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Oxidative, Biochemical and Hematological Parameters Alterations in Canine Hypothyroidism

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Abstract

THYROID hormones and body metabolism are closely linked, therefore thyroid gland disturbance will affect the body's metabolism The purpose of this study is to compare the changes in oxidative stress biomarkers, biochemical, and hematological parameters in the serum of hypothyroid dogs and euthyroid dogs as controls. Thirty-three dogs ranging in age from 3 to 6 years were used in this study (20 hypothyroid and 13 euthyroid dogs). Assessment of thyroid hormone levels and clinical manifestations was enrolled to diagnose hypothyroidism. Each animal's serum was collected for assessment of free T4 (fT4), total T4 (TT4), thyroid-stimulating hormone (TSH), evaluation of Malondialdehyde (MDA), total antioxidant capacity (TAC) and catalase, selected trace and major minerals, cholesterol triglycerides, blood glucose, alkaline phosphatase (ALP), liver enzymes (ALT, AST, GGT), and hematological pictures. Laboratory results for hypothyroid and euthyroid dogs were compared. In hypothyroid dog's oxidative biomarkers showed non-significant changes in both MDA and TAC and a significant decrease in catalase. Zinc, iron, and calcium showed a significant decrease, but phosphorus showed a significant elevation, the lipid profile showed a significant elevation of cholesterol, triglycerides, LDL, and VLDL, while HDL showed non-significant changes. ALT, AST, and ALP are significantly increased, Hematological blood pictures RBCs, HGB, HCT, and RDWc were significantly deceased, MCHC, MONO, and BASO cells were increased significantly. The results showed that hypothyroidism is associated with considerable changes in oxidative, biochemical and hematological parameters in dogs, highlighting their importance in the assessment and follow up of canine hypothyroidism.

Keywords: TSH, Euthyroid, Catalase, FT4, Minerals.

Introduction

Hypothyroidism is defined as a lack of thyroid hormone synthesis, specifically tetra iodothyronine (T4) and triiodothyronine (T3) [1, 2, 3]. According to the location of the hypothalamic-pituitary-thyroidal axis abnormality, hypothyroidism can be categorized as primary, secondary, or tertiary. However, 95% of diagnosed cases in dogs are associated with a primary hypothyroidism caused by an immune-mediated process in the thyroid gland itself (lymphocytic thyroiditis) or idiopathic thyroid atrophy [4]. On the other hand, up to 5% of cases that are found have congenital hypothyroidism [5]. Hypothyroidism prevalence has been reported to be 0.2-0.8% and usually affects middle-aged and spayed dogs [6]. Thyroid hormones and body metabolism are closely linked; therefore, thyroid gland failure will affect the body's metabolism and have an impact on most of its system [7]. In light of this, hypothyroidism is typically linked to a combination of clinical symptoms where the most prevalent of which are metabolic and dermatological symptoms [8]. However, the diagnosis of hypothyroidism is not always simple and can be confirmed by monitoring the patient's reaction to hormonal therapy.

The diagnosis is typically based on clinical observations and the results of a thyroid hormone profile [9]. These changes decreased after

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levothyroxine therapy [10]. The most prevalent clinical features of hypothyroidism dullness, obesity or weight gain, exercise intolerance, a delayed healing of wound, and hair coat and skin abnormalities such as alopecia, hyperpigmentation, dull and brittle hair coat, oily or dry skin, and thickened skin (myxedema), [11,12]. Furthermore, obesity is found in over 40% of dogs with hypothyroidism. Anemia, hyponatremia, lipemia, hypercholesterolemia, hypertriglyceridemia, hypoglycemia, and hypercapnia are among the pathological abnormalities that are frequently seen in dogs with hypothyroidism [13]. About 75% of patients have hypercholesterolemia, which is caused by a combination of increased hepatic synthesis, impaired hepatic clearance, and hepatic utilization of cholesterol [11]. Thyroid hormones regulate both catabolic and anabolic processes, which has a good effect on metabolism. However, these reactions consume oxygen, which is essential for the formation and synthesis of reactive oxygen species (ROS). Furthermore, thyroid hormones play a significant role in antioxidant defense by acting as both enzymatic and non-enzymatic free radicals [2]. Thus, oxidative stress (OS) and thyroid hormones are significantly correlated [14]. Oxidative stress occurs when the body generates more reactive oxygen species (ROS) than it can remove. Catalase levels are lower and lipid peroxidation is higher in the oxidative stress markers linked to hypothyroidism [14]. Serum has long been used to assess alterations in the oxidative status of individuals suffering from various thyroid conditions [15].

