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Article

Effect of Hyperthyroidism in Serum Samples Utilizing Cyclic Voltammetry

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Abstract: Hyperthyroidism is a speeds up the body's metabolism by excessive production of thyroid hormones, which may lead to various physiological changes in the body. The aim of this study was to examine the effect of hyperthyroidism on the oxidative profile of serum samples using cyclic voltammetry, and to evaluate changes in redox behavior, identify potential biomarkers, and the mechanisms of oxidative stress in hyperthyroidism. The influence of serum samples was obtained from individuals diagnosed with hyperthyroidism and healthy controls by using a cyclic voltammetry. samples of 30 patients of hyperthyroidism showed significant differences in oxidative stress by enhanced the current peak compared to the control group, indicating altered redox properties. Specific oxidation stress parameters were found to be elevated in the hyperthyroidism patients against to different diseases suffered these patients by analyses each of T3, T4, TSH, FBG, HbA1C, TC, TG, and HDL. The oxidative stress of the hyperthyroidism of the patients can be treated by ascorbic acid which acts as anti-oxidative reagent. The identified biomarkers and mechanistic understanding gained from this research could contribute to a better understanding of the role of oxidative stress in the pathophysiology of hyperthyroidism

Keywords: Hyperthyroidism, Serum Samples, Cyclic Voltammetry, Ascorbic Acid, Redox Reaction

Introduction

Cyclic voltammetric technique (CV) is one of the most effective and valuable electroanalytical methods and it has very famous for different electrochemical studies. CV was used in the field of biochemistry to finding the effect the oxidative effect in blood composition, many studies in .electrochemical properties were added to the literature a new important knowledge [1] Hyperthyroidism is one of the medical condition, which caused by a thyroid gland too active reaction the human body. The thyroid gland makes thyroxine hormone, that hormone manage the body's metabolism. The thyroid-stimulating hormone is also called "TSH." TSH is made in the pituitary gland .[2]

Many studies have been focused on the hyperthyroidism, one of them is determined the .relationship between plasma Coenzyme Q_{10} (CoQ_{10}) and thyroid hormones in hyperthyroid patients The study suggest that oxidative stress of hyperthyroid has been effected on the heart diseases [3]. In the other study found the Malondialdehyde (MDA) level was significantly higher in hyperthyroid

patients treated with carbimazole alone. Therefore, the supplementation of antioxidants could be utilized to improve thyroid function in hyperthyroid patients by boosting antioxidants and restoring oxidant-antioxidant balance [4]. Electrochemical study using cyclic voltammetry to find the effect of .different concentrations of thiamazole in the absence and presence of sodium pertechnetate (99mTc) The hyperthyroidism state in patients is due to the production of free radicals and disturbance of antioxidant balance, which increased significantly compared to the control group [5]. New information about dietary antioxidants and their protective roles against poor redox balance in various thyroid diseases. A novel findings regarding the association between the thyroid and gut microbiome and analysis of the effects of probiotics with antioxidant properties on thyroid diseases [6].

Recently, the relationship between oxidative stress and thyroid tumors was studied by measuring the oxidative stress in tissues affected by free radicals which effected on the thyroid gland [7]. Ascorbic acid (AA) is one of the factors effected to the thyroid function which study at different levels. Also, AA is treated in different diseases related to the thyroid gland such as thyroid cancers, goitre, Graves' disease and other causes of hyperthyroidism [8]. Vitamin C (ascorbic acid) is used as a treatment for patients with hyperthyroidism, toxic nodular goiter and Graves' disease. In this study, the electrochemical properties of blood samples for hyperthyroidism patients has been studied by cyclic voltammetry to determine the oxidative stress of these disease on blood components and treated with ascorbic acid.

Materials and Methods

Sampeling and examine

Samples were collected in sterile container then, left for 15 minutes to clot and centrifuged at rpm for 10 minutes for serum obtaining, which was placed in small tubes and kept at -20 ^{o}C until 3000 use.Serum sugar and cholesterol and triglyceride and high density lipoprotein was measured using the enzymatic method technique and according to special kit from spine, while the thyroid hormones (T3, T4 and TSH) and Hba1c were measured using the i-Chroma II reader ELISA kits (Republic of Korea).

