

RADIATION RELATED HEART DISEASE: AN EVALUATION ON OCCUPATIONAL RADIATION EXPOSURE

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ABSTRACT Background: Occupational radiation exposure is a concern for radiologic technologists. Therefore, highly efficient protection methods are required to evade the risk of diseases development. The present study aimed to evaluate cardiac function among radiologic technologists with higher thermoluminescent dosimeters readings and long records of work experience. **Materials and Methods:** The selection of radiologic technologists was strictly recruited based on work period, and cumulative doses amount measured by thermoluminescent dosimeters reading among all participants. Blood samples were collected for cardiac function evaluation. Radiologic technologists revealed an accumulation of an average of 7.6 mSv among the selected group for ten years. **Results:** The cardiac biomarkers such as creatine kinase and chloride displayed a significant variation between the groups. An increase in creatine kinase was seen in radiologic technologists compared to the control group. However, a slight reduction in chloride was observed in the radiologic technologists' group. **Conclusion:** The data variation observed in this study may highlight the requirement to researchers to investigate further the risk of developing radiation-induced cardiovascular effects on a larger cohort.

KEYWORDS Ionizing radiation, Radiologic technologists, Cumulative radiation doses, Chronic exposure

Introduction

The consequences of exposure to radiation during diagnostic radiology procedures in the short- or long-term are of significant interest to radiologic technologists (RTs). Radiology techniques are now widely used in many fields of research and hospitals

and treatment centers worldwide. The methods of using ionizing radiation (IR) for diagnostic or therapeutic purposes in medicine vary [1]. An investigation into the potential effects of chronic exposure to radiation on the human body is essential to the health and wellbeing of RTs globally. Cancer and cardiovascular diseases are significant causes of morbidity and mortality worldwide [2], and evidence that exposure to high doses of radiation may increase the risks of both exist [3]. For example, patients with Hodgkin's lymphoma who received radiation treatment normally die due to cardiovascular disease [2]. Heart damage might be caused by substantial radiation doses of >30 Gy during mantle radiotherapy for Hodgkin's lymphoma. However, several independent sources revealed that doses below 20 Gy might also lead to radiation-related heart disease [4]. Additionally, the risk of a fatal myocardial infarction increases 1.5- to 3.0-fold in patients treated with mediastinal radiation therapy compared to non-irradiated patients [2]. Radiology

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practitioners, including radiologists and RTs, receive varying low doses of radiation every year and might be at a higher risk of developing these diseases. A study of radiologists registered between 1897 and 1920 showed a higher rate of cancer mortality than that of other medical practitioners [4]. However, reducing occupational radiation exposure over time significantly reduced the rate of mortality [5]. The relationship between radiation exposure and heart disease has been investigated. Still, several questions remain, including the correlation between age, sex and time of exposure and the development of heart disease [3]. Investigation into the association between long-term exposure to low IR doses and radiation-related heart disease among selected RTs will provide robust evidence for the relationship.

The present study aims to analyze the presence of markers in blood samples taken for cardiac function tests from technologists who have been chronically exposed to IR and determine the link between radiation-related heart disease and long-term IR exposure.

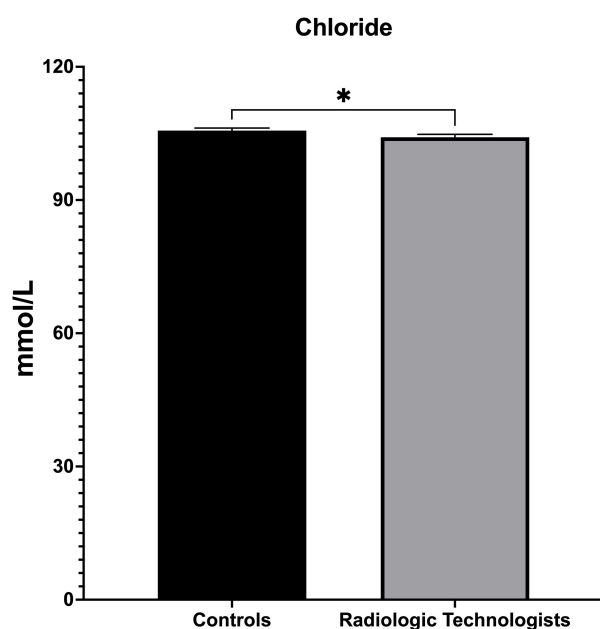


Figure 1. Effect of radiation exposure on serum chloride levels in radiologic technologists. A total of 25 control individuals and 10 radiologic technologists were included.

