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Studying The Effect Of Radiation Therapy On Leucocytes In Cancer Patients With Diabetes Before, During And After Radiation Therapy

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ABSTRACT

Background: Ionizing radiation is a standard treatment for brain tumors, but it may cause hematological changes, including leukopenia, anemia, and thrombocytopenia. Patients with chronic diseases such as diabetes may have altered responses during radiotherapy.

Objective: This study aimed to evaluate the effect of radiotherapy on white blood cell (WBC) counts in brain tumor patients with and without diabetes, assessed before, during, and after treatment.

Methods: A total of 50 patients with brain tumors (25 males, 25 females; mean age 42.6 years) were treated with Volumetric Modulated Arc Therapy (VMAT) using the TrueBeam 3.0 system at Al-Amal Hospital, Baghdad. Blood samples were collected at three stages: pre-, during, and post-radiotherapy. Patients who received chemotherapy or immunosuppressive drugs were excluded. WBC counts were analyzed in relation to age, tumor grade, and diabetic status.

Results: Significant variations in WBC counts were observed across treatment stages according to age ($p < 0.05$) and tumor grade ($p < 0.05$). Grade 4 tumors (36%) and patients aged 25–59 years (38%) were the most affected groups. In contrast, no significant association was found between diabetes status and WBC counts during radiotherapy ($p > 0.05$).

Conclusion: Radiotherapy significantly impacts WBC levels in brain tumor patients, with effects influenced by age and tumor grade, but not by diabetic status. Continuous hematologic monitoring is essential for optimizing patient management during treatment.

Keywords: Brain tumors, Radiotherapy, White blood cells, VMAT, Diabetes.

INTRODUCTION

Ionizing radiation is a type of energy that has enough power to remove electrons from atoms or molecules, causing ionization (Hall & Giaccia, 2018). It originates from natural sources like cosmic rays and radioactive materials, or artificial sources like medical X-ray machines and nuclear reactors (Mettler & Upton, 2008). Ionizing radiation includes two main types: particulate (e.g., alpha and beta particles) and electromagnetic (e.g., X-rays and gamma rays) (Salim, D. A. et al.2024) (Bushberg et al., 2011). Its biological effects depend on the radiation's energy, dose, and the type of tissue exposed (UNSCEAR, 2000).

It is widely used in medicine for disease diagnosis (e.g., imaging) and treatment (e.g., radiotherapy for cancer) (IAEA, 2014). Despite its benefits, excessive exposure can damage cells and tissues, potentially causing genetic mutations and cancer (Little, 2009). Therefore, proper precautions and protective measures are essential to minimize harm to patients and healthcare workers (NCRP, 2010).

Radiotherapy is the use of high-energy waves or particles(Khalili, A.H., Kammona, A. and Ahmed, M.A., 2005), such as gamma rays or X-rays, to destroy or stop the growth of cancer cells (Delaney et al., 2005). It is commonly used as a primary or supportive treatment in many cancers, including brain tumors, usually given in multiple sessions (Stupp et al., 2005). In brain tumors, radiotherapy targets cancer cells precisely to minimize damage to surrounding healthy brain tissue. It helps shrink the tumor, relieve neurological symptoms, and reduce the risk of recurrence after surgery or when surgery is not possible (Mulvenna et al., 2016).

Despite its effectiveness, it may cause side effects like fatigue, temporary memory loss, or limited damage to nearby brain tissue (Mulvenna et al., 2016). Radiation therapy, especially whole-brain radiotherapy (WBRT), can significantly affect the bone marrow, which is responsible for producing blood cells (Kumar et al., 2021). Although the skull contains less active bone marrow than other parts of the body(Saadoon, Z.Z., Al-Khateeb, H.M. and Alkhafaji, K.R., 2019), radiation exposure can still lead to measurable changes in blood components (Shah et al., 2016).

Patients with brain tumors undergoing radiotherapy may experience a decrease in red blood cells (anemia), white blood cells (leukopenia), and platelets (thrombocytopenia) (Deek et al., 2016). These hematological changes can increase the risk of fatigue, infections, and bleeding(Fadhil, A.H. and Al-Rubaye, M.G., 2023), and may require careful monitoring of complete blood counts during treatment (Vikram et al., 1984). The severity of blood changes depends on the radiation dose (Khalisi, K.K.et al.,2014), treatment duration, and whether chemotherapy is used alongside radiotherapy (Deek et al., 2016).

