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Superoxide Dismutase and Vitamin E Levels in Serum as Indicators in Patients with Acute and Chronic Leukemia

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Abstract

Oxidative stress has been linked to the development of a variety of malignancies, including leukemia. Furthermore, the incidence of leukemia increases with age due to an increase in the number of free radicals reacting with age and a lower ability of the immune system to detoxify those free radicals. This study aims to investigate the levels of antioxidant activity and their relationship with various types of leukemia. The current study was carried out in the Hematology section of Baghdad Teaching Hospital/Medical City from November 2020 to January 2021. Patients with leukemia (n = 60) were divided into four groups based on their leukemia type: Acute lymphoid leukemia (ALL), acute myeloid leukemia (AML), chronic lymphoid leukemia (CLL), and chronic myeloid leukemia (CML). These groups were compared to 30 healthy subjects. In this study, serum levels of superoxide dismutase (SOD) and vitamin E were measured using an enzyme-linked immunosorbent assay. The findings revealed that (Mean±SE) SOD levels were observed to be raised with age, but (Mean±SE) vitamin E levels decreased with age in leukemia patients. There were no statistically significant differences in gender (males and females). Compared with healthy subjects, the results showed a significant increase in SOD levels in ALL, AML, CLL, and CML ($P < 0.01$). There were no statistically significant differences observed in vitamin E levels in ALL, AML, and CML except for the CLL group, which showed a significant decrease compared to the healthy subjects. Positive correlations were found between SOD and age ($r = 0.367$ $P < 0.01$). These results suggest that SOD and vitamin E levels play a critical role as an indicator of acute and chronic leukemia.

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1. Introduction

According to the International Agency for Research on Cancer (IARC), cancer cases have increased to 8.8 million per year, with the rate anticipated to rise to 13.2 million by 2030 [1]. Cancer is known for the uncontrolled proliferation and spread of aberrant cells. Chemotherapy and radiation therapy were developed to treat various types of cancer, but they also harmed, damaged, and killed normal cells [2, 3]. Leukemia is a kind

