

Is ionizing radiation a risk factor for anxiety in employees?

 Aslı Kurtar Mansiroglu¹
 Murat Erer²
 Mehmet Coşgun¹
 İsa Sincer¹
 Yılmaz Güneş¹

1. Abant İzzet Baysal University, Faculty of Medicine, Department of Cardiology, Bolu, Turkey
2. Kırıkkale University, Faculty of Medicine, Department of Cardiology, Kırıkkale, Turkey

<http://dx.doi.org/10.1590/1806-9282.66.12.1685>

SUMMARY

OBJECTIVE: Workers describe many physical and mental symptoms when working in radiation areas. This study aimed to assess these symptoms in radiation workers using the Beck Anxiety Inventory (BAI).

METHODS: A total of 42 radiation workers (22 males and 20 females, mean age 34±7 years) and 47 control subjects (22 males and 27 females, mean age 31±8 years) who work in non-radiation areas in the hospital were included in the study. All participants anonymously filled out the Beck Anxiety Inventory (BAI) questionnaire.

RESULTS: The demographic data of workers were not significantly different between groups. In the BAI, the dizzy or lightheaded ($p=0.01$), terrified ($p=0.01$), unsteady ($p=0.02$), heart-pounding and racing ($p=0.02$) items were significantly higher in the radiation-exposed group compared to the control group. [The BAI score was also significantly higher in the radiation-exposed group (11.1±6.8 vs. 8.7±3.8, $p=0.04$)]

CONCLUSION: These results suggest the possibility that radiation may play a role in the psychometric properties of workers. The effects of radiation on the health of employees need to be further investigated and understood.

KEYWORDS: Radiation, Ionizing. Anxiety. Psychological Tests. Stress, psychological/etiology. Occupational diseases.

INTRODUCTION

Radiation is an important part of both the diagnosis and treatment management of many diseases in medicine.

The types of radiation are alpha, beta, gamma, and x-rays, and one can be exposed to exposed radiation externally and internally. Ionizing radiation has sufficient energy to affect the atoms in cells and thereby damage their genetic material (DNA)^{1,2}. If this damage is not repaired correctly, a cell may die or eventually

become cancerous¹. Exposure to radiation can have acute health effects, such as skin burns, and long-term health effects, such as cancer and cardiovascular disease. Radiation effects have been shown by numerous studies in the literature, particularly in radiotherapy patients, atomic bomb survivors, and radiation industry workers³.

Anxiety is a very common health problem in every part of society. Anxiety is seen in all humans, but

DATE OF SUBMISSION: 09-Jul-2020

DATE OF ACCEPTANCE: 08-Aug-2020

CORRESPONDING AUTHOR: Aslı Kurtar Mansiroglu

Abant İzzet Baysal University Hospital, Department of Cardiology, Golkoy, 14280, Bolu, Turkey; Phone: +903742534656; Fax: +903742534615

E-mail: dr.asli.kurtar@gmail.com

the level of anxiety may change with some triggers. Although many scales are used in the literature to determine the level of anxiety, the Beck Anxiety Inventory (BAI) is one of the most commonly used. Since the test construction by Beck and colleagues in 1988, it has been employed in numerous empirical studies⁴. BAI is used to evaluate patients' psychological levels of anxiety. Patients describe how frequently the symptoms have been true for them during the past 2 weeks, including the test day.

The level of job-related stress is determined by many factors including age, sex, working area, workload, working hours, and individual aspects. Anxiety and stress levels among hospital workers have been studied in the literature⁵⁻⁷. However, there is limited data on depression and anxiety in radiation workers.

The effects of radiation on depression and anxiety in radiotherapy patients and seasonal global radiation differ in the literature⁸⁻¹⁰.

Radiotherapy patients have common complaints such as drowsiness, headache, hand tremor, palpitation, dormancy, general weakness, discomfort, and flushing on therapy days¹¹⁻¹⁴. Although there is no study available in the literature, in our daily practice we observe similar symptoms among invasive cardiologists and radiologists. This observation was the basis of our study.

This study aimed to compare the anxiety levels among radiation workers and non-radiation workers using the BAI and to attract attention to these complaints.

METHODS

This is a two-centered cross-sectional study conducted between June and December 2019 at the Bolu University Hospital and Kırıkkale University Hospital.

