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Thyroid Ultrasonography Findings in Hospital Employees Exposed to Radiation: An Observational Descriptive Study

Radyasyona Maruz Kalınan Bölümlerde Çalışan Hastane Personelinde Tiroid Ultrasonografi Bulguları: Gözlemsel Tanımlayıcı Bir Çalışma

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This study was presented as an oral presentation at 9th National ISTAHED Family Medicine Congress, October 5-9, 2022, İskele, TRNC.

ABSTRACT Objective: It was aimed to retrospectively evaluate the thyroid ultrasonography (USG) findings taken during periodic examinations of hospital staff in departments exposed to radiation. **Material and Methods:** Thyroid USG reports and demographic information of employees who worked in these departments in the past 2 years were recorded at the time of their first employment and during regular health examinations. Our study included 153 subjects that last two USG reports on the thyroid gland could be accessed retrospectively. **Results:** The mean age of the 153 individuals who participated in the study was 38.58 years, and the mean time worked was 11.13 years. The mean time between the participants' first and second thyroid USG was 11.9 months. While the rate of nodule detection on the first ultrasound was 30.1%, the rate of nodule detection on the second ultrasound was 34.6%. The rate of nodule detection at the second ultrasound was significantly higher in people who had nodules detected at the first ultrasound (p=0.000). No significant correlation was found between the presence of nodules on the first and second ultrasounds by participants' occupation and gender. The number of nodules on the second thyroid USG increased significantly with increasing age and years of work (p=0.05 and p=0.008, respectively). The presence of irregular nodal margins was significantly increased on the first and second ultrasound examination when the duration of radiation exposure increased (p=0.02 and 0.013, respectively). **Conclusion:** The presence of irregular nodule margins increased significantly with increasing radiation exposure.

Keywords: Nuclear medicine; occupational health; radiology; thyroid nodule; ultrasonography

ÖZET Amaç: Bu çalışmada, radyasyona maruz kalınan bölümlerde çalışan hastane personelinin periyodik muayeneleri sırasında çekilen tiroid ultrasonografi (USG) bulgularının retrospektif olarak değerlendirilmesi amaçlandı. **Gereç ve Yöntemler:** Radyasyona maruz kalınan bölümlerde son 2 yıl içinde çalışmış olan hastane personelinin ilk işe girişlerinde ve düzenli sağlık muayeneleri sırasında tiroid USG raporları ve demografik bilgileri kaydedildi. Çalışmamıza tiroid bezi ile ilgili son 2 USG raporuna retrospektif olarak ulaşılabilen 153 olgu dâhil edildi. **Bulgular:** Çalışmaya katılan 153 kişinin yaş ortalaması 38,58 ve ortalama çalışma süresi 11,13 yıldı. Katılımcıların ilk ve ikinci tiroid USG'leri arasındaki ortalama süre 11,9 aydı. İlk ultrasonda nodül saptanma oranı %30,1 iken, ikinci ultrasonda nodül saptanma oranı %34,6'dır. İlk ultrasonda nodül saptanan kişilerde ikinci ultrasonda nodül saptanma oranı anlamlı olarak daha yüksekti (p=0,000). Katılımcıların mesleği ve cinsiyetine göre birinci ve ikinci ultrasonlarda nodül varlığı arasında anlamlı bir ilişki bulunmamıştır. İkinci tiroid USG'sindeki nodül sayısı yaş ve çalışma yılı arttıkça anlamlı olarak artmıştır (sırasıyla p=0,05 ve p=0,008). Radyasyona maruz kalma süresi arttıkça ilk ve ikinci ultrason muayenesinde düzensiz nodal sınırların varlığı anlamlı olarak artmıştır (sırasıyla p=0,02 ve 0,013). **Sonuç:** Düzensiz nodül kenarlarının varlığı radyasyon çalışanlarında anlamlı olarak daha yaygındı.