of blood cancer characterized by an increase in abnormal white blood cells known as blasts or leukemia cells that have not fully matured. Leukemia cells grow faster than healthy ones. They gradually replace normal WBCs and RBCs and may move the lymph nodes and other organs [4]. Leukemia is classified as acute or chronic based on the rate at which it progresses. Leukemia is further divided into two categories depending on cell type: lymphoid and myeloid leukemia. Acute lymphoid leukemia (ALL), acute myeloid leukemia (AML), chronic lymphoid leukemia (CLL), and chronic myeloid leukemia (CML) are the four forms of leukemia [5]. Antioxidants are substances that prevent oxidative damage by interacting with free radicals [6]. The increase in free radical levels is linked to cancer etiology because it may damage DNA, cause protein destruction, and eventually contribute to tumor development [7]. According to scientific research, antioxidants reduce the risk of chronic illnesses such as cancer and heart disease [8]. Antioxidants exist in intracellular and extracellular settings in both enzymatic and non-enzymatic forms. Enzymatic antioxidants work by reducing and removing free radicals. Antioxidant enzymes convert damaging oxidative products to hydrogen peroxide (H_2O_2) and, eventually, the water in a multistep process that includes cofactors such as copper, zinc, manganese, and iron. An example of the enzyme antioxidant is superoxide dismutase (SOD) [9, 6]. Non-enzymatic antioxidants work by interfering with the chain reactions of free radicals. Vitamin E is an example of a non-enzymatic antioxidant. Normal metabolic processes increase environmental exposure, such as ultraviolet radiation exposure, and larger amounts of dietary xenobiotics result in reactive oxygen species (ROS) and reactive nitrogen species (RNS). Both ROS and RNS are responsible for oxidative stress in various pathophysiological situations. In oxidative stress circumstances, cellular components of the human body can change, resulting in different disease states. By boosting cellular defenses with antioxidants, oxidative stress can be successfully mitigated [9, 10]. Superoxide dismutase (SOD) is the most important enzymatic oxidant, acting as a free radical scavenger alongside other nutritional antioxidants, providing the first line of defense against ROS-induced tissue damage [11]. Over the last 50 years, it has become increasingly clear that SOD plays a critical function in maintaining cellular health and that SOD dysregulation leads to a range of illnesses. SOD is a necessary enzyme that catalyzes the conversion of superoxide (O_2^-) radicals into H_2O_2. Oxygen (O_2) is subsequently transformed into O_2 and H_2O in a process catalyzed by glutathione peroxidase (GPx) or catalase (CAT). Furthermore, in the presence of transition metal ions, H_2O_2 can be degraded into hydroxyl radical (•OH) and hydroxide ions (OH^-). As a result, SOD plays a crucial role in balancing oxidation and anti-oxidation [12]–[14]. However, there is conflicting information about the activities of antioxidant enzymes in cancer patients [15], where higher SOD levels have been shown in previous studies [16, 17]. In contrast, other studies have indicated a decrease in SOD levels in leukemia patients [18,19]. Vitamin E (α-tocopherol) is a lipid-soluble component of the cell's antioxidant defense system acquired only via diet. Because of its antioxidant function, it protects against various diseases associated with oxidative damage, including cancer, aging, arthritis, Alzheimer's disease, and cataracts. Vitamin E may also help reduce platelet hyperaggregation, a risk factor for atherosclerosis. Furthermore, it aids in reducing prostaglandins such as thromboxane, which induces platelet clumping [20, 21]. The primary biologic function of vitamin E is to protect polyunsaturated fatty acids (PUFAs) and other components of cell membranes and low-density lipoprotein (LDL) against oxidation by free radicals. Vitamin E is predominantly found in the phospholipid bilayer of cell membranes. It is especially efficient at preventing lipid peroxidation, a sequence of chemical processes involving the oxidative degradation of PUFAs. Vitamin E can help prevent the production of nitrosamines, which are carcinogens produced in the stomach from nitrites ingested in the diet. It may help protect against the development of cancer by boosting immune function [22], [23]**.** Several studies have found a reduction in vitamin E levels in leukemia patients [23, 24]. Tsamesidis *et al*. revealed that increased oxidative stress in the serum of leukemia patients is associated with a decrease in vitamin E concentration, total antioxidant capacity (TAC), and an increase in ROS levels [25]. The antioxidant activity of non-enzymatic antioxidants and antioxidant enzymes balances the effect of reactive species. Antioxidant defenses are critical because they represent the direct elimination of free radicals (pro-oxidants), offering the best possible protection for biological sites [15]. Hence, this study aims to investigate the serum levels of SOD and vitamin E in acute and chronic leukemia to determine the role of oxidative stress in disease progression.

2. Materials and Methods

2.1. Study Design

This study was carried out in the Hematology section of Baghdad Teaching Hospital/Medical City from November 2020 to January 2021. This study comprised 90 people: 60 patients with leukemia (30 females and 30 males) and 30 healthy subjects (15 females and 15 males). The patients were categorized by age and sex with

healthy subjects. The patients were sent and admitted to the Baghdad Teaching Hospital's hematology department for diagnostic assessment and treatment of their hematological illness, where consultant hematologists established the diagnosis following the hematology unit's baseline protocol. Age, gender, body mass index (BMI), numbers of (WBC, RBC, hemoglobin, and platelets), chronic disease, period of smoking, duration of the disease, and kind of leukemia were all obtained from each patient. The following equation was used to calculate body mass index (BMI) [26]:

$$BMI = \frac{W}{h^2} \quad (1)$$

Where; W indicates weight in kilograms, h indicates the height in meters. Following that, patients were divided into four groups depending on the type of leukemia as follows: The first group included fifteen patients with acute lymphocytic leukemia (ALL), age (Mean±SE) was (27.9 ± 3.44) years. The second group included fifteen patients with acute myeloid leukemia (AML), age (Mean±SE) was (40.33 ± 4.1) years. The third group included twelve patients with chronic lymphocytic leukemia (CLL), age (Mean±SE) was (55.8 ± 3.8) years. The fourth group included eighteen patients with chronic myeloid leukemia (CML), age (Mean±SE) was (50.9 ± 3.0) years.

2.2. Sample Collection

Blood samples were obtained from leukemia patients and healthy subjects; 5 ml of blood was drawn intravenously and placed in a vacuum gel tube. After clotting, the serum samples were separated by centrifugation (for 20 minutes (at approximately 1000 x g)). The serum was then put in tiny tubes (Eppendorf tubes) and stored in a deep freeze (-30^{o}C) at a blood bank (at Ghazi al-Hariri Surgical Specialties Hospital in Medical City) until analysis. The Sandwich-ELISA method was utilized to identify SOD obtained from Sunlong and vitamin E obtained from MYBISOURCE. Thyroid dysfunction, asthma, and arthropathies were all ruled out in this study.