A total of 42 radiation workers (38 of them were interventional cardiologists and catheterization lab staff, 4 of them were interventional radiologists) and 47 control subjects matched for age and sex working in non-radiation areas were included in the study.

We received informed consent from each participant after approval of the study protocol by the Local Ethics Committees.

All participants filled out a self-reporting questionnaire; the Beck Anxiety Inventory. There were 21 questions in the test. In these questions, patients chose one of a total of 4 frequency scales: none, mild, moderate, severe. Each marked option had a score:

the 'none' option was worth 0 points; 'mild', 1 point, 'moderate', 2 points; 'severe', 3 points. After marking 21 questions in this way, these points were added up and the total score was in the range of 0 to 63. Scores over 25 indicated severe anxiety, those from 16 to 25 indicated moderate anxiety, those from 8 to 15 indicated mild anxiety; those from 0 to 7 indicated no/minimal anxiety¹⁵.

The presence of hypertension (HT) was considered when blood pressure was $\geq 140/90$ mmHg or when there was the use of antihypertensive drugs. Smoking was understood as active smoking or a history of >10 years of smoking.

Exclusion criteria were as follows: absent consent, younger than 18 years old, having cognitive deficits, neurologic impairment and /or communicative disabilities, history of psychiatric diagnoses, or psychiatric drug use, and pregnancy.

Radiation workers undergo regular examinations in their institutions including blood tests, eye examination, dermatological examination, and thyroid ultrasound. No employee had a history of radiation accidents.

STATISTICAL ANALYSIS

The quantitative variables were presented as mean \pm standard deviation (SD), and qualitative variables were expressed in numbers and percentages. The differences between independent groups were analyzed by the Student *t*-test in the case of normal distribution. The Chi-Square test was used for the qualitative variables. Spearman's correlation analyses were used to assess the correlations of feeling heart-pounding or racing and unsteady with the radiation exposed group. A *p*-value < 0.05 was considered significant. Statistical analysis was carried out using the SPSS 18.0 Statistical Package Program for Windows (SPSS Inc, Chicago, Illinois, USA).

RESULTS

The final analyses in the present study included 89 workers; there were no significant differences between the radiation and control groups regarding demographic characteristics such as age, gender, presence of HT, and smoking (Table 1). There were 12 (28.6%) doctors, 16 (38.1%) technicians, and 14 (33.3%) nurses in the radiation worker group; in the non-radiation group, there were 7 (14.9%) doctors, 22 (46.8%) nurses, and 18 (38.3%)

TABLE 1. DEMOGRAPHIC CHARACTERISTICS AND BAI SCORE

Baseline characteristics	Radiation exposed (N=42)	Control (N=47)	p
Age (years) (Mean ±SD)	34±7	31± 8	0.12
Male/female	22/20	22/25	0.60
Hypertension (%)	4 (9%)	2 (4%)	0.32
Smoking (%)	16 (38%)	12 (25%)	0.20
Nightshifts (%)	38 (90%)	34 (72%)	0.03
BAI Score (Mean ±SD)	11.1±6.8	8.7±3.8	0.04
BAI Items			
Numbness or tingling	21 (%50)	23 (49%)	0.58
Feeling hot	23 (55%)	19 (40%)	0.29
Wobbliness in legs	23 (55%)	20 (47%)	0.56
Unable to relax	18 (43%)	22 (47%)	0.32
Fear of the worst happening	13 (31%)	18 (43%)	0.39
Dizzy or lightheaded	31 (66%)	20 (48%)	0.01
Heart-pounding or racing	28 (66%)	15 (32%)	0.02
Unsteady	33 (%78)	25 (53%)	0.02
Terrified or afraid	38 (90%)	35 (74%)	0.01
Nervous	30 (71%)	39 (83%)	0.17
Feeling of choking	9 (21%)	14 (30%)	0.65
Hands trembling	17 (41%)	20 (43%)	0.88
Shaky or unsteady	8 (19%)	6 (13%)	0.48
Difficulty in breathing	9 (21%)	10 (21%)	0.56
Fear of dying	5 (12%)	8 (17%)	0.55
Scared	13 (28%)	12 (29%)	0.36
Indigestion or discomfort in the abdomen	20 (48%)	21 (66%)	0.26
Faint	8 (17%)	3 (7%)	0.11
Face flushed	20 (48%)	17 (%36)	0.50
Sweating	20 (48%)	13 (28%)	0.08
Fear of losing control	12 (25%)	8 (19%)	0.46

