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Nagella Naveen
Ph.D. Scholar, Division of Medicine, ICAR-IVRI, Izatnagar, Bareilly, Uttar Pradesh, India

N Lakshmi Rani
Professor and Head, Department of Veterinary Medicine, NTR College of Veterinary Science, Gannavaram, Sri Venkateswara Veterinary University, Andhra Pradesh, India

K Basava Reddy
Assistant Professor and Principal, Animal Husbandry Polytechnic, Sri Venkateswara Veterinary University, Andhra Pradesh, India

V Devi Prasad
Professor and Head, Department of Veterinary Surgery and Radiology, NTR College of Veterinary Science, Gannavaram, Sri Venkateswara Veterinary University, Andhra Pradesh

Corresponding Author:
Nagella Naveen
Ph.D. Scholar, Division of Medicine, ICAR-IVRI, Izatnagar, Bareilly, Uttar Pradesh, India

Imaging studies in canine hypothyroidism

Nagella Naveen, N Lakshmi Rani, K Basava Reddy and V Devi Prasad

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Abstract
The present study was conducted at Veterinary Clinical Complex, NTR College of Veterinary Science, Gannavaram, from March to November 2023, to record the electrocardiographic, radiographic, echocardiographic and ultrasonographic findings in canine hypothyroidism. Twenty-seven hypothyroid dogs underwent ECG examination, while 15 were subjected to additional imaging studies. ECG abnormalities were observed in 55.56 percent of dogs, with low-voltage QRS complexes being most common. Radiography revealed cardiomegaly, pericardial effusion and hepatic changes, whereas ultrasonography showed hepatomegaly, hyperechoic liver, and renal alterations. Echocardiography demonstrated dilated cardiomyopathy, valvular regurgitations and ventricular enlargement. The study highlights the diagnostic utility of multimodal imaging for comprehensive assessment of systemic alterations in hypothyroid dogs.

Keywords: Diagnostic imaging, echocardiography, electrocardiography, hypothyroidism

Introduction

Acquired primary hypothyroidism is a frequently encountered thyroid disorder in dogs, which could lead to a reduced metabolic rate and impaired function of nearly all body systems. A deficiency occurring at any point within the hypothalamus-pituitary-thyroid axis results in decreased thyroid hormone production (Ko *et al.*, 2018) [11]. The most commonly observed clinical signs in affected dogs include dermatological changes, along with reproductive, neurological, and cardiovascular abnormalities (Guglielmini *et al.*, 2019) [9]. In dogs with thyroid hormone deficiency, common cardiovascular abnormalities include decreased left ventricular systolic function, low QRS voltages, inverted T waves, a weak apex beat, and sinus bradycardia (Beier *et al.*, 2015; Kosková *et al.*, 2022) [2, 12]. While thyroid hormones play a role in nervous system function, the precise relationship between hypothyroidism and neurological abnormalities remains unclear. Megaoesophagus is one of the peripheral nervous system disorders that has been documented in dogs with hypothyroidism (Jaggy *et al.*, 1994) [10]. Thyroid hormones regulate numerous metabolic processes in the body, and when their production is disrupted, clinical signs may manifest across multiple organ systems.

Materials and Methods

During the study period from March to November 2023, a total of 5957 dogs were presented to the Veterinary Clinical Complex, NTR College of Veterinary Science, Gannavaram. Of these, 78 dogs exhibiting one or more clinical signs suggestive of hypothyroidism were selected for further evaluation and subjected to thyroid hormone estimation and haemato-biochemical analysis. Dogs showing reduced total T4 and free T4 concentrations in conjunction with compatible clinical and biochemical abnormalities were diagnosed as hypothyroid (Bugbee *et al.*, 2023) [4]. Among these, 27 dogs were confirmed to have hypothyroidism. All the confirmed hypothyroid dogs (n = 27) underwent electrocardiographic (ECG) examination, while 15 dogs were further subjected to radiographic, ultrasonographic, and echocardiographic evaluations based on clinical indications.

Electrocardiography

All 27 hypothyroid dogs underwent electrocardiographic (ECG) examination to assess cardiac electrical activity.

ECG recordings were obtained in right lateral recumbency using the standard bipolar limb lead system (Lead II) at a paper speed of 25 mm/sec and sensitivity of 10 mm/mV with a BPL CARDIART-6108T machine, following the guidelines described by Tilley and Smith (2008). Parameters such as heart rate, rhythm, P wave, QRS complex, ST segment, and T wave changes were evaluated.

Imaging Studies

Out of 27 hypothyroid dogs, 15 dogs were subjected to thoracic radiography, abdominal radiography, ultrasonography and echocardiography as per clinical indication.