Materials and methods

This retrospective study included 10 medical RTs and 25 control individuals. The individuals who participated in the study were adults, non-alcoholic, non-smokers, and presented with no history of hypertension or diabetes. The study was carried out in the Department of Radiology, Sabya General Hospital, Jazan Region, Saudi Arabia from August to October 2020. Ethical approval for the study was obtained from the Ethical Committee of Scientific Research, King Khalid University [approval number: (ECM#2020-3201) — (HAPO-06-B-001)]. Participants were assured that the information would be used only for research purposes.

The analysis was performed on the effective radiation doses received by the RTs from 2009 to 2019. All RTs were provided with personal bar-coded whole-body thermoluminescent dosimeters (TLDs; containing each worker's name, age, and

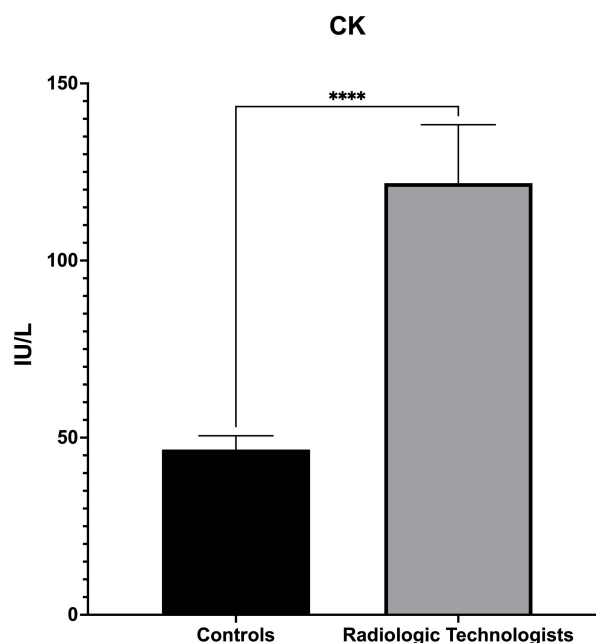


Figure 2. Effect of radiation exposure on creatinine kinase levels in radiologic technologists. A total of 25 control individuals and 10 radiologic technologists were included.

time of use) worn at chest level under a lead apron. These TLDs were made of lithium fluoride materials doped with magnesium and titanium (LiF-Mg, Ti). The TLDs were read using a Harshaw 6600 Plus Automated Reader (Thermo Electron Corporation, Ohio, USA). This study focused on the relationship between the cumulative radiation dose and the relative risk of heart injury. The cumulative radiation dose was calculated using the following equation:

$$D = \sum_{i=1}^n X_i$$

where D is the cumulative radiation dose (mSv), and X_i is the radiation dose in the i -th year. Blood samples were collected from all RTs via venipuncture and placed in plain tubes without any anticoagulant for several biochemical tests. The serum was separated from the clot by centrifugation at 3,000 rpm for 10 min at room temperature. The clear supernatant was immediately transferred to another test tube and used for serum biochemical analysis. The cardiac function tests were analyzed using a fully automated biochemical analyzer (Autoanalyser, Bechman DXC 600). Serum levels of sodium, potassium, chloride, calcium, glucose, urea, creatinine and creatine kinase were measured. For statistical analysis, GraphPad Prism was used for analyses (GraphPad Prism version 9.00 for Mac, GraphPad Software, San Diego CA). Assumptions for a parametric t-test were not met. Therefore, the Mann-Whitney U test was used to compare irradiated participants with non-irradiated controls. The P-value was considered significant when it was <0.05 .

Results

The study focused on the association between the chronic IR exposure experienced by the RTs and the related risk of heart injury. The results of the radiation dose analysis revealed that the average accumulated dose over 10 years was 7.6 mSv. The interest was in determining the significant differences between the RTs and control groups using a Mann-Whitney U test. The test suggested that the median serum chloride for the control

Table 1 Effect of radiation exposure on cardiac function tests in radiologic technologists. A total of 25 control individuals and 10 radiologic technologists were included.

