THE IMPACT OF ABSORBED RADIATION DOSE ON BLOOD AND ITS EFFECT ON COMPLETE BLOOD COUNT IN THYROID CARCINOMA PATIENTS TREATED WITH RADIOIODINE-131

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ABSTRACT

The study aimed to estimate the blood radiation dose and assess its impact on complete blood count (CBC) in differentiated thyroid carcinoma (DTC) patients treated with radioiodine-131 (RAI-131). Blood dosimetry was performed on 190 patients from January 2015 to December 2023, with CBC data analyzed for 35 patients from January-December 2023. RAI-131 (50-300 mCi) was administered orally. Patients were divided into Group A (≤150 mCi) and Group B (>150 mCi). Whole-body residence time, total blood volume (TBV), and absorbed blood dose were calculated. CBC samples were collected pre-therapy and 1-2 months post-therapy. Mean absorbed dose to the blood per unit activity was 0.1296 mGy/MBq (Group-A) and 0.1666 mGy/MBq (Group-B). Only three Group-B patients exceeded the blood dose threshold. Pre-therapy dosimetry is essential, especially for those receiving >150 mCi. Significant percent decreases ($P < 0.05$) were observed in most blood parameters, white blood cells, neutrophils, monocytes, RBC, HB, HCT, platelets, MPV, and PCT, except for a significant increase ($P < 0.05$) in basophils. A non-significant decrease ($P > 0.05$) was noted in lymphocytes, eosinophils, and PDW 1-2 months post-therapy.

Keywords: Radiation dose, Radioiodine-131, Blood dosimetry.

INTRODUCTION

Thyroid cancer is estimated to affect 12.9 out of every 100,000 people annually, with a fatality rate of 0.5 per 100,000 (Pellegriti *et al.*, 2013). According to National Cancer Institute (NCI), the global prevalence of thyroid cancer has been steadily increasing, with an average annual growth of 5.5% over the past few decades (Educatia, 2018; Mazzaferri, 2006; Nguyen *et al*., 2015). This rise is attributed to increased radiation exposure and heightened surveillance (Cabanillas *et al.*, 2016), as well as the extensive use of diagnostic imaging techniques such as X-rays, mammograms, CT, (Carr, 2019) and PET, which can spontaneously detect thyroid cancer (Educatia, 2018). Approximately 90% of thyroid cancers are classified as DTC (Boltz *et al.*, 2013), which account for 1-2% of all human tumors (Ejeh and Adedapo, 2011; Mazzaferri, 2006). Despite its rarity, DTC affects 1.18 individuals per 100,000 people worldwide (Mazzaferri, 2006), with a higher incidence in women than in men i.e. 3:1 (Fancy *et al.*, 2010). Treatment options for thyroid cancer include RAI-131 therapy, surgery, and molecular-targeted treatments using various tyrosine kinase inhibitors (Nguyen *et al*., 2015). RAI-131 therapy has been particularly effective in treating DTC patients following surgery 2016). Radioiodine isotopes, such as RAI-123, RAI-125, and RAI-131, are routinely used in both diagnostic and therapeutic procedures for thyroid disorders (Josefsson and Forssell-Aronsson, 2013), with RAI-131 also being employed to reduce distant metastases in DTC (Lassmann *et al.*, 2004).The concept of blood dosimtery in this therapy was first described by Benua *et al*. in 1962 and was later expanded by Leeper in 1985. Benua *et al.* proposed parameters for the retention of RAI-131 in the body and the amount of radiation absorbed by the blood (Benua *et al.*, 1962). RAI-131 is though widely used in the treatment of thyroid cancer, nevertheless the exact dose absorbed by the bone marrow during this therapy cannot be directly measured (Hänscheid *et al*., 2009). Instead, the dose absorbed by the blood is considered a first-order approximation of the radiation dose to the hematopoietic system and is a better method for assessing susceptibility to this therapy, as it is assumed to correlate with exposure to the red bone marrow (Sgouros, 2005). According to Thomas *et al*.(1993) absorbed blood dose calculation is based on the amount of RAI-131 retained in the body. Dosimetry enable clinicians to determine the maximum tolerated activity of RAI-131 that can be administered without causing bone marrow toxicity (Sisson, 2002; Tuttle *et al*., 2006). Short-term changes in the hematologic system i.e. changes in

CBC following RAI-131 ablation treatment have been studied (Hu *et al*., 2016; Sönmez *et al.*, 2010), detailed research on CBC in relation to administered activity, gender, and age particularly for the population in Pakistan, remains limited, highlighting the significance of this study.