The current study was planned to monitor and evaluate the changes in oxidative stress biomarkers, biochemical, and hematological parameters in hypothyroidism dogs compared to euthyroid dogs. To address the usefulness of selected parameters for assessment and follow up of canine hypothyroidism patients.

Materials and methods

Ethical acceptance

This study was approved by the Institution of Animal Care and Use Committee of the Faculty of Veterinary Medicine at Cairo University in Egypt with the number (VETCU 03162023671).

Study period and location

The research was carried out between March 2020 and December 2023. Blood Samples were collected from Armed Forces Veterinary Pets Hospital, Egypt and laboratory investigations were conducted at the hospital's laboratory.

Animal grouping

Thirty-three dogs were enrolled (age:3-6 of both sexes) into the present study. All animals were vaccinated and regularly received a deworming course Across all samples.

The studied dogs were subdivided into two groups:

Euthyroid (control) dogs (N = 13) 3 females (non-pregnant) and 10 males apparently healthy without visible clinical signs.

Hypothyroid dogs (N = 20): 5 females (non-pregnant) and 15 males with clinical manifestations (as mentioned in (fig.1) and results of thyroid hormone profiles showed a significant decrease ($P \leq 0.0001$) in tT4 and fT4 and significant increase ($P \leq 0.0001$).

Samples and laboratory investigations

Blood samples were withdrawn from cephalic vein in each dog and divided into two parts:

-The first part was collected on tubes containing (EDTA) was used for complete blood count using an automated hematology analyzer LASERCYTE (IDEXX) – United States.

-The second part was separated using centrifugation at 3000 rpm collected in plain tubes for serum separation. Serum was used to evaluate total T4 (TT4) by using VETSCAN VS2 ZOETIS, Thyroid-stimulating hormone (TSH), free T4 (FT4) and lipid profile, blood glucose level, enzymatic profile, ALP and minerals by using VIDAS, IDEXX CATALYST ONE. Malondialdehyde (MDA), catalase (CAT) and total antioxidant capacity (TAC) were evaluated in the collected serum using dedicated test kits (Bio- Diagnostic, Egypt).

Statistical analysis

Data were expressed as means ± standard errors (SE). The results were analyzed using an independent sample t-test. Significance was set at $P<0.05$. PASW statistics, version 18.0 (SPSS Inc., Chicago, IL, USA), was used for statistical analysis.

Results

clinical signs in dogs with hypothyroidism were lethargy, obesity, cold intolerance, muscle weakness While dermatological signs ranged from bilaterally symmetrical alopecia. Cutaneous manifestations such as dry or oily seborrhea, skin thick hyperpigmentation, puffy skin (called myxedema), patchy hair loss with redness and pustule (called pyoderma), rat tail appearance. were manifested (Fig.1).

Results of thyroid hormones profile are represented in Table 1. a significant decrease ($P \leq 0.0001$) in tT4 and fT4 and significant increase ($P \leq 0.0001$) were

observed when comparing thyroid hormones profile in hypothyroid and euthyroid (control) dogs.

Results of oxidative stress biomarkers are shown in Table 2. Hypothyroid dogs group were linked with non-significant changes in both MDA (P = 0.764) and TAC (P = 0.1010) compared to euthyroid counterparts. While catalase showed a significant reduction in hypothyroid (P<0.0001) compared to euthyroid dogs.

Results of minerals profile are shown in Table 3. Zinc, iron and calcium showed a significant decrease (P<0.0001) in hypothyroid dogs group compared to euthyroid (control) ones and Phosphorous showed a significant elevation (P ≤ 0.0001) in hypothyroid compared to euthyroid (control) dogs, while copper level did not show any significant change.

Results of Serum biochemical profile are represented in Table 4. Significant increase in cholesterol, triglycerides, LDL, and VLDL, Glucose (P ≤ 0.0001) in serum was reported in dogs with hypothyroidism compared to euthyroid (control) ones. While HDL showed non-significant changes.

