PET Scanning

Dosimetry Calculations of Radiopharmaceuticals

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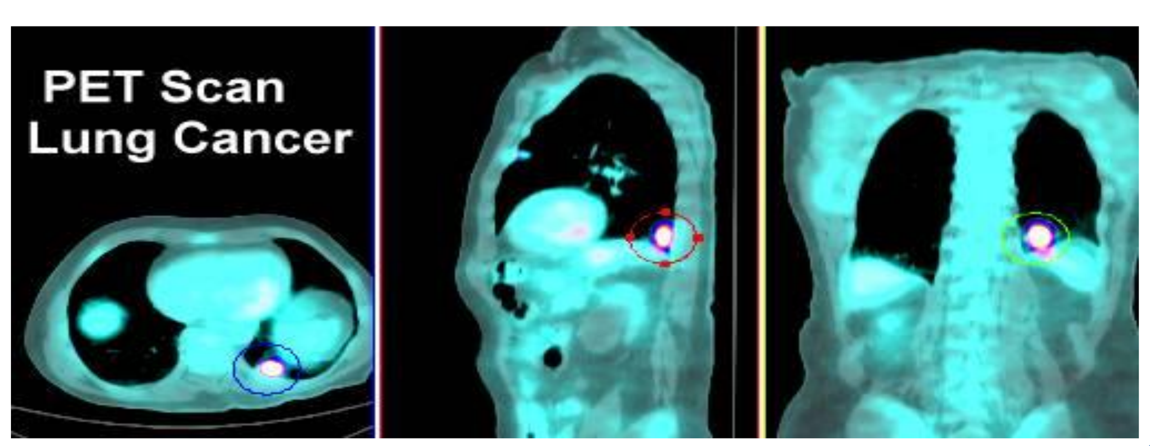
Abstract

The goal of this project is to determine the absorbed dose of radiation to a patient using ^{99m}Tc-MAA as a tracer for a lung scan using the MIRD formula accounting only for the radiation dose contributed by the target organ. The radiation dose for other organs to the target organ is considered negligible as the uptake of ^{99m}Tc-MAA from other organs is less than 1%. In addition to calculating the absorbed dose of radiation, the initial dose rate was also calculated by back solving to determine the total mass of the lungs. The radiation dose to the patient by the target organ was calculated to be $269.44 mrads$ and the initial dose rate was determined to be $156\frac{mrads}{hr}$.

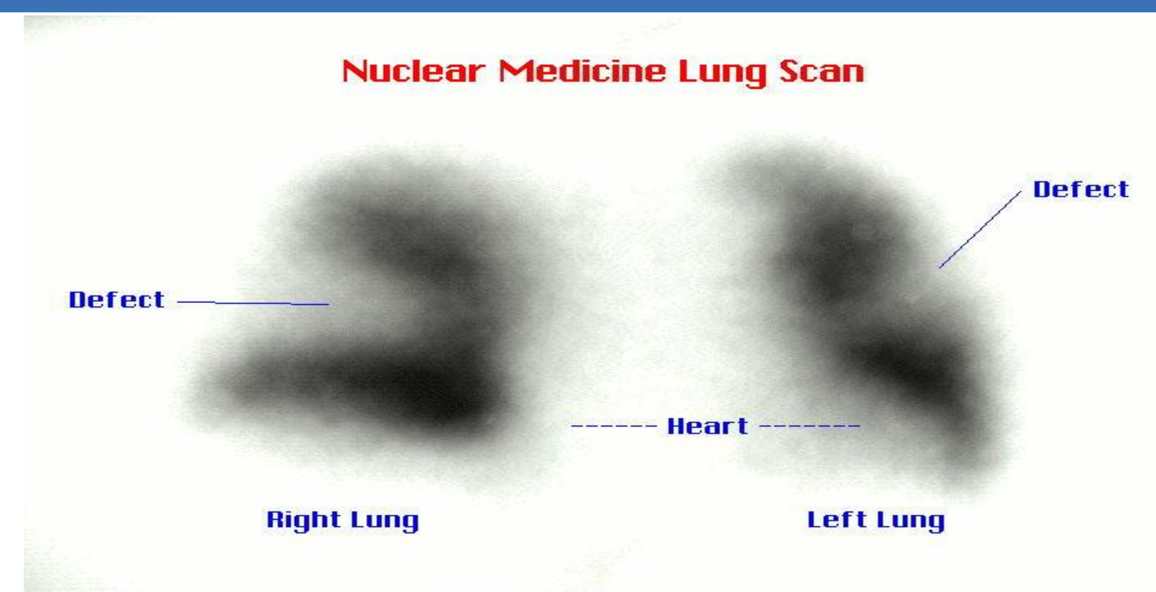
Problem Statement

Calculate the absorbed dose to the lungs of an adult patient who received 3 mCi (111MBq) ^{99m}Tc-MAA, assuming 99% uptake and uniform distribution of the radioactivity in the lungs. Pertinent data are: $T_b = 1.5$ hr and $S = 5.25 * 10^{-5} \frac{rad}{\mu Ci * hr}$ or $0.0142 \frac{Gy}{GBq * hr}$.[1]