This study has two main objectives: (i) to calculate the absorbed dose to the blood in thyroid carcinoma patients who received fixed dosages of RAI-131 for ablation (ii) to examine the effects of radiation on CBC after RAI-131 therapy in thyroid cancer patients.

MATERIALS AND METHODS

The study was conducted at Swat Institute of Nuclear Medicine, Oncology and Radiotherapy (SINOR) hospital in Saidu Sharif, Swat, Pakistan, targeting patients with DTC, who received RAI-131 ablation dosages in Nuclear Medicine Division (NMD) from January 2015 to December 2023. Radiation doses absorbed in the blood were estimated for 190 patients with DTC following RAI-131 therapy. Additionally, the impact of radiation on CBC was evaluated in 35 thyroid carcinoma patients treated between January-December 2023.

Patients were organized into groups based on age, gender, and RAI-131 activity levels. The total patient cohort was divided into two groups: Group-A and Group-B. Patients in Group-A received RAI-131 activity ≤ 150 mCi, while those in Group-B received activity > 150 mCi. All patient related parameters were recorded prior to the administration of RAI-131 activities.

The study was divided into two parts: blood dosimetry and the effects of radiation on CBC, following the steps below:

Calculation and Administration of RAI-131 Activity

Fixed RAI-131 activities, ranging from 50-300 mCi and prescribed by nuclear physicians based on varying clinical scenarios, were administered orally to all patients on an empty stomach. All RAI-131 activities were calibrated using a CAPINTEC Inc. dose calibrator (Model CRCR-25R).

Blood Sample

Blood samples were collected from patients before RAI-131 therapy on the same day and 1-2 months after RAI-131 therapy. Disposable syringes were used to collect the samples in EDTA tubes. The samples were analyzed by a hematologist at Amreek Clinical Lab, Saidu Sharif, Swat, Pakistan, using Sysmex xn-2000 machines to assess the effects of radiation on CBC.

Calculation of Residence Time

The dose rate (µSv/h) at 1 meter distance from all patients was measured at 24-hour intervals using a survey meter (Model No: RM 1001 RD). The whole-body residence time was calculated using the slope (m) of a plot of dose rate versus time of reading on semi-log paper, as illustrated in Fig. 1.

$$\tau = \frac{Log(1/e)}{m} \quad (1)$$

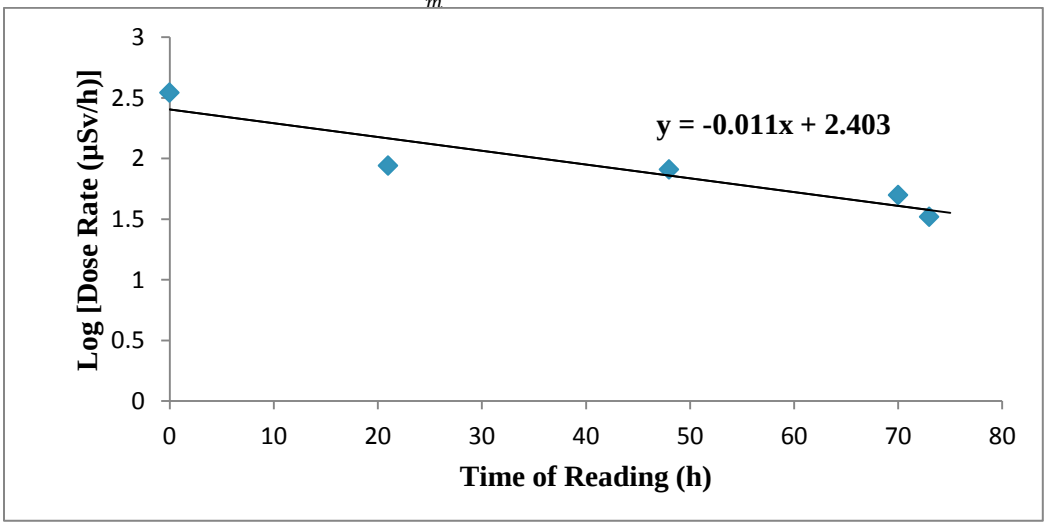

Fig. 1. Graph of the Logarithm of Dose Rate at 1 meter vs. Time for Dose Rate.