2.3. Determination of Superoxide Cismutase and Vitamin E

Superoxide dismutase levels were determined by using the sandwich ELISA method. The Micro-Elisa strip plate included in this kit has been pre-coated with a SOD-specific antibody. Standards or samples were added to the relevant Micro-Elisa strip plate wells and mixed with the particular antibody. Then, a horseradish peroxidase (HRP)-conjugated antibody specific for SOD was added and incubated in each Micro-Elisa strip plate well. Following incubation, unbound components are washed away. The substrate solution, tetramethylbenzidine (TMB), was added to each well. Only the wells containing SOD and HRP conjugated SOD antibodies showed blue at first, then turned yellow once the stop solution was added. The optical density (OD) was measured spectrophotometrically at 450 nm. The OD value was correlated with the concentration of SOD. A standard curve was drawn between OD and the concentration of standards to determine the concentration of SOD in the samples. Vitamin E levels were determined by using the sandwich ELISA method. Human vitamin E antibody has been pre-coated on the plate. First, vitamin E from the sample was introduced and bound to antibodies coated in the wells. Next, the biotinylated human vitamin E antibody was added and bound to vitamin E in the sample. Streptavidin-HRP was then added, which binds to the biotinylated vitamin E antibody. Following incubation, unbound Streptavidin-HRP has washed away during a washing phase. After that, the substrate solution was added, and the color was developed by the quantity of human vitamin E. The process was stopped by adding an acidic stop solution, and the absorbance was measured at 450 nm. The concentration of vitamin E in the samples was determined by comparing the OD of the samples to the standard curve.

2.4. Statistical Analysis

The SPSS statistical program (Version/16.0; SPSS Inc., Chicago, IL) was used to analyze the data. T-test analysis was used to determine whether there were any statistically significant differences between the means. Data was presented as (mean ± Standard Error). Pearson's correlation (r-correlation) was used between SOD, vitamin E, BMI, and age. Data were considered as a significant (S) at p-value < 0.05, high significant (H.S) at p-value < 0.01, and non-Significant (N.S) at p-value> 0.05.

3. Results and Discussion

3.1. Demographic and Hematologic Features in the Present Study

This study included 60 patients with acute and chronic leukemia and 30 healthy subjects. The results showed no statistically significant differences in age, body mass index (BMI), and red blood cell (RBC) in leukemia patients compared to healthy subjects. However, the results also showed a significant increase in white blood cells (WBC) and a highly significant decrease in hemoglobin (Hb) and platelets in leukemia patients as compared to healthy subjects (Table1).

Table 1: Demographic and hematological features of leukemia patients and healthy subjects

Parameter	Healthy subjects Mean ± Std. Error	Patients Mean ± Std. Error	p-value	Sig.
Age (Year)	41.5 ± 2.7	43.5 ± 2.2	٠,٥٩	N.S
BMI (Kg/m^2)	28.4 ± 1.04	27.5 ± 0.95	0.561	N.S
WBC ($\times10^9/l$)	6.84 ± 0.35	13.76 ± 4.71	0.019	S
RBC ($\times10^{12}/l$)	4.88 ± 0.10	3.76 ± 0.48	0.179	N.S
Hb (g/dl)	13.12 ± 0.35	9.44 ± 0.37	0.001	H.S
PLT ($\times10^9/l$)	237 ± 17.12	135 ± 18.18	٠,٠٠١	H.S

H.S: High significant, N.S: Non-significant, S: Significant.

As shown in Table 1, WBC levels in patients were higher than in healthy subjects. Leukemia is a blood malignancy that originates in the bone marrow. Leukemia is characterized by an uncontrollable rise in the number of white blood cells that inhibits the production of normal red blood cells, platelets, and mature white cells (leukocytes) [27]. This causes erythrocytopenia, thrombocytopenia, and various symptoms when typical blood components are suppressed, resulting in anemia [28]. The results revealed a highly significant decrease in Hb levels in patients compared to healthy subjects. This could be due to anemia, which is one of the symptoms of leukemia and is defined as a decrease in either the number of circulating erythrocytes or the quantity of hemoglobin in the blood [29]. This might explain why patients have low hemoglobin levels. In the current study, the platelet count may have decreased in patients due to the buildup of blast cells in the bone marrow, which leads to the bone marrow being unable to create normal blood components [28]. Therefore, the findings of this study were consistent with the results of previous studies [28, 30].

