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Original Article

A novel approach to assess mean lethal radiation dose with water proton spin lattice relaxation times

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Abstract

The assessment of mean lethal radiation dose (D_0) in human organs, using multi-target and linear quadratic models, with water proton nuclear magnetic resonance spin lattice relaxation time yields a correlation coefficient of 0.90 and 0.82, respectively. Results of this study reveal that as the spin lattice relaxation time increases, the D_0 decreases.

Keywords

Mean lethal radiation doses; proton spin lattice relaxation times; multi-target model; linear quadratic model

INTRODUCTION

The efficacy of radiation treatment of cancer patients is inhibited by the lack of comprehensive knowledge of radiation effect for normal human organs. No comprehensive radiation sensitivity data are available for normal human organs. The cell population kinetic parameters derived from either the multi-target or linear quadratic models are not readily available. The spin lattice relaxation time (T1) of water protons varies from organ to organ in all species. This variation within the organ may be due to changes in the physiological state of the organism. It is generally argued that the water content of the organ is responsible for the observed changes in T1.[1] Many investigators have observed that the T1 changes cannot be correlated with water content.[1] Akber[2] showed that the T1 is very much influenced by the weight of the organ in all species. Akber[3,4,5,] also showed that radiation tolerance dose (TD50) and mean lethal radiation dose (D_0) correlates well with organ weight in humans. As both the T1 and TD50 dose are dependent on organ weight,[4,5] it is interesting to assess the D_0 for radiation injury of normal human organs with the water proton nuclear magnetic resonance (NMR) T1. It is important to note that as the T1 value decreases, D_0 increases.

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MATERIALS AND METHODS

Cohen[6] has reported D_0 using the multi-target model and linear quadratic model for few human organs (Table 1). These mean lethal radiation doses are computed for the patients of different age, sex, and body weight as well as organ weight. Cohen,[7] in personal communication, had provided us the values of D_0 for different organs, such as skin, spine, lung,

Table 1. Mean lethal radiation dose along with spin lattice relaxation times of water protons and organ weights in human.

Organs	Mean lethal dose (D_0) (Gy) Multi-target model	Mean lethal dose (D_0) (Gy) linear quadratic model	Water proton spin lattice relaxation times (ms)	Organ weight (g)
Skin	1.26	2.76	616 ± 19	2600.00
Lung	1.24	3.41	788 ± 63	1000.00
Gut	1.68	4.28	641 ± 80	0090.00
Brain	1.20	4.92	998 ± 16	1400.00
Kidney	1.47	2.32	862 ± 53	0310.00
Stomach	1.76	4.00	765 ± 75	0150.00

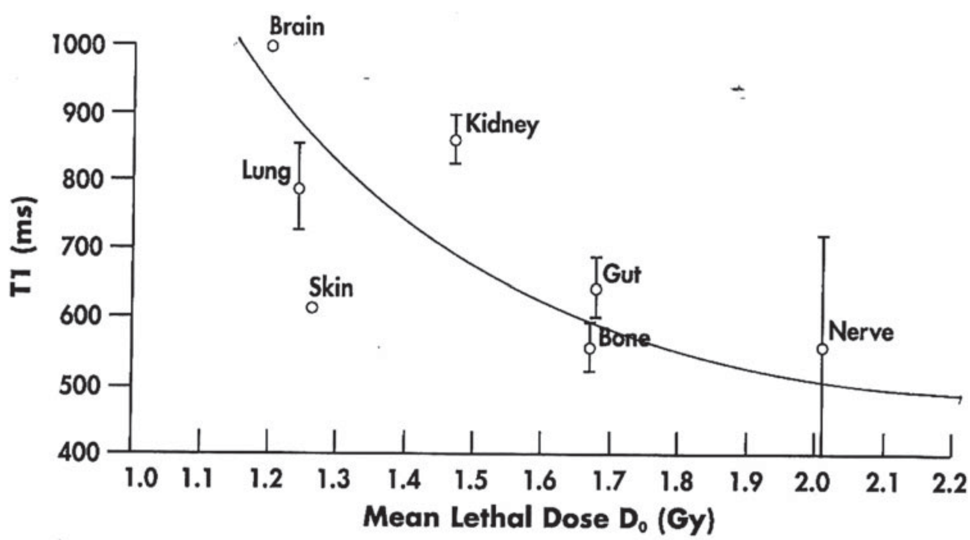

Figure 1. Correlation between mean lethal radiation dose (single hit multiple target model) and water proton nuclear magnetic resonance (NMR) spin lattice relaxation times in human organs.

and gut, whereas D_0 for brain and kidney were extracted from his published works. The water proton T1 values of normal human tissues are abstracted from Damadian et al.[8] and are given in Table 1.