1. Calculate the absorbed dose of radiation from the target organ.
2. Calculate the initial dose rate.



Mathematical Approach



$$\frac{1}{T_e} = \frac{1}{T_p} + \frac{1}{T_b}$$

$$T_e = \frac{1}{\frac{1}{6} + \frac{1}{1.5}} = \frac{1}{.83} = 1.2hr$$

$$A_o = A * percent\ uptake$$

$$A_o = 3000\mu Ci * 99\% = 2970\mu Ci$$

$$\tilde{A} = 1.44 T_e A_o$$

$$\tilde{A} = 1.44 * 1.2\text{hr} * 2970\mu\text{Ci} = 5132.16\mu Ci * hr$$

$$D\ rad = \tilde{A} * S$$

$$D = 5132.16\mu Ci * hr * 5.25 * 10^{-5} \frac{rad}{\mu Ci * hr} = .26944 rads$$

$$m = \frac{\sum_i \Delta_i \phi_i}{S}$$

$$m = \frac{.0806}{5.25 * 10^{-5}} = 1535.24g$$

$$\lambda_e = \frac{.693}{T_e}$$

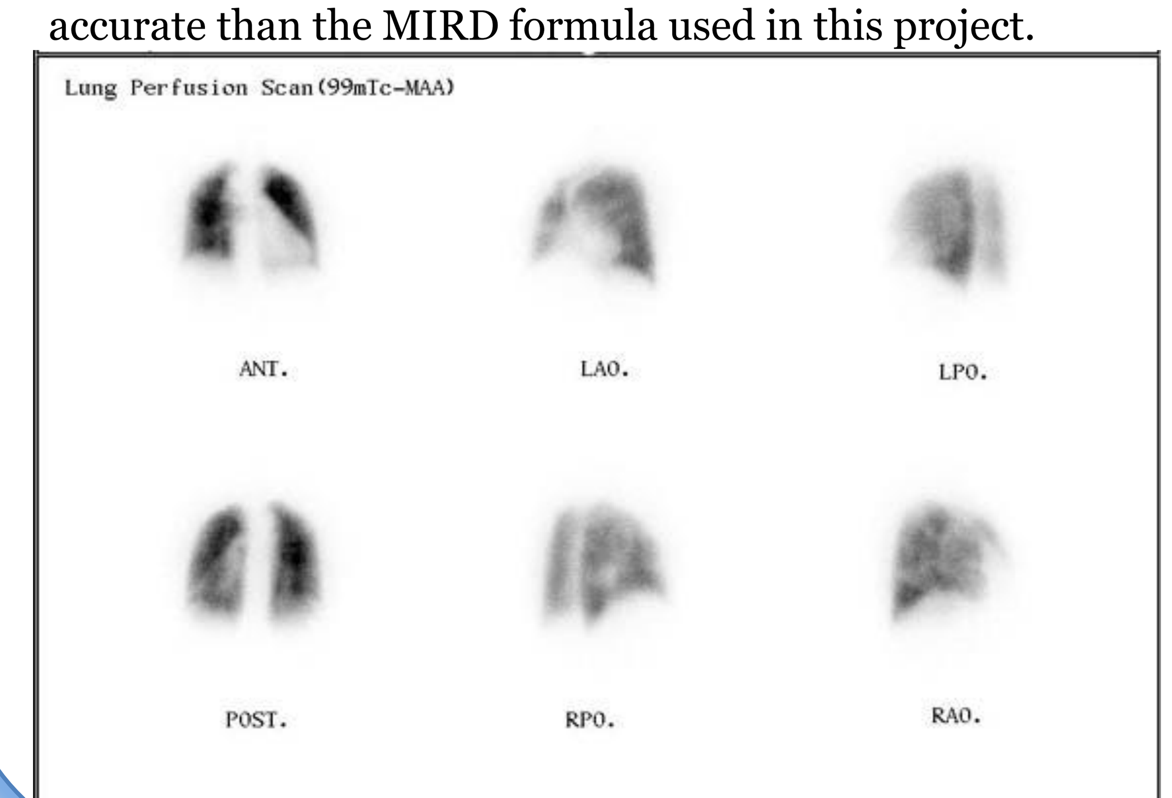
$$\lambda_e = \frac{.693}{1.2hr} = .5775$$

$$R_i \frac{rad}{hr} = \left(\frac{A_o}{m}\right) \Delta_i e^{-\lambda_e t} \phi_i (v \leftarrow r)$$

$$R_i \frac{rad}{hr} = \frac{2970\mu Ci}{1535.24g} * .0806 * e^{-.5775*0} = .156 \frac{rad}{hr}$$

Discussion

The MIRD formula has improved the accuracy of dosimetry calculations by reducing the number of assumptions needed to perform dosimetry calculations as opposed to the classic method of dosimetry (Early and Sodee 90). However, the MIRD formula has proved to be limited by other factors. One of these limitations is the coefficient of variation, "This is a statistical limitation. A coefficient of variation of 50% or greater represents the considerable uncertainty in the estimate of the absorbed fraction" (Early and Sodee 90). Other limitations include biological calculation factors such as "the kidney model is not divided into cortex and medulla, and the bladder and stomach are a fixed size" (Early and Sodee 90) and "the MIRD formula presupposes that the source is uniformly distributed within a standard-size organ, which is subject to much patient variation" (Early and Sodee 92). It is imperative to take these factors into account and that the dosimetrist should be knowledgeable of the assumptions and limitations (Early and Sodee 92). With the invention of more powerful computers and additional formulas to take limitations such as the coefficient of variation, organ size and shape, and the uniform distribution of the radionuclide dosimetry calculations have become far more accurate than the MIRD formula used in this project.



Conclusions

The project was successful in the calculation of the absorbed dose of radiation from the target organ and the initial dose rate. The calculated dose of radiation was $269.44 mrads$ and the calculated initial dose rate was $156\frac{mrads}{hr}$. This problem however, does not account for other dose contributions from other source organs to the target organ and only accounts for the dose contribution of the target organ to itself. These additional dose contributions would have proved negligible as the remaining 1% of uptake would have been distributed among the organs that ^{99m}Tc-MAA implants in. These organs would have included the kidneys, liver, ovaries or testes, and the whole body. Although negligible in this problem, future problems could account for these additional dose contributions from organs other than the target organ.

References

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