3.2. Super Oxide Dismutase (SOD) and Vitamin E Levels in Leukemia Patients and Healthy Subjects according to Age

As shown in (Table 2), the results found a highly significant increase in SOD levels (9.35 ± 0.65 ng/ml) of patients aged 50 years or above as compared to the age-matched healthy subjects (5.08 ± 0.46 ng/ml), and a significant increase in SOD levels of patients (7.99 ± 0.51 ng/ml) under 50 years of age as compared with healthy subjects (5.55 ± 0.80 ng/ml). While vitamin E levels (25.06 ± 2.91nmol/ml) showed a significant decrease in patients aged 50 years or above as compared to the age-matched healthy subjects (38.35 ± 6.01 nmol/ml), also there was no significant difference in vitamin E levels of patients (30.76 ± 2.59 nmol/ml) under 50 years of age as compared with the healthy subjects (36.86 ± 3.39 nmol/ml).

Table 2: Comparison of SOD and vitamin E levels in leukemia patients and healthy subjects according to age

Parameter	Healthy subjects Age ≥ 50 No=11	Leukemia Age ≥ 50 No=28	p-value	Sig	Healthy subjects <٥٠ Age No= 19	Leukemia <٥٠ Age No= 32	p-value	Sig.
SOD (ng/ml) Mean ± SE	5.08 ± 0.46	9.35 ± 0.65	0.001	H.S	5.55 ± 0.80	7.99 ± 0.51	0.01	S
Vitamin E (nmol/ml) Mean ± SE	38.35 ± 6.01	25.06 ± 2.91	0.032	S	36.86 ± 3.39	30.76 ± 2.59	0.158	N.S

H.S: High significant, N.S: Non-significant, S: Significant

3.3. Super Oxide Dismutase (SOD) and Vitamin E levels in Leukemia Patients according to Age and Gender

The results found no significant differences in SOD and vitamin E levels when leukemia patients were divided according to age, as they were split into two groups; more than or equal to 50 years old and less than 50 years old. Furthermore, the results found no significant differences in SOD and vitamin E levels when leukemia patients were divided according to gender, as shown in Table 3.

Table 3: Comparison of SOD and vitamin E levels in leukemia patients according to age and gender.

Group		Case number	SOD (ng/ml) Mean ± SE	P-value	Sig	Vitamin E (nmol/ml) Mean ± SE	P-value	Sig.
Age	Age ≥ 50	28	9.35 ± 0.65	0.102	N.S	25.064 ± 2.91	0.98	N.S
	Age < 50	32	7.99 ± 0.51			30.76 ± 2.59		
Gender	Males	30	9.06 ± 0.66	0.89	N.S	28.94 ± 2.62	0.64	N.S
	Females	30	8.92 ± 0.71			27.26 ± 2.94		

N.S: Non-significant.

The results in Tables 2 and 3 showed that SOD levels were higher in patients aged 50 years or older compared to healthy subjects of the same age, as well as when compared with younger patients. This reflects the extent of free radicals that may have caused the triggering antioxidant production, as shown in a previous study where it was observed that (Mean±SE) SOD levels increased with age in leukemic patients [17]. On the contrary, vitamin E levels in leukemia patients aged 50 years and over were decreased in this study. Furthermore, Pujari *et al.* found that (Mean±SE) vitamin E levels were decreased in leukemia patients over the age of 50 compared to younger patients. Several studies have found that antioxidant activity is related to the aging process [23]. For example, Casado *et al*. observed that the antioxidant enzyme was elevated in age-related diseases such as cardiovascular disease, chronic obstructive pulmonary disease, myomas, and acute cerebral accidents [31]. Another study found that excessive free radical generation in the body and an imbalance between these free radicals and antioxidant defenses were linked to processes like aging and the development of various diseases like cancer [32]. Concerning gender, (Mean±SE) SOD and vitamin E levels were found to be slightly higher in males than in females, but there was no significant difference found in patients when compared according to gender. Previously, it was found that males had a higher total antioxidant status than females, indicating that genetic variation was identified in the regulation of the oxidation state [33]. Poongothai *et al*. found no significant difference in superoxide dismutase activity between genders in all types of leukemia except for chronic myelogenous leukemia (CML) patients [17]. A previous study observed a difference in vitamin E levels between the genders only in AML and CML patients, and the gender difference was not apparent in both (ALL and CLL) [23].

