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Investigating the Effect of Therapeutic Application of Radioactive Material on Human Blood Parameters

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Abstract
The hematopoietic system plays an important role in the life of mammals. Damage due to various radiations can lead to external, internal and anemia effect. The various cancers due to radioactive radiation also affects blood parameters. In this paper, the effect of intravenous iodine 131 in blood parameters has been investigated using MCNPX code and 4th order Runge Kutta method. The results indicate the dose rate absorbed in the whole ORNL phantom equivalent to the adult human due to intravenous injection of 1mCi iodine 131 is equal to 5×10^{-4} mSv/d. Therefor the percentage of changes in blood parameters as a function of the 131I activity injected between 15-1500 milligrams was also calculated using the 4th order Runge Kutta method. Also the percentage of stem cell population, immature cells and platelets in the range of 15-300 mCi of iodine activity injected for 2 days was between 5.93 and 6.79 and 6.795 respectively.

Keywords: Blood parameters, MCNPX, 4th order Runge Kutta, Iodine 131, ORNL, Thyroid

Introduction
Hematopoiesis is one of the most sensitive systems in the body[1-3]. Damage to this system by treating various diseases and cancers with ionizing and non-ionizing agents can lead to external and internal infections and anemia. Many mathematical models that examine the stages of production, transformation, and alteration of various blood cells are presented, which is followed by a subset of the blood equations according to the dose received from various nuclear and atomic sources. The production of blood cells from blood stem cells is considered as a multiparty mode.

Experimental
Preparation of the materials
In this system, stem cells become immature cells and subsequently become mature cells. At each stage of this transformation, a number of cells are damaged by natural processes, and some are also exposed to external radiation, or are generally lost. This model is used to describe the stages of production, reproduction and destruction of various types of blood cells such as platelets, and only biological coefficients vary for different types of cells[4,5]. The treatment of various cancers by using radioactive radiation affects blood parameters(blood parameters are Stem cells , immature cells and platelets that an immature cell can develop into all types of blood cells, including white blood cells, red blood cells, and platelets) and its equations. In order to investigate the radioactive radiation in cancer treatment on blood parameters, the effect of thyroid cancer therapy on intravenous injection of iodine 131 on blood parameters during the course of treatment using the MCNPX code and the 4th Runge–Kutta method are investigated. Runge–Kutta is a computational method for solving differential equations.4th Runge–Kutta method for Solving Differential Equations in Nuclear Physics and Health and etc has been used perviously. Also, the use of 4th Runge–Kutta method for solving equations of blood has also been reported. In this paper, we try to investigate the effect of thyroid cancer treatment using intravenous iodine 131 on blood parameters during the course of treatment using the MCNPX code 4th Runge–Kutta method.
Runge Kotta is a computational method for solving differential equations that have different orders. The 4th of order Runge Kotta has been used to solve differential equations in nuclear physics, health etc. Using of the 4th order Runge Kotta in solving blood equations has also been reported. This article tries to calculate the dose effect of thyroid cancer treatment by iodine 131 on blood parameters during the treatment period. The dose level was calculated using MCNPX code. This dose is put in the blood equations and the effect of dose on blood parameters was investigated by solving the blood equations by 4th order Runge Kotta method.

Results and discussion
In a decay of iodine 131, iodine intravenous iodine 131 is required for blood parameters according to the blood equation to the total dose rate. For this purpose, a volumetric iodine source 131 for phantom thyroid hormones ORNL is considered. The f6 tally was used for dosimetry calculation. For arrived to error level less than 1 percent, the 10^8 particle was run and simulated. The error was ± 0.0003.The output of the code indicates the total dosage of the whole body induced by a particle (photon). So, since 9 photons are emitted from iodine 131 in a decay, so the code output is multiplied at 9, indicating the remaining dose resulting from a decay. If

