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# Electrocardiographic findings in dogs with obstructive airway diseases

## *Achados eletrocardiográficos em cães com doenças obstrutivas das vias aéreas*

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**ABSTRACT:** Cardiac rhythm disorders are diagnosed through electrocardiography, which is an important tool to investigate other systemic conditions that may be related to the cardiac conduction system. Cardiac regulation is controlled by the autonomic nervous system, and in dogs, it is mainly modulated by a parasympathetic action exerted by the vagus nerve, called vagal tone. Increased vagal tone can occur physiologically or pathologically, leading to the occurrence of bradyarrhythmias. However, some studies report that airway diseases can exacerbate this tone, together with the reduction of sympathetic pathway activities. This study aimed to analyze the cardiac rhythms in dogs presenting with electrocardiographic alterations related to respiratory diseases, in connection with the exacerbation of vagal tone. Medical records of animals whose diagnoses involved at least one respiratory condition and who underwent electrocardiographic assessment between March 2017 to March 2021 were compiled. Data obtained were compiled in Microsoft Excel®[1] spreadsheets and evaluated using descriptive statistics through the BioEstat®[2] software. Pearson's correlation was used for quantitative data. A correlation between autonomic regulation and vagal exacerbation was observed in cases with obstructive airways diseases.

**KEYWORDS:** arrhythmia; respiratory diseases; electrocardiogram; vagal tone.

**RESUMO:** Os distúrbios do ritmo cardíaco são diagnosticados por meio da eletrocardiografia, que é uma importante ferramenta para investigar outras condições sistêmicas que podem estar relacionadas ao sistema de condução cardíaco. A regulação cardíaca é controlada pelo sistema nervoso autônomo e, em cães, é modulada principalmente pela ação parassimpática exercida pelo nervo vago, denominada tônus vagal. O aumento do tônus vagal pode ocorrer fisiologicamente ou patologicamente, levando à ocorrência de bradiarritmias. No entanto, alguns estudos relatam que as doenças das vias aéreas podem exacerbar esse tônus, juntamente com a redução das atividades das vias simpáticas. Este estudo teve como objetivo analisar os ritmos cardíacos em cães com alterações eletrocardiográficas relacionadas a doenças respiratórias, relacionadas à exacerbação do tônus vagal. Foram compilados os prontuários dos animais cujos diagnósticos envolvessem pelo menos uma condição respiratória e que realizaram avaliação eletrocardiográfica, no período entre março de 2017 a março de 2021. Os dados obtidos foram compilados em planilhas do Microsoft Excel®[1] e avaliados por meio de estatística descritiva por meio do software BioEstat®[2]. A correlação de Pearson foi usada para dados quantitativos. Foi observada correlação entre regulação autonômica e exacerbação vagal em casos com doenças obstrutivas das vias aéreas.

**PALAVRAS-CHAVE:** arritmia; doenças respiratórias; eletrocardiograma; tônus vagal.

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## INTRODUCTION

Cardiac regulation is controlled by the autonomic nervous system, mainly modulated through the parasympathetic action of the vagus nerve and the activation of the sympathetic pathways (WARE, 2015). The increase in vagal tone occurs physiologically, as in cases of respiratory sinus arrhythmia (RSA), or due to disturbances in electrical stimulation and propagation in the conduction system, such as in the case of a migratory pacemaker, first-degree atrioventricular block (AVB), or sinus arrest (TILLEY; BURTNICK, 2004).

RSA is characterized by an alternating heart rate that reduces on expiration and increases on inspiration (GOLDBERGER, 1999). In contrast, the first-degree AVB represents a conduction disorder, where there is a delay in the electrical impulse after activation of the atrioventricular node. In turn, sinus arrest occurs when there is a delay in impulse generation of the sinoatrial node (FILIPPI, 2011), increasing the R-R interval, and is characterized by lasting twice as long (or even longer) than the previous R-R interval (TILLEY; GOODWIN, 2002).

Respiratory diseases increase parasympathetic modulation in the cardiovascular system (PAIVA; ALAM, 2005). Decreased airway diameter and hypoxia are correlated with changes in the autonomic system of the heart due to increased vagal tone, as well as reduction in lung compliance (PANTONI, 2007).

