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Evaluation of the absorbed dose in the lungs due to Xe^{133} and Tc^{99m} (MAA)

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Abstract: -The absorbed dose in lungs of an adult patient has been evaluated using the biokinetics of radiopharmaceuticals containing Xe^{133} or Tc^{99m} (MAA). The absorbed dose was calculated using the MIRD formalism, and the Cristy-and-Eckerman lungs model. The absorbed dose in the lungs due to ^{133}Xe is 0.00104 mGy/MBq. Here, the absorbed dose due to remaining tissue, included in the ^{133}Xe biokinetics is not significant. The absorbed dose in the lungs, due Tc^{99m} (MAA), is 0.065 mGy/MBq. Approximately, 4.6% of the absorbed dose is due to organs like liver, kidneys, bladder, and the rest of tissues, included in the Tc^{99m}biokinetics. Here, the absorbed dose is very significant to be overlooked. The dose contribution is mainly due to photons emitted by the liver.

***Keywords*: -** *Lungs,MIRDdosimetry, Tc^{99m} (MAA), Xe^{133}.*

I. INTRODUCTION

The estimated dose absorbed by the lungs from an adult, during uptake studies can be performed through the analysis of the biokinetics of radiopharmaceuticals used,containingTc^{99m} (MAA) or el Xe^{133}.

II. MATERIALS ANDMÉTHODS

To estimate the dose absorbed by the lungs, due to contributions dosimetric the organs that are part of the biokinetics, were used formalism and representation MIRD Cristy-Eckerman to those tissues. Medical Internal Radiation Dosimetry considered equations [1]:

$$\frac{D_{photons}(lungs)}{A_0} = \sum_{i=1} \left[\sum_k \Delta_k \Phi_k (lungs \leftarrow i) \right] \tau_i \qquad rad / \mu C_i$$

$$\frac{D_{particle}(lungs \leftarrow lungs)}{A_0} = [\overline{E}_{particle} \frac{\tau_{lungs}}{m_{lungs}} + \overline{E}_{particle} \frac{\tau_{TB}}{m_{TB}}] x\, 2,13 \qquad rad / \mu C_i$$

$\tau_{TB} = total\ residence\ of\ the\ body$

$m_{TB} = total\ body\ mass$

The absorbed fractions,Φk (lungs ← i) g-¹, of the "i" analized organs(lungs, liver,kidneys, bladder,remaining tissue forTc^{99m} (MAA); and lungs, remaining tissue, for Xe^{133}), for photon energies "k" of $Tc^{99m}$and Xe^{133}were obtained from ORNL/TM-8381/V7 [2]. Residence times of radiopharmaceuticals mentioned, in each organ biokinetics, given in tables 1and 2, were obtained from thewebsite [3].

Table 1.Residence time (hours) for organs of the biokinetics of Tc^{99m} (MAA) [3]

Órgans / RFM	Lungs	Liver	Kidneys	Bladder	Remaining tissue (excluding bladder)
Tc^{99m} (MAA)	4.890	1.04	0.018	0.217	7.6

Table 2. Residence time (hours) for organs of the biokineticsofXe^{133}("rebreath-ing" for 5 minutes) [3]

Órgans / RFM RFM	Lungs	Remaining tissue
Xe^{133}	0.013	0.533

$\Delta_k = 2{,}13\ n_k\ E_k \quad (\frac{rad - gm}{\mu Ci - hr})$, represents average energy of the "k" photons emitted in the decay of Tc^{99m} (MAA) and Xe^{133}, given in Table 3, were obtained from web page [4].

Table 3. Data nuclear emitted photons (MeV) of $Tc^{99m}$and Xe^{133}most significant [4]

RFM	Photons	E_k (Me V)	n_k/des	$\Delta_k = 2{,}13\ n_k\ E_k$ $(\frac{rad - gm}{\mu Ci - hr})$
Tc^{99m}	Gammaradiation	0,1405	0,8906	0,2665
		0,1426	0,0002	0,0001
	Characteristicradiation	0,0183	0,021	0,0008
		0,0184	0,040	0,0016
		0,0206	0,012	0,0005
Xe^{133}	Gammaradiation	0.1606	0.0007	0.0002
		0.0796	0.0027	0.0004
		0.0810	0.3800	0.0656
	Characteristicradiación	0.0306	0.1410	0.0092
		0.0310	0.2620	0.0173
		0.0350	0.0940	0.0070

$\bar{E}_{particle}$ (MeV/des.), represents the average energy of particles emitted by the Tc^{99m} (MAA) and Xe^{133}, this is, represents the electron appearing in the decay processes for capturing and Auger electrons, are given in Table 4 and were obtained from web page [4].