Results of the liver function test are shown in Table 5. ALT, AST, and ALP are significantly increased (P<0.0001) in hypothyroid compared to euthyroid (control) dogs. While GGT level was non-significantly decreased.

Results of Hematological pictures of both euthyroid and hypothyroid dogs are represented in Table 6. RBCs and HGB, HCT, RDWc were significantly (P<0.0001) decreased in hypothyroid dogs compared to euthyroid ones. MCHC, MONO and BASO cells increased significantly (P<0.0001) in hypothyroid compared to euthyroid dogs.

Discussion

Hypothyroidism is known to produce multisystem symptoms, with dermatological abnormalities are the most frequently seen sign. Throughout the diagnostic process, weight increase and dermatological symptoms were the most reliable clinical indicators [16]. The existence of lethargy as a neuropathy or myopathy were linked to a reduction in thyroid hormone [17]. Numerus owners could observe weight gain which is not associated with increase in feed intake. The production of "proteoglycan" in the skin is thought to be controlled by thyroid hormones, which are linked to epidermal differentiation by activating fibroblasts and keratinocytes. However, generalized alopecia may develop later in the disease [18]. Severe hypothyroidism induces loss of hair and a dry, brittle coat earlier, while generalized alopecia may appear later [9].

In the present study, hypothyroid dogs showed that the mean total thyroxine levels were significantly lower and the mean TSH levels were significantly higher as compared to those of euthyroid dogs. These results were in agreement with previous one that documented that the diagnosis of hypothyroidism was accomplished by the demonstration of decrease T4 and elevation TSH levels in serum [19]. The evaluation of T4 level is a one of diagnostic tool for differentiating canine hypothyroidism which suggested by [20]. The production of TRH and TSH are regulated via a negative feedback mechanism by concentrations of thyroid hormones, i.e. decreased serum concentrations of free T4 and T3 stimulate TSH production and increase the TRH-mediated stimulation of TSH, whereas increased serum concentrations of free T4 and T3 decrease TSH and inhibit TRH-mediated stimulation of TSH [21].

Many chronic diseases are linked to oxidative stress, which is attributed by an imbalance in reactive oxygen species (ROS) created during normal cell metabolism and/or the efficacy of scavenging antioxidant defense [22]. It has become recognized in relation to thyroid conditions, primarily hyperthyroidism and overt hypothyroidism [23].

The oxidative stress biomarkers in the present study showed a non-significance result in MDA and TAC with a significant reduction in catalase. The association with hypothyroidism revealed contradictory and inconsistent results, according to [24]. Some previous researches documented that Hypothyroid dogs appear to undergo an oxidative process manifested by elevation in both MDA and TAC reported by [25]. On the other hand, some reports documented that hypothyroidism is not associated with an oxidative stress process [26,27].

The catalase activity in hypothyroid dogs was significantly reduced in the present study and this finding was lined with other results [10]. Contradict an elevation of catalase levels in hypothyroidism have been reported by others [28]. Catalase enzyme catalyze the decomposition of hydrogen peroxide (H_2O_2) in water. This suggests that hypothyroidism is associated with decrease in catalase activity and diminished antioxidant defense. A possible excess of hydrogen peroxide (H_2O_2) in an organism could react with nitrogen oxide (NO), producing hydroxyl radicals. When catalase activity is reduced in hypothyroidism. These radicals will consequently react with cellular structures lead to damage in a process known as lipid peroxidation [29]. MDA in the latest years has been recognized as an important lipid peroxidation indicator [30]. However, non-significance changes were reported in the MDA level in hypothyroidism.

Available papers that discusss alterations in TAC in canine hypothyroidism are scanty. Nevertheless,

TAC estimation is supposed to give a crude information about antioxidant status in the body [31], In agreement with our obtained results no changes in TAC between euthyroid (control), hypothyroid and hyperthyroid human patients were reported [32]. A significant increase in TAC in canine patents was previously reported by [25]. However, the total antioxidant level was declined in experimentally induced hypothyroidism in rats [33], non-significant changes in antioxidant level was also associated with decrease in oxidative stress parameters in hypothyroidism [24], because The antioxidant system can be enzymatic or non-enzymatic [34].