Significant at alpha $p < 0.05$. SD standard deviation

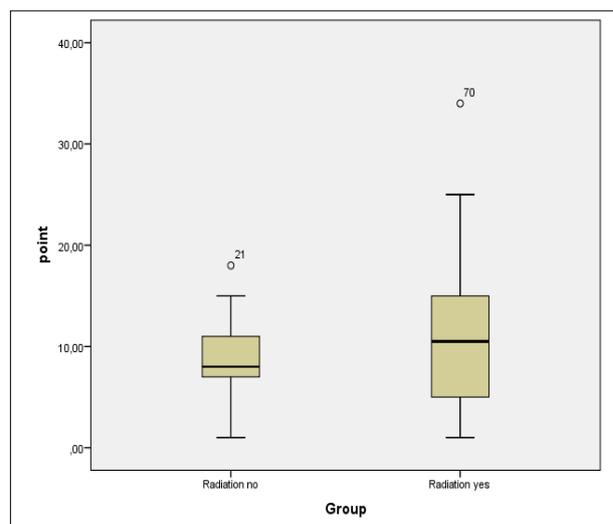
office staff. In the radiation group, 38 (90%) employees had nightshifts, while 4 (10%) employees did not. In the control group, 34 (72%) employees had nightshifts, while 13 (18%) employees did not.

Scores on the BAI for radiation and control groups are also summarized in Table 1. The total BAI score of the radiation-worker group (11.1±6.8) differed significantly from that of the non-radiation-worker group (8.7±3.8; $p=0.04$); also, there were significant group differences for several BAI subscales.

The BAI subscale scores for feeling dizzy or lightheaded ($p=0.01$), feeling heart-pounding or racing ($p=0.02$), feeling unsteady ($p=0.02$), and feeling terrified or afraid ($p=0.01$) were significantly higher in radiation workers than in those without radiation.

There were no significant differences on items relating to numbness or tingling, feeling hot,

FIGURE 1. IN SPEARMAN'S CORRELATION TEST, THE HEART-POUNING OR RACING ($R=0.44$, $P=0.003$) AND UNSTEADY ($R=0.34$, $P=0.022$) ITEMS WERE SIGNIFICANTLY CORRELATED WITH THE RADIATION-EXPOSED GROUP.



wobbliness in legs, being unable to relax, fearing the worst happening, feeling nervous, feeling of choking, hands trembling, shaky, difficulty in breathing, fear of dying, scared, indigestion or discomfort in the abdomen, faint, face flushed, or sweating.

DISCUSSION

In this study, we examined differences of anxiety levels using the BAI in working areas with or without radiation exposure at two university hospitals. We found that the frequencies of the dizzy or lightheaded, terrified, unsteady, heart-pounding, and racing items and the BAI score were significantly higher among health employees working in radiation areas.

Depression and anxiety are common health problems in society. The BAI is among the most used self-rating scales worldwide for measuring anxiety⁴.

While many studies about job stress or anxiety have attracted attention, emotional or psychological events in employees who are exposed to ionizing radiation at work have not been well defined.

Studies show that radiation causes oxidative stress, sperm/testicular damage, apoptosis, cellular DNA damage, endocrine changes². Radiation has effects on the cardiovascular, hematopoietic, reproductive, endocrine, nervous, respiratory, and gastrointestinal systems^{2,16}.

It is known that all forms of ionizing radiation have the potential to produce toxicity in the central

nervous system, and the mechanisms of neurotoxicity and neurodegeneration following ionizing radiation are poorly understood¹¹.

Ionizing radiation disrupts serotonin, norepinephrine, and dopamine neurotransmission, synthesis, and exchange of other neurotransmitters, which are responsible for the neurochemical effects of radiation^{12,13}.

Following radiation accidents, the incidence of stress-related disorders, anxiety, and depression have been reported to be significantly increased¹². Also, recent studies showed that after an atomic bombing, the survivors got easily tired, lost interest in life, had a depressed mood, and were introverted and even autistic¹⁴.