Thus, during inspiration, contractions of the intercostal muscles and the diaphragm promote chest expansion, and consequently, retraction of the vagus nerve, thereby increasing the heart rate (HR) (SHALES, 2014). Conversely, with the relaxation of these structures during expiration, vagal innervation reduces the RH, through parasympathetic mediation (GOLDBERGER, 1999).

This study aimed to analyze and correlate the electrocardiographic findings of patients assessed by a private cardiology and respiratory disease service, which presented alterations associated with respiratory infections, consistent with vagal exacerbation.

## MATERIAL AND METHODS

The medical and clinical care records and electrocardiographic examinations of dogs attended at a private cardiology and respiratory disease service were surveyed.

To identify those with vagal exacerbation during respiratory diseases, the animals were selected according to the diagnoses that involved at least one obstructive respiratory disease, such as bronchopneumonia, bronchitis, tracheal collapse, and brachycephalic dog syndrome, who underwent electrocardiographic evaluation using the InCardio®[1] device. Patients with radiographic and clinical findings compatible with bronchopneumonia, bronchitis, and tracheal collapse were included.

Clinical findings and electrocardiographic assessment were performed by the same examiner. Animals with valve alteration on auscultation who underwent Doppler echocardiographic examination, and patients with B2, C, or D valve disease, according to the American College of Veterinary Internal Medicine-ACVIM consensus (KEENE et al., 2019), were excluded from the analysis. Animals with B1 valve disease, that is, those with structural changes but without hemodynamic repercussions, were included in the study.

In all cases, systemic systolic blood pressure was measured using a vascular Doppler, having the value ranges as a reference Acierno et al., (2018).

Data were obtained through the book minutes and the service records of the referred service compiled in Excel® spreadsheets. Clinical and demographic data, as well as the percentage frequencies of the respiratory disease diagnosis and the corresponding electrocardiographic alterations, were compiled in the aforementioned software, and a descriptive statistical analysis was performed.

For the clinical and complementary findings, Pearson's correlation was performed to assess the associations between parameters for the clinical and complementary findings. The BioEstat® software was used for the statistical analysis, with a significance level of 5% ($\alpha = 0.05$).

## RESULTS

After the initial screening of clinical records and observing the inclusion criteria, 108 dogs were finally selected. The average age of the treated animals was 102 ± 18 months, with 67.5% being female and 32.5% being male. The most common type of dogs was mixed breed, comprising 15% of the sample, followed by Poodles (n=14) and Shih-tzus (n=12), Yorkshires, Malteses, and Pugs (n=10 animals each), with the same absolute values.

The average weight of the animals was of 8.07 ± 6.07 kg. Data of the study population are summarized in Table 1.

On clinical examination, a murmur on auscultation was observed in 53 animals, without hemodynamic changes on clinical examination and Doppler echocardiography. The mean systolic blood pressure was 129 ± 19 mmHg. A strong positive correlation between patient age and systemic systolic blood pressure was noted (0,812, p=0,031, 0,05%). However, a weak correlation between weight and systemic systolic blood pressure (0,180, p=0,461, 0,05%), and between weight and age (0,215, p=0,389, 0,05%), was observed, although not statistically significant.

Continuous expiratory noise was the most prevalent finding on respiratory auscultation, at 53.7% (n=58), followed by increased expiratory noise at 18.6% (n=10), continuous inspiratory noise at 16.6% (n=16), and harsh discontinuous noise at 11.1% (n=12). Cough was present in 65% of patients, after performing the reflex test, with the intensity classified using a scale of 1 to 4. For quantitative correlation, pulmonary noise

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was converted into numerical values ranging from 0 to 4 to help indicate findings and their intensity, and to allow the parallel comparison with cough intensity, revealing a moderately positive correlation with cough (0,515, p=0,029, 0,05%).

The pulmonary pattern obtained in the analysis of the radiographic image reports were as follows: bronchial and interstitial patterns, 43.5% (n= 47 animals); bronchial, alveolar, and interstitial patterns, 23.1% (n= 25 animals); bronchial and vascular patterns, 11.1% (n=12 animals); interstitial patterns, 7.4% (n=8 animals); and without alteration or compatible with senility, 14.9% (n=16 animals). The patterns showed a higher prevalence of radiographic alterations in animals with clinical alterations, with a moderate positive correlation observed between the intensity of cough and pulmonary noise (0,614, p= 0,035, 0,05% e 0,514, p= 0,038, 0,05%).

