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A New Approach to Estimates Radiopharmaceutical Organ Dose in Human

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Abstract

Analysis of NMR water proton spin lattice relaxation (T1) with radiopharmaceutical Beta-methyl-p-I-123-iodophenyl-pentacanoic acid (I-123 BMIPP) organ doses in ORNL/MIRD phantom and GSF reference voxel male (RVM) phantom in 12 human organs yield a nice correlation of 0.84 and 0.79 respectively. Further correlation is established between I-123 BMIPP organ doses (Gy/Bq) with reference man organ weight yielding a correlation of 0.85 and 0.77 in 13 human organs in ORNL/MIRD and GSF RVM phantoms. This methodology provides a new approach to measure organ doses of therapeutic and diagnostic radiopharmaceutical in nuclear medicine by measuring the T1 of the organ or using organ weight.

Keywords: MIRD, BMIPP, Organ weight, T1, Radiation dose.

Introduction

In nuclear medicine, radiopharmaceuticals are employed for both diagnostic and therapeutic procedures. MIRD (Medical internal radiation dose), on the other hand is developed to estimate radiopharmaceutical radiation dose in human organs from administered radiopharmaceutical (1). Accurate dosimetry to estimate radiation doses to the human organs is of paramount importance in nuclear medicine (2, 3). It is therefore important to develop a patient-specific procedure such as age, body weight and gender difference and the measurement of radiopharmaceutical kinetics to estimate/assess radiation doses to human organs rather than to estimate from anthropomorphic phantoms using computer algorithm. (4, 5). Radiopharmaceuticals dose estimate using MIRD scheme have been reported for a number of radiopharmaceuticals (6-11). Uncertainties in internal dose calculation are, however, significant (6). Given the constraints of MIRD schemes and anthropomorphic phantoms, a new approach is presented here to estimate radiopharmaceuticals radiation dose to the human organs.

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Materials and Methods

Human organ doses for a radiopharmaceutical such as I-123 BMIPP (Beta-methyl-p-I-123-iodophenyl-pentacanoic acid) in MIRD-type mathematical anthropomorphic phantom of oak-ridge national laboratories (ORNL/MIRD Phantom) and GSF reference voxel male phantom are abstracted from the literature (7). The NMR water proton spin lattice relaxation time (T1) of normal human organs was measured by Damadian et al (11). And the organ weight of 70 kg reference man is abstracted from ICRP 27 (12). The data of T1, organ doses (Gy/Bq), organ weight is given in table 1.

Result

Analysis of T1 measurements in 12 human organ with corresponding organ doses (Gy/Bq) of I-123 BMIPP (Beta-methyl-p-I-123-iodophenyl-pentacanoic acid) on ORNL/MIRD phantom and also in reference voxel male (RVM) phantom yield a logarithmic correlation coefficients of 0.84 and 0.79 respectively (Figs. 1 and 2). Father correlation is established between 13 human organs of I-123 BMIPP organ doses (Gy/Bq) with corresponding organ weight of the 70 kg reference man using the best fit regression method yielding a linear correlation coefficients of 0.85 and 0.77 respectively (Figs. 3 and 4).

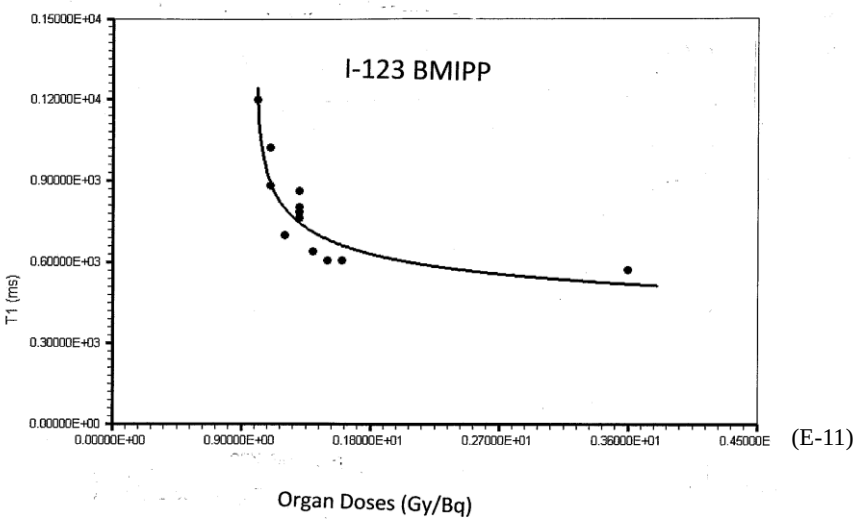

Figure 1. Correlation between NMR water proton spin lattice relaxation in 12 normal human organs and organ doses of I-123 BMIPP in ORNL/MIRD phantom.