Zinc was evaluated in the present study as an indicator for non-enzymatic antioxidant status and showed a significant decrease in agreement with other studies [35]. Non-enzymatic antioxidants were reduced in hypothyroid patients. Zinc is a key component of Cu-Zn SOD, and the point that it plays a vital role in the protection of lipid membrane content against oxidation may explain the reduction of zinc level as a consequence of high zinc demand due to overproduction of ROS [36].

The current study showed that serum Fe levels in hypothyroid group were significantly lower than the control group. In previous study iron deficiency was linked with second and subclinical hypothyroidism in human patient [37]. The majority of Fe in the body is involved in heme-biosynthesis in erythropoietic bone marrow and other heme-containing enzymes, but the remaining amount exists in hepatocytes and reticuloendothelial system cells [38]. Patients with hypothyroidism frequently exhibit low ferritin levels and anemia, which may be associated with malabsorption due to hormonal imbalance [39].

In the present study hypothyroid dog's calcium levels showed signifcant decrease which was consistent with studies conducted by [40] in hypothyroid dogs and in humans, [41] suggesting that hypothyroidism is the main factor contributing to the decline in serum calcium levels. Also The results of serum phosphorus values were significantly elevated, and these observations in hypothyroid dogs were in agreement with studies [40,42] who similarly reported a significant elevation of phosphate levels in hypothyroid dogs. The reduction of Glomerular filtration rate (GFR) as a result of low thyroid hormone level may lead to retention of phosphorus together with low calcium level in hypothyroid dogs which lead to stimulation of parathyroid hormone (PTH) which moreover result in elevation of serum phosphate concentration documented by [43]. The low thyroid levels were associated with decrease intestinal brush border absorption of calcium from dietary calcium reported by [44]. And calcium homeostasis alterations [45].

Significant elevations in cholesterol and triglycerides were observed in hypothyroid dogs. Hypercholesterolemia and hypertriglyceridemia have been suggested as common findings in hypothyroid dogs [4,46]. Lipid metabolism is in part regulated via thyroid hormones. Hypercholesterolemia was present in 75% of hypothyroid dogs reported by [7,47,48] while hypertriglyceridemia was present in 88% of the dogs. The excess of lipid levels in animal body, such as cholesterol and triglycerides, is related to atherosclerotic changes in the vasculature of not only humans [46], but also dogs [49]. Lipid metabolism depends critically on thyroid hormones; a reduction in thyroid hormone levels in serum is expected to cause a decrease in lipid metabolism and the development of hyperlipidemia [50]. Reduced thyroid hormone activity is connected with a decrease in cholesterol clearance in serum, hence cholesterol will accumulate as a result [51]. Moreover, thyroid hormones influence protein lipase activity; so, the decrease in this enzyme activity of the former will affect lipids, causing an increase in triglycerides level [52].

Blood glucose levels in the current study were increased in hypothyroid dogs; the results were in agreement with [53], who found that thyroid hormones affect the glucose homeostasis regulation, including circulating insulin levels alterations, counter-regulatory hormones, intestinal glucose absorption, hepatic glucose production, and peripheral tissues (fat and muscle) uptake of glucose. In another study, the cause was the appearance of insulin resistance in canine hypothyroidism reported by [54].

The findings of the present study regarding enzymatic activity were in agreement with [55] findings, who reported elevated levels of these enzymes in hypothyroidism, probably due to hepatopathy and myopathy caused by fat infiltration and elevation alkaline phosphatase enzyme (ALP), it have been suggested as a common finding in hypothyroid dogs [4,46].

Hematological pictures of both euthyroid and hypothyroid dogs were studied. RBCs, HGB were significantly decreased and monocytes, basocytes showed a significant increase in hypothyroid dogs compared to euthyroid dogs. Hypothyroid dogs revealed a mild normocytic, normochromic, and non-regenerative anemia due to thyroid hormone stimulate erythropoiesis stimulate the production of erythropoietin in normal healthy dog, but in hypothyroid dog, it may result from bone marrow suppression and deficiencies in erythropoietin, iron, vitamin B12 and folic acid. Additionally, it has been noted that hypoxia resulting from the anaemia disturbs the peripheral conversion of T4 to T3

triiodothyronine, therefore the existence of anemia in hypothyroidism may be a result of erythropoiesis impairment [56]. This observation recorded in the present investigation was in accordance with the reports documented by [47,55,57] in hypothyroid dogs. The detection of these parameters for assessing hypothyroid dog's health status still needs additional studies to be conducted on a larger number of dogs.

