Received: 13 January 2024 | Revised: 11 April 2024 | Accepted: 18 April 2024

DOI: 10.1002/vetr.4266

Vet Record

ORIGINAL RESEARCH

Impact of preanaesthetic electrocardiogram on decision making and modification of anaesthetic protocols in dogs

Rocío Bustamante[1] | **Eva González-Pérez**[2] | **Alicia Caro-Vadillo**[1] | **Delia Aguado**[1]

[1]Department of Animal Medicine and Surgery, Veterinary Teaching Hospital, Complutense University of Madrid, Madrid, Spain

[2]Faculty of Health and Medical Sciences, University of Copenhagen, Copenhagen, Denmark

Correspondence
Delia Aguado, Anaesthesiology Service, Department of Animal Medicine and Surgery, Veterinary Teaching Hospital, Complutense University of Madrid, Avda. Puerta de Hierro s/n, Madrid 28040, Spain.
Email: deliaagu@ucm.es

Abstract

Background: This retrospective observational study explored the impact of preanaesthetic electrocardiogram (ECG) assessment on preoperative echocardiography requests and modifications to a standardised anaesthetic protocol in healthy dogs.

Methods: A total of 228 healthy dogs with no previously diagnosed heart disease that underwent general anaesthesia at Complutense Veterinary Teaching Hospital from December 2017 to June 2018 were included. Preanaesthetic ECGs were assessed for abnormalities, and the findings were documented. The number of dogs requiring echocardiography, based on ECG findings, and the echocardiography results were recorded. All anaesthesia-related decisions were documented.

Results: Overall, 72 dogs (31.6%) exhibited ECG abnormalities. Echocardiography was requested for five dogs (2.2%). The anaesthetic protocol was changed in 11 dogs (15.3% of those with ECG abnormalities). P wave disturbances, ventricular premature complexes and impulse conduction issues were abnormalities that prompted echocardiography. Bradycardia and electrical impulse conduction abnormalities influenced protocol modifications.

Limitations: The limited sample size meant that it was not possible to investigate potential correlations between demographics and ECG alterations.

Conclusions: Preanaesthetic ECG screening was useful for promoting echocardiography and influencing anaesthesia plans in a subset of dogs. Despite this, further assessment of the impact of routine use of non-targeted preoperative ECG on anaesthesia-related outcomes is warranted.

KEYWORDS
anaesthesia, electrocardiogram, dog, preoperative evaluation

INTRODUCTION

Preoperative patient assessment includes consideration of information from the history, physical examination and results of medical tests, such as laboratory blood or electrocardiographic (ECG) screenings.[1] Such an assessment allows anaesthesiologists to evaluate each patient individually, identifying those at increased risk and tailoring the anaesthetic plan accordingly,[2] thus possibly minimising anaesthesia-related morbidity and mortality.[3] A routine test is an examination conducted according to protocol in all patients, regardless of the results of the clinical evaluation: these tests are performed in the absence of any specific clinical indication or purpose.[4] In veterinary patients, routine preanaesthetic tests are recommended for geriatric animals,[5] where benefits have been reported.[6] However, there is controversy regarding the benefits of routine preanaesthetic tests if no potential problems are identified in the history or on physical examination. A previous study demonstrated little benefit of preoperative laboratory tests, as only 1.5% of clinically healthy dogs required additional preanaesthetic therapy and anaesthetic protocol modifications were made in only 0.2% of the dogs.[7] The percentage of changes in the anaesthetic protocol due

to preanaesthetic tests in cats and dogs older than 8 years remains low (2.5%),[8] questioning its necessity in these patients.[3]

ECG examination consists of the evaluation of waveforms generated by cardiac electrical activity (depolarisation and repolarisation processes).[9] It is the initial test of choice in the diagnosis of arrhythmias and may also provide information regarding myocardial morphology.[10] This test is simple, non-invasive, inexpensive and reproducible. Nevertheless, in the absence of arrhythmias, the sensitivity of ECG for detecting underlying cardiac dysfunction and disease is relatively poor.[10] Echocardiographic screening is considered the gold-standard technique for the diagnosis of structural heart diseases.[11,12]

Routine preoperative ECG examination has little utility in healthy human patients[13,14]; furthermore, it has been recommended only for patients with known or suspected cardiovascular risk factors, and not simply based on age.[1] The American Animal Hospital Association guidelines for senior care in dogs and cats suggest including preoperative ECG evaluation of geriatric patients with evidence of cardiac disease or arrhythmias.[2,5] However, the usefulness of routine preoperative ECG in veterinary patients has not been fully established.

