Hidden Heartbreak: Diagnosing Early Cardiac Disease

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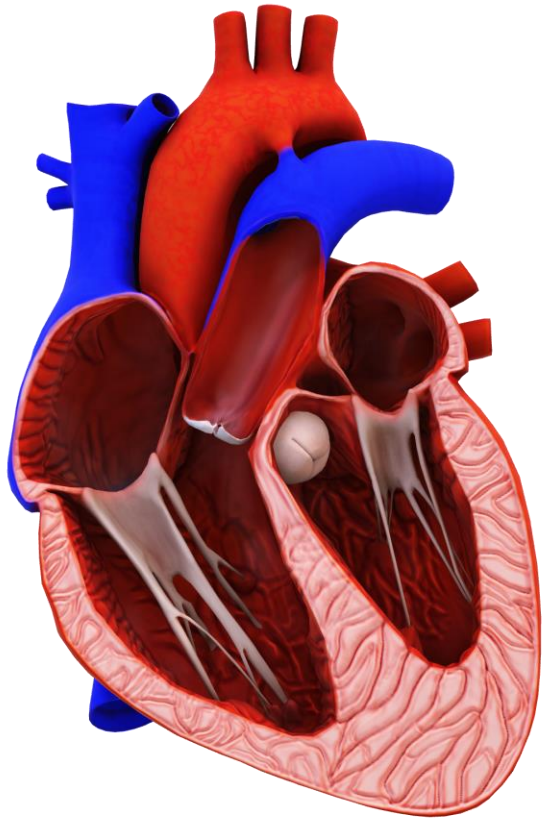
January 26, 2025

Agenda

- Overview of most common screening tests
- Overview of most common diseases in dogs and cats and how to screen for these diseases
- Case examples
- Some fun trivia along the way



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Is a not-for-profit group of board-certified veterinary cardiologists from both academia and private practice that offers independent recommendations to veterinary practitioners for the evaluation and treatment of canine and feline heart disease.

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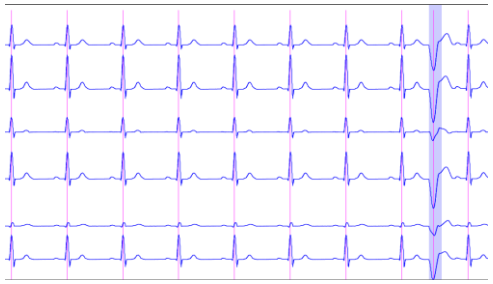
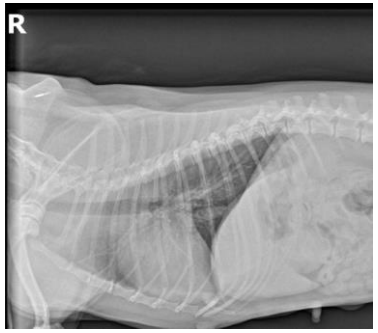
Deep thoughts with Terri D…..

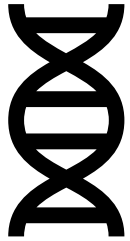
Terri D likeness generated by ChatGPT

Screening tests

- Widely available
- Inexpensive
- Non-invasive
- Reliable







What happens when you screen all healthy patients?

	Sensitivity	Specificity
Definition	Proportion of patients with a disease who test **positive**	Proportion of patients without a disease who test **negative**
100% Means	The test correctly identifies every patient who **has** the disease	The test correctly identifies every patient who **does not have** the disease
Test result (if you are the patient)	Negative test result	Positive test result
Test interpretation	Patient is definitely not positive → they **don't** have the disease	They are definitely not negative → they **do** have the disease
Rule	Rule out (SnOut)	Rule In (SpIn)

Status of patient according to reference standard

Result from screening test	Affected	Not affected
Positive	True positive	False positive
Negative	False negative	True negative

← Positive Predictive Value

← Negative Predictive Value

↑ Sensitivity

↑ Specificity

Sensitivity = (True positive/True positive + False negative) x 1

Specificity = (True negative/False positive + True negative) x 1

Positive PV = (True positive/True positive + False positive) x 1

Negative PV = (True negative/True negative + False negative

Table 1. Diagnostic performance of P wave width for identification of left atrial enlargement in a random population of dogs with a 10% disease prevalence at a cutoff of 40 msec. Specificity and sensitivity based on Savarino et al.[1] Prevalence of heart disease based on Keene et al. 2019.[9]