Regarding the lateral cervicothoracic radiography in two moments (inspiratory and expiratory), in patients with suspected collapse of the trachea, narrowing of the lumen in a portion of the cervical trachea occurred in 55.5% of cases (n=10), mainly in the thoracic entry region, occurring at the inspiratory moment. Intrathoracic trachea collapse was observed in 44.5% of cases (n=8), occurring at the time of expiration. A strong positive correlation was observed for both cases: collapsing cervical trachea vs. inspiratory moment, and collapse of thoracic trachea vs. expiratory moment (0,765, p=0,046, 0,05%). In eight animals, although the clinical suspicion and the findings were compatible, narrowing was not observed on cervicothoracic radiographic examination, when performed in two moments.

Among the electrocardiographic findings, sinus arrhythmia (Figure 1) was the most frequent, at 64.8% (n=55), followed by sinus rhythm at 21.2% (n=23) (Figure 2), sinus arrest at 20.0%, (n=17) (Figure 3) and first-degree AVB at 15.2% (n= 13) (Figure 4).

Thus, 78% of the animals evaluated (Table 2) presented with bradyarrhythmia, showing a strong positive correlation between respiratory disease and electrocardiographic alterations consistent with bradyarrhythmias.

The most prevalent disease was chronic bronchitis (51,9%; n= 56 animals), followed by tracheal collapse (23,2%; n= 25

**Table 1.** Demographic data of dogs assisted by the private cardiology and respiratory disease service.

| **Total animals (n)** | ***n* sample = 108** |
|---|---|
| **Average age** | 102±18 months |
| **Breeds** | Mixed breeds – 16/108 (15,0%)<br>Poodle - 14/108 (13,0%)<br>Shih-tzu – 12/108 (11,1%)<br>Yorkshire Terrier – 10/108 (9,2%)<br>Maltês – 10/108 (9,2%)<br>Pug – 10/108 (9,2%)<br>Others* – 36/108 (33,3%) |
| * - Bichon Frise, Boston Terrier, Boxer, Buldogue inglês, Buldogue Francês, Chihuahua, Chow chow, Cocker Spaniel, chihahua, Fox Paulistinha, Fox Terrier, Galgo Italiano, Golden Retriever, Jack Russel Terrier, Labrador, Lhasa Apso, Lulu da Pomerânia, Maltês, Pastor de Shetland, Pinscher, Schnauzer, Scottish Terrier, Staffordshire, West Highland White Terrier e Whippet. | |
| **Genre** | Females - 73/108 (67,5%)<br>Males – 35/108 (32,5%) |

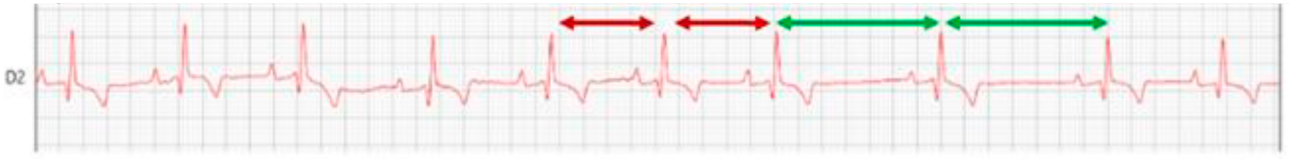


**Figure 1.** Electrocardiographic tracing at lead D2, velocity 50mm/s, amplitude 10mm/mV (N), showing sinus arrhythmia. Note irregular R-R's intervals, with slight variation between adjacent intervals (red arrows), but with a 10% increase in velocity (green arrows).

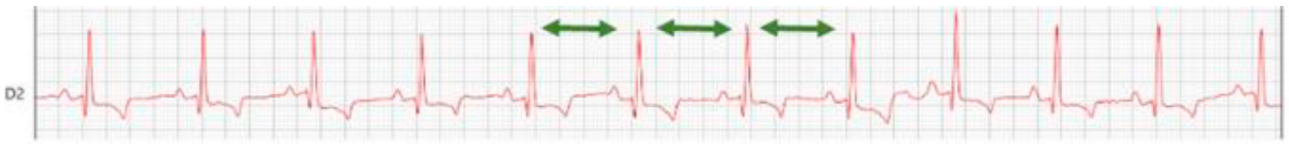


**Figure 2.** Electrocardiographic tracing at lead D2, velocity 50mm/s, amplitude 10mm/mV (N), showing sinus rhythm. Note regular R-R's intervals (green arrows), with slight variation between adjacent intervals (less than 10%).

animals), bronchopneumonia (16,6%; n= 18 animals), and brachycephalic syndrome ((8,3%; n= 9 animals). For the association between heart disease without hemodynamic repercussions and any of the aforementioned conditions, comorbidity was observed in 45 animals.

