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Blood Samples of Cancerous Patients as Biomarkers of Alpha Emitters

Haura Mohammed Abas[1*], Adie D. Salman[1], Neama Abdul-Wahid[2]

1. Department of Physics, College of Science, University of Kerbala, 56001 Kerbala, Iraq
2. Department of Physics, , Faculty of Education For Girls, University of Kufa 54001 Kufa, Iraq

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ABSTRACT

Introduction: Radioactive contamination by uranium and its emissions, such as alpha particles, is considered one of the most critical issues affecting the human race and its existence. The study investigated the high ionization capacity number of alpha particles in whole blood samples from cancer patients because these particles have the most significant impact on the shape and function of living cells, modifying them into malignancies.

Material and Methods: The TASL*Image* solid nuclear trace detector CR-39 was used to measure the effects of alpha emitters in the whole blood samples from 40 cancer patients for five types of cancer (breast, uterus, prostate, kidney, and colon) collected from a government hospital at Karbala/Iraq and compared with ten healthy samples. Moreover, the research investigated whether smoking and gender variation affect the outcomes.

Results: The radon concentration in whole blood samples from patients and healthy individuals was significantly different ($p< 0.05$), and it was slightly higher in males with (22.82254±7.38794 Bq/m^3). Women with colon cancer had higher blood levels of radon (32.13787±5.79261 Bq/m^3) than men with the same malignancy (18.80531±5.63747 Bq/m^3), regardless of gender. While the age factor had no noticeable impact, the smoking element had a considerable effect ($p< 0.05$).

Conclusion: All alpha levels were within the (ICRP) usual ranges. Women with colon cancer had the most significant alpha values. In contrast, men with the same disease had the lowest values despite cancer patients' blood levels being higher than those of the healthy group.

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Introduction

The human body is constantly exposed to natural and artificial radiation, either externally through contact with the environment or internally through inhalation, eating, or drinking. Radiation occurs when a substance emits radiation, changes from an exciting material to a stable material by releasing rays or tiny particles into the surrounding space [1]. According to the International Agency for Research on Cancer (IARC), there are various potential reasons for cancer; one explanation is radioactive substances like radon gas, alpha particles, uranium, and cosmic radiation [2]. A considerable part of radiation exposure comes from radiation sources, the radon gas often making up 50% of the background radiation. The estimated average annual effective dosage from all-natural radiation sources is around 2.4 mSv, of which about 1 mSv is attributable to radon inhalation indoors [3]. Radon is a Nobel brief-lived radioactive gas that forms naturally when uranium and thorium decay to stable lead [4]. Usually, radon concentrations are determined by monitoring the effects of alpha particles [1]. The Alpha-charged particles have energy that damages some living cells which are close to one another in tissues or other body fluids, such as blood, and also causes chromosomal abnormalities that change the DNA's structure and function, causing abnormal cell division and its transformation directly or indirectly into cancer [5-7]. The World Health Organization (WHO) has found a direct or indirect association between radon gas and cancer [1]. The only known association is between lung cancer and high radon levels, Despite the fact that more recent studies have linked alpha emitters to leukemia malignancy, particularly in youngsters. Only a few studies have examined this connection with different cancer types [8-10]. Despite significant technological advancements in the medical sciences, early disease detection especially for cancer remains ineffective, Moreover, the fundamental reasons for it continue to be not entirely appreciated [11]. Iraq has seen a significant increase in the overall incidence of cancer diseases after the end of the Gulf Wars. A total of 10,957 citizens died from cancer (2019), with 1,291 of the fatalities taking place in Karbala with a population of 1,283,484 residents [12]. Recently, radioactive element concentrations and their effects on human

**Corresponding Author:* Tel: +9647703019279; Email: haura.m@uokerbala.iq

health were determined using biomarkers, characterized as molecular, biochemical, or physiological alterations in cells, including those that occur in human tears, serum, whole blood, and other bodily fluids or parts. Different methods revealed the variations between the bodies of cancer patients and healthy individuals [13,14].

The primary goal of the study is to compare alpha emitters in whole blood samples from various cancer patients in the Iraqi province of Karbala with those employed as controls using the TASL*Image*™ Systems with the CR-39 nuclear trace detector.