Cyclic Voltammetry

Potentio state type EZstat from company NuVant Systems Inc. (USA) was used in the current study. Glassy carbon electrode (GCE), Ag/AgCl (3 M KCl) and a platinum wire (1 mm diameter) were used as working electrode, reference and counter electrode, respectively. All electrodes immersion in 10 ml (1 mL of serum blood sample dissolved in 9 mL of distilled water) of voltammetric cell.

Procedure

The cyclic voltammetry (CV) technique was adopted for the redox reaction observation. Measurements were performed in the potential range of −0.2 to 1.3 V vs. Ag/AgCl for 3 cycles each, at a scan rate of 50 mV s^{-1}. For the characterization of the working parameters of the biosensor, 15 mL voltammetry cell was used to place 10 mL of electrolyte (serum blood sample), then all electrodes were immersed in the serum sample and connected into a potentio-stat with personal computer to show the results of cyclic voltammogram.

Results and Discussion

Analysis of Serum Blood Samples of Hyperthyroidism Patients

The research included complete analysis of serum blood samples of hyperthyroidism Patients. As show in Table 1 the CBC results for 30 patients (14 female and 16 male) with ages between 32 – 45 years. In patients for each sex, T3, T4, TSH, FBG, HbA1C, TC, TG, and HDL. For Determination of Thyroid Hormones.

Table 1. Results of serum samples for hyperthyroidism patients for each sex, age, in different parameter.

No	Sex	AGE	T3	T4	TSH	FBG	HbA1C	TC	TG	HDL
1	F	38	4.5	14.1	0.05	189	8.1	203	168	63
2	F	33	4.0	15.0	0.05	98	5.6	222	112	49
3	F	37	3.1	15.2	0.05	140	9.6	223	200	40
4	F	40	5.3	17.7	0.05	282	10.2	286	328	38
5	F	35	4.6	15.9	0.05	149	6.8	209	104	44
6	F	34	7.2	18.7	0.05	163	8.1	244	152	47
7	F	43	4.8	18.4	0.05	116	6.6	212	120	46
8	F	36	3.9	16.5	0.05	183	8.6	236	296	47
9	F	43	3.6	20.3	0.05	118	7.0	192	112	46
10	F	45	4.7	19.4	0.05	215	11.9	215	88	50
11	F	43	4.6	16.7	0.05	252	12.1	204	135	65
12	F	35	6.1	19.4	0.10	134	7.8	159	88	44
13	F	36	5.4	18.0	0.05	161	8.0	196	200	43
14	F	43	4.3	17.7	0.05	194	8.4	145	280	34
15	M	44	2.9	16.1	0.05	152	7.0	232	152	40
16	M	43	4.2	15.4	0.05	94	6.5	225	144	47
17	M	37	3.7	19.6	0.20	137	6.5	157	96	43
18	M	39	4.6	17.5	0.05	149	8.4	157	319	64
19	M	30	5.8	16.9	0.30	291	8.5	193	62	52
20	M	44	5.3	16.8	0.05	337	12.9	286	328	38
21	M	33	3.7	17.5	0.05	144	8.6	254	192	46
22	M	40	5.5	20.6	0.05	405	12.8	391	184	43
23	M	41	4.9	18.7	0.05	233	12.6	237	160	28
24	M	44	4.5	16.1	0.05	191	9.7	186	136	36
25	M	45	3.6	15.4	0.05	181	13.2	196	202	43
26	M	42	5.2	19.6	0.05	226	11.0	226	128	59
27	M	36	4.0	20.8	0.05	204	8.1	173	133	32
28	M	32	4.4	20.1	0.05	90	6.0	225	344	39
29	M	43	5.1	19.4	0.05	166	7.2	212	112	45
30	M	42	3.8	18.8	0.05	128	7.2	237	160	28

Study sex and age groups of Hyperthyroidism patients

Thirty patients for hyperthyroidism disease were studied in 14 females and 16 males as show in Figure 4 and age group ranging from 32 – 45 years in Figure 5 was remember in table 2.