Table 3 shows the distribution of electrocardiographic rhythms in animals with chronic bronchitis.

## DISCUSSION

Electrocardiographic evaluation has been confirmed as an important tool to detect rhythm disturbances related to respiratory infections. Clinical examination is also of great importance, since establishing a respiratory disease diagnosis and connecting it to those found during electrocardiographic assessment is possible through assessment of the findings obtained during examination and the patient's clinical signs, as explained by Tilley (2005).

Increasingly, with the humanization of animals and the attachment of tutors to "bathing and grooming" services, the use of perfumes, cleaning products, and irritating factors favors chronic diseases that affect the respiratory system (LARSSON, 2015). Remarkably, "indoor" breeds, that is, breeds that have a smaller size, are mostly predisposed to these diseases.

A strong positive correlation between age and blood pressure was noted. According to the observed data, where most patients were not hypertensive (GOUGH, 2009), the correlation reminds us that with advancing age, endocrine and renal disorders become more evident. However, we cannot extrapolate this to the present population and confirm such a direct relationship with these conditions, as these analyses were not conducted in the present study, and this observation is only relevant to the dynamics of the study population. Thus, further analysis is recommended.

Coughing was shown to be moderately associated with the severity of lung noise, corresponding to the chronicity and severity of the disease. However, coughing, often reported by tutors, resembles choking, which was mostly not observed. Moreover, it is important to screen for the positive signs of the cough reflex during physical examination (TILLEY; BURTNICK, 2005, GOUGH, 2009).

**Table 2.** Relation between the number of animals that show changes in vagal exacerbation associated with respiratory disease.

| Electrocardiographic alteration | Animals with Respiratory Disorder | RF(%) |
|---|---|---|
| RSA* | 55 | 64,8% |
| Sinus arrest | 17 | 20,0% |
| First-degree AVB** | 13 | 15,2% |
| Total | 85 | 100% |

*Respiratory sinus arrhythmia; **Atrioventricular block; RF= Relative Frequency.

**Table 3.** Relationship between bronchitis and electrocardiographic changes, alone, in absolute and relative frequencies.

| Bronchitis (AF) | Electrocardiographic alteration | RF(%) |
|---|---|---|
| 39 | RSA* | 70% |
| 11 | Sinus arrest | 20% |
| 6 | First-degree AVB** | 10% |
| Total | 56 | 100% |

*Respiratory sinus arrhythmia; **Atrioventricular block; AF= Absolute Frequency; RF= Relative Frequency.

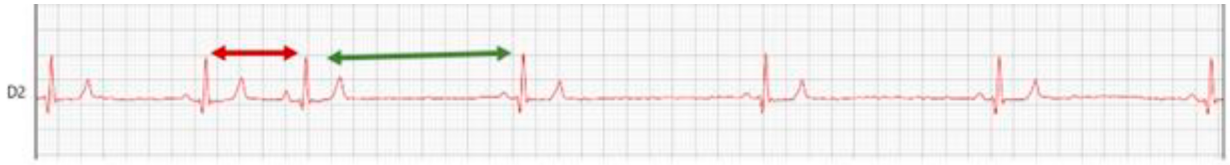


**Figure 3.** Electrocardiographic tracing at lead D2, velocity 50mm/s, amplitude 10mm/mV (N), showing sinus arrest. Note irregular R-R's intervals, with an increase greater than twice (100%) (green arrow) of the previous interval (red arrow).