Materials and Methods

From the end of 2020 to the end of 2021, forty blood samples of individuals with cancer were selected at random and obtained at the Imam Al-Hussein Medical City in the Karbala/Iraq (Al-Amal Center for Cancer Diseases). (20 males and 20 females with age mean =47.868years). While another 10 more blood samples were randomly taken from healthy individuals (5 males and 5 females with a mean of 42.400 years old), whose samples were utilized as controls. In order to conduct the study and share the data for research purposes exclusively, the agreement of all patients and healthy individuals was sought. This included information on age, gender, cancer type, treatment method, presence of additional diseases, and residence (urban or rural). The study excluded patients with hereditary cancer and received radiation therapy. Five female and eleven male patients in the sample were smokers. Furthermore, female cancers and their types were (8) breast cancer, (4) Cervical, (4) colons, and (4) kidneys, while male samples had (7) prostate cancer, (8) colon, and (5) kidney cancer types. Both patients and healthy blood was drawn using a 2.5 mm deep syringe. For proper homogeneity, the samples were initially dried in a Sterilizer oven (at 25 degrees) for 8 hours, subsequently crushed with a pestle and mortar then sieved. In plastic containers that were 5 cm high and 3 cm wide, a 0.5 gram of the produced samples was put. On the interior lid was placed the radioactive trace detector CR-39 detector with a dimension of two and a half millimeters. For sixty days, the samples were maintained in storage in order to be certain the equilibrium was attained and to see whether there were any detectable nuclear consequences. Chemical etching was performed using distilled water and sodium hydroxide solution for a total of 8 hours at an average temperature of 70 degrees in a water bath [15,16]. The TASL*Image* dosimeter device (at university of Kufa/Iraq) utilizes high-sensitivity microscopy that connects to a computing unite for determining the total number of nuclear tracks across the identifying geographical region. The statistical analysis of the information gathered was performed using the SPSS (Statistical Package for the Social Sciences V.23) application.

Results

Table 1 lists the outcomes of evaluating and contrasting the values of radon concentration (C_{Rn}), radon concentration inner samples ($C_{Rn}^{s,ac}$), radium concentrations ($C_{Ra}^{s,ac}$), effectiveness of radon (A_{Rn}^{s}), and annual radon dosages (E) in whole blood samples from healthy people and patients.

Table 1. Comparisons of the alpha particle levels

Measurements	Means± Stander error		P- Values
	Healthy group	Patient group	
C_{Rn} (Bq/m^3)	0.75566 2.38962±	± 3.26302 17.3314	0.0279
$C_{Rn}^{s,ac}$ (Bq/kg)	± 0.45902 1.66924	± 1.98206 10.52765	
$C_{Ra}^{s,ac}$ (mBq/kg)	±0.00423 ± 0.01539	0.01827 ± 0.09706	
A_{Rn}^{s} (Bq)	8.4 E-4±2.3532E-4	9.9721E-4 ± 0.0053	
E (mSv/y)	±0.00581 0.02118	0.1336 ±0.02515	

As demonstrated in table 2, the statistical comparisons showed a clear significant difference at ($p < 0.05$) between the healthy and the cancerous group relying on the various types of cancer (breast, cervical, prostate, kidney, and colon). Table 3 displays the alphas values of whole blood samples for cancers affecting both sexes. Moreover table 4 shows the difference in alpha values in whole blood samples for males and females for colon and kidney cancer. A statistical comparison of the radon levels in whole blood samples from cancer patients, smokers, and non-smokers, excluding the impact of the sex factor (p=0.027) and its existence (p=0.055), is shown in table 4.

Table 2. Comparisons of the alpha particle levels according to cancer types.

