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Original Article

# Evaluation of oxidative stress in angiography workers

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**Abstract**

**Aim:** In this study, we wanted to investigate the oxidative stress level and some antioxidant parameters in angiography workers exposed to high dose x-ray.

**Material and Methods:** The study included 47 angiography workers and 50 healthy control group. Some antioxidant parameters (superoxide dismutase, catalase, and reduced glutathione) and levels of malondialdehyde, which is a marker of oxidative stress, were measured in the blood samples of all participants.

**Results:** There was a significant increase in oxidative stress marker MDA levels and a significant decrease in antioxidant enzyme (superoxide dismutase, catalase and reduced glutathione) levels in all individuals of the study group compared to the control group ($p<0.001$ for all).

**Conclusion:** Our results indicated that oxidative stress level increased and some antioxidant enzyme levels (superoxide dismutase, catalase and decreased glutathione) decreased in angiography workers exposed to long-term high-dose ionized radiation. We have linked this to the oxidant-antioxidant balance disorder caused by increased free radicals due to ionizing radiation, as noted in the literature.

**Keywords:** Angiography workers; antioxidants; ionizing radiation; malondialdehyde

## INTRODUCTION

X-ray is defined as ionizing radiation (IR). IR can directly transfer energy to molecules such as DNA and enzymes in living tissues and indirectly may act through radiolysis of water, thereby generating reactive oxygen species (ROS) that may react with other molecules (1,2).

Oxidative stress is defined as increased ROS production during cellular metabolism and an imbalance between pro-oxidants and antioxidants due to insufficient antioxidants. Increased ROS production can damage intracellular lipids, proteins, and DNA, thereby resulting in oxidation. Oxidative damage occurring is tried to be prevented and eliminated by antioxidant defense systems (3).

In addition to patients, healthcare professionals including physicians, nurses, radiology technicians, and other staff employed in angiography units and operating rooms are exposed to radiation during diagnostic and treatment processes. Especially during angiography, there is high dose radiation exposure. Our aim is to investigate the effect of high dose radiation exposure on oxidative stress level and some antioxidant parameters in angiography workers and compare them with healthy subjects.

## MATERIAL and METHOD

This prospective study was approved by the Institutional Ethics Committee (13.02.2019/05). The procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration. The study included a group of 47 healthcare workers who had been working in angiography unit for the past one year and a control group of 50 healthy volunteers. Angiography workers include 2 radiology doctors, 15 cardiology doctors, 13 radiology technicians, 15 nurses and 2 operating room personnel. An informed consent was obtained from each participant in both groups. Exclusion criteria included pregnancy, alcohol abuse, a history of smoking and chronic drug use, and the presence of chronic or neoplastic diseases and active infections.

### Collection and analysis of blood samples

Blood samples were obtained from each participant in both groups after a minimum of an 8-h fasting period between 8 am to 9 am. Blood samples taken from the brachial vein were centrifuged at 4000 rpm for 10 minutes and the serums were separated. Serum samples were stored at -80 °C and then analyzed to measure levels of

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superoxide dismutase (SOD), catalase (CAT), reduced glutathione (GSH), and malondialdehyde (MDA).

### Determination of SOD activity

SOD levels were determined using the method proposed by Popov et al. In this method, the superoxide radicals generated by nitro blue tetrazolium (NBT) are inhibited by the SOD available in serum samples. The total SOD activity was expressed as U/ml, where one unit is equivalent to the SOD activity that causes 50% inhibition of NBT reduction (4).

### Determination of CAT activity

CAT levels were determined using the method proposed by Aebi et al. and the enzyme activity was determined using hydrogen peroxide as the substrate. Total CAT activity was evaluated by reading absorbance at 240 nm and was expressed as U/L (5).

### Measurement of GSH levels

GSH levels were measured based on the reduction of (5',5'-(2- dithiobis nitrobenzoic acid) (DTNB) by sulfhydryl groups into a yellow derivative. Absorbance readings were performed spectrophotometrically at 412 nm. GSH concentration was expressed in mmol/g of protein (6).

### Measurement of MDA levels

MDA levels were measured spectrophotometrically using thiobarbituric acid reaction. Absorbance readings were performed at 532 nm. Total MDA activity was expressed as µmol/L (7).

### Statistical analysis

Data were analyzed using SPSS for Windows version 19.0 (IBM SPSS Inc., Armonk NY, USA). Descriptives were expressed as mean ± standard deviation (SD). Group comparisons were made using the t test on normal distribution data and the Mann-Whitney-U test on non-normal distribution data. A value of $p<0.05$ was considered significant.

## RESULTS

The study group comprised a total of 47 healthcare workers, including 42 (89.4%) men and 5 (10.6%) women with an average age of 34.9 (range 21-48) years. The control group included a total of 50 healthy volunteers, including 45 (90%) men and 5 (10%) women with an average age of 35.7 (range 22-47) years. Table 1 shows the SOD, CAT, GSH, and MDA values measured in both groups. In the study group, the SOD, CAT and GSH values were significantly lower and the MDA values significantly higher than in the control group ($p<0.001$ for all) (Table 1, Figure 1). In angiography, working times ranged from 1 to 18 years, and there was no relationship between working times and changes in parameters.