Table 2. Distribution of sex group for thirty Hyperthyroidism patients.

Parameter	Sex	N	Mean	Std. Deviation	Std. Error Mean
T3	M	16	8.4963	14.34914	3.58729
	F	14	5.7400	13.94702	3.72750

Parameter	Sex	N	Mean	Std. Deviation	Std. Error Mean
T4	M	16	3.3881	0.50504	0.12626
	F	14	3.2793	0.55527	0.14840
TSH	M	16	12.7000	3.26047	0.81512
	F	14	13.8857	5.04607	1.34862
FBG	M	16	209.6875	78.56948	19.64237
	F	14	197.6429	81.30910	21.73077
HbA1c	M	16	9.1688	2.16632	0.54158
	F	14	9.5571	2.63284	0.70366
TC	M	16	234.0000	61.41552	15.35388
	F	14	229.6429	55.37926	14.80073
TG	M	16	201.5000	111.97023	27.99256
	F	14	163.2587	76.11169	20.34170
HDL	M	16	42.3125	5.91854	1.47964
	F	14	46.5000	7.68365	2.05354

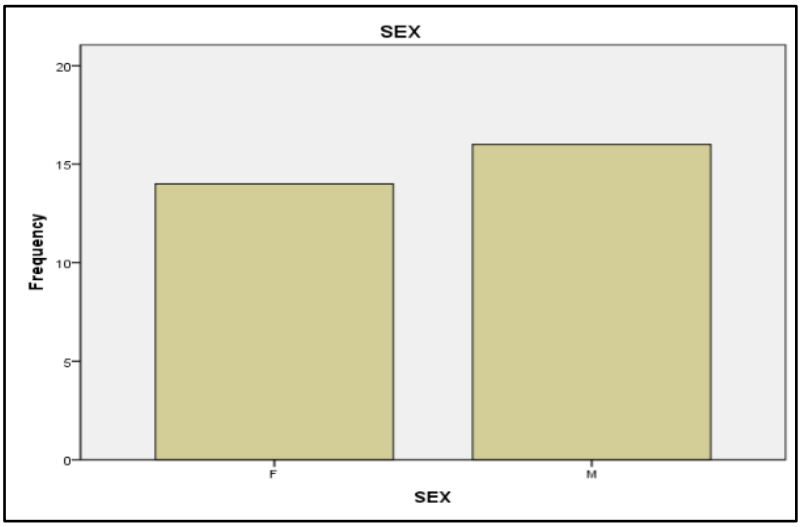

Figure 1. Distribution of sex group of Hyperthyroidism patients.

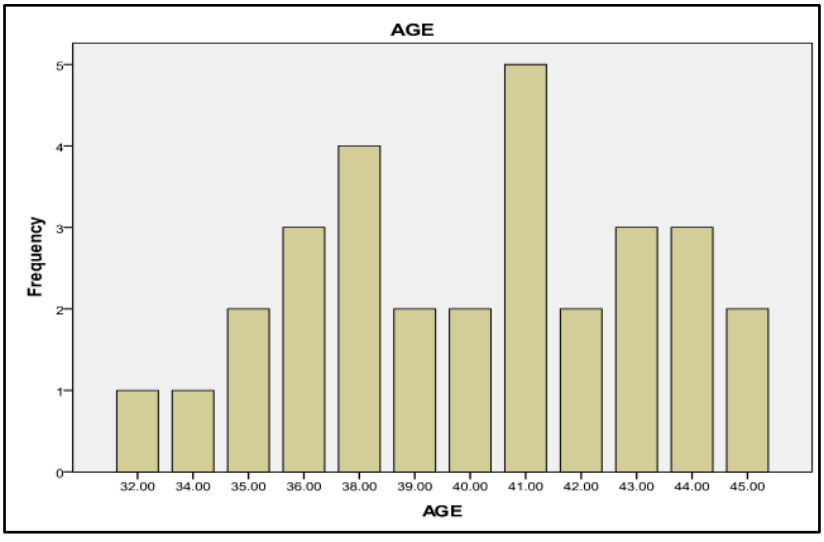

Figure 2. Distribution of age group of Hyperthyroidism patients.