Dogs diagnosed with hypothyroidism were subjected to radiographic and ultrasonographic evaluations to assess thoracic and abdominal involvement. Radiography was performed using a 500 mA X-ray machine (Siemen's Medical Equipment Ltd.) with a computerized radiographic system (Kodak Carestream Ltd.). Thoracic radiographs were taken in lateral and ventrodorsal projections, while lateral abdominal radiographs were obtained to evaluate organ size and radiodensity of the liver, spleen, and kidneys following Thrall (2002) [22].

Standard transthoracic echocardiography was performed in 15 dogs using an ALOKA Prosound α6LT (Hitachi Aloka Medical Ltd.) equipped with a 5.5-7.5 MHz phased array transducer. Echocardiographic evaluations included M-mode and two-dimensional imaging, assessment of the LA/AO ratio, and color Doppler studies, following the methodology described by Boon *et al.* (2011) [3].

Abdominal ultrasonography was carried out at the time of diagnosis using the same equipment with 5-10 MHz curvilinear, convex, or linear transducers, depending on the animal's size (Nyland *et al.*, 2002) [14]. Dogs were positioned in dorsal or lateral recumbency, the abdominal region was clipped and acoustic gel was applied to ensure clear imaging for evaluating visceral organ changes.

Results and Discussion

Electrocardiographic findings, electrocardiographic abnormalities, thoracic radiographic findings, abdominal radiographic findings, abdominal ultrasonographic findings and echocardiographic findings are presented in Tables 1 to 7, respectively.

Overall, ECG abnormalities were detected in 15 (55.56%) out of 27 hypothyroid dogs, consistent with the observations of Kumar and Srikala (2013) [13] and Guglielmini *et al.* (2019) [9]. Panciera (1994) [17] observed that 58 percent of dogs with spontaneous hypothyroidism showed a significant rise in R-wave amplitude (initially <1.0 mV) after L-thyroxine supplementation. Similarly, in the present study, the mean±SE R-wave amplitude (1.06±0.12 mV) was in agreement with the findings of Panciera (1994) [17] and Stephan *et al.* (2003) [20].

Atrial fibrillation in hypothyroid dogs has also been documented by Gaalova *et al.* (2008) [6]. These ECG changes might be attributed to the altered inotropic and chronotropic function associated with of thyroxine deficiency (Tappin, 2014) [21]. Factors such as obesity, reduced myocardial mass, and decreased circulating blood volume could contribute to bradycardia and low-voltage R waves, which are often of limited clinical importance unless a pre-existing cardiac condition is present (Panciera, 2001; Scott-Moncrieff, 2007) [16, 19].

Thoracic radiographic findings in this study were consistent with those reported by Panciera (2001) [16], Kumar and Srikala (2013) [13], and Ojeda *et al.* (2015) [15]. The megaesophagus observed in three dogs was likely due to generalized polyneuropathy associated with hypothyroidism (Jaggy *et al.*, 1994) [10]. The exact mechanism by which hypothyroidism leads to megaesophagus is unclear. However, it is evident from human studies that, reduced neuronal metabolism may disrupt axonal transport, while mucopolysaccharide accumulation with in Schwann cells and nerve connective tissue may contribute to demyelination (Ko *et al.*, 2018) [11].

Abdominal radiographic and ultrasonographic findings were in line with Gori *et al.* (2023) [8], indicating hepatic, gallbladder, and renal involvement in hypothyroid dogs, suggesting a possible metabolic association between hypothyroidism and hepatobiliary alterations. Thyroid hormones play an important role in regulating the function of multiple organs including the kidneys. Thyroid dysfunction alters renal function through both direct renal mechanisms and pre-renal influences, such as metabolic, cardiovascular, and hemodynamic changes. In hypothyroid states, decreased cardiac output, increased peripheral vascular resistance, intrarenal vasoconstriction, reduced renal responsiveness to vasodilators, and lowered activity of the renin-angiotensin-aldosterone system act together to lower renal blood flow (Vargas *et al.*, 2006; Di Paola *et al.*, 2020) [24, 5].

Echocardiographic findings (B-mode, M-mode, and Doppler) revealed ventricular enlargement, reduced ejection fraction and fractional shortening, mitral regurgitation, aortic and tricuspid regurgitation, and pericardial effusion which were in partial agreement with Aiswariya (2018) [1]. Mitral valve insufficiency observed in three dogs corroborated Aiswariya's findings, who noted a significant decline in serum T4 levels in dogs with mitral valvular insufficiency (MVI). The myxomatous degeneration of the mitral valve may be attributed to glycosaminoglycan deposition in the valve tissue. Pericardial effusion, noted in three dogs, may have resulted directly from hypothyroidism or could be idiopathic, occurring coincidentally (Ojeda *et al.*, 2015) [15]. The same authors reported that pericardial effusion secondary to hypothyroidism is rare in dogs, describing a cholesterol-rich effusion in a single case.