Estimation of Surface Area and total blood volume

The TBV and surface area (S) for all patients were calculated using the following equations-2 and 3, for males and females, respectively:

$$\text{TBV} = [(1.06 \times \text{age}) + (822 \times \text{S})] + (1395 \times \text{S}) \quad (2)$$

$$\text{TBV (ml)} = [(1486 \times \text{S}) - 825] + (1578 \times \text{S}) \quad (3)$$

In these equations age is expressed in years, S in m^2 (Willegaignon, Sapienza, and Buchpiguel, 2011), and calculated using equation-4.

$$\text{S} = [\text{Wt(kg)}]^{.425} \times [\text{h (cm)}]^{.725} \times 0.007184 \quad (4)$$

Where, Wt (kg) is the patient's weight, and h (cm) is the patient's height.

Absorbed dose to the blood

Equation-5 was utilized to calculate the dose absorbed in the blood per unit administered activity for all patients [8]. Finally, using Equation-6, the total blood doses for all patients were determined.

$$\frac{D_{blood}}{A_0}\left(\frac{mGy}{MBq}\right) = \left[\frac{15.12}{BLV(ml)} + \frac{0.0188}{Wt(kg)^{2/3}}\right] \times \tau_{(total\ body)} \quad (5)$$

$$D(mGy) = \frac{D_{blood}}{A_0}\left(\frac{mGy}{MBq}\right) \times Adm.\,Dose\ (MBq) \quad (6)$$

Blood parameters

The effects of RAI-131 therapy were observed on white blood cells (WBCs), neutrophils (Neu), lymphocytes, monocytes, eosinophils , basophils, red blood cells (RBCs), hemoglobin (Hb), hematocrit test (HCT), platelets, mean platelet volume (MPV), platelet distribution width (PDW), and procalcitonin test (PCT) with respect to administered activity, age, and gender, as determined by blood smear tests.

RESULTS AND DISCUSSION

Blood Dosimetry

Table-1 summarizes the average administered activities, height, weight, residence time, mean blood dose absorbed per unit administered activity, and total blood dose for all patients.

Table 1. Average Administered Activities, Height, Weight, Residence Time, Mean Blood Dose per Administered Activity, and Total Blood Dose for All Patients.

No. of Patients	Group	Administered Activity (mCi)	Mean Height (cm)	Mean Weight (Kg)	Mean Residence time (h)	Mean dose to the blood / administered activity (mGy/MBq)	Total dose to the blood/ Bone marrow (mGy)
190	**Group-A (145)**	50-150	158.8 (150.0-180.0)	63.30 (45-115)	25.07 (11.43-66.83)	0.1296 (0.0579-0.4001)	610.57 (143.6-1572.5)
	Group-B (45)	›150‹300	158.84 (153-170)	63.71 (45-105)	31.56 (13.06-94.75)	0.1666 (0.066-0.522)	1356.1 (489.8-4833.6)
Number of Patients exceeded threshold dose to the blood (Group-A)			No	Number of Patients exceeded threshold dose to the blood (Group-B)			3

Table 1 reveals that in Group-B, only three patients (two females and one male) exceeded the 2 Gy threshold absorbed radiation dose to the blood. These three patients received an activity of 250 mCi. However, the absorbed blood dose for activities 50-150 mCi remained within normal limits. The whole-body residence time emerged as the most critical factor influencing the absorbed blood dose, and in most cases, even with higher administered activities (250-300 mCi), the limits were not exceeded. Fig. 2 and Equation-7 illustrate the relationship between whole-body residence time and blood dose absorbed per unit administered activity for Group-A.

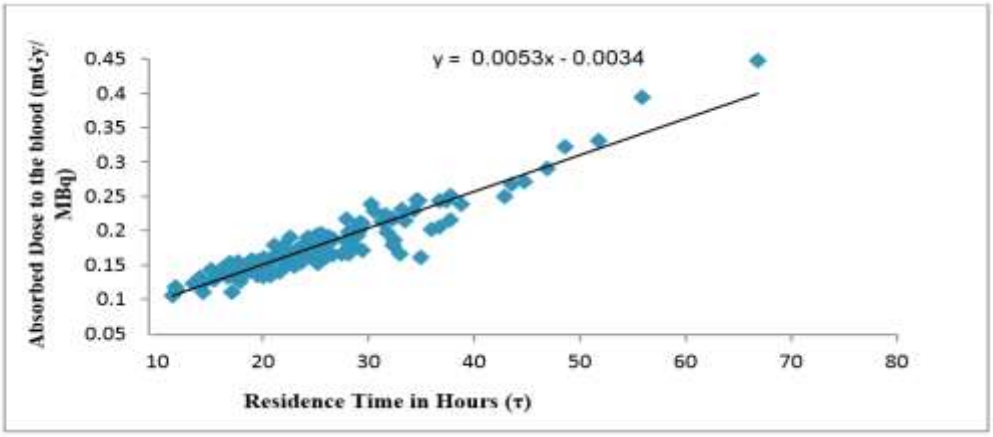

Fig. 2. Graph between residence time vs. dose absorbed in the blood for Group-A.