		Affected	Not affected	
Positive	(10*0.68)	6.8	32.4	Sensitivity: 68.0
Negative		3.2	57.6	Specificity: 64.0
10% prevalence of disease				PPV: **17.3**
Total patients: 100.0		10.0	90.0	NPV: **94.7**
				(90*0.64)

*Sensitivity of P wave duration for left atrial enargement = 68%

PPV= 6.8 / (6.8+32.4)

PPV= 17.3

Sensitivity=TP / TP+FN

PPV= TP / TP+FP

Specificity= TN/ FP+TN

NPV= TN / TN + FN

Table 2. Diagnostic performance of P wave width for identification of left atrial enlargement in a random population of dogs with a 25% disease prevalence at a cutoff of 40 msec. Specificity and sensitivity based on Savarino et al.[1] Prevalence of heart disease represents an arbitrary value to show the effect of higher disease prevalence on positive and negative predictive values.

		Affected	Not affected	
Positive	(25*0.68)	17.0	27.0	Sensitivity: 68.0
Negative		8.0	48.0	Specificity: 64.0
Increase to 25% prevalence				PPV: **38.6**
Total patients: 100.0		25.0	75.0	NPV: **85.7**

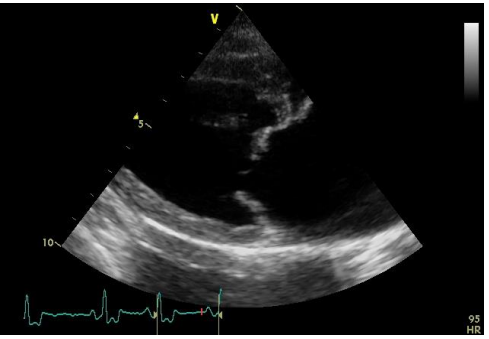
PPV = 17 / (17+27)

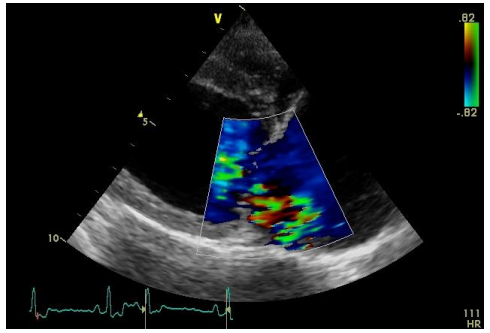
PPV = 38.6

Screening tests for cardiac disease

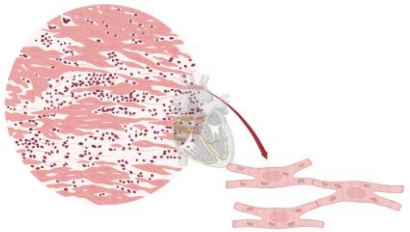
- **History**: Family history? Breed? Coughing? Tachypnea? History of syncope? Medication list?
- **Physical exam:** Murmur or arrhythmia?
- **Biomarkers:** NT-proBNP, Troponin-I
- **Thoracic Radiographs**
- **Genetic Testing**
- **ECG**

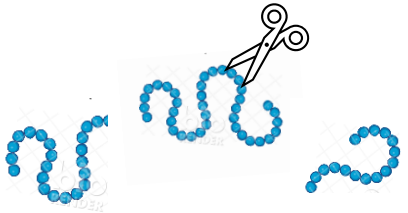
BNP Refresher





Increased Wall Stres





Cells increase production of BNP

NT-proBNP

- Longer half life
- Detected by NT-pro BNP assay
- Cleared by the kidneys

Pro-BNP (“Nature’s Lasix”)

