Late Effect of Radiation on Blood Clearance of ^{99m}Tc Sodium Pertechnetate

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The late effect of gamma radiation on blood clearance of ^{99m}Tc -sodium pertechnetate (^{99m}Tc -SP) in rats was examined.

The disappearance rate of ^{99m}Tc -SP from blood decreased with the increase in dose of ionizing radiation. Changes of the blood clearance of ^{99m}Tc -SP after irradiation treatment in rats may be influenced by the disorder in the hepatocytes rather than in the bile ductule cells. The blood clearance test of ^{99m}Tc -SP in rats showed a sensitive reaction for the acute hepatic dysfunction induced by gamma radiation.

Key Words : technetium-99m-sodium pertechnetate, blood clearance, gamma radiation, hepatic dysfunction, rat

1. Introduction

^{99m}Tc -Sodium pertechnetate (^{99m}Tc -SP) is a radio-active substance which has been widely used for patient diagnosis¹⁾. In addition, since ^{99m}Tc decays by isomeric transition with a physical half life of 6.01 h and emits single γ -ray at 140.5 keV²⁾ can be treated in safety and makes it easy to handle the radioisotope-treated animals. Then we have attempted to study the effect of gamma radiation on blood clearance of ^{99m}Tc -SP for the evaluation of hepatic dysfunction in albino rats. In previous study reported that the blood clearance test of ^{99m}Tc -P was one of more sensitive methods for evaluation of hepatic dysfunction in rats, equally to or rather than the serum transaminase test or the histological test³⁾.

The purpose of this work is to study the blood clearance of ^{99m}Tc -SP for evaluation on hepatic dysfunction in rats were subjected to different gamma irradiation doses under anaesthesia with ether, the relation between the blood clearance of ^{99m}Tc -SP and the severity of hepatic dysfunction was examined.

2. Material and Methods

Eighty four premature albino rats were used in this experiment 42 male, 42 female and kept under optimal conditions (temperature, diet, light.....). All of them of the same age group 50–58 days. Animals of each group were randomly assigned to one of six subgroups for treatment with a single dose of either 0, 5, 10, 15, 20, 25 Gy on cobalt 60 unit each subgroup comprised seven rats. The whole rat body was irradiated, except head that was shielded with lead plate 7 cm thickness and the rats were anaesthetized with ether during irradiation, also the control subgroups were given the same dose of ether. ^{99m}Tc -SP was diluted with sterilized isotonic saline to give a solution suitable for injection.

By the use of the decay tables for ^{99m}Tc , the decay of the stock could be known. Accurate physical correction calculations was done before injecting any rat. The dose given was in the range of 1.85–5.55 MBq (50–150 μCi)/0.1 ml/100 g, and about 0.25 ml of blood sample was collected each time 5, 10, 15, 20, 30, 45

and 60 min after the administration. An amount of 0.2 ml was accurately picked up out of the blood and counted. Counting was carried out using an extended range high purity germanium detector for the purpose of calculation of ^{99m}Tc -SP level in blood. Since two-phase change was observed in ^{99m}Tc -SP concentration in blood after intravenous injection of ^{99m}Tc -SP, the blood clearance rate of ^{99m}Tc (K) was calculated from the first phase and second phase of the clearance curve, respectively⁴⁾. The K -values from the first phase was obtained from the values of blood level at 5 and 10 min after the injection of ^{99m}Tc -SP, and the K -values from the second phase were obtained from the values at 30, 45 and 60 min.

The K -value was calculated from the following formula:

$$K = 2.303 \times (\log C_1 - \log C_2) / (t_1 - t_2) \\ = \frac{0.693}{T_{1/2}}$$

where: C_1 and C_2 are the concentration of ^{99m}Tc -SP at times t_1 and t_2 , respectively.

Every seven rats were sacrificed at 30 min, 1, 1.5, 6, 12, and 24 h after intravenous injection of ^{99m}Tc -SP to measure the radioactivity of the organ samples. Organ distribution of ^{99m}Tc -SP per organ (% of the administered dose per whole organ).

3. Results and Discussion

Blood clearance of ^{99m}Tc -SP was determined after each dose administration. At each dose, ^{99m}Tc -SP concentration in blood rapidly decreased for the first 10 min, and slowly later on, that is, two-phase change was observed in level. Although there was a tendency to rise with the increase in irradiation dose. Both C_0 (the level at time=0) and $T_{1/2}$ grew from 3 500 cpm/ml (control) to 15 690 cpm/ml (25 Gy) and from 5.6 min (control) to 13.1 min (25 Gy) as the dose level of gamma-ray was in-

creased. Therefore, the K -value decreased to about a 43%, from 0.123 (control) to 0.053 (25 Gy) with the increase of irradiation dose level. A significant decrease was observed in the K -value compared with the control at each irradiation dose level. (Fig. 1, Table 1). Though it is well known that this seems to be a direct result of damage effect of the acute irradiation syndrome in the form of acute myositis mainly on the organ cell biology leading to cellular damage, *via* action on its protoplasm, nucleic acids and enzymes by changing the ionic radicals $\text{H}^\cdot$ and $\text{OH}^{+\cdot}$, and may be influenced by the disorder in the hepatocytes rather than in the bile ductule cells. As shown in Fig. 2, a major part of ^{99m}Tc -SP administered intravenously was taken up into liver while the remainder of small amount into the spleen, kidneys, and lung. Though the uptake ratios into the liver, spleen, and

Fig. 1 Relation between blood clearance of ^{99m}Tc -SP and dose of irradiation.

Table 1 Relation between blood clearance of ^{99m}Tc and subgroup dose

Subgroups doses (Gray)	C_0 (CPM/ml)*	C_{10} (CPM/ml)	$T_{1/2}$ (min)	K Mean value $\pm$ S.D.
0	3 560	1 070	5.6	0.123 ± 0.010
5	3 800	1 415	7.1	0.097 ± 0.008
10	4 230	1 741	7.8	0.089 ± 0.009
15	5 500	2 430	8.5	0.082 ± 0.009
20	11 730	6 260	11	0.063 ± 0.006
25	15 690	9 200	13.1	0.053 ± 0.006

* count per minute/milli litre

Fig. 2 Organ distribution of radioactivity after intravenous injection ^{99m}Tc -SP.

lung decreased with the passage of time, that into the kidneys showed a tendency to increase.

In addition, the disappearance rate of ^{99m}Tc -SP from blood flow and the whole circulating blood volume⁶. Therefore, the blood clearance of ^{99m}Tc -SP as represented by K -value reflects hepatic function in a broad sense. In this study, the K -values were determined from the first phase of the clearance curve, since significant changes with the increase in the dose of irradiation.

From these findings, it would be concluded that the effect of radiation play an important role on the blood clearance test of ^{99m}Tc -SP which is one of more sensitive methods for evaluation of hepatic dysfunction in laboratory animals.

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要 旨

放射線の晩発影響による過テクネチウム酸ナトリウム ($^{99m}\text{Tc-SP}$) の血液クリアランスの低下

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γ 線照射の晩発効果をラットについて $^{99m}\text{Tc-sodium pertechnetate}$ ($^{99m}\text{Tc-SP}$) の血液クリアランスについて調べた。 $^{99m}\text{Tc-SP}$ 血液からの消退率は、照射線量が増大すると減少した。ラット照射後の $^{99m}\text{Tc-SP}$ の血液クリアランス変化は肝細胞内の変化より胆道細胞に影響される。ラットの $^{99m}\text{Tc-SP}$ 血液クリアランス検査は γ 線照射による急性肝障害に対して感受性高い反応を示した。