Table 4. Nuclear data for emitted particles (MeV) of $Tc^{99m}$and Xe^{133}most significant [4]

RFM	Partícles	E_k(MeV)	n_k/des	$n_k E_k$ (MeV / des)	$\bar{E}_{particle} = \sum n_k E_k$ (MeV / des)
Tc^{99m}	Conversiónelectróns	0,1195	0,088	0,01052	0,01439
		0,1216	0,0055	0,00067	
		0,1375	0,0107	0,0015	
		0,1396	0,0017	0,00024	
		0,140	0,0019	0,00026	
		0,0016	0,746	0,0012	
	Augerelectrons	0,0022	0,102	0,00022	0,00054
		0,0155	0,0207	0,00032	
Xe^{133}	Beta	0.0750	0.0081	0.00061	0.1001
		0.1005	0.9900	0.09949	
	Conversiónelectrons	0.0436	0.0041	0.00018	0.03284
		0.0450	0.5510	0.02479	
		0.0753	0.0820	0.00617	
		0.0798	0.0169	0.00135	
		0.0808	0.0044	0.00035	
	Augerelectrons	0.0035	0.5100	0.00178	0.00326
		0.0255	0.0582	0.00148	

Mass values the lungs and remaining tissue of the biokinetics,were obtained from ORNL/TM-8381 /V1 [5].

Table 5.Mass values (g) to lungs and remaining tissues of adults, in the representation representationCristy - Eckerman[5]

Mass (grams)	ADULT
Lungs	1000
Remaining tissue (TB)	73700

Using the methodology MIRD and representation of Cristy-Eckerman for the lungs of adults patients , the study is to demonstrate whether the dosimetric contributions of the organs that are part of the biokinetics (excluding lungs) of Tc^{99m} (MAA), and Xe^{133}, are significant in the estimated absorbed dose.

III. RESULTS

Table 6. Absorbed dose in adult lungs, dueto Tc^{99m} (MAA) andXe^{133}, in the representation of Cristy-Eckerman and formalism MIRD (mGy/MBq)

RFM	Emissions	D(lung←lung)/A_0	D(lung←i)/A_0*	Sub-total	Total (mGy/MBq)
Tc^{99m} (MAA)	Gammaradiation	0.0179 (27.5%)	0.003 (4.6%)	0.023 (35.4%)	0.065
	CharacteristicRadiation	0.0021 (3.2%)			
	Conversionelectrons	0.0405 (62.3%)	-	0.042 (64.6%)	
	Augerelectrons	0.0015 (2.3%)			
Xe^{133}	Gammaradiation	0.00002 (1.9%)	<0.01%	0.00005 (4.7%)	0.00106
	CharacteristicRadiation	0.00003 (2.8%)			

(rebreath	Beta Radiation	0.00075 (70.8%)		
	Conversionelectrons	0.00024 (22.6%)		
ingfor 5	Augerelectrons	0.00002 (1.9%)	-	0.00101 (95.3%)
minutes)				

(*) i = all source except the lungs

IV. DISCUSSION

The results in Table 6 show:

(1) Absorbed dose to the lungs of an adult, due to emissions of Tc^{99m} (MAA): 0.065 mGy / MBq: 95.3% are self-dose (62.3% to electron conversion, 2.3% to Auger electrons, 27.5 % due to gamma photons, and 3.2% to radiation characteristics); and the remaining 4.6%, corresponding to the organs that are part of the biokinetics of Tc99m (MAA): Liver, kidney, bladder and remaining tissue. This dosimetric contribution is significant value to be ignored

(2) Absorbed dose to the lungs of an adult, due to emissions of Xe^{133} (rebreathing for 5 min): 0,0106mGy / MBq: 99.9% corresponds to the self- doses (70.8 % to beta emissions; 22.6 % to conversion electrons; 1.9% to Auger electrons; 1.9 % due to gamma photons,and2.8 % to radiation characteristics).Dosimetric contribution remaining tissue, corresponding to the organs that is part of the biokinetics of Xe133 is negligible.

The results obtained absorbed dose to the lungs of an adult, are consistent with those published in PEDOSE [6].

Depending on the type of radiopharmaceutical and its biokinetics, shall the significance of their contributions in the estimated dose absorbed by the lungs [7, 8].

V. CONCLUSSION

Using the methodology MIRD ,and representation of Cristy-Eckerman in lungs of adults , it demonstrated that , the dosimetric contributions organs that are part of the biokinetics (excluding lungs) of Xe^{133} are not significant in the estimated dose. The total dose absorbed by the lungs is self-dose. While dosimetric contributions Tc^{99m} (MAA), excluding the lungs, is significant in the estimated absorbed to be ignored.

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