Conclusion

Based on the findings derived in this study, the determination of these oxidative stress, biochemical and hematological parameters seem to be an appropriate additional tool for evaluation of hypothyroid dog's health status. This study is considered a preliminary study and Supplementary laboratory investigations are still essential to confirm the practicality of this results and requires more future research on a larger number of dogs.

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Conflicts of interest

The authors stated that have no conflicts of interest regarding the publication of this article.

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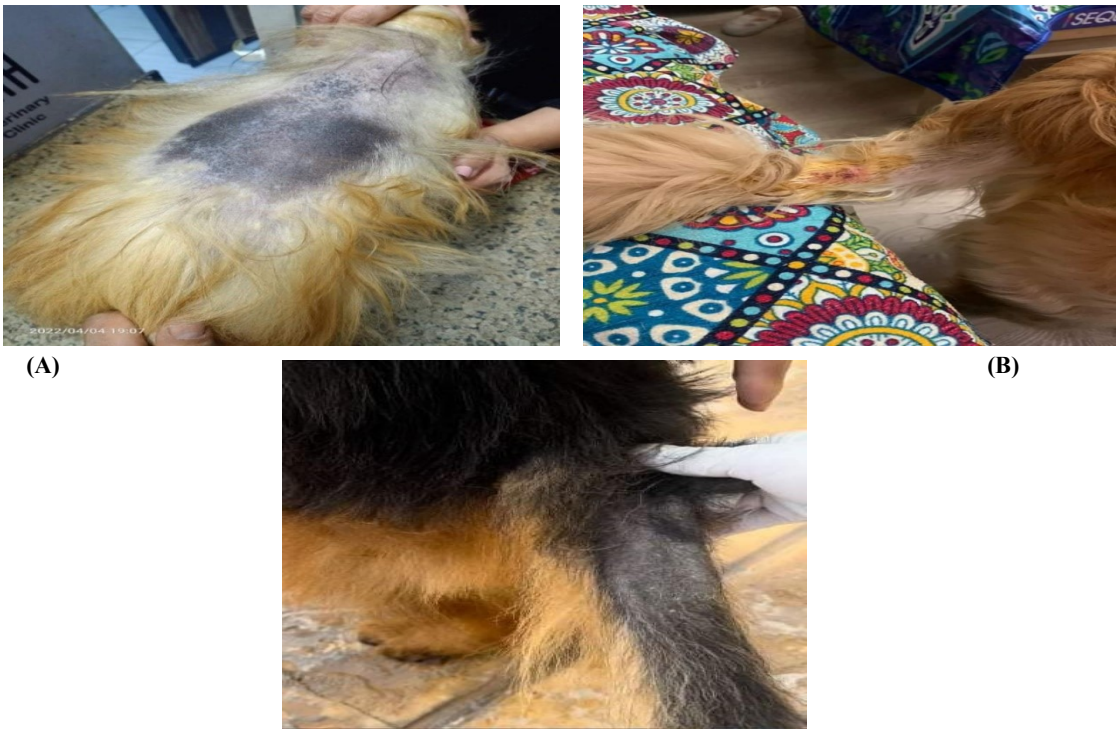

(A) **(B)** **(C)**

Fig. 1 Photographic images of hypothyroid dogs (A) Bilateral symmetrical Alopecia in Pomeranian 3 years' male dog. (B) patchy hair loss with redness and pustula in tail of 4 years' golden retriever dog. (C) Rat tail appearance in 4 years German Shepard male dog.