Measurem--ents	Type of cancer (Means± Stander error)				
	Breast	Cervical	Prostate	Kidney	Colon
C_{Rn} (Bq/m^3)	11.73731±3.79586	3.84257±0.69541	20.8264±11.09198	15.37028±7.03365	23.2495±6.30454
$C_{Rn}^{s,ac}$ (Bq/kg)	7.12962±2.30573	2.3341±0.42241	12.65062±6.73762	9.3364±4.27246	14.12249±3.82958
$C_{Ra}^{s,ac}$ (mBq/kg)	0.06573±0.02126	0.02152±0.00389	0.07601±0.02402	0.08607±0.03939	0.1302±0.03531
A_{Rn}^{s} (Bq)	0.00358±0.00116	0.00118±0.000012	0.00415±0.00131	0.0047±0.00215	0.00711±0.00193
E (mSv/y)	0.09047±0.02926	0.02962±0.00536	0.10463±0.03307	0.11848±0.05422	0.17921±0.0486

Table 3. Comparisons of the alpha particle levels according to cancer types in term of gender

Measurements	Type of cancer according to gender (Means± Stander error)			
	Colon(males)	Colon (females)	Kidney(males)	Kidney(female)
C_{Rn} (Bq/m^3)	18.80531±5.63746	32.13787±15.79261	20.68002±8.9004	2.09595±0.23288
$C_{Rn}^{s,ac}$ (Bq/kg)	11.42295±3.42437	19.52157±9.59294	12.56171±5.40639	1.27315±0.14146
$C_{Ra}^{s,ac}$ (mBq/kg)	0.10531±0.03157	0.17997±0.08844	0.11581±0.04984	0.01174±0.0013
A_{Rn}^{s} (Bq)	0.00575±0.00172	0.00983±0.00483	0.00633±0.00272	6.41E-4±7.1E-5
E (mSv/y)	0.14496±0.04346	0.24773±0.12173	0.15941±0.06861	0.01616±0.0018

Table 4. Comparisons of the alpha particle levels according to smoking factor

C_{Rn} (Bq/m^3)	Means± Stander error		P- Values
	Non- Smokers group	Smokers group	
Absence of gender distinction	10.98785± 0.75566	25.29693±5.98495	0.002275
C_{Rn} (Bq/m^3)	Means± Stander error		0.005581
	Females (smokers)	Males (smokers)	
Under gender distinction	22.82254±7.38794	±10.9023130.74057	

Furthermore figures 1,2,3,4 and 5 have been used to display each radon concentration (C_{Rn}), radon concentration inner samples ($C_{Rn}^{s,ac}$), radium concentrations ($C_{Ra}^{s,ac}$), the effectiveness of radon (A_{Rn}^{s}), and annual radon dosages (E) in whole blood samples from healthy people and patients. In Figure 6, there was a noticeable positive statistical correlation between the radon concentration and the radon concentration inner the samples. Figure 7 shows the exact statistical correlation between the levels of radon and radium in whole blood samples. Gender had a negligible impact, according to the static studies. As indicated in figure 8, the radon and radium concentrations revealed the straightforward superiority of males over females. The association between radon levels and age is demonstrated in figure 9.

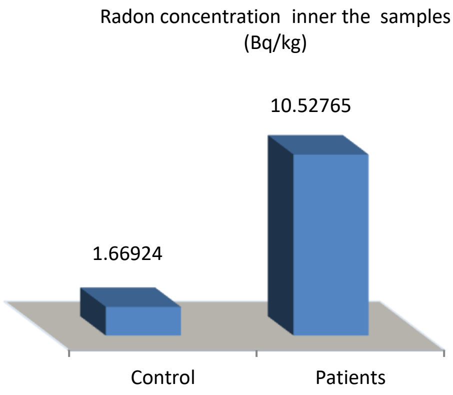

Figure 2. Comparison of Radon concentrations inner samples for control and patient group