the activity of the swallowed iodine is equal to A, the dose remaining in A is multiplied. According to the calculations done by the ORNL phantom caused by a photon, the decay of iodine 131 accumulated in the thyroid is reported to be $D_1 = 3.72 \times 10^{-6}$ (1± 0.0003) in terms of MeV/g that must multiply to A(Bq) for total dose calculation. Considering the conversion factor of MeV to Joule, due to the release of iodine 131 in a decay of 9 photons, This dosage resulting from a decomposition of iodine 131 is as $D_1 = 5.33 \times 10^{-15}$. The radiation dose in whole body is $D = D_1 \times A$ that A is in terms of Bq. In this case, if A is in mCi, the dose-is $D = 1.97 \times 10^{-7} \times A$. For example, the dose for the 15-mCi activity was 2.95×10^{6} Gy, and for the 300 mCi activity is 5.91×10^{5} Gy. Due to the radioactive iodine penetration of the body, this radioactive material is excreted biologically and radioactive with a decay constant of $\lambda = 1 \times 10^{-5}$ / day. The accumulated dose absorbed in the body $\acute{D}$ is due to radioactive iodine intake to $\acute{D} = D / \lambda\ (1- e^{-\lambda t})$ that D is the result of the activity in whole body and **t** is time passed after iodine entering the body. If the time is five times as large as half life, the total absorbed dose in the body is equal to $\acute{D} = D / \lambda \times A$(for $\lambda = 1\times10^{-5}/S$, $D = 1.97\times 10^{-7} \times A$).The amount of accumulated dose absorbed in the body is $\acute{D} = D/\lambda = 1.97\times 10^{-2} \times A$ in terms of Gy. By using the conversion factor that is equal 1 for photon, this dose convert to Sv. The total accumulated cumulative dose resulting from 1 mCi iodine is 131 times that of 1.97×10^{-2}. The activity of iodine 131 in treating thyroid is between 15 and 300 (mCi). As a result, the cumulative dose rate absorbed is between 0.296-5.91Gy. Considering that the activity of iodine 131 in treating thyroid is between 15 and 300 (mCi),the amount of total accumulated leakage varies between 0.296 to 5.91, Concentration of blood parameters (stem cells, immature cells and adult cells) as a function of time, the time intervals of 2 days for activates 15, 150, and 300 mCi are calculated using the 4th order Runge-Kutta method and the results are shown in Table 1.

Table 1. The percentage of blood parameters varies over the 2-day intervals for various activities

	Percentage change after 2 days		
Activities	Stem cells	immature cells	adult cells (platelets)
15 mCi	0.1	0.35	0.35
150 mCi	3.02	3.46	3.46
300 mCi	5.93	6.79	6.79

Conclusions

In this paper, the effect of thyroid cancer treatment using intravenous iodine 131 in blood parameters has been investigated during the treatment using MCNPX code and 4th order Runge Kutta method. The simulation results indicate that the dose rate absorbed in the whole ORNL phantom equivalent to the adult human being due to intravenous injection of 1mCi iodine 131 is equal to 5×10^{-4} mSv/d. The results show that the percentage of stem cell population, immature cells and platelets in the range of 15- 300 mCi of iodine activity injected for 2 days was between 5.93 and 6.79 and 6.795 Percent respectively. The results show that thyroid treatment with iodine 131 does not have a significant effect on blood parameters.

References

[1] Munker R., Hiller E., Glass J., Paquette R. (Eds.).Modern Hematology, 2nd ed. Totowa, NJ:Humana Press 2007.

[2] Romanov J.A., Ketlinsky S.A., Antokhin A.I.Okulov V.B. Chalones and Regulation of Cell Division. Moscow: Meditsina, 1984 (Russian).

[3] Fedorov N.A. Normal Haemopoiesis and Its Regulation, 1st ed. Moscow: Meditsina, 1976 (Russian).

[4] Cucinotta FA, Manuel FK, Jones J, Iszard G, Murrey J, Djojonegro B, et al. Space radiation and cataracts in astronauts. Radiat Res, 2001, 156(5 Pt1):460-6.

[5] Smirnova, Olga A.. Environmental Radiation Effects on Mammals: A Dynamical Modeling Approach. Netherlands: Springer New York, 2010.