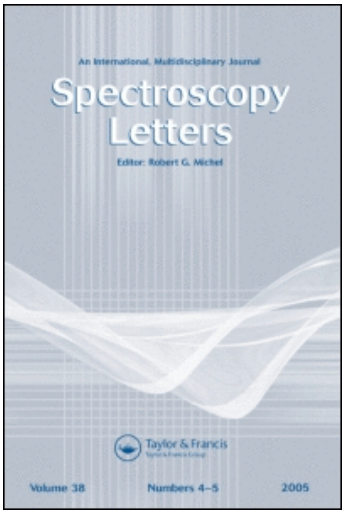

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Effects of Dynamic Renal Scintigraphy and Bone Scintigraphy Studies on Oxidative Damage in Patients

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ABSTRACT The aim of this study was to investigate gamma radiation–induced oxidative damage in erythrocytes after dynamic renal scintigraphy with 370 MBq Tc-99m diethylene trimine pentaaceticacid (DTPA) and bone scintigraphy with 740 MBq Tc-99m methylene diphosphonate (MDP). Thirty patients who performed dynamic renal scintigraphy (15 patients) and bone scintigraphy (15 patients) were included in this study. The median ages were 50 ± 7 years (range, 21–69 years) and 55 ± 8 years (range, 34–78 years) for dynamic renal scintigraphy and bone scintigraphy, respectively. The blood samples were taken from patients just before, 1 h after, and 3 h after injection of the radiopharmaceutical. Malondialdehyde (MDA) and antioxidant enzymes such as glutathione peroxidase (GPX), superoxide dismutase (SOD), and catalase (CAT) levels were measured to evaluate the gamma radiation–induced oxidative damage. The enzyme activities of CAT were decreased 1 and 3 h after injection of the radiopharmaceutical in both groups ($p < 0.05$). In both groups, the enzyme activities of SOD and GPx were decreased 1 and 3 h after injection of the radiopharmaceutical, respectively. MDA levels were increased 3 h after ($p < 0.05$) injection of the radiopharmaceutical in both groups.

KEYWORDS Bone scintigraphy, dynamic renal scintigraphy, free radicals, ionizing radiation, oxidative stress

INTRODUCTION

Ionizing radiation is known to induce oxidative stress through generation of reactive oxygen species (ROS) resulting in imbalance of antioxidant activities ultimately resulting in cell death.[1]

Cells have developed a defense against ROS—the antioxidant system—which includes enzymatic and nonenzymatic components.[2] The antioxidant system consists of low-molecular-weight antioxidant molecules such as glutathione (GSH), melatonin, and various antioxidant enzymes.[3,4]

Lipid peroxidation is considered to be a critical event of ionizing radiation effect.[5] Malondialdehyde (MDA), an end product of lipid peroxidation, has been used as an index of oxidative damage.[6]

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The aim of this study was to investigate gamma radiation–induced oxidative damage in erythrocytes after dynamic renal scintigraphy with 370 MBq Tc-99m diethylenetriamine pentaacetic acid (DTPA) and bone scintigraphy with 740 MBq Tc-99m methylene diphosphonate (MDP).

MATERIALS AND METHODS

The study was approved by the ethics committee of our hospital. MDA and several antioxidant enzymes such as glutathione peroxidese (GPX), superoxide dismutase (SOD), and catalase (CAT) were measured to evaluate gamma radiation–induced oxidative damage.

The blood samples were taken from patients before, 1 h after, and 3 h after injection of the 370 MBq Tc-99m DTPA and 740 MBq Tc-99m MDP.

MDA was determined by the double heating method of Draper and Hadley.[7] The activities of SOD,[8] GPX,[9] and CAT[10] were measured by previously described methods. An autoanalyzer, Abbott Aeroset (Abbott Park, IL, USA), was used to determine the activities of SOD and GPX, and a spectrophotometer, Shimadzu UV-1601 (Kyoto, Japan), was used to estimate MDA and CAT. The details of the measurements can be found in our published article.[11]

Statistical Analysis

Fifteen patients (5 women and 10 men) who had dynamic renal scintigraphy with 370 MBq Tc-99m DTPA and 15 patients (8 women and 7 men) who had bone scintigraphy with 740 MBq Tc-99m MDP were included in our study. The median ages were 50 ± 7 years (range, 21–69 years) and 55 ± 8 years (range, 34–78 years) for dynamic renal scintigraphy and bone scintigraphy, respectively.