Volumetric Modulated Arc Therapy (VMAT) is an advanced form of radiotherapy that allows precise delivery of radiation to brain tumors while minimizing exposure to surrounding healthy tissues (Otto, 2008). VMAT delivers radiation in a continuous arc around the patient, with the ability to change the intensity and shape of the beam in real time as the machine rotates (Otto, 2008). This technique is especially valuable in brain tumors, where critical structures like the optic nerves, brainstem, and healthy brain tissue must be protected. VMAT enables higher conformity to complex tumor shapes and can reduce treatment time compared to traditional techniques. As a result, patients benefit from improved tumor control, fewer side effects, and greater comfort during therapy sessions.

METHODOLOGY

The TrueBeam 3.0 system (Version 03.00.0013) is a modern linear accelerator installed at Al-Amal Oncology Hospital in Baghdad since August 2024. It delivers advanced radiotherapy techniques including VMAT, IMRT, and IGRT with high precision. This study utilized VMAT for treating patients with primary or metastatic brain tumors. Fifty patients aged 18–80 years were included, receiving 6 MV photon beam therapy tailored using Monaco TPS. Blood samples were collected at three points: before, during, and after radiotherapy to assess changes in hematologic and coagulation indices (WBC). Patients were selected based on strict inclusion/exclusion criteria, ensuring no interference from chemotherapy or immunosuppressive drugs. The radiotherapy workflow involved patient immobilization with a thermoplastic mask and real-time image-guided treatment delivery. All treatment plans were verified for quality assurance. VMAT allowed for shorter sessions and precise targeting with minimal dose to healthy tissue. The collected data were analyzed using SPSS software to evaluate statistical significance.

RESULTS

A total of 50 patients were included in this study. As shown in Table (1), the gender distribution was equal, with 25 females (50.0%) and 25 males (50.0%). This indicates a balanced representation of both sexes among the study population.

Table (1): Gender distribution of 50 patients.

Gender	No.	Percentage (%)
Female	**25**	**50.00**
Male	**25**	**50.00**
Total	**50**	**100.00**

The mean of age is 42.60, standard deviation is 15.206 and the range is between 17-72 years. Age factors can be divided into four main groups (15-24years), (25-39 years), (40-59 years) and equal or more than 60 years in order to be easy dealing with it. It can be obviously showed that the most affected age group (19) patients with (38.00%) percentage of age group (25-39 years) and(40-59 years), followed by (8) patients with (16.00%) percentage of age group equal or more than 60 years, and (4) patients with (8.00%) percentage of age group (15-24 years), as displayed in Figure (1).