Anahtar Kelimeler: Nükleer tıp; iş sağlığı; radyoloji; tiroid nodülü; ultrasonografi

Ionizing radiation is a type of radiation that can eject electrons from an atom and form ions, which are charged particles in the matter it encounters. X-rays, gamma rays, and cosmic rays are examples of ionizing wave-type electromagnetic radiation. 80% of ionizing radiation exposure comes from natural

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sources and cosmic rays, 20% from artificial sources.[1]

In cells exposed to ionizing radiation, DNA single- or double-strand breaks, oxidative damage, or DNA protein cross-linking damage can occur.[2,3] The biological response to radiation varies depending on the radiation dose, type, characteristics of the affected cell, and type of DNA damage.[4]

Most artificial ionizing radiation sources are radiation sources used in medicine for diagnosis and treatment.[1] Hospital staff working in areas such as radiology, nuclear medicine, and radiation oncology are occupationally exposed to ionizing radiation. The working conditions of personnel in radiation-exposed departments are determined by the regulations and guidelines of international agencies such as the International Atomic Energy Agency, the International Commission on Radiological Protection, and national protocols.[5]

In Türkiye, the regulation and monitoring of standards for the working environment of hospital staff exposed to ionizing radiation is carried out in accordance with the "Regulation on Radiation Dose Limits and Working Principles for Healthcare Personnel Working with Ionizing Radiation Sources". According to this regulation, the controlled area is the area where the entrance and exit of the radiation source and the employees are subject to special control, their work is subject to special rules and the annual dose limits of the working persons can be exposed to a radiation dose of more than 6 mSv, where the ionizing radiation source device is located and directly exposed to radiation, under supervision. The area is defined as the area in which the annual dose limits for persons working with the radiation source are expected to be exceeded by 1 mSv, which does not require personal dose measurement but does require monitoring of ambient radiation and is connected to the equipment room and allows visual monitoring with the ionizing radiation source.[6] The effective dose to radiation workers shall not exceed 20 mSv for an average of five consecutive years and 50 mSv in any one year. The annual equivalent dose limit for hands and feet or skin is 500 mSv and 150 mSv for the lens of the eye.[1]

The thyroid gland is radiosensitive and sensitive to ionizing radiation. Although radiation therapies are commonly used for thyroid diseases, adverse effects of acute and chronic radiation exposure can be observed.[7] Thyroid nodules are observed as incidental findings in the general population with a prevalence between 19-68% on ultrasonography (USG). Suspicious findings such as microcalcification, hypoechogenicity, larger than 2 diameter, increased vascularization, irregular and lobulated margin and absence of halo in the nodule on ultrasound correlate with malignancy.[8,9]

The aim of our study was to retrospectively examine the thyroid ultrasound findings obtained during regular follow-up examinations of hospital personnel working in departments exposed to ionising radiation and to investigate the changes in the findings in these ultrasound reports according to the place of work.

MATERIAL AND METHODS

ETHICS APPROVAL

This study was carried out in accordance with the Declaration of Helsinki. For this survey, Ethical approval was obtained from the İstanbul Prof. Dr. Cemil Taşcıoğlu City Hospital Clinical Research Ethics Committee on December 6, 2021 with decision number 411.

STUDY DESIGN

Our study was designed as a retrospective observational study. The study sample consisted of people who applied to the occupational health and safety outpatient clinic of our hospital, working in departments exposed to ionising radiation or working by carrying dosimeters. Regular examinations of hospital employees are carried out in the occupational health and safety outpatient clinic of our hospital. In accordance with the health surveillance procedure of the İstanbul Provincial Health Directorate, thyroid USG is performed on employees working in departments exposed to ionising radiation and other dosimeter users at their first employment and then at 5-year intervals or as often as deemed necessary, and the examination reports are kept in the file. In our study, these records

were accessed retrospectively. Patient age, gender, chronic diseases, medications, and thyroid USG reports in the last 2 years were obtained from the patient files. In our study, 153 participants whose last two USG reports of the thyroid gland could be accessed were included from a total of 200 subjects who worked under supervision and monitoring in radiology, radiation oncology and nuclear medicine departments and were considered as other dosimeter users exposed to radiation during interventional procedures such as angiography outside these departments. Forty seven participants with missing information in their files were excluded from the study.