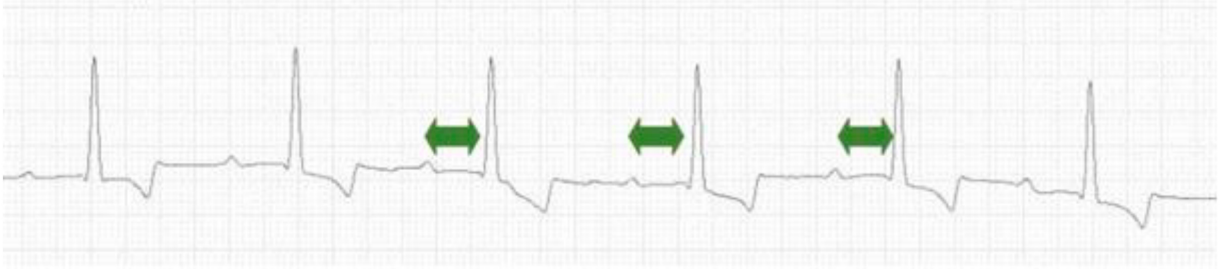

**Figure 4.** Electrocardiographic tracing at lead D2, velocity 50mm/s, amplitude 10mm/mV (N), first-degree atrioventricular block. Note regular R-R's intervals with increasing P-R interval (green arrows).

In the analysis of the radiographic reports, pulmonary patterns were most frequently bronchial and interstitial, which are commonly observed in dogs with chronic bronchitis (McKierman, 2000). Thickening of the bronchial wall and increased interstitial density on radiography are triggered by the inflammatory process of the disease, which reinforces the wide margin of this finding in patients with bronchitis (MANTIS et al., 1998; FILHO et al, 2018). Further, bronchial, alveolar, and interstitial patterns are correlated with bronchopneumonia (GOUGH, 2009).

According to radiographic data of cases with tracheal collapse, the timing of the respiratory cycle is highly associated with the site of collapse, suggesting the importance of conducting radiography twice in those with suspected collapse (ALONSO, 2007). It further reinforces the theory of dynamics, according to which, a higher pressure is observed on the cervical structures during inspiration and a higher pressure on the lungs during expiration to expel air from the small airways to the main bronchi and trachea, promoting collapse in the thoracic cavity (LEMOS et al, 2019).

Animals with an exacerbation of vagal tone due to respiratory disease presented with evidence of its chronicity, the primary disease being chronic bronchitis (ROZANSKI, 2014). The chronicity of the infections already influenced the development of rhythm disorders (MONTOYA, 2007; FILHO et al., 2020). Notably, RSA was the most frequent finding. Although RSA is a physiological finding in dogs, studies already point to exacerbation in brachycephalic animals or in animals with chronic respiratory disease or during sleep (LARSSON, 2015).

Sinus arrhythmia is linked to increased parasympathetic activity in the sinoatrial node and is common in dogs (MARTIN, 2007). Data that register the occurrence of heart rate variation according to the moment of breathing are available, with improvement in clinical indices and parameters after weight loss in obese dogs and in the surgical correction of morphological changes associated with the brachycephalic syndrome (FILHO et al., 2019; FILHO et al., 2020).

Some authors have reported the frequent association of sinus arrhythmia with a brachycephalic state in dogs, and four (20%) of the animals in the present study had sinus pauses of 4 s and 6 s, which demonstrates a stimulated vagal tone (DIAS, 2014). A change in P wave conformation, called migratory pacemaker, occurred in 45 animals in this study, which is also related to increased activation of the vagus nerve, common in dogs (PANTONI et al., 2007), especially those that are brachycephalic (MARTIN, 2007).

Brachycephalic dogs have more exacerbated vagal tone compared to non-brachycephalic dogs, and the cause is still unknown (DOXEY; BOSWOOD, 2004). However, exacerbation intensity is not affected by the severity of the respiratory disease, occurring both in patients with lesser clinical alterations and in those that are significantly impaired. Nevertheless, disease chronicity has been considered a determining factor of cardiac bathmotropism (SHALES, 2014; ROZANSKI, 2015), as the increase in airway resistance decreases the oxygenation rate, even though respiratory failure is not evident, triggering dysfunction due to the respiratory effort and the increase in vagal tone due to the exacerbated respiratory cycle (VOLTERRANI, 1994).

Another important finding observed was the sinus rhythm, wherein only 23 of the 108 dogs evaluated had a normal heart rhythm. This proportion can be attributed to the presence of respiratory infections. It cannot be ruled out that in quiet conditions and environments without the stress and consequent sympathetic activation due to the assessment itself, these patients might not develop sinus rhythm (TILLEY; BURTNICK, 2005). Containment and care environment can contribute to the release of catecholamines, which accelerate the heart rate by activating the sympathetic pathways, superimposing the normal sympathovagal balance (BERNS, 2012).