Data were analyzed using the statistical package SPSS for Windows (ver. 9.05: SPSS Inc., Chigago, IL). Results were expressed as mean ± SD. Statistical significance was set at the 0.05 level. Differences within the same group were tested by repeated measures analysis of variance (ANOVA) as all are time-dependent data.

RESULTS

Results are tabulated in Table 1 for the dynamic renal scintigraphy group. The enzyme activities of SOD were decreased 1 h after ($p = 0.288$) but increased 3 h after ($p = 0.136$) injection of the radiopharmaceutical. The enzyme activities of GPX were increased 1 h after but decreased 3 h after (respectively $p = 0.208$, $p = 0.320$) injection of the radiopharmaceutical. The GPx activities changes are not significant compared with the before-radiopharmaceutical group. The enzyme activities of CAT were decreased 1 and 3 h after (respectively $p = 0.000$ and $p = 0.001$) injection of the radiopharmaceutical. MDA levels were increased 1 h after and 3 h after (respectively $p = 0.321$ and $p = 0.006$) injection of the radiopharmaceutical.

Results are tabulated in Table 2 for the bone scintigraphy group. The enzyme activities of SOD were decreased 1 h after ($p = 0.004$) but increased 3 h after ($p = 0.025$) injection of the radiopharmaceutical. The enzyme activities of GPX were decreased 1 h and 3 h after (respectively $p = 0.041$, $p = 0.041$) injection of the radiopharmaceutical. The enzyme activities of CAT were decreased 1 and 3 h after (respectively $p = 0.010$ and $p = 0.016$) injection of the radiopharmaceutical. MDA levels were decreased 1 h after and increased 3 h after (respectively $p = 0.524$ and $p = 0.010$) injection of the radiopharmaceutical. The decrease in MDA levels is not significant 1 h after injection of the radiopharmaceutical. According to our results, ionized radiation affects MDA levels and enzyme activities.

TABLE 1 MDA and Antioxidant Levels (Ort ± Sd) for Dynamic Renal Scintigraphy

N = 15	MDA (nmol/mgHb)	SOD (U/g Hb)	GPX (U/g Hb)	CAT (k/g Hb)
Before radiopharmaceutic	67,98 ± 11,76	2006,59 ± 305,87	69,165 ± 23,085	58,03 ± 20,75
1 hour after radiopharmaceutic	71,28 ± 11,11	1920,55 ± 188,01	76,364 ± 20,367	26,59 ± 10,30[a]
3 hour after radiopharmaceutic	79,35 ± 16,20[a]	2133,46 ± 96,67[b]	60,896 ± 18,453[b]	35,94 ± 9,90[a,b]

[a] $p < 0.05$ compared to before radiopharmaceutical group.
[b] $p < 0.05$ compared to 1 hour after radiopharmaceutical group.

TABLE 2 MDA and Antioxidant Levels (Ort ± Sd) for Bone Scintigraphy

N = 15	MDA (nmol/mgHb)	SOD (U/g Hb)	GPX (U/g Hb)	CAT (k/g Hb)
Before radiopharmaceutic	65,33 ± 16,65	2006,04 ± 436,47	83,220 ± 24,958	51,18 ± 20,49
1 hour after radiopharmaceutic	47,59 ± 22,94	1655,17 ± 337,92[a]	79,882 ± 17,372[a]	48,73 ± 15,85[a]
3 hour after radiopharmaceutic	91,09 ± 21,89[a,b]	2630,71 ± 616,84[a,b]	77,198 ± 22,840[a]	35,41 ± 14,08[a]

[a] $p < 0.05$ compared to before radiopharmaceutical group.
[b] $p < 0.05$ compared to 1 hour after radiopharmaceutical group.