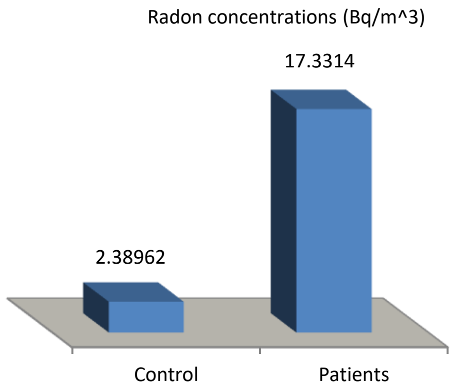

Figure 1. Comparison of Radon concentrations for control and patient group

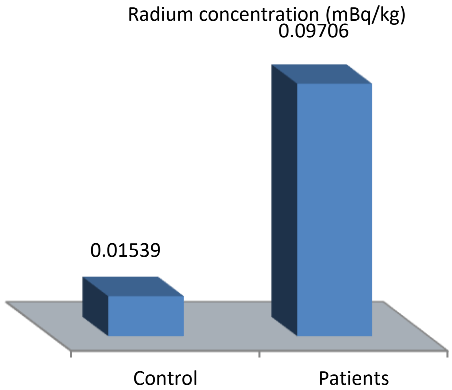

Figure 3. Comparison of Radium concentrations for control and patient group

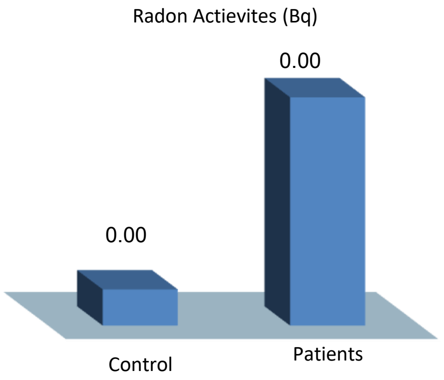

Figure 4. Comparison of Radon Activities for control and patient group

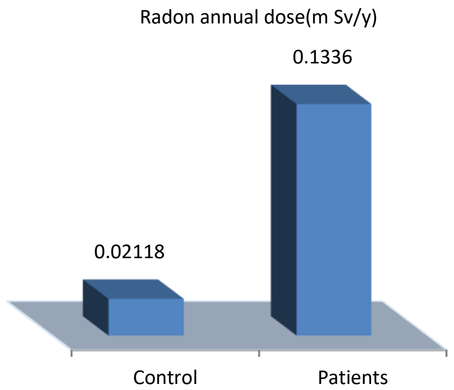

Figure 5. Comparison of Radon Annual dose for control and patient group

Calculation

Utilizing the following equation, the concentrations of alpha emitters in the samples were determined [17-19].

$$C_{Rn} = \rho / Kt \quad (1)$$

C_{Rn} :concentrations of radon, ρ: density of the alpha-track, K: diffusion coefficient equal to 0.0412 (Track.m^3.day /Bq .cm^2) calculated by (k=0.25r (2cos Θ_c -r/r$_a$)), r: container's radius, : detector's critical angle equal (35^0), r_a : denotes the alpha particle range in the atmosphere equal (4.15 cm) during the time of exposure (t) [19-21].

An estimate of the sample's radon content C_{Rn}^s they were based on the following equation[22].

$$C_{Rn}^s = C_{Rn} \lambda_{Rn} \, h \, t \, / l \quad (2)$$

λ_{Rn}=$(0.814 \, d^{-1})$ is radon's gas's decay rate constant, h the separation between the sample surface and the detector, and l represents the sample's thickness.

Equations (3and4) provided the sample's radon and radium concentrations respectively [23,24].

$$C_{Rn}^{s,ac} = C_{Rn}^s \; A^s \, l / \, M_s \quad (3)$$

$$C_{Ra}^{s,ac} = C_{Ra}^s \; A^s \, l / \, M_s \quad (4)$$

Where A^s and M_s are, respectively, the sample's mass and surface area.

The samples' radon activity is determined using equation (5), often known as [24].

$$A_{Rn}^s = C_{Rn}^s \, V^s \quad (5)$$

V^s : the sample's volume. The annual effective dose is defined by [25].

$$\mathrm{E} = A_{Rn}^s \times \mathrm{F} \times \mathrm{O} \times \mathrm{DCF} \quad (6)$$

F: factor of equilibrium equal 0.4, O: the typical time spent indoors per person (7000 hours per year), where DCF stands for dose conversion factor which is 9.0 nSv h^{-1}(Bq. m^{-3}.h^{-1}).