Cardiac function	Median		U-statistic (P-value)
	Control group (n=25)	RT group (n=10)	
Serum glucose mmol/l	5.280	5.480	95 (0.5087)
Urea mmol/l	3.70	3.90	70 (0.0995)
Serum creatinine mmol/l	59.50	65.34	104 (0.5574)
Serum calcium mmol/l	2.160	2.080	83.50 (0.2665)
Serum sodium mmol/l	138	137.8	115.5 (0.7385)
Serum potassium mmol/l	3.80	3.915	106 (0.4988)

group (M = 106, U = 62.5) was significantly greater than the median for the RTs group (M = 104, U = 62.5), P = 0.0489, as seen in Figure 1. Also, the results reveal that the mean creatine kinase for the control group (M = 40, U = 15) was significantly lower than the mean for RTs (M = 123.5, U = 15), P = <0.0001, as seen in Figure 2. As shown in Table 1, no significant difference (P > 0.05) was observed between the RTs and control groups in serum glucose, urea, creatinine, calcium, sodium, and potassium levels.

Discussion

Radiation-associated cardiac disease is an under-recognized and challenging disease that is correlated with high risks of morbidity and mortality. Typical presentation in patients is usually years or even decades after chronic radiation exposure with delayed-onset cardiac damage sustained from cumulative doses of radiation. Unearthing the association between the elevation of some biochemical markers following the long-term exposure to low-dose IR below the threshold limit was the main focus of this study. To the best of our knowledge, this is the first study to scrutinize the long-term blended risk factors, in terms of blood investigations, for developing cardiac dysfunction among selected technologists RTs with chronic radiation exposure. This research complements existing risk assessments, which in other studies focus primarily on heart damage caused by an acute radiation exposure [6-9].

To sustain its energetic demands and run smoothly, the human heart requires approximately 20 times its weight in ATP per day [10]. In myocytes (of the heart), creatine kinase is one of the key enzymes involved in the transference of energy in the form of high energy phosphate from its place of production, such as the mitochondria to ATP-consuming targets such as the myofilaments [11,12]. Therefore, elevated creatine kinase in the bloodstream may be a manifestation of damage to rich tissues in this enzyme. High creatine kinase levels are also detected in rhabdomyolysis, myositis, myocarditis, and myocardial infarction [13-15]. This is in accordance with our findings of a significant elevation in creatine kinase levels in RTs compared to controls. Therefore, elevated creatine kinase levels in RTs might be an indication of future heart disease.

Researchers suggested in a number of studies that hypochlo- raemia is a common electrolyte that is depleted during heart

failure and is a marker of an unfavourable outcome in patients with heart failure, unbiased of other prognostic markers. However, the exact mechanism of hypochlo- raemia activity in heart failure remains poorly understood. The significant correlation of hypochlo- raemia with IR exposure in our study is similar to many previous studies in which chloride depletion was found in heart failure patients [16-20].

Certain cardiac markers such as troponin I and troponin T, which are considered to be the best biomarkers for heart damage, were not assessed in this study, as the data were lacking. Also, due to the long-term follow-up, we were unable to enroll more patients in our study. In addition, shortcomings were present in our study due to its retrospective nature.

Conclusion

Although echocardiography, multimodality imaging, cardio- thoracic CT, and various radionuclide imaging strategies are considered the most common tools for detecting and monitoring radiation-associated cardiac disease. The existing study was carried out to investigate the impact of years of occupational exposure to low doses of radiation on heart function using blood tests. Further research is required to monitoring the serum chlo- ride and creatine kinase level among RTs group. Chronic occupa- tional exposure to a low dose of radiation may contribute to induce heart dysfunction. Therefore, the incidence of radiation- associated cardiac disease is likely to be elevated over the next decade; thus, supplementary blood tests will be required to sat- isfactorily identify those at risk in addition to multimodality imaging-based screening programs.

Author's contribution

Conceptualization, S.A. and M.M.; methodology, H.K.; valida- tion, S.A. and M.M.; formal analysis S.A. and M.M.; investiga- tion, H.K.; data curation, N.E.; writing—original draft prepara- tion, S.A., M.M., N.S., Y.A. and G.Z.; writing—review and editing, S.A., M.M., N.S., Y.A. and G.Z.; supervision, S.A. and M.M. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

There are no conflicts of interest to declare by any of the authors of this study.

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