To the best of the authors' knowledge, there are no studies evaluating the impact of routine ECG examination results on anaesthesia management in dogs. Therefore, this study aimed to describe the influence of preanaesthetic ECG on the decision to request preoperative echocardiography and the need for anaesthetic protocol modifications in clinically healthy dogs (American Society of Anesthesiologists physical status classification I–II). The secondary aim was to describe the ECG abnormalities that may prompt additional diagnostic examinations, such as echocardiography.

MATERIALS AND METHODS

This retrospective, observational and descriptive study was designed based on a review of the medical records of dogs undergoing general anaesthesia at the Complutense Veterinary Teaching Hospital between December 2017 and June 2018. The STROBE-Vet guidelines were followed.

Animals

Client-owned dogs of all ages, sexes and breeds scheduled for elective surgical or diagnostic procedures requiring general anaesthesia and subjected to routine preanaesthetic ECG examination were included. Dogs with previously diagnosed heart disease or alterations in physical examination findings (abnormalities on cardiopulmonary auscultation) or laboratory tests (haematology and serum biochemistry) were excluded. Physical examination was performed by a qualified veterinary technician. No sample size was calculated because the authors were unable to identify any pre-existing data upon which to base these calculations.

ECG collection

Preanaesthetic ECG examination was hospital policy for all animals scheduled to undergo general anaesthesia. During ECG evaluation, all animals were positioned in right lateral recumbency and gently held by a veterinary assistant. Standard ECG leads with electrode gel-moistened flattened crocodile clips were positioned at the level of the olecranon on the caudal aspect of the right and left thoracic limbs and over the patellar ligament on the cranial aspect of the left pelvic limb, according to Tilley's recommendation.[10] ECG leads I, II, III, aVR, aVL and aVF were recorded at a speed of 50 mm s^{-1} and an amplitude of 0.1 mV mm^{-1}, and a final lead II was recorded for at least 1 minute to determine the cardiac rhythm. All ECG recordings were performed by the same veterinary technician using the same ECG machine (Cardioline AR1200view 3-channel, Cardioline).

The evaluated parameters during the ECG assessment were heart rate, mean electrical axis, cardiac rhythm, durations of the P wave, QRS complex and PR interval, presence of wandering sinus pacemaker, amplitudes of P, R and T waves, ST segment alterations, QRS complex morphology, presence of atrioventricular blocks (AVBs), ventricular premature complexes, atrial fibrillation, bundle branch block and J point alterations. An ECG abnormality was considered to be a value outside the reference range. Reference ranges described by Santilli and Perego were used.[15] The results of the ECG assessment were recorded. The decision on whether to request echocardiography before general anaesthesia was based on both ECG assessment and data from the medical records. The number of dogs for which echocardiography was recommended was also recorded, along with those patients in which the type of ECG alteration was not considered to require echocardiography (Figure 1). All ECG evaluations and echocardiography recommendations were provided by the same veterinary cardiologist (A.C.V.), who also performed the echocardiography when applicable.

Echocardiography examination

Conscious dogs were placed in right and left lateral recumbency during the examination. For each measurement, six continuous cardiac cycles were recorded, and ECG monitoring was also performed during the entire test. Completed transthoracic 2D, M-mode and Doppler echocardiography examinations were conducted by the same investigator (A.C.V.) following standard echocardiography guidelines.[16] An ultrasound machine (Phillips Affiniti 50 Ultrasound Machine, Phillips) with spectral and colour Doppler