$$\frac{D_{blood}}{A_0}\left(\frac{mGy}{MBq}\right) = 0.0053 \times \tau_{total\ body\ (h)} - 0.0034 \qquad (7)$$

Fig. 3, for Group-B, shows a linear relationship between whole-body residence time and the dose absorbed in the blood per unit administered activity, as described in Equation-8.

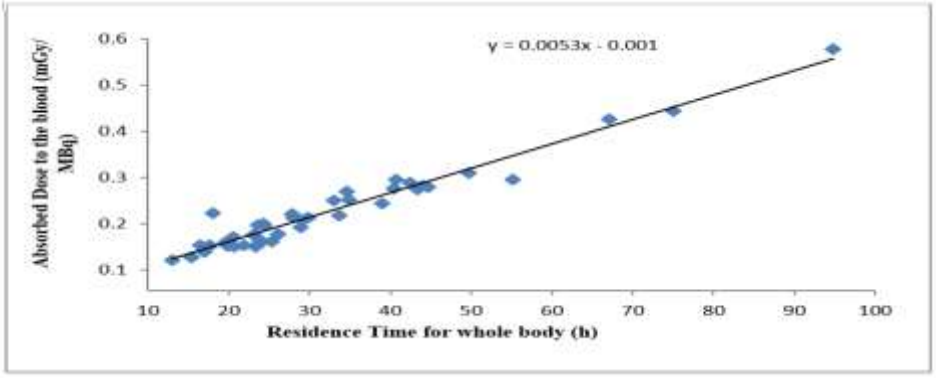

Fig. 3. Plot of the whole-body residence time (h) vs. dose absorbed in the blood for group-B

$$\frac{D_{blood}}{A_0}\left(\frac{mGy}{MBq}\right) = 0.005 \times \tau_{total\ body\ (h)} - 0.001 \quad \text{---------- (8)}$$

Table 2. Comparison of Mean Blood Absorbed Dose with the Current Investigation.

Prior Studies	Mean Blood Absorbed Dose (Gy) With 3.7GBq Administrated Activity
M'Kacher *et al* (1998)	0.54
Monsieur's *et al* (1999)	0.32
Watanabe *et al* (2004)	0.45
Hänscheid *et al* (2006)	0.62
Piruzan, Elham, *et al* (2016)	0.65
Present study***	0.61(Group-A)*** 1.36 (Group-B)***

Equations-7 and 8, derived from Figure-2 and Figure-3 for Group-A and Group-B respectively, are highly effective for calculating the dose absorbed in the blood per unit administered activity based on whole-body residence time. As more data from various patients is collected in future, these equations are expected to become even more specific and accurate. They will be valuable tools for determining the absorbed dose to the blood using only whole-body residence time. Additionally, our study compares absorbed dose to the blood with findings from published results, as shown in Table 2.

The blood absorption levels for Group-A are comparable to those reported by Hänscheid *et al*. (0.62 Gy) and Piruzan *et al*. (0.65 Gy) (Piruzan, Haghighatafshar, Faghihi, and Entezarmahdi, 2016). However, there is insufficient data available for comparison regarding the 1.36 Gy absorbed dose in blood for Group-B patients in this study.

Higher absorbed doses to blood were observed in individuals with longer retention periods, lower TBV, lower weight, smaller surface area, greater prescribed activity and shorter height and vice versa. It is evident that pre-therapy dosimetry is crucial for all thyroid carcinoma patients, especially those receiving an activity > 150 mCi.

Effects of Radiation on CBC

Table 3 presents the CBC test results for all patients both on the day of RAI-131 administration and after the therapy.

Table 3. CBC changes in pre and post RAI-131 ablation for all patients.