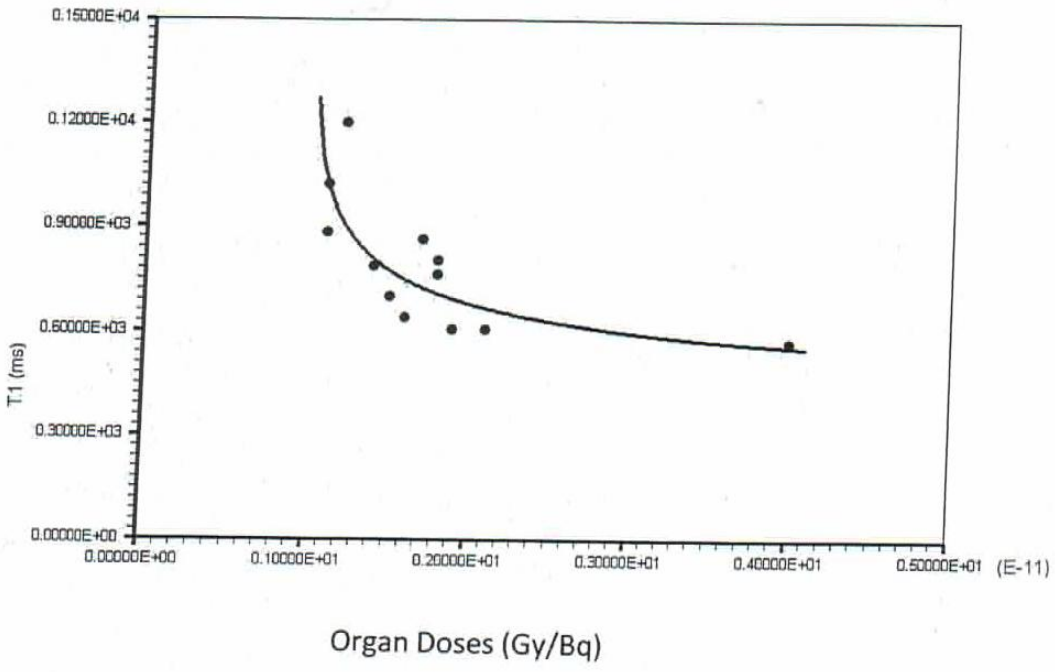

Figure 2. Correlation between NMR water proton spin lattice relaxation in 12 normal human organs and organ doses of I-123 BMIPP in GSF reference voxel male phantom.

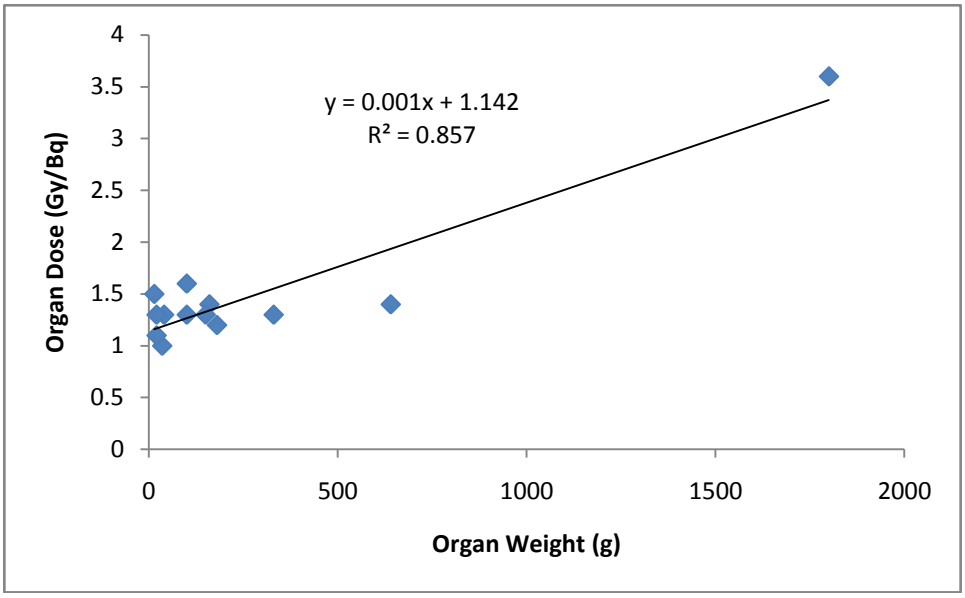

Figure 3. Correlation between organ doses of I-123 BMIPP in ORNL/MIRD phantom with 13 human organ weight of 70 kg reference man.