Sinus arrest presented itself with considerable frequency, which is common in brachycephalic breeds, due to abnormalities in the brachycephalic syndrome, such as stenosis of the nostrils, prolonged soft palate, and hypoplastic trachea (GOUGH, 2009). These abnormalities can lead to airway obstruction to varying degrees and result in increased inspiratory effort, in turn affecting vagal tone, favoring the widespread occurrence in animals presenting with this alteration (FILHO et al., 2020).

First-degree AVB was the least frequent finding in the animals evaluated, as it does not directly cause hemodynamic changes, which is a physiological finding when not associated with obstructive diseases (TILLEY; BURTNICK, 2005). However, its occurrence is important in the clinical and electrocardiographic follow-up of patients with obstructive diseases, as it can indicate a future possibility of the occurrence of other bradyarrhythmias, such as more advanced blocks (BERNS, 2012).

## CONCLUSION

In the present study, respiratory sinus arrhythmia was present in 95% of the animals diagnosed with bronchitis, suggesting its strong association with this disease as well as with chronic conditions. Our results reveal an association between autonomic regulation and the exacerbation of vagal tone in those with obstructive airway diseases that in some way affected cardiac bathmotropism. Further clinical and controlled studies, considering only one group of animals, are required to better elucidate these occurrences.

## REFERENCES


ACIERNO, M. J., BROWN, S., COLEMAN, A. E., JEPSON, R. E., PAPICH, M., STEPIEN, R. L. & SYME, H. M. (2018). ACVIM consensus statement: guidelines for the identification, evaluation, and management of systemic hypertension in dogs and cats. **Journal of veterinary internal medicine**, 32, 1803-1822. Doi: http:/doi.org/10.1111/jvim.15331

BERNS, G. S. (2012). Functional MRI in Awake Unrestrained Dogs. **PLOS ONE**, v.7, p.1-7, https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0038027.

DIAS, M.L.M. (2014). **Variáveis anatômicas, cardiovasculares e hemogasométricas em cães com a síndrome braquicefálica**. Dissertação (mestrado em saúde animal) – Universidade de Brasília, DF. https:/repositorio.unb.br/bitstream/10482/16226/1/2014_MariaLuizaMeloDias.pdf.

FILIPPI, L.H. (2011). **O eletrocardiograma na medicina veterinária**. (1ª ed.) São Paulo: Roca, 264p.

FILHO, M. DOS S., HAINFELLNER, D. C., DE OLIVEIRA LEMOS, N. M., MENDES, C. DE O. F., MALANDRIM, P., CAMPOS, J. M., BALLOT, S., DE OLIVEIRA, P. C., & PAIVA, J. P. (2019). Influence of weight loss on heart rate variability in dogs. **Brazilian Journal of Veterinary Medicine**, *41*(1), e98119.

FILHO, M.S., HAINFELLNER, D. C., LEMOS, N. M. DE O., MACAMBIRA, K. D. DA S. M. B., DO CARMO, J. S., ALBERIGI, B. R. S. A. DA S., ABEN ATHAR, C. DO V., MENDES JUNIOR, A. F., DA VEIGA, C. C. P., SOARES, A. M. B., BOTTEON, P. DE T. L., FERNANDES, J. I., & PAIVA, J. P. (2020). Study of the heart rate variability in dogs with brachycephalic syndrome submitted to rhinoplasty surgery. **Brazilian Journal of Veterinary Medicine**, *42*(1), e104919.

FILHO, M.S., HAINFELLNER, D.C., ALBERIGI, B.R.S., LEMOS, N.M.O., CARMO, J.S., SANTOS, M.O. & PAIVA, J.P. Canine chronic bronchitis – literature review. **Medicina Veterinária (UFRPE)**, v. 13, n. 3, p. 329-337, 2019.

GOLDBERGER, J.J. (1999). Sympathovagal balance: how should we measure it? American Journal of Physiology. **Heart and Circulatory Physiology**, v.276., n.1., 1273-1280.

GOUGH, A. (2009). Cardiorespiratory Signs Reported in the Clinical History. In: GOUGH, A. (Eds.). **Differencial Diagnosis in Small Animal Medicine**. 1ªed. Oxford: Blackwell Publishing. pp.40-46.