Dilated cardiomyopathy (DCM) recorded in two hypothyroid dogs aligned with the observations of Gomes *et al.* (2015) [7] and Koskova *et al.* (2022) [12], who reported an association between hypothyroidism and DCM. However, Beier *et al.* (2015) [2] found no association between hypothyroidism and with the development or progression of DCM in dogs. The observed reduction in ejection fraction and fractional shortening, along with increased EPSS and LA/AO ratio, could be attributed to decreased myocardial contractility and low cardiac output (Phillips and Harkin, 2003; Aiswariya, 2018) [18, 1]. Nonetheless, Panciera (2001) [16] suggested that although electrical conduction and contractility changes results in detectable echocardiographic abnormalities, their clinical significance is often minimal.

Table 1: Electrocardiographic findings recorded in hypothyroid dogs (n = 27)

Parameter	Mean ± SE
P wave-duration (sec)	0.05±0.00
P wave-amplitude (mV)	0.19±0.01
QRS-duration (sec)	0.04±0.00
QRS-amplitude (mV)	1.06±0.12
T wave-duration (sec)	0.06±0.01
T wave-amplitude (mV)	0.25±0.05
PR-interval (sec)	0.10±0.01
QT-interval (sec)	0.18±0.01
ST-interval (sec)	0.12±0.01

Table 2: Electrocardiographic abnormalities in hypothyroid dogs (n = 27)

Change	Frequency	Percentage
Absence of P wave	1	3.70
Atrial flutter	1	3.70
Bradyarrhythmia	2	7.41
Low voltage QRS complex	12	44.44
Tall R wave	1	3.70
Tall T wave	4	14.81
Electrical alternans	4	14.81
ST coving	2	7.41

Table 3: Thoracic radiographic findings in hypothyroid dogs (n = 15)

Radiographic feature	Frequency	Percentage
Cardiomegaly	4	26.67
obscured cardiac silhouette	2	13.33
Globoid heart	4	26.67
Elevated trachea	2	13.33
Right atrial enlargement	3	20.00
Pericardial effusion	3	20.00
Pleural effusion	2	13.33
Consolidation of lungs	1	6.67
Mixed lung pattern in lung lobes	1	6.67
Megaoesophagus	3	20.00

Table 4: Abdominal Radiographic findings in hypothyroid dogs (n = 15)

S. No	Radiographic feature	Frequency	Percentage
1	Ground glass appearance	2	13.33
2	Loss of serosal details	3	20.00
3	Gas filled intestines	2	13.33
4	Hepatomegaly with rounding of liver lobes	1	6.67
5	Shrunken kidneys	2	13.33

Table 5: Abdominal ultrasonographic findings in hypothyroid dogs (n = 15)

Organ	Ultrasonographic feature	Frequency	Percentage
Liver	Hepatomegaly	2	13.33
	Hyperechoic liver	2	13.33
	Irregular liver margins	1	6.67
	Mixed echogenicity	1	6.67
Gall bladder	Increased wall thickness	2	13.33
Spleen	Splenomegaly	1	6.67
Kidney	Renomegaly	1	6.67
	Shrunken kidneys	2	13.33
	Indistinct CMJ	2	13.33
Peritoneal cavity	Anechoic peritoneal fluid	2	13.33
	Fibrinous strands in the fluid	1	6.67

Table 6: Echocardiographic findings in hypothyroid dogs (n = 15)

Echocardiographic feature	Number of affected dogs	Percentage
Dilated cardiomyopathy	2	13.33
Tricuspid regurgitation	1	6.67
Mitral regurgitation	3	20.00
Aortic regurgitation	1	6.67
Left ventricular enlargement	3	20.00
Right ventricular enlargement	1	6.67
Pericardial effusion	3	20.00
Pleural effusion	2	13.33

Table 7: Mean ± SE Values of Echocardiographic variables of healthy and hypothyroid dogs

Parameter	Healthy dogs (n = 8)	Hypothyroid dogs (n = 15)
LA/AO	1.02±0.02	1.27±0.14
EPSS (mm)	2.91±0.10	5.40±0.96*
Ejection fraction (%)	69.55±0.95	54.26±3.61**
Fractional shortening (%)	32.88±0.77	26.99±1.69**

*Means differ significantly ($p<0.05$) between healthy and hypothyroid dogs.
**Means differ significantly ($p<0.01$) between healthy and hypothyroid dogs.

Conclusion
This study demonstrates that multimodal imaging enhances the identification of cardiovascular and systemic alterations in canine hypothyroidism. Combining ECG, radiography, ultrasonography and echocardiography provide more comprehensive and reliable clinical assessment.

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Conflict of Interest
The authors declare that there are no conflicts of interest.

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