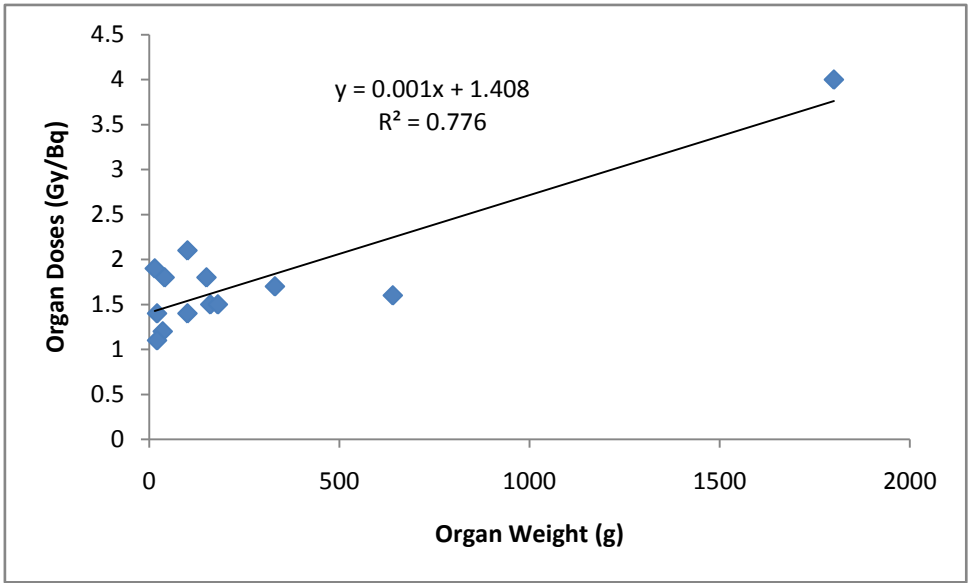

Figure 4. Correlation between organ doses of I-123 BMIPP in GSF reference voxel male phantom with 13 human organ weight of 70 kg reference man.

TABLE I

I-123 BMIPP radiopharmaceutical doses per activity along with NMR spin lattice relaxation time with organ weight in humans

Organs	I-123 BMIPP Dose per activity (7) (Gy/Bq) in ORNL/MIRD	Organ weight (g) (12)	I-123 BMIPP Dose/activity (7) (Gy/Bq) in RVM	T1 (ms) (11)
Colon	1.4 E-11	160	1.5 E-11	641
Testes	1.0 E-11	35	1.2 E-11	1200
Liver	3.6 E-11	1800	4.0 E-11	570
Lungs	1.3 E-11	1000	1.4 E-11	788
Esophagus	1.3 E-11	40	1.8 E-11	804
Stomach	1.3 E-11	150	1.8 E-11	765
Thyroid	1.1 E-11	20	1.1 E-11	882
Adrenals	1.5 E-11	14	1.9 E-11	608
Pancreas	1.6 E-11	100	2.1 E-11	605
Sm Intestine	1.4 E-11	640	1.6 E-11	641
Spleen	1.3 E-11	180	1.5 E-11	701
Kidneys	1.3 E-11	330	1.7 E-11	862
Thymus	1.3 E-11	20	1.4 E-11	

( ) number in parentheses refers to reference number.

Discussion

NMR water proton spin lattice relaxation time (T1) and the uptake of I -123 BMIPP is very much dependent on organ metabolism. Akber (13-16) has shown that T1 correlated with organ weight which in turn reflects the organ metabolism. Akbar (15) has also shown that radiation tolerance dose (TD50) correlate with T1. Further it has been shown that TD50 and T1 yield a linear relationship. Figs. 1 and 2 clearly reveal that as the organ increases in size and weight by assembling many cells of different functions, T1 decreases. Whereas organ doses of I-123 BMIPP increases. This is consistent with Akber (13-16) observations. Figs. 3 and 4 illustrate a very interesting feature. The yielding of a linear relationship between organ doses of radiopharmaceutical I-123 BMIPP and organ weight of 70 kg reference man is indeed interesting. As the organ weight increases, the radiation dose increases as well. The organ weight dictates the organ metabolism. The organ weight can easily be estimated using the body weight of the patient specific and multiply with 70 kg reference man which will yield the organ weight. The methodology presented in this paper will provide an estimate of organ doses of any radiopharmaceuticals (diagnostic and therapeutic alike) in humans. This procedure will eliminate the problem of

patient with different body weights, age, and gender difference.

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