Blood Parameters	Before RAI-131ablation ($X_1 \pm SD$)	1-2 month after RAI-131ablation ($X_2 \pm SD$)	P-Value	% difference $\frac{X_2 - X_1}{X_1} \times 100\%$
Mean WBC, 10^3/uL,	8.61 (4.2, 14.9) ± 2.72	5.96 (5. 79, 10.32) ± 4.73 ↓	0.002894	30.8%
Mean Neutrophil, 10^3/Ul	5.94 (2.36, 12.8) ± 2.88	3.57 (6.79, 0.86) ± 2.02 ↓	0.00009	36.8%
Mean Lymphocyte,10^3/Ul	2.06 (0.81, 3.59) ± 2.25	1.37 (0.26, 3.99) ± 1.05 ↓	0.053762	33.5%
Mean Monocyte, 10^3/Ul	0.43 (0.21, 0.65) ± 0.16	0.33 (0.13, 0.55) ± 0.15 ↓	0.004375	23.2%
Mean Eosinophil, 10^3/Ul	0.21 (0.04, 0.32) ± 0.1	0.18 (0.02, 0.38) ± 0.1 ↓	0.153521	14.3%
Mean Basophil, 10^3/Ul	0.04 (0.01, 0.09) ± 0.03	0.69 (0.01, 0.13) ± 0.04 ↑	< 0.00001	16.2%
Mean RBC, 10^6/Ul	4.62 (4.2, 5.22) ± 0.39	4.19 (3.78, 4.72) ± 0.37 ↓	< 0.00001	9.3%
Mean Hb, g/Dl	12.97 (11.1, 14.4) ± 1.18	11.6 (10.4, 13.3) ± 1.10 ↓	< 0.00001	10.56%
Mean HCT	37.21 (32.5, 41.4) ± 2.85	30.54 (10.8, 37.2) ± 9.26 ↓	0.000106	17.9%
Mean Platelets, 10^3/Ul	300 (162, 502) ± 116.11	240 (170, 465) ± 82.53 ↓	0.006816	20%
Mean MPV, Fl	9.92 (7.8, 10.8) ±1.01	9.44 (7.9, 10.8) ± 0.96 ↓	0.022623	4.83%
Mean PDW, Fl	11.58 (9.1, 10.8) ± 2.36	11.31 (8.6, 12.5) ± 1.38 ↓	0.282145	2.3%
Mean PCT, Fl	0.27 (0.15, 0.43) ± 0.09	0.22 (0.17, 0.28) ± 0.04 ↓	0.002156	18.51%

CBC Findings in the Full Cohort

It is clear from Table-3 that significant decreases were observed in WBCs, neutrophils, monocytes, RBCs, Hb, HCT, platelets, MPV, and PCT, all with p-values < 0.05. Basophils were the only parameter to show a significant percentage increase ($p < 0.05$) across all patients. Similar reductions in WBCs, neutrophils, Hb, HCT, and platelets have been reported in other studies 1-2 months following RAI-131 therapy (Molinaro *et al*., 2009; Sönmez *et al*., 2010; Van Nostrand, Neutze, and Atkins, 1986). In contrast, lymphocyte counts, eosinophil counts, and PDW did not exhibit significant reductions, with p-values of 0.053762, 0.153521, and 0.282145, respectively.

CBC Findings Stratified by Gender

CBC assessments were conducted on 35 patients with DTC, comprising 10 males and 25 females, to investigate potential gender-based differences. The analysis revealed no statistically significant differences in CBC results before and after RAI-131 therapy between the genders (Hu *et al*., 2016).Therefore, the study does not present a separate table for gender-specific data.

CBC Findings Stratified by Administered RAI-131 Activity

Table-4 presents the CBC results for all patients, categorized by administered RAI-131 activity levels. Changes in CBCs before and after RAI-131 administration were found to be more significant in patients from Group-A, compared to those in Group-B, as shown in Table-4. In Group-A, all blood counts significantly decreased, with p-

values < 0.05, except for PDW and platelets, which had p-values > 0.05. In Group-B, only RBCs showed significant decreases and eosinophils significant increases, both with p-values < 0.05. Although lymphocytes, basophils, MPV, and PCT showed increases in Group-B, these changes were not statistically significant (p-values > 0.05). Similarly, WBCs, neutrophils, monocytes, hemoglobin, HCT, platelets, and PDW counts decreased in Group-B, but these reductions were also not statistically significant, as indicated in Table 4. Notably, eosinophils showed a significant increase with p-values < 0.05 in Group-B, as highlighted in Table 4.