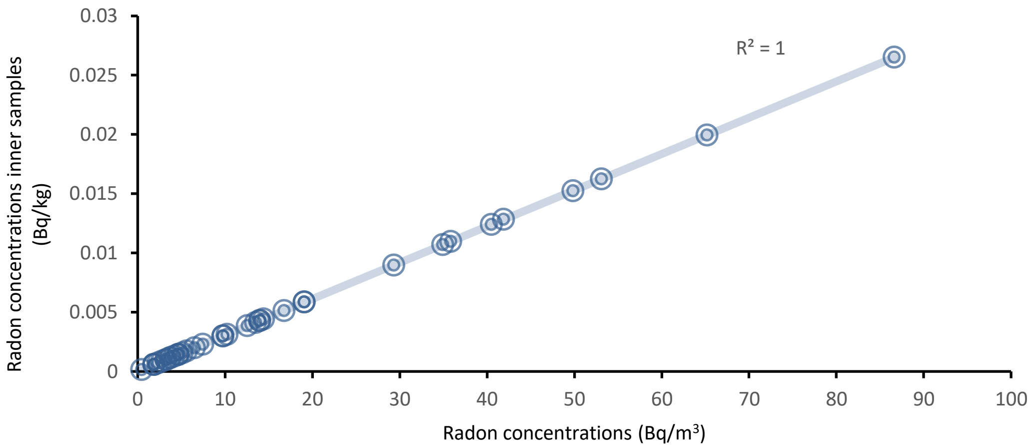

Figure 6. Correlation of the radon concentrations and radon concentrations inner samples

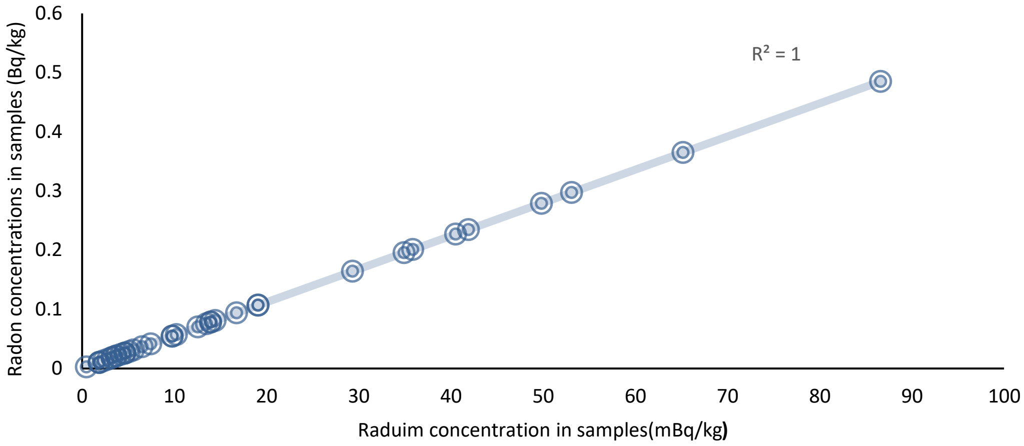

Figure 7. Correlation of the radon concentrations and radium concentrations.