DISCUSSION

Free radicals react with cellular macromolecules resulting in cellular dysfunction and mortality.[1] It is known that ionizing radiation generates hydroxyl radicals in cells and induces cell damage.[12] Oxidative damage can lead to radiation-induced chromosomal damage and gene mutations if overproduction of ROS occurs.[13]

Exposure to ionizing radiation produces significant alterations in oxidant activity.[14] SOD, CAT, and GPX are capable of scavenging ROS.[15]

Srinivasan et al. observed a decrease in the activities of SOD, CAT, and GPX in gamma-irradiated hepatocytes. They reported that this decrease could be due to a feedback inhibition or oxidative inactivation of enzyme protein caused by ROS generation.[1]

Sabitha and Shyamaladevi[16] reported that activities of erythrocyte SOD, CAT, and GPX enzymes were significantly lower after radiotherapy than before radiotherapy in their study. This suggests that ionizing radiation causes enzyme deficiencies, arising as a result of enormous production of free radicals in the system. Lee et al.[17] reported that SOD was an important antioxidant protein in the protection of yeast cells against ionizing radiation.

Lipid peroxidation was found to increase with increase in radiation dose in rat.[18] Greenstock[19] reported that ionizing radiation increased the level of MDA. In agreement with these results, we found that gamma radiation increases erythrocyte MDA levels 3 h after injection of the radiopharmaceutical in both groups.

Nikishkin et al.[20] reported that levels of enzymatic and nonenzymatic antioxidants decrease after irradiation. SOD and GPX each play a role in the antioxidant defense system, but their response to radiation is unclear. Gren et al.[21] found that radiation did not significantly affect GPX activities in the long term, and Kaya et al.[22] reported that GPX activities were not decreased significantly after irradiation compared with that of sham controls.

In our previous study,[11] we investigated gamma radiation–induced oxidative damage in erythrocytes after thyroid scintigraphy with Tc-99m pertechnetate. We reported that the activities of GPX are not different in the before-radiopharmaceutical and after-radiopharmaceutical groups. The enzyme activities of CAT were decreased 1 and 3 h after injection of the Tc-99m pertechnetate. The enzyme activities of SOD were found increased in 1st hour samples and decreased in 3rd hour samples. MDA levels were decreased 1 h after and increased 3 h after injection of the radiopharmaceutical in our previous study.[11] Although ionizing radiation effects are not well known, the amount of radioactivity can affect the results of enzyme activities.

In the dynamic renal scintigraphy group, the enzyme activities of CAT were decreased 1 and 3 h after injection of the radiopharmaceutical ($p < 0.05$). The enzyme activities of SOD were found decreased in 1st hour samples ($p > 0.05$) but increased in 3rd hour samples ($p > 0.05$). MDA levels were increased 1 h after ($p > 0.05$) and 3 h after ($p < 0.05$) injection of the radiopharmaceutical.

In bone scintigraphy group, the enzyme activities of CAT and GPX were decreased 1 and 3 h after injection of the radiopharmaceutical ($p < 0.05$). The enzyme activities of SOD were found decreased in 1st hour samples ($p < 0.05$) but increased in 3rd hour samples ($p < 0.05$). MDA levels were decreased 1 h after ($p > 0.05$) and increased 3 h after ($p < 0.05$) injection of the radiopharmaceutical.

Klucinski et al. measured erythrocyte activities of SOD, CAT, and GPX in 45 workers from X-ray departments and in 30 persons who constituted the control group. They observed the erythrocyte activities of SOD, CAT, and GPX. A significant decrease

of GPX, SOD, and CAT activity in workers compared with that of controls was observed. In this study, our results are similar to those of Klucinski's report.[23]

In conclusion, it is known that ionizing radiation affects the cells by increasing the levels of free radicals. On the other hand, the effects of nuclear medicine studies on free radicals are not clear. In this study, we found that radiation due to dynamic renal scintigraphy and bone scintigraphy applications decreased the erythrocyte antioxidant levels and increased MDA levels 3 h after injection of the radiopharmaceutical.

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