Table 4. CBC changes before and after RAI ablation with respect to RAI-131 activities.

Blood Parameters	Activity ≤ 150 mCi (21) [Group-A]			Activity > 150 mCi (14) [Group-B]		
	Before RAI-131 ($X_1 \pm SD$)	**After RAI-131 ($X_2 \pm SD$)**	**P-Value**	**Before RAI-131 ($X_1 \pm SD$)**	**After RAI-131 ($X_2 \pm SD$)**	**P-Value**
Mean WBC,10^3/uL	7.73 (4.55, 11.84) ± 2.43	4.17 (4.17, 5.21) ± 1.24 ↓	<0.00001	8.12 (4.56, 14.02) ± 3.26	7.40 (5.33, 10.32) ± 2.37↓	0.254662
Mean Neu, 10^3/uL	4.59 (2.36, 7.29) ± 1.54	2. 20 (0.86, 4.03) ± 1.46 ↓	<0.00001	6.20 (3.78, 12. 8) ± 3.34	5.05 (3.68, 6.79) ± 1.39↓	0.125029
Mean ym,0^3/uL	2.66 (0.74, 4.6) ± 1.13	0.99 (0.26, 3.99) ± 0.55 ↓	<0.00001	1.40 (0.46, 2.73) ± 0.79	1.74 (0.89, 13.99) ± 1.50↑	0.231059
Mean Mon, 10^3/uL	0.41 (0.28, 0.60) ± 0.19	0.26 (0.13, 0.55) ± 0.19 ↓	0.007354	0.40 (0.17, 0.65) ± 0.18	0.37 (0.27, 0. 51) ± 0.11↓	0.300772
Mean Eos, 10^3/uL	0.30 (0.21, 0.52) ± 0.10	0.18 (0.02, 0.38) ± 0.12 ↓	0.00056	0.09 (0.04, 0.16) ± 0.05	0.18 (0.05, 0.38) ± 0.16↑	0.031072
Mean Bas, 10^3/uL	0.03 (0.01, 0.07) ± 0.01	0.02 (0.02, 0.13) ± 0.01 ↓	0.001205	0.04 (0.01, 0.09) ± 0.03	0.05 (0.01, 0.13) ± 0.05↑	0.2645
Mean RBC, 10^6/uL	4.60 (4.08, 5.48) ± 0.54	4.24 (3.78, 4.72) ± 0.50 ↓	0.015375	4.74 (4.2, 5.22) ± 0.34	4.27 (3.91, 4.52) ± 0.28↓	0.000253
Mean Hb, g/dL	12.4 (11.1, 14) ± 1.07	11.4 (10.4, 12.3) ± 0.94 ↓	0.001286	12.81 (9.2, 14.4) ± 1.93	11.92 (10.6, 13.3) ± 1.32↓	0.083116
Mean HCT	37.08 (32.5, 42. 6) ± 3.47	25.83 (10.8, 37.2) ± 13.49 ↓	0.000603	36.08 (27.2, 41.42) ± 5.17	34.07 (30.7, 37.2) ± 3.40↓	0.117558
Mean PLT, 10^3/uL	333.6 (233, 502) ±121.6	278.6 (178, 465) ± 108.55 ↓	0.064559	283 (162, 326) ± 63.17	249 (170, 315) ± 63.54↓	0.083744
Mean MPV, fL	10.12 (8.7, 11.4) ± 0.93	9.63 (7.9, 97) ± 0.05 ↓	0.01282	9.06 (7.8, 9.6) ± 0.68	9.3 (7.9, 10.8) ± 1.33↑	0.277732
Mean PDW, fL	12.58 (10.3, 17.1) ± 2.29	11.93 (8.6, 12.5) ± 0.66 ↓	0.111855	11.36 (9.1, 13.7) ± 1.95	10.85 (8.6, 12.5) ± 1.69↓	0.233031
Mean PCT, fL	0.32 (0. 22, 0.43) ± 0.09	0.21 (0. 17, 0.26) ± 0.03 ↓	<0.00001	0.21 (0.15, 0.31) ± 0.06	0.22 (0.18, 0.28) ± 0.05↑	0.317685

CBC Findings Analyzed by Age

Table 5 presents the CBC parameter results with respect to age. Patients were divided into two age groups: Group-A consisted of those under 45 years, while Group-B included those 45 years and older.