- Vasodilation
- Naturesis
- Diuresis
- Short half life

Blood pressure & blood volume regulation

Images generated from biorender.com

IDEXX

Natriuretic Peptides

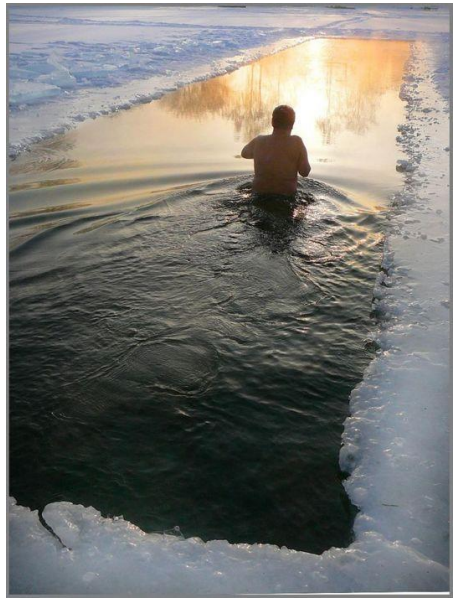
- ANP, BNP, CNP, DNP, and VNP
- ANP, BNP and VNP expressed in cardiomyocytes
- CNP does not have natriuretic or diuretic properties. *All NP appear to originate from CNP (sharks)*
- DNP found in the venom of the Green Mamba Snake
- Actions of all NPs mediated by specific natriuretic peptide receptors (NPR)

Dendroaspsi natriuretic peptide (DNP)

+ Structurally similar to VNP
+ Vasorelaxing effect may potentiate venom of Green Mamba

Experience BNP for Yourself

Vasodilation → blood in periphery
→ decrease wall stress

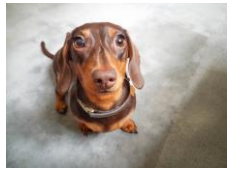


Acute vasoconstriction→ blood rushes back to heart → increase wall stress and release of ANP and BNP

J Vet Intern Med 2014;28:451–457

Breed Differences in Natriuretic Peptides in Healthy Dogs

K. Sjöstrand, G. Wess, I. Ljungvall, J. Häggström, A-C. Merveille, M. Wiberg, V. Gouni, J. Lundgren Willesen, S. Hanås, A-S. Lequarré, L. Mejer Sørensen, J. Wolf, L. Tiret, M. Kierczak, S. Forsberg, K. McEntee, G. Battaille, E. Seppälä, K. Lindblad-Toh, M. Georges, Hannes Lohi, V. Chetboul, M. Fredholm, and K. Höglund



≠

- 535 dogs of 9 breeds
  - Healthy by PE, ECG and Echo
- Significant differences within breed and between breeds
- **Labs and Newfoundland highest (3X higher than Dachshunds)**
- Dachshunds lowest
- Limitation - young adult to middle-aged dogs

BNP Dachshund ≠ **BNP Labrador**

Sjöstrand K, Wess G, Ljungvall I, Häggström J, Merveille AC, Wiberg M, Gouni V, Lundgren Willesen J, Hanås S, Lequarré AS, Mejer Sørensen L, Wolf J, Tiret L, Kierczak M, Forsberg S, McEntee K, Battaille G, Seppälä E, Lindblad-Toh K, Georges M, Lohi H, Chetboul V, Fredholm M, Höglund K. Breed differences in natriuretic peptides in healthy dogs. J Vet Intern Med. 2014 Mar-Apr;28(2):451-7.

Journal of Veterinary Cardiology (2017) 19, 124–131

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ESVC

www.elsevier.com/locate/jvc

Biologic variability of N-terminal pro-brain natriuretic peptide in healthy dogs and dogs with myxomatous mitral valve disease

Randolph L. Winter, DVM [a,*], Ashley B. Saunders, DVM [a], Sonya G. Gordon, DVM, DVSc [a], Jesse S. Buch, PhD [b], Matthew W. Miller, DVM, MS [a]

- 28 dogs with MMVD and 10 healthy controls.
- NTproBNP was measured hourly, daily, and weekly x 6 wk (272 observations)

	BNP (pmol/L)	CCV – 95%
Healthy (n=10)	543 (16 – 1,558)	70.8% (62.3 - 82.1%)
MMVD B1 (n=10)	677 (24 - 1,344)	73.4% (64.6 - 85.2%)
MMVD B2 (n=10)	1,553 (531 – 3,010)	51.4% (45.2 - 59.6%)
MMVD C – stable (N=8)	1,963 (424 – 4,086)	53.3% (46.9 - 61.9%)
All MMVD (n=28)		58.2% (51.2 -