3.4. Super Oxide Dismutase (SOD) Levels in Lleukemia Patients and Healthy Subjects

This study classified leukemia patients into different subtypes (AML, ALL, CML, and CLL). SOD levels were elevated in all groups of leukemia patients compared with healthy subjects (Figure 1). The results demonstrated there was a highly significant increase in SOD levels (ng/ml) in ALL, AML, CLL, and CML (6.24 ± 0.46, 8.52 ± 0.66, 7.79 ± 0.50, and 11.95 ± 0.76 respectively) as compared with healthy subjects (4.91 ± 0.27) (Table 4). These findings are consistent with the study of Mahmoud *et al.* that showed an increase in SOD levels in ALL patients compared to the healthy subjects [16]. SOD can protect cells from low levels of oxidative stress by catalyzing the dismutation of superoxide anion generated in the cell. However, this enzyme works as a

peroxidase at high levels, which can be detrimental to the cell by increasing hydrogen peroxide production. Furthermore, hydrogen peroxide is more toxic than superoxide anion in the presence of iron or copper owing to the production of hydroxyl radicals via the Fenton-Haber Weiss reaction, one of the most toxic reactive oxygen species in vivo [16, 34]. In AML patients, the levels of SOD were higher than in the healthy subjects. This is consistent with a previous study that found serum SOD activity was significantly increased in acute leukemia patients (ALL and AML) than in healthy subjects [35].

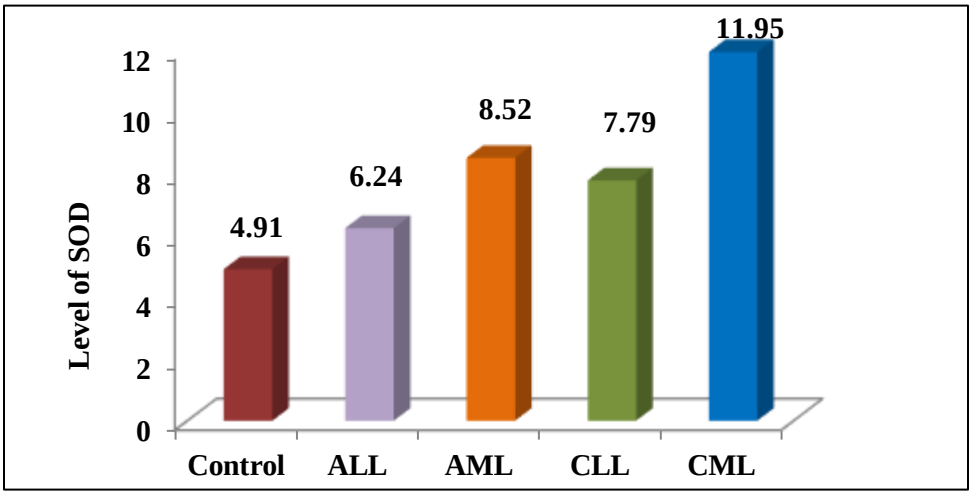

Figure 1: Serum SOD levels in subtypes of leukemia and healthy subjects.

Table 4: Serum levels of super oxide dismutase (Mean±SE) in different types of leukemia and healthy cases.

Groups	SOD (ng/ml) Mean ± Std. Error	P-Value	Sig.
Healthy subjects	4.91 ± 0.27		
Acute lymphoblastic leukemia (ALL)	6.24 ± 0.46	0.01	H.S
Acute myelogenous leukemia (AML)	8.52 ± 0.66	0.001	H.S
Chronic lymphocytic leukemia (CLL)	7.79 ± 0.50	0.001	H.S
Chronic myelogenous leukemia (CML)	11.95 ± 0.76	0.001	H.S

H.S: High significant, S: Significant.