Study different parameters for Hyperthyroidism patients

Hyperthyroidism is a condition characterized by excessive production of thyroid hormones by the thyroid gland. The diagnosis and management of hyperthyroidism involve assessing various parameters to evaluate the severity of the condition, identify the underlying cause, and guide treatment decisions [9]. Here are some important parameters that are commonly studied in hyperthyroidism patients, Table 3 illustrated the statistical values for the different parameters each of T3, T4, TSH, FBG, HbA1C, TC, TG, and HDL, in the Fig.6 and 7, as show the level of the values as in the following results for Thyroid hormone levels the two main hormones to consider are thyroxine (T4) and triiodothyronine (T3). the order of decreasing of the higher and lower values as elevated levels of these hormones, along with suppressed thyroid-stimulating hormone (TSH) levels, are indicative of hyperthyroidism. is crucial for diagnosing hyperthyroidism the result agree with [10].

Thyroid-stimulating hormone (TSH). In hyperthyroidism, TSH levels are typically low due to negative feedback from high thyroid hormone levels as in the following order:The effect of hyperthyroidism on various parameters can vary among individuals, but here's a general overview of how it may impact TC (total cholesterol), TG (triglycerides), HbA1c (glycated hemoglobin), HDL (high-density lipoprotein), and FBG (fasting blood glucose) levels in hyperthyroidism patients:

Total Cholesterol (TC): Hyperthyroidism can lead to higher TC levels. The increased metabolic rate associated with hyperthyroidism can cause the liver to produce more cholesterol and alter the expression of cholesterol transporters. However, the increase in TC levels is often attributed to a rise in HDL cholesterol rather than LDL cholesterol.

Triglycerides (TG). The increased metabolic rate and enhanced lipolysis (breakdown of fats) in hyperthyroidism can lead to higher TG synthesis and release from adipose tissue.

HbA1c: Hyperthyroidism typically does not significantly affect HbA1c levels in individuals without preexisting diabetes. HbA1c reflects average blood glucose levels over several months and is primarily influenced by prolonged high blood glucose. However, if hyperthyroidism coexists with diabetes, it can potentially affect glycemic control and HbA1c levels.

HDL Cholesterol: Hyperthyroidism tends to increase HDL cholesterol levels. The mechanisms underlying this increase are not fully understood, but it may be related to altered expression of proteins involved in HDL metabolism and clearance.

Fasting Blood Glucose (FBG): In individuals without preexisting diabetes, hyperthyroidism typically does not significantly affect FBG levels. However, in rare cases, hyperthyroidism can lead to impaired glucose tolerance or transient hyperglycemia.

Table 3. Distribution of the T3, T4, TSH, FBG, HbA1C, TC, TG, and HDL Hyperthyroidism patients.

Hormones	T3	T4	TSH	FBG	HbA1c	TC	TG	HDL
T3	1	0.264	0.371-	-	0.071-	0.235	0.319	0.192-
Person correlation				0.065				
sig (2 tailed)								
N		0.159	0.043	0.732	0.710	0.212	0.085	0.308
	30	30	30	30	30	30	30	30
T4	0.264	1	-0.447-	0.338	0.161	0.048	0.031	-0.12-
Person correlation								
sig (2 tailed)	0.159		0.013	0.068	0.396	0.800	0.870	0.949
N	30	30	30	30	30	30	30	30
TSH	0.371-	-	1	-	0.102	0.135-	0.126	0.018-
Person correlation		0.447		0.147				