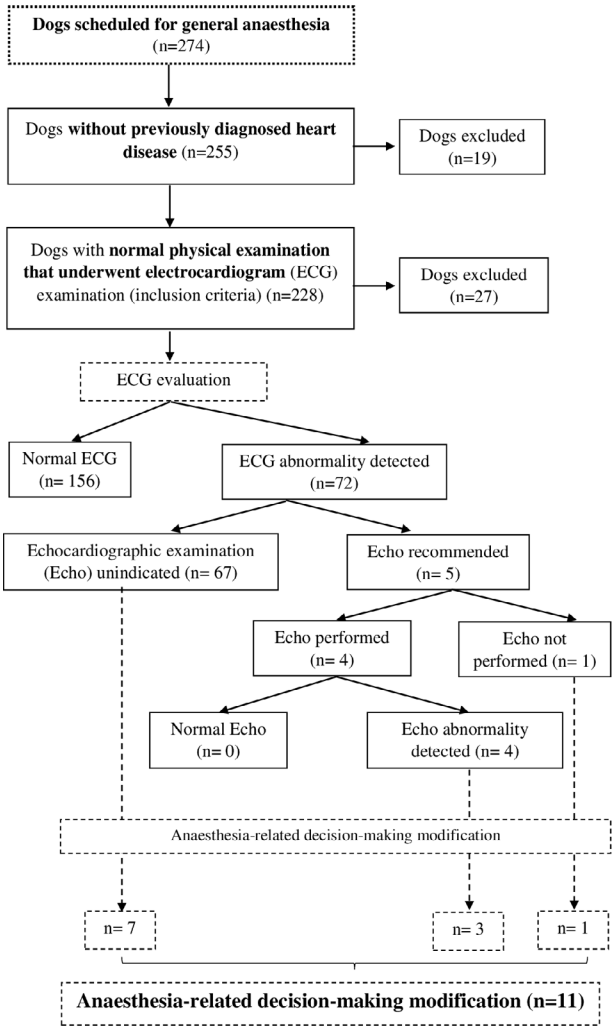

FIGURE 1 Flow diagram of preanaesthetic procedures performed in healthy dogs scheduled for elective procedures

and different frequency probes (4–12 MHz) was employed.

Anaesthesia-related decision making

Anaesthesia-related decision making modification was considered to be any deviation from our standard anaesthetic protocol (methadone plus alpha-2 receptor agonist for premedication and propofol for anaesthetic induction), inotropic support or delay/cancellation of the planned procedure. All decisions related to anaesthesia were made by several experienced veterinary anaesthesiologists. Decisions related to ECG or echocardiography results were recorded.

Statistical analysis

A descriptive statistical analysis was performed. For numerical variables, the normality of the data was evaluated with the Kolmogorov–Smirnov test. None of the numerical data were normally distributed; therefore, numerical data are presented as medians and interquartile ranges (IQR). Categorical data are presented as absolute and relative (%) numbers from the dogs' medical records. The SPSS program (IBM SPSS Statistics v.22) was used for data analysis.

TABLE 1 Demographic data of dogs scheduled for general anaesthesia with no previously diagnosed heart disease, normal physical examination and subjected to routine electrocardiogram examination ($n = 228$).

Variable	Value
Age (months)	92 (41–120)
Weight (kg)	14 (7–28)
Body condition score	5 (5–5)
Sex (male/female)	93/135

Note: The results are expressed as median (interquartile range) or number of dogs as appropriate.

RESULTS

A total of 274 dogs scheduled for general anaesthesia between December 2017 and June 2018 were evaluated. Of those, 19 dogs (6.9%) had previously diagnosed cardiac disease and were thus excluded. Another 27 dogs were excluded due to abnormalities detected during physical examination. A total of 228 dogs were therefore included in the study; these patients had a normal physical examination and had undergone preoperative ECG assessment (Figure 1). The demographic data of the dogs included are shown in Table 1. None of the data were normally distributed.

Of the 228 dogs that met the inclusion criteria, 156 (68.4%) had a normal ECG, while 72 (31.6%) had ECG abnormalities. The types and incidences of ECG abnormalities are detailed in Table 2. Preanaesthetic echocardiography was requested for five dogs due to the detection of various ECG abnormalities (6.9% of dogs with ECG abnormalities or 2.2% of all dogs included) (Table 2). Echocardiographic examinations were performed in four out of these five (80%) animals, as the owners of one dog refused to perform the test. Echocardiographic abnormalities were detected in all four of these dogs. These abnormalities included severe right atrial and ventricular dilations due to pulmonary hypertension in one dog, systolic dysfunction in another, myocardial asynchrony between the interventricular septum and left ventricular wall along with left ventricular hypertrophy in a third dog and signs of minimal systolic dysfunction and mild interventricular septum thinning in the fourth dog.