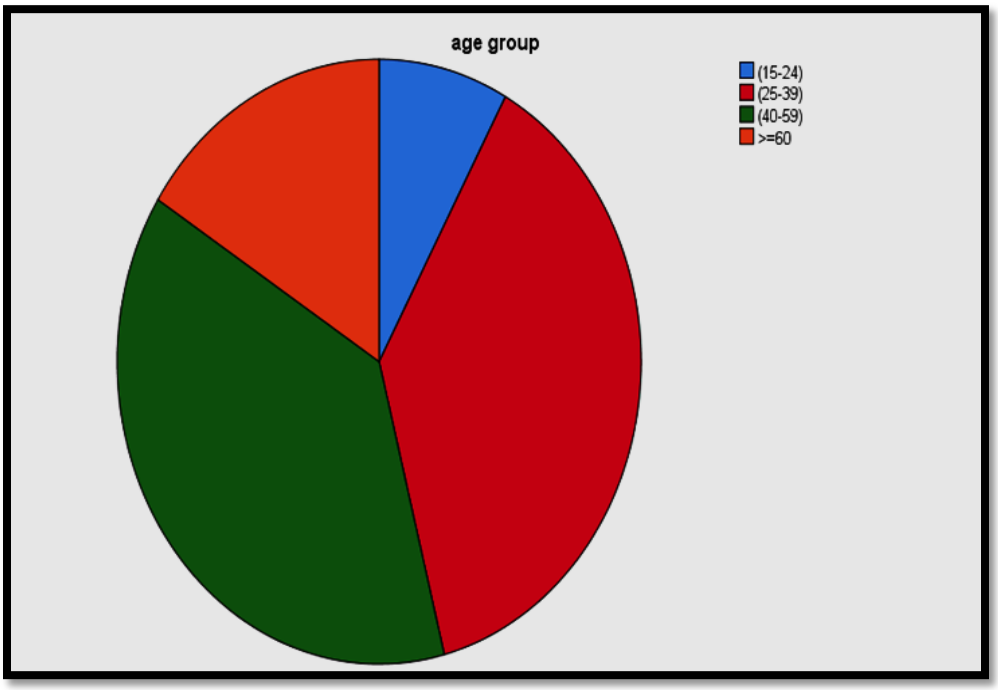

Figure (1):Frequency and percent of age groups of patients.

The tumor types of the brain cancer were observed and analyzed 50 patients from from March 2025 to June 2025 at Al-Amal radiotherapy hospital. Out of the total number of 50 patients, the tumor types was recorded(19) types. The highest value (6) patients with (12.00%) percentage of Anaplastic Oligodendroglia, as shown in Figure (2).

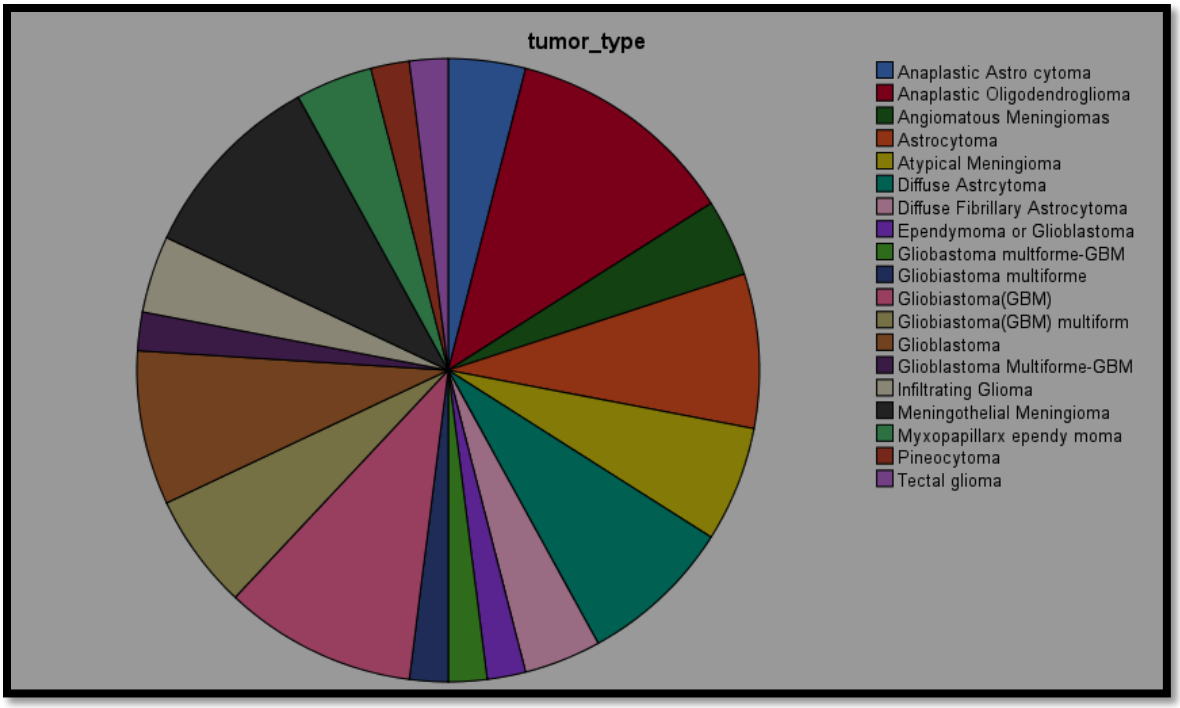

Figure (2): Pie-chart of tumor type.