In Group-A, there were significant decreases (P < 0.05) in lymphocytes, eosinophils, Hb, platelets, MPV, PDW, and PCT levels, as shown in Table-5. Although WBCs, neutrophils, monocytes, basophils, RBCs, and HCT levels also declined, these changes were not statistically significant (P > 0.05). In Group-B, significant decreases were noted in WBCs, neutrophils, basophils, RBCs, hemoglobin, and HCT levels, while eosinophils significantly increased (P < 0.05). However, decreases in lymphocytes, monocytes, platelets, MPV, PDW, and PCT levels were not statistically significant (P > 0.05), as detailed in Table 5.

Thyroid cancer rates have surged globally over the past few decades. Despite this, most patients DTC have an excellent prognosis, with a 5-10 year survival rate of 90-95% (Davies and Welch, 2014; Rui *et al*., 2021). RAI-131 ablation therapy is widely used to eliminate thyroid remnants and iodine-avid metastases after surgery in DTC patients (Haugen *et al*., 2016). However, this therapy can cause temporary or long-term side effects, including myelosuppression, pulmonary fibrosis, and hematological toxicity (Fard-Esfahani *et al*., 2014; Prinsen *et al*., 2015),

Rui *et al*., 2021). Part-II of this study carefully examined the impact of RAI-131 ablation therapy on the CBC in DTC patients, detailing changes in peripheral blood cells during treatment. The severity of these changes is linked to the cumulative dose received (Marks, 1947). Within one month to a year post-therapy, Hb, WBC, and platelet levels can be significantly lower than baseline in most DTC patients (Sönmez *et al*., 2010). Von Nostrand *et al.*(Van Nostrand *et al*., 1986) reported moderate temporary declines in blood cell counts in 90% of patients. Molinaro *et al.*(Molinaro *et al*., 2009) investigated the CBC effects one year after RAI-131 therapy, whether following traditional thyroid hormone withdrawal (THW) or recombinant human thyroid-stimulating hormone (rhTSH) stimulation, noting significant temporary drops in platelets and WBCs, without addressing gender differences in these abnormalities.

Table 5. Changes in CBC parameters before and after RAI-131 ablation therapy with respect to age.

Blood parameters	< 45 (n = 20) [Group-A]			≥ 45 (n =15) [Group-B]		
	Before RAI-131(X_1± SD)	After RAI-131 (X_2 ± SD)	P-Value	Before RAI-131 (X_1 ± SD)	AfterRAI-131 (X_2 ± SD)	P-Value
Mean WBC,10^3/uL,	7.89 (4.55, 10.28) ± 2.20	6.78 (8.36, 6.78) ± 5.21 ↓	0.196197	8.53 (4.97, 14.02) ± 3.43	6.44 (4.51, 10.32) ± 2.62↓	0.035638
Mean Neu, 10^3/Ul	4.57 (3.03, 6.24) ± 1.15	3.82 (0.86, 6.79) ± 4.19 ↓	0.224773	6.35 (2.36, 12.8) ± 3.87	4.36 (3.68, 5.55) ± 0.81↓	0.034922
Mean Lym,10^3/Ul	2.43 (0.74, 4.6) ± 1.28	1.35 (0.26, 3.99) ± 0.21 ↓	0.000675	1.68 (0.81, 2.73) ± 0.76	1.50 (0.26, 3.99) ± 1.68↓	0.354026
Mean Mon, 10^3/Ul	0.43 (0. 31, 0.49) ± 0.06	0.41 (0.13, 0.55) ± 0.19 ↓	0.332044	0.40 (0. 21, 0.65) ± 0.19	0.34 (0.18, 0.51) ± 0.14↓	0.165695
Mean Eos, 10^3/Ul	0.33 (0.15, 0.52) ± 0.11	0.16 (0.02, 0.38) ± 0.15 ↓	0.000121	0.06 (0.04, 0.17) ± 0.06	0.17 (0.02, 0.38) ± 0.16↑	0.011431
Mean Bas, 10^3/Ul	0.04 (0.01, 0.09) ± 0.03	0.03 (0.02, 0.13) ± 0.007 ↓	0.080894	0.32 (0.01, 0.07) ± 0.02	0.04 (0.01, 0.13) ± 0.05↓	<0.00001
Mean RBC, 10^6/Ul	4.68 (4.08, 5.48) ± 0.55	4.56 (3.78, 4.72) ± 0.12 ↓	0.176511	4.59 (4.02, 5.22) ± 0.48	4.10 (3.78, 4.52) ± 0.32↓	0.001521
Mean Hb, g/Dl	12.4 (11.1, 14.1) ± 1.40	11.58(10.4, 13.3) ± 0.70 ↓	0.013328	13.0 (11.4, 14.4) ± 1.20	11.2 (10.4, 12.8) ± 1.09↓	0.000095
Mean HCT	37.08 (32.5, 42. 6) ± 3.78	37.05 (10.8, 37.2) ± 0.21 ↓	0.484254	37.28 (32.5, 41. 4) ± 3.56	32.22 (29.8, 36.8) ± 3.13↓	0.000152
Mean PLT, 10^3/Ul	340.2 (233, 502) ± 118.8	242 (178, 465) ± 12.52 ↓	0.000772	263 (162, 326) ± 83.80	236.5 (170, 315) ± 73.41↓	0.182784
Mean MPV, Fl	9.73 (7.8, 11.4) ± 1.32	8.75 (7.9, 9.7) ± 1. 20 ↓	0.0093	9.56 (8.8, 10.5) ± 0.61	9.75 (8.5, 10.8) ± 0. 95↑	0.26095
Mean PDW, Fl	12.5 (9.1, 9.7) ± 2.82	10.55 (8.6, 12.5) ± 2. 75 ↓	0.016604	11.9 (9.5, 14.1) ± 1.91	11.72 (10.6, 12.5) ± 0. 81↓	0.368805
Mean PCT, Fl	0.31 (0. 21, 0.43) ± 0.09	0.20 (0. 17, 0.26) ± 0.03 ↓	0.000014	0.24 (0. 15, 0.31) ± 0.07	0.22 (0. 17, 0.28) ± 0.05↓	0.188297