Previous studies have found alterations in antioxidant enzyme activities in the serum [36], leukocytes [37], and erythrocytes [38] of leukemia patients. Because H_2O_2 is not reactive, it may flow through cellular membranes and enter any cellular compartment, including the nucleus and DNA. High amounts of oxidative DNA base damage might be the reason for the reduction in O_2^-, which resulted in the accumulation SOD levels [35]. In a recent study, SOD levels in (CML, CLL) patients were higher than in healthy subjects. Oxidative stress has been related to various acute and chronic diseases, cancer, and leukemia. Furthermore, the body's defensive system would play an essential role in antioxidants in attempting to limit the damage and adjusting to stressful situations [39]. Treatment may also contribute to an increase in SOD levels in leukemia patients related to the increased free radical generation caused by chemotherapy. This increase in free radicals triggers a cascade of reactions that rise antioxidants like SOD [17, 40]. These findings are consistent with a study by Al-Gayyar *et al*. that found high levels of serum SOD activity in chronic leukemia patients (CML and CLL) before and after treatment compared to healthy subjects [40]. In addition, Poongothai *et al*. found that (Mean±SE) SOD levels in treating AML and CML patients were higher than those in untreated AML and CML patients [17]. This rise occurred in response to both ROS and chemotherapy [40].

3.5. Vitamin E levels in Leukemia Patients and Healthy Subjects

Vitamin E levels were investigated in the serum of leukemia patients and healthy subjects. The mean value of leukemia patients in all types was lower than the healthy subjects (Figure 2), but the results demonstrated there were no statistically significant differences observed in vitamin E levels (nmol/ml) in ALL, AML, and CML

(32.35 ± 4.26, 29.63 ± 4.51, and 30.83 ± 2.92, respectively) compared with the healthy subjects (37.41 ± 3.01). At the same time, the CLL group revealed a significant decrease compared to the healthy subjects (24.45 ± 2.11 vs. 37.41± 3.01). The results of leukemia patients and healthy subjects are summarized in Table 5.

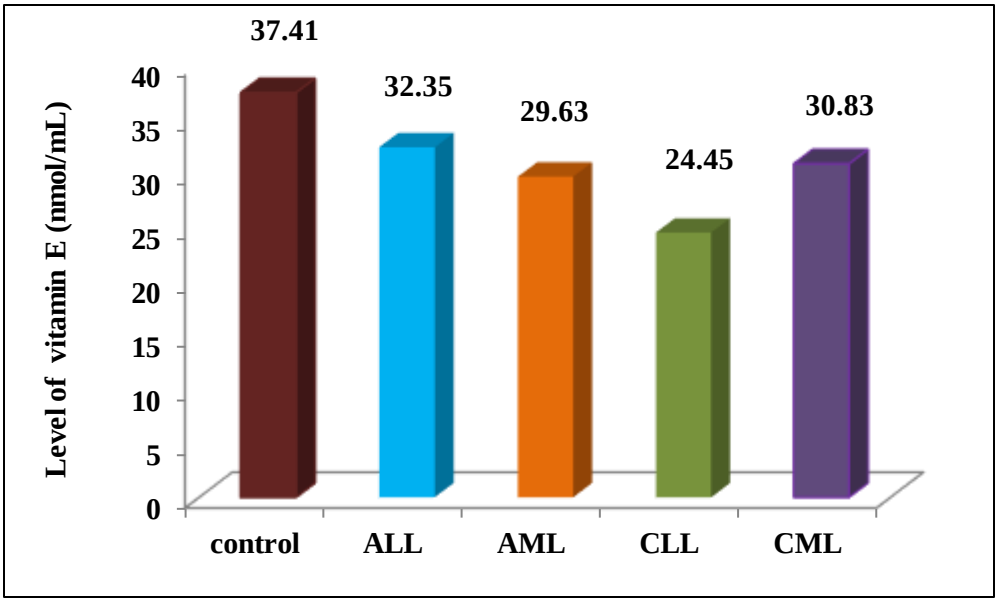

Figure 2: Vitamin E levels in the serum of leukemia patients and healthy subjects.

Table 5: Serum levels of vitamin E (Mean±SE) in different types of leukemia and healthy subjects' cases.

Groups	Vitamin E (nmol/ml) Mean ± Std. Error	P-Value	Sig.
Healthy subjects	37.41 ± 3.01		
Acute lymphoblastic leukemia (ALL)	32.35 ± 4.26	٠,٣٣٨	N.S
Acute myelogenous leukemia (AML)	29.63 ± 4.51	٠,١٥٦	N.S
Chronic lymphocytic leukemia (CLL)	24.45 ± 2.11	٠,٠١٣	S
Chronic myelogenous leukemia (CML)	30.83 ± 2.92	٠,١٥٣	N.S

S: Significant, N.S: Non-significant.