It is known that conventional radiotherapy that is applied to the temporal bone causes vestibular dysfunction in approximately 30% of patients, and the patients perceived dizziness¹⁷. The mechanism underlying vestibular dysfunction is cell death in the vestibular nerve following radiation exposure¹⁸. Also, studies show that the amount of radiation that interventional cardiologists or radiologists are exposed to the head area annually is approximately 10 times higher than the whole-body exposure, and the left side of the head is exposed two times more than the right side¹⁹.

The conduction system may also be affected by radiation²⁰. Radiation stimulates the sympathetic nervous system by increasing beta-adrenergic receptors²¹. Also, radiation-induced fibrosis can damage the conduction system². These may be the mechanisms underlying the feeling of heart-pounding or racing in workers.

Feeling terrified and unsteady are some of the depressive symptoms. It has been shown that in radiotherapy patients and atomic bomb survivors depression and depressive symptoms are increased^{8-10,12}. In our current study, these complaints were significantly higher among healthy employees working in radiation areas too.

Radiation causes different symptoms in workers. Since the dose is much less than the dose received in nuclear accidents, atomic bombing, or radiotherapy patients, it is more difficult to explain these symptoms

in this group. However, these complaints by health employees working in radiation areas should be taken into consideration and should be searched in larger sized and longer follow-up protocols.

Limitations

There are some limitations to this study. We tried to choose employees from similar work environments, though there were some differences between the working conditions of the two groups. While all employees in the radiation group worked face to face and had voice to voice interactions with patients, some workers in the control group were working with patients inwards, while others were working in the office environment. In the control group, doctors, nurses, and the office staff were selected from the cardiology unit. Thus, we tried to match a similar working area, stress, and workload. While the daytime hours were similar between the two groups, there was a difference in nightshifts, and this is one of the limitations of our study.

CONCLUSION

This study carefully suggests that radiation is likely to be related to some complaints by radiation workers. In this study, we tried to document the neuropsychiatric effects of radiation among occupational workers using the BAI. It is recommended to organize the system of long-term neuropsychiatric care and control programs for radiation workers.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

Funding

None

Author's Contribution

Concept: Y.G., M.C.; Design: I.S.; Supervision: A.K.M.; Materials: M.C.; Data collection &/or processing: A.K.M., M.E.; Analysis &/or interpretation: I.S.; Literature search: A.K.M.

Writing: A.K.M.; Critical review – I.S., Y.G.

RESUMO

OBJETIVO: Ao trabalhar em áreas de radiação, trabalhadores descrevem muitos sintomas físicos e mentais. Este estudo teve como objetivo avaliar esses sintomas em trabalhadores expostos à radiação utilizando a Escala de Ansiedade de Beck (BAI - Beck Anxiety Inventory).

MÉTODOS: Um total de 42 trabalhadores expostos à radiação (22 homens e 20 mulheres, com idade média de 34±7 anos) e 47 controles (22 do sexo masculino e 27 do sexo feminino, com idade média de 31±8 anos) que trabalham em áreas do hospital sem radiação foram incluídos no estudo. Todos os participantes responderam anonimamente ao questionário da BAI.

RESULTADOS: Os dados demográficos dos trabalhadores dos dois grupos não apresentaram diferenças significativas. Na BAI, os itens de tonturas ou vertigens ($p=0,01$), medo ($p=0,01$), instabilidade ($p=0,02$) e batimento cardíaco mais forte e acelerado ($p=0,02$) foram significativamente mais elevados no grupo exposto à radiação em comparação ao grupo de controle. A pontuação da BAI também foi significativamente maior no grupo exposto à radiação ($11,1 \pm 6,8$ versus $8,7 \pm 3,8$, $p=0,04$).

CONCLUSÃO: Esses resultados sugerem a possibilidade de que a radiação pode desempenhar um papel importante nas propriedades psicométricas dos trabalhadores. Os efeitos da radiação na saúde dos funcionários precisam ser mais bem investigados e compreendidos.

PALAVRAS-CHAVE: Radiação Ionizante. Ansiedade. Testes Psicológicos. Estresse psicológico/etiologia. Doenças profissionais.