TABLE 1: Gender and jobs of the participants.

		n	%
Sex	Woman	109	71.2
	Man	44	28.8
Job description	Doctor	35	22.9
	Technician	71	46.4
	Nurse	10	6.5
	Secretary	12	7.8
	Cleaning staff	16	10.5
	Other	9	5.9
Department	Radiology	67	43.8
	Nuclear medicine	33	21.6
	Radiation oncology	43	28.1
	Other dosimeter carriers	10	6.5

STATISTICAL ANALYZES

The SPSS 25.0 package program was used for statistical analysis. (IBM Corp. 2011. IBM SPSS Statistics for Windows, version 25.0. Armonk, NY: IBM Corp.) The distribution of interval data was analyzed using the Kolmogorov-Smirnov or Shapiro-Wilk test. Data were expressed as mean±standard deviation and median. The normality of numerical variables was assessed using the Kolmogorov-Smirnov test. The comparison of proportions in independent groups was performed using the chi-square test. Since the numerical variables satisfied the assumption of normal distribution, independent two-group analyses were conducted using the independent samples t-test. $p<0.05$ was considered statistically significant.

RESULTS

The mean age of the 153 people included in the study was 38.58 (minimum: 22, maximum: 65) years, and the average working time was 11.13 (minimum: 1, maximum: 36) years. The gender and job information of the people included in the study are shown in Table 1.

The mean time between the first and second thyroid USG of the participants was 11.9 months (minimum: 1, maximum: 60). While the rate of nodule detection in the first ultrasound was 30.1%, the rate of nodule detection in the second ultrasound was 34.6%. The rate of nodule detection in the second ultrasound was found to be significantly higher in people who were found to have nodules in the first ultrasound (p=0.000). No significant correlation was found between the presence of nodules in the first and second ultrasound according to the occupation and gender of the participants (p=0.630, p=0.400, p=0.387, p=121, respectively). As the age and working years of the participants increased, the number of nodules in the first thyroid USG increased significantly (p=0.033, 0.006, respectively). As age and working year increased, the number of nodules on the second thyroid USG increased significantly (p=0.05, p=0.008, respectively). The nodule characteristics in the first and second thyroid USGs of the participants are given in Table 2.

When we look at the status of nodule detection on thyroid USG according to the place of work of the participants, it was found that nodule detection in the first ultrasound was significantly lower in nuclear medicine workers than in other workers (p=0.03), and nodule detection in the second USG was mostly seen in radiation oncology, but the results were not significant (p=0.107).

As the duration of radiation exposure increased, the probability of irregular nodule borders on the second ultrasound increased significantly (p=0.01). No significant correlation was found between the duration of radiation exposure and the probability of nodules larger than 2 cm, microcalcification, hypoechoic nodules, diameter longer than transverse diameter, presence of lymphadenopathy (LAP), increase in thy-

TABLE 2: The nodule characteristics in the first and second thyroid USGs of the participants.

		First thyroid USG findings (n)	Second thyroid USG findings (n)
Detection of a nodule larger than 2 cm		5	6
Presence of microcalcification		7	5
Presence of hypoechoic nodule		29	23
Irregularity at the nodule borders		6	5
The long diameter of the nodule is greater than the transverse diameter		3	1
Increase in vascularity		5	3
Nodule structure	Solid	15	13
	Cystic	18	14
	Mixed	7	15
Nodule internal structure	Homogeneous	8	9
	Heterogeneous	19	12
Presence of parenchymal sign		26	20
Presence of LAP		12	16
Increase in thyroid size		7	8

USG: Ultrasonography; LAP: Lymphadenopathy.

roid size, and parenchymal findings (p>0.05). When the duration of radiation exposure was grouped as before and after 10 years, irregularity in nodule borders was significantly higher in the group with more than 10 years of exposure, while no significant difference was found in other findings (Table 3).

As the duration of working with radiation increases, the probability of irregularity in the nodule borders on the second ultrasound increases significantly (p=0.01). There was no significant relationship between the duration of working with radiation and probability of nodules larger than 2 cm, microcalcification, hypoechoic nodule, longer diameter greater than the transverse diameter, presence of LAP, increase in thyroid dimensions, parenchyma finding (p>0.05).