Studies by Padovani *et al.*(2014) and Prinsen *et al.*(Prinsen *et al*., 2015) reported significant reductions in platelet counts following high doses of RAI-131. Rosario *et al*. (2008) found that in the first 02-months after 3700 MBq RAI-131 ablation, patients undergoing THW experienced a greater mean reduction in platelets compared to those treated with rhTSH. Another study indicated that changes in WBCs and platelets a year after RAI-131 therapy were influenced by the preparation method or the RAI-131 dose administered (Molinaro *et al*., 2009). Several authors (Hu *et al*., 2016; Sönmez *et al*., 2010) have explored CBC alterations following RAI-131 ablation in different populations. This study observed a significant decrease ($P < 0.05$) in WBCs, neutrophils, monocytes, RBCs, hemoglobin, HCT, platelets, MPV, and PCT across all patients, while basophils showed a significant increase ($P < 0.05$). A slight, non-significant decrease ($P > 0.05$) in lymphocytes, eosinophils, and PDW was also noted 1-2 months after RAI-131 therapy. The study thoroughly documents the effects of RAI-131 on CBC, highlighting variations based on the administered dose and age, as detailed in Tables-3, 4, and 5, underscoring the importance of these findings for the Pakistani population.

Limitation of the Study

The main limitation of this study is that only a single blood sample was collected from each of the 35 patients, 1-2 months after RAI-131 ablation therapy. Future research should monitor CBC changes in thyroid carcinoma patients who receive high fixed dosages of RAI-131 at intervals of 1, 2, 3 weeks, 3 months, 6 months, 1 year, and 2 years post-therapy. To confirm the CBC changes observed in these patients, similar studies should be conducted

with a larger patient cohort and across multiple centers to ensure the findings are representative of the broader population in Pakistan.

Conclusions

The study concluded that RAI-131 therapy is generally safe for most patients. However, in a small subset of cases, 3 out of 190 (1.58%) in the overall data, and 3 out of 45 (6.66%) among those receiving dosages > 150 mCi, the absorbed dose in the blood exceeded safe threshold levels. Additionally, a very low absorbed dose in the blood may be less effective, offering minimal therapeutic benefit to the target area. Therefore, pre-therapy dosimetry is essential for all thyroid carcinoma patients, especially those receiving doses exceeding 150 mCi.

Regarding the impact of radiation on complete blood count (CBC), significant decreases were observed in WBCs, neutrophils, lymphocytes, monocytes, platelets, and PCT, while only minor changes were noted in eosinophils, basophils, RBCs, hemoglobin, MPV, and PDW within 1-2 months after RAI-131 therapy. Further research with a larger patient population is needed to validate these CBC changes and better understand their implications for thyroid carcinoma patients undergoing RAI-131 ablation therapy.

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