sig (2 tailed)	0.043	0.013		0.438	0.590	0.478	0.507	0.924
N	30	30	30	30	30	30	30	30
FBG Person correlation	0.065-	0.388	0.147-	1	0.603	0.180	0.061	0.370
sig (2 tailed)	0.732	0.068	0.438		0.000	0.342	0.748	0.044
N	30	30	30	30	30	30	30	30
HbA1c Person correlation	0.071-	0.161	0.102	0.603	1	0.180	0.061	0.370
sig (2 tailed)	0.710	0.396	0.590	0.000		0.342	0.748	0.044
N	30	30	30	30	30	30	30	30
TC Person correlation	0.235	0.048	0.135-	0.180	0.188	1	0.533	0.101
sig (2 tailed)	0.212	0.800	0.478	0.342	0.319		0.002	0.597
N	30	30	30	30	30	30	30	30
TG Person correlation	0.319	0.031	0.126	0.061	0.026-	0.533	1	0.117-
sig (2 tailed)	0.085	0.870	0.507	0.748	0.890	0.002		0.539
N	30	30	30	30	30	30	30	30
HDL Person correlation	0.192-	-0.012	0.018-	0.370	0.122	0.101	0.117-	1
(sig 2tailed)	0.308	0.949	0.924	0.044	0.522	0.597	0.539	
N	30	30	30	30	30	30	30	30

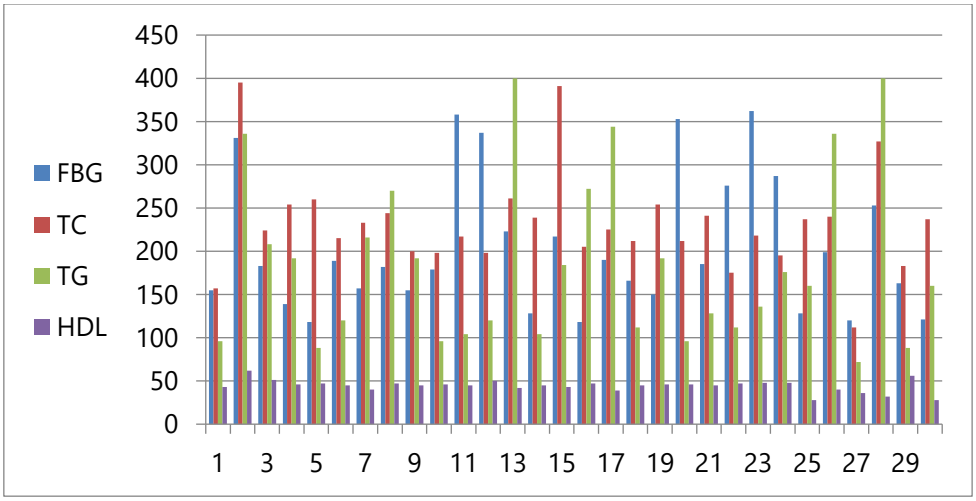

Figure 3. Relationship between Hyperthyroidism patients with each of FBG, TC, TG, and HDL.

Cyclic voltammetry study

Cyclic voltammetry (CV) was used to determine the oxidative effect of hyperthyroidism disease, and the results were compared with the use of uninfected blood to identify the extent of the effect of patients on the patient's blood terms of oxidation and its future effects on affected patients, as well as the use of AA as anti-oxidative reagent a treatment to inhibit the oxidative effect of hyperthyroidism patients.

Oxidative effect of hyperthyroidism in serum samples

Table 2, the study of blood infected with hyperthyroidism patients compared with control group ΔIpa = (Ipa, infected – Ipa, control) appeared with high oxidation effect as in sample 11 and low effect in sample 1 as shown in Fig.8, so, the oxidation stress of the hyperthyroidism patients illustrated in the following order. This study similar with other studies done by[11]:

Anti-oxidative effect of AA in hyperthyroidism serum samples

From the Table 2, we can observe the treatment of infected hyperthyroidism patients with AA, the deference between oxidation peak current of infected serum samples and with treated with AA, ΔIpa = (Ipa, infected – Ipa, AA) which appeared the inhibition of oxidative effect of hyperthyroidism serum samples by the anti-oxidative reagent (AA) as in sample 9 and low effect in sample 7 and 15 as shown in Fig. 9 and 10 in cyclic voltammogram of blood sample of hyperthyroidism patients, so, the oxidation stress of the hyperthyroidism patients was treated with AA. This research similar with other studies done by [12]:

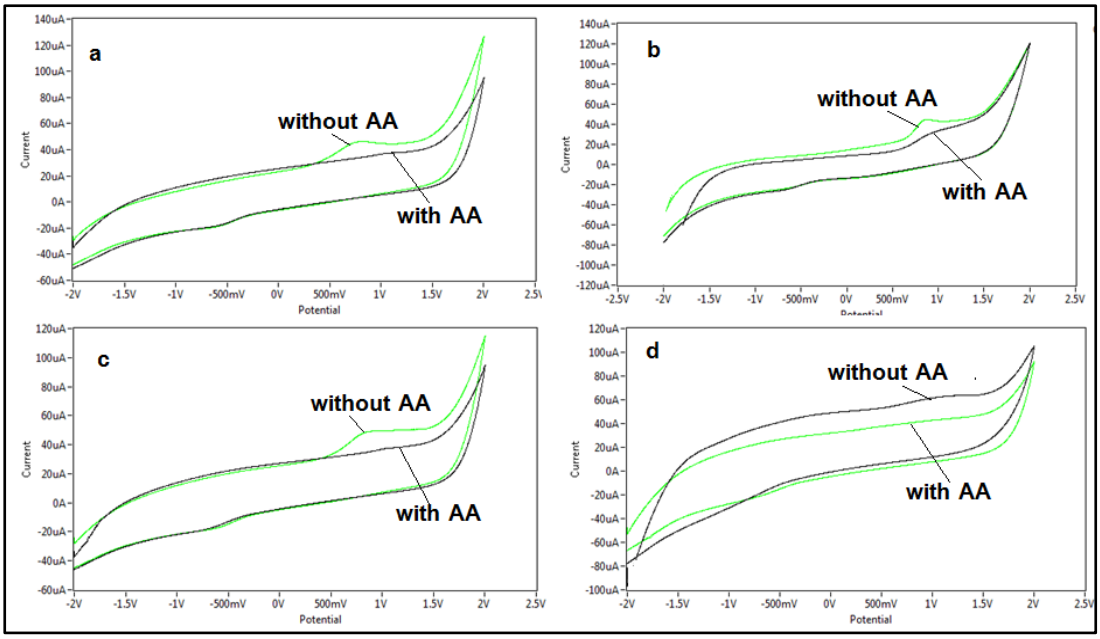

Figure 4. Cyclic voltammogram of blood sample of hyperthyroidism patients with and without AA: (a) sample 9, (b) sample 11, (c) sample 13, and (d) sample 17.

Table 4. Oxidation peak of serum samples for hyperthyroidism patients with control treated by ascorbic acid (ΔIpa, AA).

Sample no.	ΔIpa, control	ΔIpa, AA
5	1	1
5	11	2
6	6	3
4	10	4
2	12	5
5	5	6
1	6	7
4	9	8

13	12	9
5	14	10
12	17	11
11	5	12
3	2	13
10	4	14
1	2	15
9	11	16
2	2	17

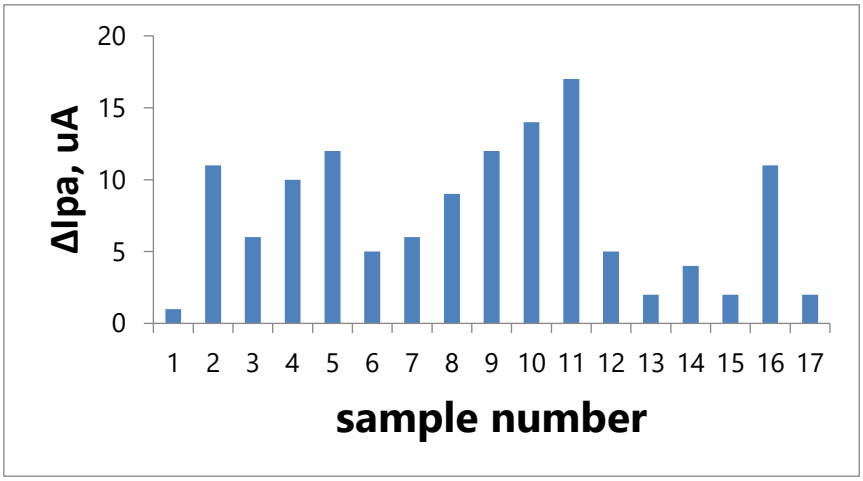

Figure 5. Oxidation current peak difference (ΔIpa) of control serum and hyperthyroidism patients.