CCV - Critical Change Value: change that can be attributed to progression of disease vs. biological variability

BNP in Dogs

Who should I run an NT-proBNP test on	NT-proBNP result (pmol/L)	Interpretation of test result
Dog with respiratory signs in which the cause of the signs is not obvious despite other appropriate diagnostic tests	< 900	Does NOT support at diagnosis of CHF
	900-2,500	CHF is possible; review the balance of evidence from the other tests
	> 2,500	Supports a diagnosis of CHF
Single evaluation of Stage B2 MMVD	>1500	Increased risk of developing CHF in next 6-12 months
Serial evaluation of Stage B2 MMVD	Increase of >750 or 60%	Increased risk of CHF in the next 6 months, particularly if the absolute value is > 1500
Asymptomatic Doberman who is >5 years of age and declined an echocardiogram (especially if there is physical exam evidence suggestive of occult DCM)	> 450*	Identifies this Doberman to be at increased risk for occult DCM and more specific testing such as an echocardiogram should be strongly recommended or referral to a cardiologist

* This range is currently being finalized

References

1. Reynolds CA1 to Reynolds CA, Rush JE et.al. Prediction of first onset of congestive heart failure in dogs with degenerative mitral valve disease: the PREDICT cohort study. J Vet Cardiol. 2012 Mar;14(1):193-202. doi: 10.1016/j.jvc.2012.01.008. Epub 2012 Feb 25.
2. Fox PR, Oyama MA, Hezzell MJ, Rush JE, et.al. Relationship of Plasma N-terminal Pro-brain Natriuretic Peptide Concentrations to Heart Failure Classification and Cause of Respiratory Distress in Dogs Using a 2nd Generation ELISA Assay. J Vet Intern Med. 2014 Oct 10. doi: 10.1111/jvim.12472. [Epub ahead of print]

Suggested Reading

- Oyama MA, Boswood A, Connolly DJ, et. Al. Clinical usefulness of an assay for measurement of circulating N-terminal pro-B-type natriuretic peptide concentration in dogs and cats with heart disease. JAVMA. 2013;243(1):71–82.

https://cardiaceducationgroup.org/wp-content/uploads/2015/10/CEG_Circulations_Canine-Biomarkers_FINAL.pdf

Received: 25 August 2020 | Accepted: 30 April 2021
DOI: 10.1111/jvim.16156

STANDARD ARTICLE

Journal of Veterinary Internal Medicine Open Access ACVIM American College of Veterinary Internal Medicine

Point-of-care N-terminal pro B-type natriuretic peptide assay to screen apparently healthy cats for cardiac disease in general practice

Ta-Li Lu[1] | Etienne Côté[2] | Yu-Wen Kuo[1] | Hao-Han Wu[1] | Wen-Yen Wang[1] | Yong-Wei Hung[1]

- 217 cats without overtly apparen physical signs of heart disease,
- 49 (23%) had abnormal echos
- Sensitivity 43%, Sp 96%.
- With murmur, Sensitivity 71%, Sp 96%

BNP performs better in cats with a murmur, even though a murmur does not mean much in a cat. But you can't ignore a murmur either, so a BNP seems like a reasonable next step in those cases.

I would expect it to pick up all cats with moderate to severe disease… maybe geographic differences?

I also think there is something to elevated BNPs in cats with normal echos, like it is precursor to disease. I think that is good resident project.