KEENE, B.W., ATKINS, C.E., BONAGURA, J. D., FOX, P. R., HÄGGSTRÖM, J., FUENTES, V. L., OYAMA, M. A., RUSH, J. E, STEPIEN, R. & UECHI, M. (2019). ACVIM consensus guidelines for the diagnosis and treatment of myxomatous mitral valve disease in dogs. **Journal of Veterinary Internal Medicine**, 33:1127–1140 DOI: https:/doi.org/10.1111/jvim.15488.

LARSSON, M. H. M. A. (2015). Doenças Cardiovasculares. In: JERICÓ, M. M., NETO, J.P.A., KOGIKA, M. M. (1ª ed.) **Tratado de Medicina Interna de Cães e Gatos**. 126 – 140. Rio de Janeiro: Roca.

LEMOS, N. M. O. L.; FILHO, M. S.; MENDES, C., O., F., CARMO, J. S., ELEUTÉRIO, E. O., VEIGA, C. P. V.; & PAIVA, J. P. (2020). Influence of obesity on the clinical improvement of tracheal and bronchial collapse in dogs: a case report. **Brazilian Journal of Veterinary Medicine**, *42*(1), e107620.

MANTIS, P.; LAMB, C.R.; BOSWOOD, A. (1998). Assessment of the accuracy of thoracic radiograph in the diagnosis of canine chronic bronchitis. **Journal of Small Animal Practice**, 39(11): 518-520.

MARTIN, M. (2007). **Small Animal ECGsAn introductory guide**, (2ªed.)., p.9-55.

MC KIERMAN, B.C. (2000). Diagnosis and treatment of canine chronic bronchitis: Twenty years of experience. **Veterinary Clinics of North America - Small Animal Practice**, 30(6): 1267-1278.

MONTOYA, J.A. (2007). **Enfermidades respiratórias em pequenos animais**. (1ª ed.) Las Palmas: Interbook, 330p.

PAIVA, J.P.; ALAM, R.V. (2005). Bronquitis Canina. In: MUCHA, C.J.; SORRIBAS, C.E.; PELLEGRINO, F.C. (1ª ed.). **Consulta Rapida En La Clinica Diaria**. 30-34. Buenos Aires: Inter Medica.

PANTONI, C.B.F.; REIS, M.S.; MARTINS, L.E.B.; CATAI, A.M.; COSTA, D.; BORGHI-SILVA, A. (2007). Estudo da modulação autonômicas da frequência cardíaca em repouso de pacientes idosos com doença pulmonar obstrutiva crônica. **Revista Brasileira de Fisioterapia**, v.11, n.1, p.35-41.

ROZANSKI, E.A. (2014). Canine Chronic Bronchitis. **Veterinary Clinical Small Animals**, v.44., n.1., p.107-116.

ROZANSKI, E.A. (2015). Oxygenation and Ventilation. **Veterinary Clinical Small Animals**, v.46., n.1., p.1-10.

SANTILLI, R., MOISE, N.S., PARIAUT, R. & PEREGO, M. 2018. Reduction of beats and rhythms. In.: SANTILLI, R., MOISE, N.S., PARIAUT, R. & PEREGO, M. (EDS.). **Electrocardiography of the dogs and cats-diagnosis of arrhythmias**. 2nded. Tuscany: Edra, pp198-247

SHALES, C. (2014). Factors, diagnosis and treatment of BOAS in dogs**.** Veterinary Times, v.1., n.1., p.16-18.

TILLEY, L.P.; BURTNICK, N.L. (2004). *ECG:* Eletrocardiografia para o clínico de pequenos animais. (1st ed.) São Paulo: Roca.

TILLEY, L.P.; GOODWIN, J.K. (2002). Manual de cardiologia para cães e gatos. (3 th ed.) São Paulo: Roca.

VOLTERRANI, M.; SCALVINI, S.; MAZZUERO, G.; LANFRANCHI, P.; COLOMBO, P.; CLARK, A.L.; LEVI, G. (1994). Decreased heart rate variability in patients with chronic obstructive pulmonary disease. Chest, v.,106., n., 5., p.1432-1437.

WARE, W.A. (2015). Distúrbios do sistema cardiovascular. In: Nelson, R.W.; Couto, C5ª ed). Medicina interna de pequenos animais. 74-94. Rio de Janeiro: Elsevier.