TABLE 1 Thyroid function parameters (mean±SE):

Parameters	Euthyroid(N=13)	Hypothyroid(N=20)	P-value
TT4 (ug/dl)	2.76±0.24[a]	0.58±0.03[b]	<0.0001
FT4 (ug/dl	1.78±0.12[a]	0.46±0.02[b]	<0.0001
TSH (mIU/l)	19.71±2.33[b]	54.95±2.19[a]	<0.0001

[a,b] Different superscripts at the same row indicate significance at P<0.05 (independent sample *t*-test) .
we express P-value as <0.0001 When the statistical test gives a P result =0.000.

TABLE 2. Oxidative stress biomarkers (Mean±SE):

Parameters	Euthyroid(N=13)	Hypothyroid(N=20)	P-value
MDA (nmol/ml)	4.34±1.55 [a]	3.87±0.10 [a]	0.7640
Catalase (u/l)	12.61±1.71 [a]	0.90±0.07 [b]	<0.0001
TAC (mM/l)	1.05±0.02 [a]	1.10±0.02 [a]	0.1010

[a,b] Different superscripts at the same row indicate significance at P<0.05 (independent sample *t*-test) .
we express P-value as <0.0001 When the statistical test gives a P result =0.000.
MDA (Malondialdehyde).
TAC (total antioxidant capacity).

TABLE 3. Electrolytes and selected trace and major minerals (Mean±SE):

Parameters	Euthyroid(N=13)	Hypothyroid (N=20)	P-value
Trace minerals			
Zinc(umol/l)	11.28±1.21[a]	7.04±1.06[b]	<0.0001
Copper (ppm)	0.53±0.04[a]	0.51±0.04 [a]	0.6630
Iron (mg/dl)	207.08±7.43[a]	82.85±2.70[b]	<0.0001
Major minerals			
Calcium (mg/dl)	10.81±0.19[a]	8.31±0.15[b]	<0.0001
Phosphorous(mg/dl)	3.78±0.15[b]	6.78±0.45[a]	<0.0001

[a,b] Different superscripts at the same row indicate significance at P<0.05 (independent sample *t*-test) .
we express P-value as <0.0001 When the statistical test gives a P result =0.000.

TABLE 4. Lipid profile parameters and blood glucose level (mean±SE):

Parameters	Euthyroid (N=13)	Hypothyroid (N=20)	P-value
CHOLESTEROL(mg/dl)	198.62±8.41[b]	329.70±11.28[a]	<0.0001
TRIGLYCRDE (mg/dl)	126.08±11.62[b]	219.35±6.22[a]	<0.0001
LDL (mg/dl)	72.38±6.01[b]	124.30±5.98[a]	<0.0001
HDL (mg/dl)	52.69±2.74[a]	46.80±2.59 [a]	0.129
VLDL (mg/dl)	16.62±1.86[b]	40.35±3.48[a]	<0.0001
GLUCOSE (mg/dl)	86.23±2.78[b]	106.60±4.11[a]	<0.0001

[a,b] Different superscripts at the same row indicate significance at P<0.05 (independent sample *t*-test) .
we express P-value as <0.0001 When the statistical test gives a P result =0.000.

TABLE 5. Liver enzymatic profile (Mean±SE):

Parameters	Euthyroid (N=13)	Hypothyroid (N=20)	P-value
ALT (u/l)	45.92±4.22 [b]	107.35±9.22 [a]	<0.0001
AST (u/l)	30.38±1.30 [b]	52.00±1.55 [a]	<0.0001
GGT(u/l)	9.96±0.30 [a]	7.28±0.76 [a]	0.003
ALP (u/l)	63.46±4.37 [b]	146.45±14.61 [a]	<0.0001

[a,b] Different superscripts at the same row indicate significance at P<0.05 (independent sample *t*-test) .
we express P-value as <0.0001 When the statistical test gives a P result =0.000.