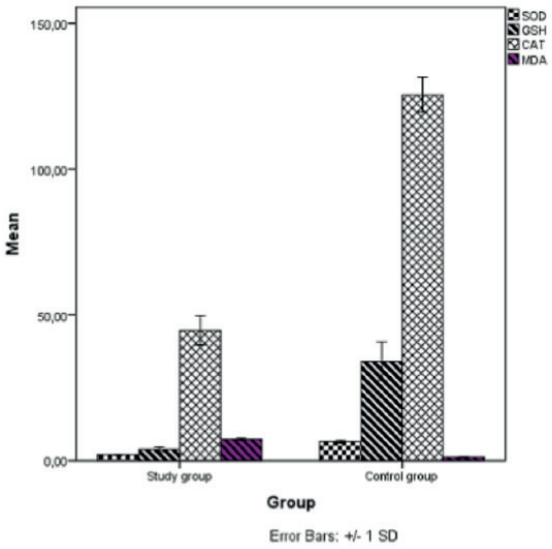


**Figure 1.** Increased MDA levels and decreased SOD, CAT and GSH levels in angiography workers compared to control subjects

**Table 1. SOD, CAT, GSH, and MDA levels**

| | Group | n | Mean±Std. Deviation | p |
|---|---|---|---|---|
| **SOD** | Angiography workers | 47 | 2.0147±0.06893 | <0.001 |
| (U/mL) | Control | 50 | 6.3948±0.41890 | |
| **CAT** | Angiography workers | 47 | 44.6170±5.00644 | <0.001 |
| (U/L) | Control | 50 | 125.5380±5.87144 | |
| **GSH** | Angiography workers | 47 | 3.7511±0.70799 | <0.001 |
| (mmol/gpr) | Control | 50 | 33.9960±6.62414 | |
| **MDA** | Angiography workers | 47 | 7.2532±0.38139 | <0.001 |
| (µmol/L) | Control | 50 | 1.2048±0.09281 | |

CAT: Catalase, GSH: Reduced Glutathione, MDA: Malondialdehyde, SOD: Superoxide Dismutase

## DISCUSSION

In this study, the presence of oxidative stress and antioxidant response in angiography workers were investigated. The results of our study group showed that when compared to the control group, MDA, an oxidative stress marker, increased ($p<0.001$) and some antioxidant enzymes (SOD, CAT, GSH) decreased ($p<0.001$).

X-ray, i.e. IR, causes increased ROS production in living organisms. ROS production increases during or within a few minutes or hours after radiation exposure, leading to

oxidative damage to macromolecules such as DNA, lipids, and proteins. A great portion of the damage occurs during the acute phase of exposure. In later phases, the increase in ROS production continues and the resultant oxidative damage may persist for months (8,9). Although the molecular mechanisms explaining the biological effects of IR in living tissues are not fully explained yet, the most appropriate hypothesis is the disruption of the oxidant-antioxidant balance due to the increase of free radicals (10,11).

Lipid peroxides that result from the effect of ROS on the lipids in cell membranes convert to aldehydes such as MDA. MDA is an end-product of lipid peroxidation and a key marker of oxidative stress (12). Living organisms develop an antioxidant defense mechanism against the harmful effects of ROS. Antioxidants work by inhibiting ROS production and eliminating the harmful effects of the resulting ROS. Commonly known antioxidants include reduced GSH, glutathione peroxidase (GPO), glutathione reductase (GPO), glutathione S transferase (GST), SOD, and CAT (13,14). All of our cases in the study group had been working in angiography for the past one year and were exposed to x-ray intensively. We linked our results to the oxidant-antioxidant balance disorder caused by increased free radicals due to intense x-ray exposure, similar to the literature (10,11).

There are studies in the literature where similar results are obtained with our study. Al-Helaly et al. evaluated diagnosis workers exposed to radiation and reported that the increased radiation exposure in these workers led to decreased antioxidant levels and eventually to oxidative stress associated with increased oxidant levels. The authors also noted that the MDA levels increased and the GSH levels decreased in the workers (15). Çelik et al. reported that antioxidant levels decrease and ROS levels increase in individuals working in radiation environments (16). Malekirad et al. found that oxidative stress markers increased significantly in radiology staff compared to the control group (17).

On the other hand, Doukali et al. when evaluating 29 healthcare professionals exposed to chronic IR, it was found that MDA, SOD and CAT values were significantly higher in these individuals compared to healthy controls (18).

Yoshida et al. exposed cells to irradiation in vitro and suggested that mitochondrial dysfunction leads to persistent oxidative stress that may result in radiation-induced genomic instability (19). Simone et al. administered IR on human fibroblasts in vitro and reported that the radiation led to oxidative genotoxic stress (20).

The limitation of our study is that the number of angiography workers included in the study is low.

## CONCLUSION

Our results indicated that oxidative stress level increased and some antioxidant enzyme levels (GSH, SOD, and CAT) decreased in angiography workers exposed to long-term high-dose ionized radiation. Larger populations and multicenter studies are needed to confirm the findings.

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