The present study results agree with the prior study, which found there was no significant difference observed in vitamin E levels in AML, ALL, and CML compared with healthy subjects [41]. CLL group revealed a significant decrease as compared to the healthy subjects. This agreed with the previous study, which found there was a significant decrease in all types of leukemia patients compared to the healthy subjects [23]. Vitamin E is a powerful peroxyl radical scavenger and a chain-breaking antioxidant that inhibits free radical propagation in membranes and plasma lipoproteins. Tocopherol's hydroxyl group (Vit E-OH) interacts with the peroxyl radical (ROO•) to generate the corresponding lipid hydroperoxide and tocopheryl radical (Vit E-O•). The tocopheryl radical (Vit E-O•) interacts with vitamin C (or other hydrogen donors, AH), oxidizing the latter and restoring vitamin E to its reduced state [42]. The ability of leukemic cells to proliferate is controlled by highly viscous intracellular glycosaminoglycans. The cells secrete the hyaluronidase enzyme to deal with the condition described above. Vitamin C may be used in the production of hyaluronidase, resulting in a reduction in total vitamin C levels. When compared to healthy subjects, the total number of white blood cells in leukemia is greatly increased, which increases the requirement for ascorbic acid or vitamin C. These white blood cells may consume the available vitamin C in plasma or serum, resulting in a fall in plasma vitamin C levels. Low vitamin C levels can lead to a buildup of tocopherol radicals that are not regenerated back into tocopherol. As a result, vitamin E levels may be reduced in leukemia patients [23, 43]. In the current study, it was revealed that the CLL group had lower levels of vitamin E than the other subtypes of leukemia when compared to the healthy subjects. This disease is particularly common in older people [44]. The majority of CLL patients in this study were above the age of 50 years. This study agreed with a previous study that found that the level of vitamin E declined in

leukemia patients over the age of 50 years compared to those under this age, indicating that the process of aging is related to the level of antioxidant activity [23]. Malnutrition is also a major cause of vitamin E deficiency in leukemia because malnourished people have weakened immune and hematopoietic systems. Another basic causative reason for vitamin E deficiency in leukemic patients is oxidative stress, which is associated with an increase in ROS buildup in the biological system [18].

3.6. Correlations between Parameters in Leukemia Patient

As shown in Table 6, the results showed a non-significant correlation ($P > 0.05$) between SOD with vitamin E, SOD with BMI, vitamin E with age, and vitamin E with BMI, while the results observed a highly significant positive correlation between SOD and age ($r = 0.367$, $P < 0.01$).

Table 6: Correlations between parameters in leukemia patients.

Correlation between	Pearson Correlation (r)	P-value	Sig.
SOD and Vitamin E	0.216	0.103	N.S
SOD and Age	0.367	0.006	H.S
SOD and BMI	0.110	0.405	N.S
Vitamin E and Age	- 0.132	0.313	N.S
Vitamin E and BMI	- ٠.232	0.074	N.S

In this study, as shown in Table 3, there was an increase in SOD levels in older leukemia patients compared to younger patients. This represents the number of free radicals that may have prompted antioxidant activity [17]. This was consistent with the findings of Poongothai *et al*., [17] which found that SOD levels increased with age in leukemic patients. Another study revealed an increase in SOD levels in human cerebrospinal fluid (CSF) in rectal carcinoma, cervical cancer, endometrial cancer, leiomyoma, inguinal hernia, ovarian cyst, and pregnancy, and found that SOD activity in these patients increased with age, explaining that the reason for that could be the expression of a self-protective mechanism from free radicals [45]. These results correspond to the positive correlation between SOD and age.

4. Conclusions

In this study, the high levels of SOD and low levels of vitamin E regardless of the type of leukemia reflect the pathogenic condition, free-radical buildup, and high levels of oxidative stress in leukemia patients. The discovery and assessment of antioxidant activities and sufficient oxidative stress biomarkers of cancer cell metabolism might be beneficial for the early diagnosis of leukemia patients as well as cancer progression evaluation. Furthermore, they serve as predictive variables and have prognostic significance in the prediction of clinical illness outcomes and the development of leukemia disease. As a result, antioxidants are recommended to be assessed continuously to improve the identification of leukemia diseases since antioxidants play a significant function as a protective mechanism against these free radicals, thereby reducing the risk and consequences of leukemia disease.

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Conflict of Interest

There are no conflicts of interest.

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