TABLE 6. Hematological parameters (Mean±SE):

Parameters	Euthyroid (N=13)	Hypothyroid (N=20)	P-value
RBC (10^6/mm^3)	7.51±0.16[a]	5.14±0.26[b]	<0.0001
HGB (gm/dl)	16.78 ±0.37[a]	11.90±0.52[b]	<0.0001
HCT %	52.66±1.60[a]	38.21±2.95[b]	<0.0001
MCV (um^3)	68.69±1.74[a]	63.75±2.75 [a]	0.191
MCH (pg)	22.36±0.36 [a]	23.30±0.41[a]	0.118
MCHC (g/dl)	32.06±0.24[b]	34.79±0.82[a]	<0.0001
RDWc %	16.96±0.54[a]	15.47±0.46[b]	<0.0001
WBC (10^6/mm^3)	13.95±1.42 [a]	15.96±3.10[a]	0.562
LYMF %	2.07±0.28[a]	2.14±0.39 [a]	0.891
MONO %	0.54±0.06[b]	1.81±0.31[a]	<0.0001
NEU %	10.72±1.33 [a]	12.41±2.57[a]	0.565
EOS %	0.54±0.26[a]	0.42±0.18 [a]	0.694
BASO%	0.09±0.02[b]	0.21±0.04[a]	<0.0001
PLT (10^6/mm^3)	306.77±33.77 [a]	324.80±49.67[a]	0.791

[a,b] Different superscripts at the same row indicate significance at P<0.05 (independent sample *t*-test) .
we express P-value as <0.0001 When the statistical test gives a P result =0.000.

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القياسات التأكسدية والكيميائية الحيوية وتغييرات حدود الدم في الكلاب المصابة بقصور الغدة الدرقية

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المستخلص

ترتبط هرمونات الغدة الدرقية وعملية أيض الجسم ارتباطًا وثيقًا، وبالتالي فإن اضطراب الغدة الدرقية سيؤثر على حيوية وأيض الجسم والغرض من هذه الدراسة هو مقارنة التغيرات في المؤشرات الحيوية للإجهاد التأكسدي، والكيمياء الحيوية، والمعلمات الدموية في مصل تلك الكلاب المصابه بقصور الغدة الدرقية ومقارنتها مع الكلاب الظاهريا سليمه كعناصر تحكم. تم استخدام ثلاثة وثلاثين كلبًا تتراوح أعمارهم بين 3 إلى 6 سنوات في هذه الدراسة (20 كلبًا مصابًا بقصور الغدة الدرقية و13سليم ظاهريا). تم استخدام تقييم مستويات هرمون الغدة الدرقية والمظاهر السريرية لتشخيص قصور الغدة الدرقية.

تم جمع مصل كل حيوان لتقييم T4 الحر (fT4)، و(TT4) T4 الإجمالي، والهرمون المحفز للغدة الدرقية (TSH)، والمالونديالدهيد (MDA)، والقدرة الكلية لمضادات الأكسدة (TAC) وcatalase كاتالاز، وبعض المعادن، والكوليسترول الثلاثي، نسبة الجلوكوز في الدم، ALP، وإنزيمات الكبد (ALT، AST، GGT)، وصور الدم. وتمت مقارنة النتائج المختبرية للكلاب المصابة بقصور الغدة الدرقية السليمه ظاهريا.

في الكلاب المصابة بقصور الغدة الدرقية، قد أظهرت المؤشرات الحيوية المؤكسدة تغيرات غير مهمة في كل من MDA وTAC وانخفاضًا ملحوظًا في كاتالاز catalase. أظهرت المعادن انخفاضاً ملحوظاً في مستويات الزنك والحديد والكالسيوم، بينما أظهر الفسفور ارتفاعاً ملحوظاً، ولم تظهر مستويات النحاس أي تغيير. أظهر الدهون ارتفاعًا ملحوظًا في مستويات الكوليسترول والدهون الثلاثية وLDL وVLDL، بينما أظهر HDL تغيرات غير مهمة. تم زيادة ALT وAST وALP بشكل ملحوظ، كما تم نقص خلايا الدم الحمراء وHGB الهيموجلوبين وHCT وRDWc بشكل ملحوظ، كما تم زيادة خلايا MCHC وMONO وBASO بشكل ملحوظ.

أوضحت الدراسة أن قصور الغدة الدرقية يرتبط بتغيرات كبيرة في مؤشرات الأكسدة والكيمياء الحيوية والدم في الكلاب، مما يسلط الضوء على أهميتها في تقييم ومتابعة قصور الغدة الدرقية في الكلاب.

الكلمات الدالة : هرمون المنبه للغدة الدرقيه TSH، السليم ظاهريا ، كاتالاز catalase ، هرمون الغدوة الدرقيه الثيروكسين FT4 ، المعادن.