Anaesthesia-related decision making

Anaesthesia-related decision making was influenced by the ECG findings in a total of 11 dogs (4.8% of the 228 dogs included and 15.3% of the 72 dogs with ECG abnormalities). Anaesthetic procedures were not delayed or cancelled in any case. All anaesthesia-related decision making modifications involved the anaesthesia protocol (a change in either premedica-

TABLE 2 Number of dogs with variables detected as being outside of the reference range during electrocardiogram (ECG) evaluation and whether preanaesthetic echocardiographic examination was requested for these dogs ($n = 72$).

ECG variable	*Number of dogs (%)*	Echocardiography recommended (*n*)
Heart rate	7 (9.7)	0
Cardiac axis	5 (6.9)	0
Cardiac rhythm	2 (2.8)	0
P wave	1 (1.4)	1
Wandering atrial pacemaker	6 (8.3)	0
PR interval	2 (2.8)	1
R wave	3 (4.2)	1
Altered voltage QRS complex	13 (18.1)	1
Altered morphology of QRS complex	3 (4.2)	1
ST segment	17 (23.6)	0
T wave	23 (31.9)	1
Atrioventricular block	5 (6.9)	2
Ventricular premature complex	2 (2.8)	1
Atrial fibrillation	0 (0)	0
Bundle branch block	4 (5.6)	0
J point	4 (5.6)	0
Others	5 (6.9)	2

Note: The results are expressed as absolute and relative (%) number of all dogs with abnormal ECG. Some dogs showed more than one ECG abnormality.

tion or induction agents or both). Inotropic support was used in one dog (Table 3).

Among the dogs with detected ECG abnormalities but no indicated echocardiography, the anaesthesia protocol was modified in seven out of 67 (10.4%) dogs. Premedication was adjusted in six (9.0%) dogs, and anaesthetic induction was altered in five (7.5%) dogs. For the four dogs that underwent echocardiography, the anaesthesia protocol was modified in three (75%) cases. Both premedication and anaesthetic induction were adjusted for these three dogs. Additionally, the premedication was modified for the dog for which echocardiography examination was recommended but not performed. Detailed descriptions of the patients whose anaesthesia protocol was modified, along with the ECG (and applicable echocardiography) alterations, are provided in Table 3.

DISCUSSION

To the authors' knowledge, this is the first report describing the impact of routine preoperative ECG on anaesthetic management in clinically healthy dogs scheduled for elective surgical or diagnostic procedures under general anaesthesia. The perioperative anaesthetic plan was modified in nearly 5% of dogs based on preoperative ECG results, even though ECG abnormalities were detected in 32% of the dogs. Therefore, the different ECG alterations observed do not possess the same clinical relevance from the perspective of preoperative anaesthesia-related decision making. Furthermore, there were no procedure cancellations or rescheduling in any case; only anaesthetic plan modifications were implemented. This suggests that routine, non-targeted ECG in healthy dogs may have a limited impact on anaesthesia-related decisions.

The difference between the number of dogs with ECG abnormalities and those requiring adjustments to the anaesthetic protocol based on such abnormalities might be explained by some patients having ECG variables outside of the normal reference ranges but these changes being considered clinically insignificant. The interpretation of preoperative test findings is crucial to determine the clinical significance of the results obtained.[10] Therefore, preanaesthetic ECG screening should be interpreted by qualified personnel and not be seen as a substitute for thorough physical examination and anamnesis.[13] Additionally, this result is influenced by the standard protocol used in our centre, which combines an alpha-2 adrenergic agonist and methadone for premedication, followed by propofol for anaesthetic induction. Nevertheless, this percentage of anaesthetic plan modification is much higher than that reported by Alef et al.[7] after preanaesthetic laboratory examination (0.2%), thus suggesting the usefulness of ECG for improving anaesthetic management. Unlike the situation in human anaesthesia, secondary medical history sources such as the owner's perception, animal handling, temperament and breed differences may complicate disease diagnosis, underscoring the greater value of preoperative screening in healthy veterinary patients.[3] Since patients with normal physical examination, including cardiopulmonary auscultation, were included in our study, the ECG may serve as a complementary tool for detecting abnormalities. This can improve patient safety and allow for tailoring of the anaesthetic protocol accordingly.[17] However, the value of routine preoperative ECG examination still needs to be evaluated in terms of appropriate clinical outcomes, such as perianaesthetic complications. Although intraoperative complications were not evaluated in this study, it should be noted that these complications are related not only to the patient's condition but also to the anaesthetic protocol used. Therefore, further research is warranted to elucidate the usefulness of routine non-targeted preoperative ECG in dogs.