The highest frequency from all tumor grade is (18) patints with (36.00 %) percentage of Grade 4, it followed by (14) with (28.00 %) percentage of Grade 2, as showed in Table (2).

Table (2) : The frequency distribution of tumor grade.

Tumor_grade	Frequency	%
Grade 1	9	18.0
Grade 2	14	28.0
Grade 3	9	18.0
Grade 4	18	36.0
Total	50	100.0

Radiotherapy can significantly impact blood components, with effects observed in pre, during and postexposure. Pre-treatment blood counts are generally utilized as a baseline for comparison. Common effects include decreases in white blood cells, red blood cells, hemoglobin, and platelets. WBC status results The WBCs were investigated to show the effect between their number in WBC-pre, WBC during and WBC-postexposure with age group to radiotherapy. One-way ANOVA test were used to compare between the mean, standard deviation and standard error mean differences. When P-Value >0.05 that indicates no significant differences between the number in WBC-pre, WBC during and WBC-postexposure with age group to radiotherapy, while P-Value < 0.05 that represents the significant differences between the number in WBC during, WBC-pre and WBC-postexposure with age group to radiotherapy was found. The findings exhibited a highly significant difference between WBC-Pre, WBC-

During, WBC-Post and age group according to (P-value=0.000, P-value=0.000, P-value=0.010), respectively, as displayed in Table (3).

Table (3): Descriptive statistical analysis of WBC status in each age group.

WBC		NO.	Mean	SD	SR	P-value
WBC_Pre	(15-24)	4	5.4925	1.25122	.62561	0.000
	(25-39)	19	6.9942	1.45203	.33312	
	(40-59)	19	5.2437	1.50641	.34559	
	>=60	8	7.8000	1.52784	.54017	
	Total	50	6.3378	1.75388	.24804	
WBC_Post	(15-24)	4	6.2900	1.25661	.62830	0.000
	(25-39)	19	6.0147	1.55379	.35646	
	(40-59)	19	5.8342	1.23113	.28244	
	>=60	8	9.5625	2.10641	.74473	
	Total	50	6.5358	1.99272	.28181	
WBC_Durin g	(15-24)	4	7.8500	3.04467	1.52233	0.010
	(25-39)	19	11.4926	5.08720	1.16708	
	(40-59)	19	6.7726	4.15123	.95236	
	>=60	8	7.5375	2.01915	.71388	
	Total	50	8.7748	4.66106	.65917	

Moreover, the WBCs were investigated to show the effect between their number in WBC-pre, WBC during and WBC-postexposure with tumor grade to radiotherapy. The results exhibited a highly significant difference between WBC_Pre, WBC_Post, and tumor grade according to (P-value=0.000.P-value=0.005), respectively, however, there was no significant difference bwetween WBC_During and tumor grade according to P-value=0.726, as displayed in Table(4).

Table (4): Descriptive statistical analysis of WBC status in each tumor grade.

		NO.	Mean	SD.	SR	P-value
WBC_Pre	Grade 1	9	7.1589	1.96786	.65595	
	Grade 2	14	6.1221	1.33162	.35589	
	Grade 3	9	7.6422	1.22904	.40968	0.005
	Grade 4	18	5.4428	1.68314	.39672	
	Total	50	6.3378	1.75388	.24804	
WBC_Durin g	Grade 1	9	8.3211	3.87922	1.29307	
	Grade 2	14	9.9207	4.60374	1.23040	
	Grade 3	9	8.8811	3.64173	1.21391	0.726
	Grade 4	18	8.0572	5.59902	1.31970	
	Total	50	8.7748	4.66106	.65917	
WBC_Post	Grade 1	9	7.2167	1.47868	.49289	0.000
	Grade 2	14	6.1843	1.03609	.27691	
	Grade 3	9	8.8111	2.37668	.79223	
	Grade 4	18	5.3311	1.52084	.35847	

Total	50	6.5358	1.99272	.28181	

Consequently, the WBCs were investigated to show the effect between their number in WBC-pre, WBC during and WBC-postexposure with chronic diease like diabetes. It was elevated WBC levels, even within the normal range, are associated with an increased risk of developing type 2 diabetes and its complications. The findings showed no significant difference between WBC-Pre, WBC-During and WBC-Post with diabetic disease according to (P-value=0.673, P-value=0.175 and P-value=0.747), respectively, as shown in Table (5).