Considering the presence of findings that might be considered malignant in the first and second ultrasounds (microcalcification, hypoechogenicity, longer diameter than transverse diameter, increased vascularity, irregularity in the borders), no significant difference was found according to the department of workplace (p=0.876, p=0.632). When the presence of findings to be considered in favor of malignancy in the first and second ultrasounds was evaluated according to gender, no statistically significant difference was observed (p=0.197, p=0.117, respectively). Considering the presence of findings suggestive of malignancy on thyroid ultrasound in all workers, only irregularity of nodule borders was significantly increased in first and second USG (p=0.02, 0.013, respectively).

When evaluating thyroid hormone levels (T4 and TSH), we found no notable relationship between these levels-classified as low, normal, or high-and demographic factors such as gender, age, tenure, departmental affiliation, or occupation among hospital personnel exposed to radiation (Table 4).

DISCUSSION

In our study, the detection rate of thyroid nodules on USG of the thyroid gland in radiology staff was 30.1% on the first ultrasound and 34.6% on the second ultrasound. In a study that examined 24,362 patients without active complaints who had registered for examination in Türkiye, the rate of incidental detection of thyroid nodules was 23.7%.[10] A study on the detection of thyroid nodules in radiation workers was conducted at the University Hospital of Bari in southern Italy, and the rate of detection of thyroid

TABLE 3: Evaluation of the duration of radiation exposure and 1st and 2nd thyroid ultrasound findings.

Nodule characteristics	First thyroid USG findings		p value	Second thyroid USG findings		p value
	Less than 10 years of radiation exposure	10 years or more of radiation exposure		Less than 10 years of radiation exposure	10 years or more of radiation exposure	
Detection of a nodule larger than 2 cm	3	2	0.957	35	18	0.187
Presence of microcalcification	3	4	0.309	3	2	0.95
Presence of hypoechoic nodule	18	11	0.83	15	8	0.49
Irregularity at the nodule borders	2	4	0.02*	1	4	0.013*
The long diameter of the nodule is greater than the transverse diameter	3	0	0.14	0	1	0.40
Increase in vascularity	4	1	0.45	1	2	0.78
Increase in thyroid size	2	5	0.08	5	2	0.38

Chi-square test *p<0.05; USG: Ultrasonography.

nodules in radiation-exposed workers was reported to be 29%. In the same study, the rate of detection of thyroid nodules in the non-radiation exposed population was 13%.[11] In a study conducted in sub-Saharan Africa in the adult population hospitalised with thyroid problems, the rate of detection of thyroid nodules was 28.3%.[12] The detection rate of incidental thyroid nodules varies considerably depending on location, population and detection method.[8] In our study, we can conclude that the detection rate for incidental nodules was higher than in the studies conducted in healthy individuals in the literature. However, we did not have a healthy control group in our study, which is one of the limitations of our study.

In a study conducted on employees working in departments exposed to radiation for at least 5 years, the rate of nodules on USG was found to be 37.5%. This rate was found to be higher in women and those over 35 years of age, and 66.7% of the nodules were classified in the benign category.[13] It has been stated in studies that the prevalence of thyroid nodules increases with age and is higher in women.[14] Contrary to the literature, no difference was found between genders in terms of the incidence of thyroid nodules in our study.

In a cohort study involving medical personnel working in radiation fields, thyroid cancer rates were found to be higher than the normal population, regardless of gender, occupation, and duration of employment, but there was no evidence that this increase was due to the radiation dose exposed.[15] In our study, there was no significant relationship between the occupations of the participants and the nodule detection status in the first or second ultrasound. However, the rate of irregularity in the nodule borders increased with the working duration in both 1st and 2nd USG, no such relationship was found in other malignancy criteria.

Considering the status of nodule detection in thyroid USG according to the study areas of the participants, the nodule detection status in the first ultrasound was found to be significantly lower (p=0.03) in nuclear medicine workers compared to other workers, and nodule detection in the second USG was mostly seen in radiation oncology. The results are not significant (p=0.107). Radioactive materials are used to conduct studies on the functions of organs or tissues in the body in nuclear medicine. The radioactive material disperses in the tissue to be examined according to its physical and chemical properties and settles there temporarily, making scanning possible. Thus, diagnostic images are obtained with

TABLE 4: Evaluation of the TSH and T4 leves and 1st and 2nd thyroid ultrasound findings.