Almost 32% of dogs in our study exhibited some type of ECG abnormality, which is similar to the 28% of dogs that showed arrhythmias in a previous study involving routine ECG.[18] Nonetheless, other investigators have reported higher percentages of ECG abnormalities.[17,19] This discrepancy could be explained by differences in the characteristics of the study population, including size, age or population size. Our study focused solely on 228 dogs without previously diagnosed cardiac disease, all of which underwent both physical examination and routine

TABLE 3 Description of the animals in which the anaesthetic protocol was modified (breed, age and scheduled procedure) and the alterations evaluated in the electrocardiogram (ECG) and echocardiography ($n = 11$).

Breed	Age (months)	Scheduled procedure	ECG abnormalities	Echocardiography abnormalities	Anaesthetic protocol modification
Pug	28	BOAS surgery	Heart rate (low)	NA	Premedication
French Bulldog	143	MRI	Irregular RR interval Sinus block Wandering pacemaker	NA	Anaesthetic induction
Crossbreed	38	Castration	Left premature ventricular complexes QRS duration (longer)	NA	Premedication
Rottweiler	100	Exploratory laparotomy	Heart rate (low), J point	NA	Premedication and anaesthetic induction
Yorkshire Terrier	8	Patellar luxation	Atrioventricular block second degree, Mobitz II	NA	Premedication and anaesthetic induction
American Staffordshire	4	Femoral fracture repair	Right cardiac axis deviation Right bundle branch block	NA	Premedication and anaesthetic induction
Yorkshire Terrier	58	MRI	Atrioventricular block second degree, Mobitz II	NA	Premedication and anaesthetic induction
Yorkshire Terrier	131	Dental procedure	Escape complexes	Not performed	Premedication
French Bulldog	116	Ovariohysterectomy and mastectomy	T wave voltage (higher) Atrioventricular escape complexes	Right atria dilation Right ventricle dilation with mild interventricular septum flattening Myxomatous mitral valve disease stage B1 pulmonary hypertension	Premedication and anaesthetic induction
Crossbreed	109	Lipoma removal	Variable PR interval Premature ventricular complexes	Systolic dysfunction	Premedication, anaesthetic induction and inotropic support
German Shepherd	103	Buccal mass removal	P wave duration (longer, mitral P wave) R wave voltage (higher) Left ventricular enlargement pattern	Myocardial asynchrony between interventricular septum and left ventricle wall	Anaesthetic induction

Abbreviations: BOAS, brachycephalic obstructive airway syndrome; MRI, magnetic resonance imaging; NA, not applicable.

ECG. Previous studies included patients whose existing diagnoses were not taken into account.[17,18,20] Consequently, there might be a higher incidence of abnormalities during preoperative screening in geriatric dogs, given the higher prevalence of certain heart diseases within such a population.[6,21] Another possible explanation is that sinus arrhythmia, previously reported as the most common ECG finding (ranging from 25% to 55%),[17,20] was not considered an alteration in the present study. Sinus arrhythmia occurs secondary to fluctuations in vagal tone during the respiratory cycle and is considered normal in dogs.[10] Other frequently recorded ECG abnormalities, such as T wave alterations (32% of patients),[17,19,22] ST segment alterations (26%) and duration or voltage QRS complex alterations (18%),[19,22] are in accordance with previous studies.