Table (5) : Descriptive statistical analysis of WBC status according to diabetic disease.

		NO.	Mean	SD	SE	P-value
WBC_Pre	Healthy	16	6.6650	1.91155	.47789	0.673
	diabetic type 1	12	6.1750	1.25550	.36243	
	diabetic type 2	22	6.1886	1.90310	.40574	
	Total	50	6.3378	1.75388	.24804	
WBC_During	Healthy	16	9.7219	4.53796	1.13449	0.175
	diabetic type 1	12	10.0508	4.84316	1.39810	
	diabetic type 2	22	7.3900	4.48042	.95523	
	Total	50	8.7748	4.66106	.65917	
WBC_Post	Healthy	16	6.5175	1.57146	.39286	0.747
	diabetic type 1	12	6.1850	1.51857	.43837	
	diabetic type 2	22	6.7405	2.48579	.52997	
	Total	50	6.5358	1.99272	.28181	

DISCUSSION

Our results show highly significant changes in WBC counts across pre-, during-, and post-treatment phases when grouped by age (P = 0.000, 0.000, 0.010). This is consistent with previous findings that elderly patients have reduced bone marrow reserve and immune function, making them more susceptible to radiation-induced leukopenia (Wang et al., 2021).

When stratified by tumor grade, WBC-pre and WBC-post showed significant differences (P = 0.000, 0.005), whereas WBC-during was not significant (P = 0.726). Tumor-related systemic factors such as higher-grade tumors triggering inflammatory responses or marrow suppression may influence baseline and post-treatment WBC levels, while immediate during-treatment effects may be buffered by compensatory immune mechanisms (Cheng et al., 2017; Li et al., 2023).

Studies in various cancers report WBC declines of 24–37% during radiotherapy, often correlated with irradiated volume and baseline counts supporting our findings of initial decline by tumor grade and later rebounds or plateaus (Kim et al., 2019; Wang et al., 2021).

Age-based analysis revealed highly significant differences in RBC counts before and during treatment (P = 0.000, 0.000), and a significant difference post-treatment (P = 0.009). Older patients may have baseline

anemia or diminished erythropoietic function, which radiation exacerbates through marrow toxicity or systemic inflammatory disruptions (Zhao et al., 2020).

This study examined white blood cell (WBC) counts at three different stages before radiotherapy (WBC-Pre), during radiotherapy (WBC-During), and after radiotherapy (WBC-Post) in relation to diabetic status (healthy individuals, type 1 diabetes, and type 2 diabetes). The aim was to assess whether diabetes, as a chronic condition, influences WBC behavior during radiotherapy. The statistical analysis revealed no significant differences in WBC counts between the groups across all three stages, with P-values of 0.673 for WBC-Pre, 0.175 for WBC-During, and 0.747 for WBC-Post. Although slight differences in mean WBC values were observed, particularly during treatment, these were not statistically significant due to relatively high standard deviations and the small sample size, especially in the type 1 diabetic group (n = 12).The observed increase in WBC counts during radiotherapy among both diabetic and healthy individuals may be attributed to systemic inflammatory responses triggered by radiation exposure. However, the absence of statistically significant differences between groups suggests that diabetes does not independently influence WBC responses in the context of radiotherapy.

CONCLUSION

This study demonstrated that radiotherapy for brain tumor patients significantly affects hematologic parameters, particularly white blood cell counts, with variations linked to patient age and tumor grade. The highest prevalence of tumors was found in middle-aged adults, and Grade 4 tumors were most common. The significant changes in blood components before, during, and after treatment highlight the importance of continuous monitoring to manage potential side effects effectively. While no association was found between diabetes and white blood cell counts during radiotherapy. Advanced radiotherapy techniques like VMAT enable precise treatment delivery, minimizing harm to healthy tissues while addressing tumor control. Overall, these findings support the need for personalized patient care and close hematologic assessment during radiotherapy.

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