		First USG			Second USG		
		Nodule detected	No nodules	p value	Nodule detected	No nodules	p value
TSH	Normal	45	84	0.660	34	37	0.671
	Abnormal	1	4		3	2	
T4 Level	Low	3	0	0.669	1	2	0.656
	Normal	43	105		52	96	
	High	0	1		0	1	

Chi-square test *p<0.05; TSH: Thyroid stimulation hormone; USG: Ultrasonography.

devices that detect gamma rays emitted from the radionuclide in the body or are used to treat diseases. Nuclear medicine imaging methods are divided into single-photon emission computed tomography (SPECT) and positron emission tomography (PET). In nuclear medicine, SPECT, PET, as well as computed tomography (CT), and magnetic resonance are imaging methods that allow imaging. The use of CT in addition to radioactive substances significantly increases exposure to radiation dose. In radiation oncology (radiotherapy), radiation sources are used in tumor treatments. Treatment using a source that emits beams of radiation at a distance of about one meter from the patient is called teletherapy (remote therapy). As a radioactive source, devices containing cobalt-60 and high-energy electron accelerators that produce radiation are used. Brachytherapy (close-range treatment) is the treatment performed by giving radiation directly into or around the cancer tissue with special applicators or directly into the tissue. It has been reported that the annual mean exposure dose per person in radiation oncology is 0.5 mSv, while the exposure dose is higher in radiology, invasive radiology, and nuclear medicine departments.[1] In contrast, in the second thyroid USG performed in our study, the number of nodules was found to be higher in radiation oncology workers than in other departments. This may be related to radiation exposure levels. In addition, the detection of nodules as a result of the first ultrasound was found to be lower in nuclear medicine workers compared to other workers. The fact that the rate of nodule detection in the second USG is similar to that of the employees of other departments may suggest that radiation exposure may be higher.

In one study, analysis was performed on 3 groups as a control group was exposed to radioiodine, exposed to X-ray, and no radiation exposure, and thyroid volume and thyroid nodule rates were found to be higher in those exposed to radiation than in the control group. The rate of diffuse parenchymal disease in the group exposed to X-ray was found to be higher than in the control group.[16]

While there are studies showing that the incidence of thyroid cancer increases in workers exposed to radiation, there are also cohort studies that concluded that this incidence did not increase however, no statistically significant difference was found between the departments studied.[15,17] In our study, while the rate of irregularity in the nodule borders increased with the working duration in both 1st and 2nd USG, no such relationship was found in other malignancy criteria.

In a study, freeT3 levels were higher in all those exposed to radiation than in the control group, and TSH levels were lower in the X-ray-exposed group compared to the control group.[16] In another study, male radiation workers had higher T3 and T4 levels compared to female workers, and lower TSH levels, no significant difference was observed in T3, T4, and TSH levels in workers over 40 years of age and between the departments they worked in. increase was detected.[7] In our study, low, normal, or high T4 and TSH levels in hospital workers exposed to radiation were not found to be associated with gender, age, the working year, department or occupation.

Our study has limitations. First of all, the study was conducted at a certain time and on a limited number of participants. In our study, no control group was

used, and comparisons made only on radiation workers could only be made between the 1st and 2nd ultrasound findings.

CONCLUSION

The increase in the number of nodules and the presence of malignancy criteria in the second thyroid USGs may suggest that radiation has an effect on the development of thyroid nodules.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Ayşe Didem Esen, Feyzanur Erdem;* ***Design:*** *Ayşe Didem Esen, Feyzanur Erdem;* ***Control/Supervision:*** *Ayşe Didem Esen, Feyzanur Erdem;* ***Data Collection and/or Processing:*** *Ayşe Didem Esen, Feyzanur Erdem;* ***Analysis and/or Interpretation:*** *Feyzanur Erdem;* ***Literature Review:*** *Ayşe Didem Esen, Feyzanur Erdem;* ***Writing the Article:*** *Ayşe Didem Esen, Feyzanur Erdem;* ***Critical Review:*** *Ayşe Didem Esen, Feyzanur Erdem;* ***References and Fundings:*** *Ayşe Didem Esen;* ***Materials:*** *Ayşe Didem Esen, Feyzanur Erdem.*

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