The limitations of ECG in diagnosing heart disease must be considered. In our study, the presence of certain ECG abnormalities, coupled with patient-related factors such as breed or age, prompted echocardiography evaluation, which represents the gold standard for the clinical assessment of cardiac structure and function.[23] For instance, the presence of AVB may lead to severe bradycardia and be associated with cardiomyopathy; abnormal supraventricular complexes suggest atrial pathology and dilation; and prolonged P wave (mitral P wave) may indicate left atrial enlargement.[24] Increased T wave amplitude with concurrent dome-shaped ST-elevation may indicate myocardial hypoxia resulting from pulmonary hypertension and strongly indicates echocardiography evaluation in West Highland White Terriers.[25] However, the presence of other findings did not prompt further cardiological evaluation; for example, canine T wave morphology is highly variable and provides limited diagnostic information. While several conditions, such as myocardial ischaemia, potassium

disturbances or pericarditis, can alter the ST segment, T wave alteration itself does not necessarily indicate the presence of these conditions.[10] Furthermore, QRS complex alterations can be observed in obese patients and in patients with hypothyroidism, hyperkalaemia or pneumothorax or even as a normal individual variation.[25] Therefore, the most common ECG abnormalities did not lead to echocardiography examination due to their limited clinical relevance. Additionally, it is worth noting that this study included dogs with a normal physical examination, as the presence of certain alterations, such as heart murmurs, may indicate cardiac functional impairment or a subclinical disease, depending on the grade or location.[26,27] The presence of a heart murmur itself could have increased the incidence of abnormalities on ECG and subsequent modifications in the anaesthetic protocol and constitutes an indication for echocardiographic evaluation.[28]

The use of sedatives and anaesthetic drugs with reduced impact on the cardiovascular system, along with a multimodal analgesic approach and cardiovascular support when necessary, is recommended for patients with suspected cardiovascular diseases,[29] often leading to modifications in anaesthesia protocols. In this study, these modifications included the withdrawal or dose reduction of alpha-2 adrenergic agonists for premedication, the use of alfaxalone for anaesthetic induction instead of propofol, or the use of inotropic support. Alpha-2 adrenergic agonists have potent cardiovascular effects,[30] with an initial increase in systemic vascular resistance accompanied by bradycardia and bradyarrhythmias (first- and second-degree AVB) and consequently decreased cardiac output.[30] Compared with propofol, alfaxalone provides slightly better cardiovascular stability and myocardial contractility preservation at clinical doses, potentially maintaining the baroreceptor reflex.[31–33] However, this could be undesirable in patients with ventricular hypertrophy due to decreased diastolic time and ventricular filling. Dobutamine, which has a dose-dependent positive inotropic effect, was administered by infusion to one dog with echocardiographic evidence of systolic dysfunction.[34]

The results of this study are subject to several limitations, with its retrospective nature being the most important. The relatively small number of dogs included may not represent the entire canine population, and the results cannot be generalised to dogs in other veterinary centres. Consequently, the small size of the study population did not provide sufficient data to establish correlations between demographic data and ECG results or anaesthetic protocol modification. This study was not designed to assess the effect of preoperative ECG on clinical outcomes, and further prospective evaluation of clinical impact may be necessary to determine the effect of routine preoperative ECG in veterinary anaesthesia. Additionally, it is important to consider that anaesthesia-related decision making may vary depending on the protocols employed in each centre. Finally, the involvement of different veterinary anaesthetists during physical examination and anaesthetic protocol decision making could introduce some bias.[3]

In conclusion, ECG screening led to preoperative echocardiographic evaluation in 2% of dogs and anaesthetic protocol modification in 5% of healthy dogs undergoing elective procedures. This test may be a complementary tool before general anaesthesia, although the clinical relevance of observed alterations should be evaluated on an individual basis. Nevertheless, the value of routine preoperative non-targeted ECG examination still requires evaluation in terms of clinical outcomes.

AUTHOR CONTRIBUTIONS

Data management, statistical analysis, interpretation of data and preparation of the drafted and final versions of the manuscript: Rocío Bustamante. *Acquisition of data, follow-up of patients and critical revision of the manuscript*: Eva González-Pérez. *Acquisition and interpretation of data and preparation of the drafted and final versions of the manuscript*: Alicia Caro-Vadillo. *Conception and design of the study, data management, statistical analysis, supervision of the drafted article and preparation of the final version of the manuscript*: Delia Aguado.

ACKNOWLEDGEMENTS

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors. Preliminary results were presented as an oral communication at the 17th National Spanish Congress of Veterinary Anaesthesia, Granada, 1–3 June 2023.

CONFLICT OF INTEREST STATEMENT

The authors declare they have no conflicts of interest.

FUNDING INFORMATION

This research was conducted with no external funding.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

This study did not require ethical approval as it is a retrospective analysis using data collected as part of routine clinical procedure.