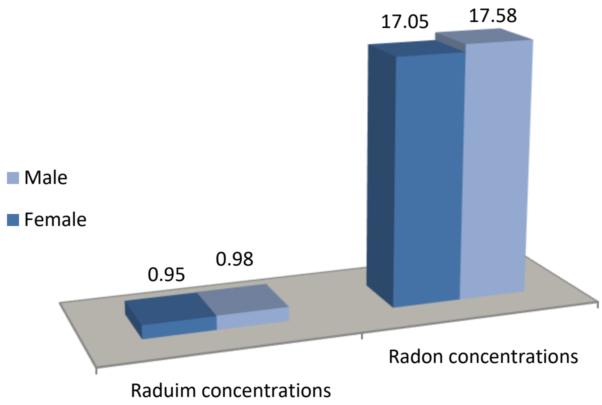

Figure 8. Comparison of the radon and radium concentrations in terms of gender

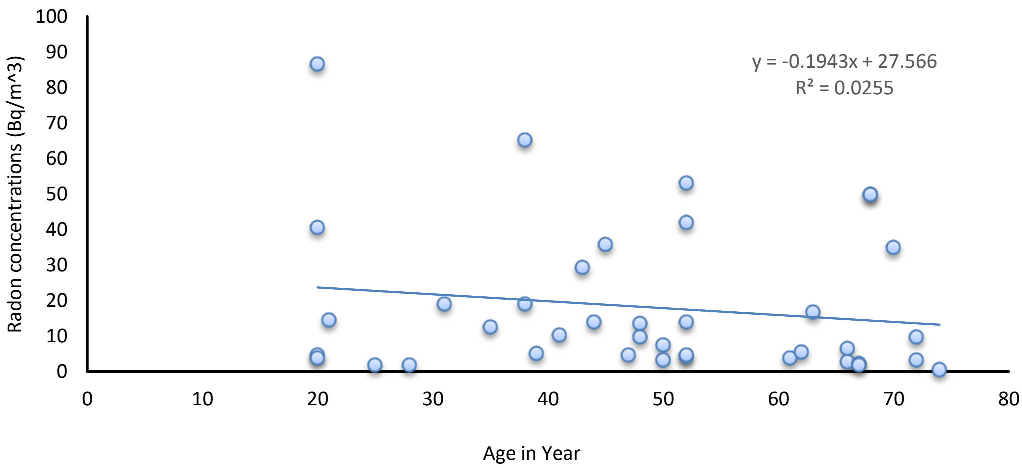

Figure 9. The association between Radon concentration levels and age

Discussion

There was a significant and noticeable variance in the amounts of radon (C_{Rn}), levels in internal samples of radon and radium concentrations ($C_{Rn}^{s,ac}$, $C_{Ra}^{s,ac}$), the effectiveness of radon (A_{Rn}^{s}), and annual radon dosages (E) in entire blood samples from both healthy individuals and patients shown by the overall conclusions. However, Comparable findings showed that radon levels value and yearly dosage were within International Atomic Energy Agency (ICRP) authorized and recommended values, which were 200Bq/m^3 and (4 msv/y at the workplace, 14 msv/y for the occupant) respectively [26]. Even though the amount of alpha emitters remains within the authorized boundaries, long-term exposure to radon gas destroys cells that exist while modifying how they function, enhancing the chance of malignancy. [1,2]. For the age factor, no significant differences were taken into account when comparing the research results for both healthy and cancer patient blood samples [24]. For cancers that affect only women (under this study), breast and uterine cancers, there was an increase in all measured alpha levels towards breast cancer. Males are more severely impacted by exposure to radiation if it co-occurs, and females are more impacted as time passes. Cancer and death rate are approximately fifty per cent greater in females compared to males while obtaining an identical amount of radiation, according to the Nuclear Information and Resources Services, females' greater reproductive organs than males rendered them more susceptible to the adverse consequences of radiation that is ionizing. It is well established that radiation damage is more probable to affect reproductive tissues. Moreover, due to how hormones and their functions link to cancer, breast cancer is among the most common type of cancer in women [27,28]. However, comparing the alpha levels for common malignancies in men and women, colon cancer was more prevalent, and kidney cancer had the lowest percentage. In contrast, prostate cancer patients had the highest percentages of alpha levels in men, and this preponderance persisted even when comparing common tumors, whereas colon cancer patients had the lowest percentages. Overall, the findings revealed that these percentages were slightly higher in men than in women. This was explained beside radiation affected the human body and hormones rolled by the smoking factor [9,27], which was found to be more prevalent in the study's men when gender distinction was not present, even though smoking behavior is not significantly influenced by gender under this study.

Conclusion

According to the research's outcomes, all whole blood samples' alpha values were within the acceptable range worldwide, although there was a statistically significant difference between the samples of cancer patients and healthy participants and a trend toward men. According to the disparities in alpha values between patients with various types of cancer, women had colon cancer with the greatest alpha levels, while males had the lowest alpha levels for the same cancer that affects both men and women. While it was evident that, depending on the role of sex hormones in cancer and other factors like radiation, alpha concentrations increased in males for prostate cancer and females for breast cancer.

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