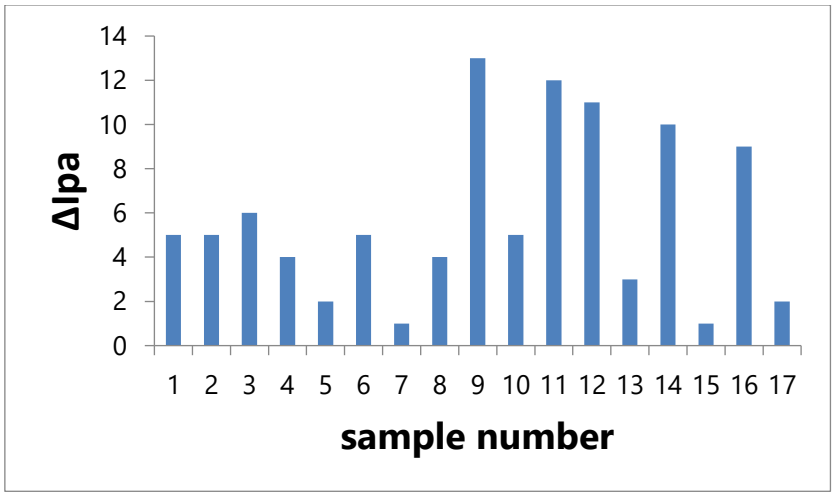

Figure 6. Oxidation current peak in difference difference (ΔIpa) treated ascorbic acid in serum samples of hyperthyroidism patients.

Relationship effect of oxidative stress on the hyperthyroidism patients in different parameters

The effective of oxidative stress in patients with hyperthyroidism, and different parameters. In T3 elevated in hyperthyroidism, from the results the effected of the all patients is less than other factors, but the effected of ascorbic acid has high reduce in the oxidation effect .T4 elevated in hyperthyroidism, the effect is ingeneral is medium effect with medium effect of ascorbic acid. TSH was decrease in hyperthyroidism due to negative feedback from high thyroid hormone levels, as the sample 8 was high effect of TSH and less effect of ascorbic acid.FBG in sample 11 can be seen the high effect value with high effected by ascorbic acid.HbA1c was show higher indicating poor blood sugar control over time.. And for TC we can see in the sample 2 and 15 with high value and less effected of ascorbic acid may be

was decreased in hyperthyroidism due to increased cholesterol utilization. For TG can see increased hepatic lipid formation. HDL as show in sample 13 with low effected of ascorbic acid Its levels was decrease in hyperthyroidism, due to cardiovascular disease. Oxidative stress can effect on the synthesis, metabolism, and action of thyroid hormones.. Glucose metabolism that mean the oxidative stress can impair insulin sensitivity and glucose homeostasis, resulting in an imbalance of blood glucose and HbA1c levels. Also efffected on fat metabolism, leading to altered cholesterol, triglyceride, and HDL levels seen in hyperthyroidism. The identified biomarkers and mechanistic understanding gained from this research could contribute to a better understanding of the role of oxidative stress in the pathophysiology of hyperthyroidism. That's agree with previous studies [13].

Conclusion

In this study can be concluded the antioxidant effects of ascorbic acid (vitamin C) in hyperthyroidism serum samples, which may lead to increased oxidative stress and generation of free radicals. Ascorbic acid is a powerful antioxidant that can help mitigate the oxidative damage associated with hyperthyroidism. The study has shown that in individuals with hyperthyroidism, blood levels of ascorbic acid are often lower than in healthy people.

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