REFERENCES

1. Apfelbaum JL, Connis RT, Nickinovich DG, Pasternak LR, Arens JF, Caplan RA, et al. Practice advisory for preanesthesia evaluation: an updated report by the American Society of Anesthesiologists Task Force on Preanesthesia Evaluation. Anesthesiology. 2012;116(3):522–38.
2. Posner LP. Pre-anaesthetic assessment and preparation. In: Duke-Novakovski T, Vries MD, Seymour C, editors. BSAVA manual of canine and feline anaesthesia. 3rd ed. Gloucester, United Kingdom: BSAVA Library; 2016. p. 6–12.
3. Mitchell K, Barletta M, Quandt J, Shepard M, Kleine S, Hofmeister E. Effect of routine pre-anesthetic lab-

oratory screening on pre-operative anesthesia-related decision-making in healthy dogs. Can Vet J. 2018;59(7):773–78.
4. de Sousa Soares D, Brandão RRM, Mourão MRN, de Azevedo VLF, Figueiredo AV, Trindade ES. Relevance of routine testing in low-risk patients undergoing minor and medium surgical procedures. Rev Bras Anestesiol. 2013;63:197–201.
5. Epstein M, Kuehn NF, Landsberg G, Lascelles BD, Marks SL, Schaedler JM, et al. AAHA senior care guidelines for dogs and cats. J Am Anim Hosp Assoc. 2005;41(2):81–91.
6. Joubert KE. Pre-anaesthetic screening of geriatric dogs. J S Afr Vet Assoc. 2007;78(1):31–35.
7. Alef M, von Praun F, Oechtering G. Is routine pre-anaesthetic haematological and biochemical screening justified in dogs? Vet Anaesth Analg. 2008;35(2):132–40.
8. Díaz MDM, Kaartinen J, Allison A. Preanaesthetic blood tests in cats and dogs older than 8 years: anaesthetists' prediction and perianaesthetic changes. Vet Anaesth Analg. 2021;48(6):854–60.
9. Tilley LP. Essentials of canine and feline electrocardiography: interpretation and treatment. 3rd ed. Philadelphia: Lea & Febiger; 1992.
10. Tilley LP, Smith FWK. Electrocardiography. In: Tilley LP, editor. Manual of canine and feline cardiology. Elsevier Health Sciences: St. Louis, Missouri, United States; 2008. p. 49–77.
11. Wingfield WE, Boon JA. Echocardiography for the diagnosis of congenital heart defects in the dog. Vet Clin North Am Small Anim Pract. 1987;17(3):735–53.
12. Chetboul V, Tissier R. Echocardiographic assessment of canine degenerative mitral valve disease. J Vet Cardiol. 2012;14(1):127–48.
13. Kumar A, Srivastava U. Role of routine laboratory investigations in preoperative evaluation. J Anaesthesiol Clin Pharmacol. 2011;27(2):174–79.
14. Feely MA, Collins CS, Daniels PR, Kebede EB, Jatoi A, Mauck KF. Preoperative testing before noncardiac surgery: guidelines and recommendations. Am Fam Physician. 2013;87(6):414–18.
15. Santilli R, Moise NS, Pariaut R, Perego M. Electrocardiography of the dog and cat: Diagnosis of arrhythmias. 2nd ed. Milan: Edra Publishing; 2018.
16. Thomas WP, Gaber CE, Jacobs GJ, Kaplan PM, Lombard CW, Moise NS, et al. Recommendations for standards in transthoracic two-dimensional echocardiography in the dog and cat. J Vet Intern Med. 1993;7(4):247–52.
17. Botelho AFM, Oliveira MS, Soto-Blanco B, Melo MM. Retrospective study of pre-anesthetic electrocardiogram examination of 700 dogs conducted at the Veterinary Hospital of UFMG (2013–2014). Pesq Vet Bras. 2016;36(2):90–93.
18. Aptekmann KP, do Carmo Fernandez Vailati M, de Oliveira Moura Fortuna T, Schwartz DS. Prevalência das arritmas cardíacas e distúrbios de condução em cães e gatos em Botucatu, Brasil (2003–2007). Braz J Vet Res Anim Sci. 2010;47(5):371–79.