REFERENCES

1. Ravanat JL, Breton J, Douki T, Gasparutto D, Grand A, Rachidi W, et al. Radiation-mediated formation of complex damage to DNA: a chemical aspect overview. *Br J Radiol*. 2014;87(1035):20130715.
2. Sincer I, Mansuroglu AK. A review of cardiovascular disease induced by radiation. *Exp Biomed Res*. 2018;1(1):1-5.
3. Jaworski C, Mariani JA, Wheeler G, Kaye DM. Cardiac complications of thoracic irradiation. *J Am Coll Cardiol*. 2013;61(23):2319-28.
4. Piotrowski C. The status of the Beck Anxiety Inventory in contemporary research. *Psychol Rep*. 1999;85(1):261-2.
5. Sohn BK, Park SM, Park IJ, Hwang JY, Choi JS, Lee JY, et al. The relationship between emotional labor and job stress among hospital workers. *J Korean Med Sci*. 2018;33(39):e246.
6. Yoon SL, Kim JH. Job-related stress, emotional labor, and depressive symptoms among Korean nurses. *J Nurs Scholarsh*. 2013;45(2):169-76.
7. Kovacs M, Kovacs E, Hegedus K. Emotion work and burnout: cross-sectional study of nurses and physicians in Hungary. *Croatian Med J*. 2010;51(5):432-42.
8. Molin J, Mellerup E, Bolwig T, Scheike T, Dam H. The influence of climate on development of winter depression. *J Affect Disord*. 1996;37(2-3):151-5.
9. Chen AM, Daly ME, Vazquez E, Courquin J, Luu Q, Donald PJ, et al. Depression among long-term survivors of head and neck cancer treated with radiation therapy. *JAMA Otolaryngol Head Neck Surg*. 2013;139(9):885-9.
10. Frick E, Tyroller M, Panzer M. Anxiety, depression and quality of life of cancer patients undergoing radiation therapy: a cross-sectional study in a community hospital outpatient centre. *Eur J Cancer Care (Engl)*. 2007;16(2):130-6.
11. Smart D. Radiation toxicity in the central nervous system: mechanisms and strategies for injury reduction. *Semin Radiat Oncol*. 2017;27(4):332-9.
12. Loganovsky KN, Vasilenko ZL. Depression and ionizing radiation. *Probl Radiac Med Radiobiol*. 2013;(18):200-19.
13. Nyagu AI, Loganovskij KN. Neuropsychiatric effects of ionizing radiation [Monograph]. Kiev: Institut klinicheskoy radiologii Nauchnogo Tsentra Radiatsionnoy Meditsiny, Natsional'naya Akademiya Nauk Ukrainy; 1998.
14. Tsuiki S, Yuzuriha T, Anzo E. Psychiatric investigations on people exposed to the atomic bomb. *Nagasaki Med J*. 1958;33:637-9.
15. Beck AT, Epstein N, Brown G, Steer RA. An inventory for measuring clinical anxiety: psychometric properties. *J Consult Clin Psychol*. 1988;56(6):893-7.
16. Yu C, Peng RY. Biological effects and mechanisms of shortwave radiation: a review. *Mil Med Res*. 2017;4:24.
17. Singh IP, Slevin NJ. Late audiovestibular consequences of radical radiotherapy to the parotid. *Clin Oncol (R Coll Radiol)*. 1991;3(4):217-9.
18. Stavas MJ, Carlson ML, Attia A, Jacobson GP, Rivas A, Morales-Paliza M, et al. Does radiation dose to the vestibule predict change in balance function and patient perceived dizziness following stereotactic radiotherapy for vestibular schwannoma? *Am J Otolaryngol*. 2014;35(5):565-71.
19. Vañó E, González L, Guibelalde E, Fernández JM, Ten JJ. Radiation exposure to medical staff in interventional and cardiac radiology. *Br J Radiol*. 1998;71(849):954-60.
20. Yusuf SW, Venkatesulu BP, Mahadevan LS, Krishnan S. Radiation-induced cardiovascular disease: a clinical perspective. *Front Cardiovasc Med*. 2017;4:66.
21. Schultz-Hector S, Böhm M, Blöchel A, Dominiak P, Erdmann E, Müller-Schauenburg W, et al. Radiation-induced heart disease: morphology, changes in catecholamine synthesis and content, beta-adrenoceptor density, and hemodynamic function in an experimental model. *Radiat Res*. 1992;129(3):281-9.