RESULTS

An assessment of mean lethal radiation doses both from the multi-target and linear quadratic models with water proton NMR T1 yield a correlation of 0.90 and 0.82, respectively. It is interesting to note that as D_0 increases in both models, the T1 value decreases (Figures 1 and 2).

DISCUSSION

It has been shown that the D_0/TD50 is dependent on organ weight.[2,3] It also appears that as the D_0 increases, water proton T1 decreases as well. It is, however, important to realize that many physiologic functions such as heat loss and oxygen diffusion from the blood to the tissue across the capillary walls are indeed functions of the tissue organization. The most important contributing factor in the increase in organ weight is water content. The dissolved oxygen in cell water determines both the rate of metabolism and radio sensitivity. Therefore, the overall metabolism cannot be independent

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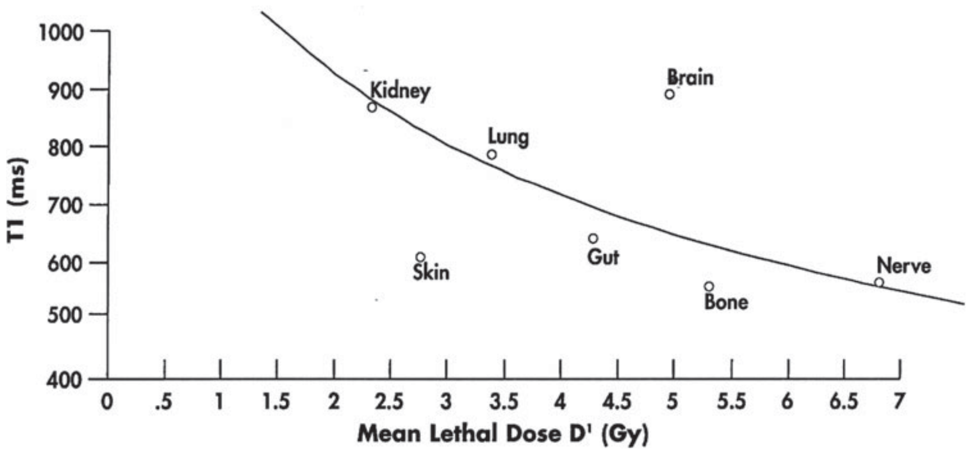

Figure 2. Correlation between mean lethal radiation dose (linear quadratic model) and water proton NMR spin lattice relaxation times in human organs.

of tissue organization/organ weight, neither is the mean lethal dose nor the water protons T1. At present, we do not have any reliable technique to assess the onset of radiation injury. Most often, radiation injury is assessed after the irreparable damage to the organ has taken place. It appears that changes (variation) in T1 value during or after radiation treatment may provide a sensitive index to evaluate the onset of radiation damage. However, it would be worthwhile to investigate this concept for different human organs to get applicable results in radiation oncology. Animal models would also be very helpful in providing an insight to the present approach.

References

1. Akber SF. Water proton relaxation times of pathological tissues. Physiol Chem Phys Med NMR 2008; 40:1–42.
2. Akber SF. Is spin lattice relaxation time independent of species?. Med Hypotheses 1996; 47:101–105.
3. Akber SF. Organ weight: a new tissue parameter to assess water proton spin-lattice relaxation time. Med Hypotheses 1997; 48:71–75.
4. Akber SF. Correlation of radiation tolerance dose of normal human organs with organ weight, blood, and water content. Am J Clin Oncol 2000; 23:345–348.
5. Akber SF, Kehwar TS. Correlation between mean lethal dose and organ weight. J Radioth Pract 2009; 8:163–164.
6. Cohen L. Biophysical models in radiation oncology. CRC publication, 1983.
7. Cohen L. The best find values of mean lethal radiation dose for skin, spine, lung, gut. Personal Communication, 1997.
8. Damadian R, Zaner K, Hor D, DiMaio T. Human tumors detected by nuclear magnetic resonance. Proc Natl Acad Sci USA 1974; 71:1471–1473.