19. Carvalho C, Tudury E, Neves I, Fernandes T, Gonçalves L, Salvador R. Eletrocardiografia pré-operatória em 474 cães. Arq Bras Med Vet Zootec. 2009;61(3):590–97.
20. Silveira SD, Gheller BG, Meirelles ACF. Preoperative electrocardiographic study of dogs at the veterinary hospital of Pontifícia Universidade Católica do Paraná. Ciênc Anim Bras. 2018;19.
21. Hamlin RL. Geriatric heart diseases in dogs. Vet Clin North Am Small Anim Pract. 2005;35(3):597–615.
22. Figueiredo VC, Pereira CS, Muzzi RA, Borges JC, Muzzi LA, Oberlender G, et al. Importância da eletrocardiografia como um exame pré-cirúrgico em cães. Pesq Vet Bras. 2016;36(11):1091–94.
23. Perkowski SZ, Oyama MA. Pathophysiology and anesthetic management of patients with cardiovascular disease. In: Grimm KA, Lamont LA, Tranquilli WJ, Greene SA, Robertson SA, editors. Lumb & Jones veterinary anesthesia and analgesia. 5th ed. Ames, Iowa, United States: John Wiley and Sons; 2015. p. 496–510.
24. Soto-Bustos A, Caro-Vadillo A, Martinez-De-Merlo E, Alonso-Alegre EG. Diagnostic accuracy of electrocardiographic P wave related parameters in the assessment of left atrial size in dogs with degenerative mitral valve disease. J Vet Med Sci. 2017;79(10):1682–89.
25. Martin M. Abnormal electricity of the heart. Small animal ECGs: an introductory guide. 3rd ed. Chichester: John Wiley and Sons; 2015. p. 15–63.
26. Cote E, Edwards NJ, Ettinger SJ, Fuentes VL, MacDonald KA, Scansen BA, et al. Management of incidentally detected heart murmurs in dogs and cats. J Vet Cardiol. 2015;17(4):245–61.
27. Ljungvall I, Rishniw M, Porciello F, Ferasin L, Ohad DG. Murmur intensity in small-breed dogs with myxomatous mitral valve disease reflects disease severity. J Small Anim Pract. 2014;55(11):545–50.
28. Keene BW, Atkins CE, Bonagura JD, Fox PR, Haggstrom J, Fuentes VL, et al. ACVIM consensus guidelines for the diagnosis and treatment of myxomatous mitral valve disease in dogs. J Vet Intern Med. 2019;33(3):1127–40.
29. Robinson R, Borgeat K. Cardiovascular disease. In: Duke-Novakovski T, Vries M, Seymour C, editors. BSAVA manual of canine and feline anaesthesia and analgesia. 3rd ed. Quedgeley: British Small Animal Veterinary Association; 2016. p. 283–313.
30. Bloor BC, Frankland M, Alper G, Raybould D, Weitz J, Shurtliff M. Hemodynamic and sedative effects of dexmedetomidine in dog. J Pharmacol Exp Ther. 1992;263(2):690–97.
31. Muir W, Lerche P, Wiese A, Nelson L, Pasloske K, Whittem T. Cardiorespiratory and anesthetic effects of clinical and supraclinical doses of alfaxalone in dogs. Vet Anaesth Analg. 2008;35(6):451–62.
32. Okushima S, Vettorato E, Corletto F. Chronotropic effect of propofol or alfaxalone following fentanyl administration in healthy dogs. Vet Anaesth Analg. 2015;42(1):88–92.
33. Amengual M, Flaherty D, Auckburally A, Bell A, Scott E, Pawson P. An evaluation of anaesthetic induction in healthy dogs using rapid intravenous injection of propofol or alfaxalone. Vet Anaesth Analg. 2013;40(2):115–23.
34. Goya S, Wada T, Shimada K, Hirao D, Tanaka R. Dose-dependent effects of isoflurane and dobutamine on cardiovascular function in dogs with experimental mitral regurgitation. Vet Anaesth Analg. 2018;45(4):432–42.

How to cite this article: Bustamante R, González-Pérez E, Caro-Vadillo A, Aguado D. Impact of preanaesthetic electrocardiogram on decision making and modification of anaesthetic protocols in dogs. Vet Rec. 2024;e4266. https://doi.org/10.1002/vetr.4266