smallest value of the annual intakes corresponding to committed effective dose of 50 mSv or committed organ dose equivalents of 500 mSv. Recently ICRP don't limits the value of committed equivalent dose in organs and tissues on ALI calculations. The recommendations of ICRP Publication 61 (3) are the first one, where the annual limit on intake for any radionuclide is based only on a committed effective dose.

It is well known, that the effective dose, E is the sum of the weighted equivalent doses in all the tissues and organs of the body, H_T. The weighting factors for different organs have wide variation in magnitude, e.g. 0.2 for gonads and 0.01 for bone surfaces or skin (3). When one is exposed to radionuclides, uniformly spread in the body, e.g. ^{137}Cs, ^{106}Ru, equivalent doses in all organs and tissues are not different from the effective dose. When one is exposed to organotropic radionuclides irradiated only some organs or tissues (e.g. ^{93}Zr - skeleton, ^{238}U - kidneys, ^{131}I - thyroid), the effective dose become the weighted equivalent dose in the only organ or tissue. In those cases the equivalent dose in organ differs from the effective dose by a factor of the inverse value of tissue weighting factor put to that organ. For ingestion of ^{131}I, as an example, committed equivalent dose in thyroid is close to 200 mSv if effective dose is equal to 10 mSv (value of tissue weighting factor for thyroid is equal to 0.05).

METHODS AND RESULTS

Ratios between committed equivalent dose in organ and committed effective dose both for inhalation and ingestion of 1148 compounds of 383 radionuclides relevant to radiology were calculated with computer code "R-MAN" (4). Computer code "R-MAN" is based on ICRP Recommendations (Publications NN 30, 38, 48, 56, 60 (2, 5-8), publications of US Oak-Ridge National Laboratory (9, 10).

Results of the ratio calculations for some organs are presented in the tab. I. Thus, in accordance with (3), ALI is a value of the annual intake corresponding to committed effective dose of 20 mSv. The list of radionuclides for which H_T/E in some organs exceed 25 includes compounds of ^{93}Zr, ^{109}Cd, ^{113}Cd, ^{113m}Cd, ^{125m}Te, ^{146}Sm, ^{147}Sm, ^{151}Sm, ^{152}Gd, ^{171}Tm, ^{181}Hf, ^{210}Pb, ^{210}Bi, ^{227}Ac, ^{228}Ac, ^{228}Th, ^{229}Th, ^{230}Th, ^{232}Th, ^{231}Pa, ^{230}U, ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{238}U, ^{237}Np, ^{238}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{244}Pu, ^{241}Am, ^{242m}Am, ^{243}Am, ^{244m}Am, ^{243}Cm, ^{244}Cm, ^{245}Cm, ^{246}Cm, ^{247}Cm, ^{248}Cm, ^{250}Cm, ^{249}Bk, ^{250}Bk, ^{249}Cf, ^{250}Cf, ^{251}Cf, ^{252}Cf and ^{254}Es.

One mast to expect in relation to the data presented in the tab. I that intake of radioactivity equivalent to ALI of some organotropic radionuclides may result in a committed equivalent dose of 920 mSv in bone surfaces or 520 mSv - in kidneys or 400 mSv

Table I: Comparison of the committed equivalent and effective doses for inhalation and ingestion of 383 radionuclides

Target organs and tissues	Fraction (%) of radionuclides for which H_T differs from E by factor of between:						Maximum of H_T/E ratio, in brackets - the inverse value of tissue weighting factor
	0 and 2	2 and 4	4 and 8	8 and 16	16 and 32	32 and 64	
Bone Surfaces	77	4.7	3.1	3.7	8.4	3.1	46 (100)
Kidneys	91	3.0	2.3	2.3	1.4	0	26 (40)
Thyroid	95	2.0	0.6	0.8	1.6	0	20 (20)
Spleen	98	1.4	0.4	0	0.2	0	20 (40)
Bladder	96	3.2	0.7	0.2	0	0	12 (20)
Liver	87	6.3	6.2	0.5	0	0	10 (20)
LLI wall†	61	15	22	2.0	0	0	8.3 (8.3)
Lungs	56	11	27	6.0	0	0	8.3 (8.3)
Pancreas	99.6	0.3	0.1	0	0	0	7.8 (40)
Red Marrow	86	11	3.0	0	0	0	6.6 (8.3)

† Wall of lower large intestine

- in thyroid and spleen or 240 mSv - in bladder or 170 mSv - in lower large intestine wall and lungs or 160 mSv - in pancreas or 130 mSv - in red marrow.

CONCLUSIONS

It stands to reason that correct applying of effective dose is bounded by share of permissible equivalent doses (*PED*) in some organs:

1/50th of PED in bone surfaces;

1/25th of PED in kidneys;

1/20th of PED in thyroid or spleen;

1/10th of PED in liver or bladder wall;

1/8th of PED in lower large intestine wall, lungs or pancreas.

Therefore, the annual limit for effective dose of 20 mSv is in good agreement with the permissible equivalent dose for any internal organ of 100 mSv established by ICRP Recommendations 1990 (8).

REFERANCES

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