IDEXX

BNP in Cats

Who should I run an NT-proBNP test on	Cardiopet® proBNP (pmol/L)	SNAP® Feline proBNP	Interpretation of test result
Cat with respiratory signs in which the cause of the signs in not obvious despite other appropriate diagnostic tests	< 100	normal	Does NOT support at diagnosis of CHF
	100-270	abnormal	CHF is possible; review the balance of evidence from the other tests
	> 270		Supports a diagnosis of CHF
Asymptomatic cat with cardiac risk factors (e.g. murmur, arrhythmia, gallop heart sound)	<100	normal	Significant heart disease can be ruled out with a high degree of accuracy
	Increase of >100	abnormal	Increased risk of having significant heart disease; recommend an echocardiogram

Suggested Reading

- Oyama MA, Boswood A, Connolly DJ, et. Al. Clinical usefulness of an assay for measurement of circulating N-terminal pro-B-type natriuretic peptide concentration in dogs and cats with heart disease. JAVMA. 2013;243(1):71–82.

https://cardiaceducationgroup.org/wp-content/uploads/2015/10/NT-ProBNP-in-Cats_SG_5-5-15.pdf

Radiographs

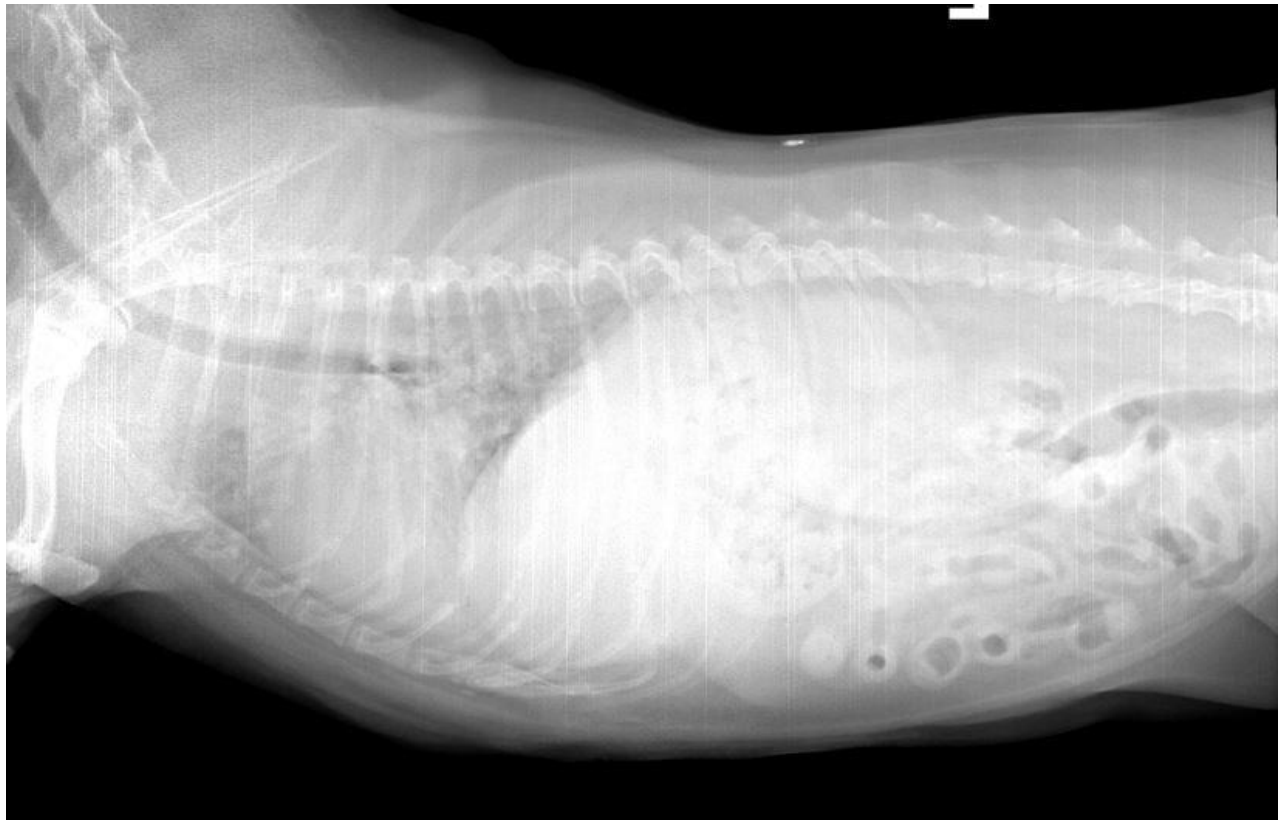
Helpful Reminders

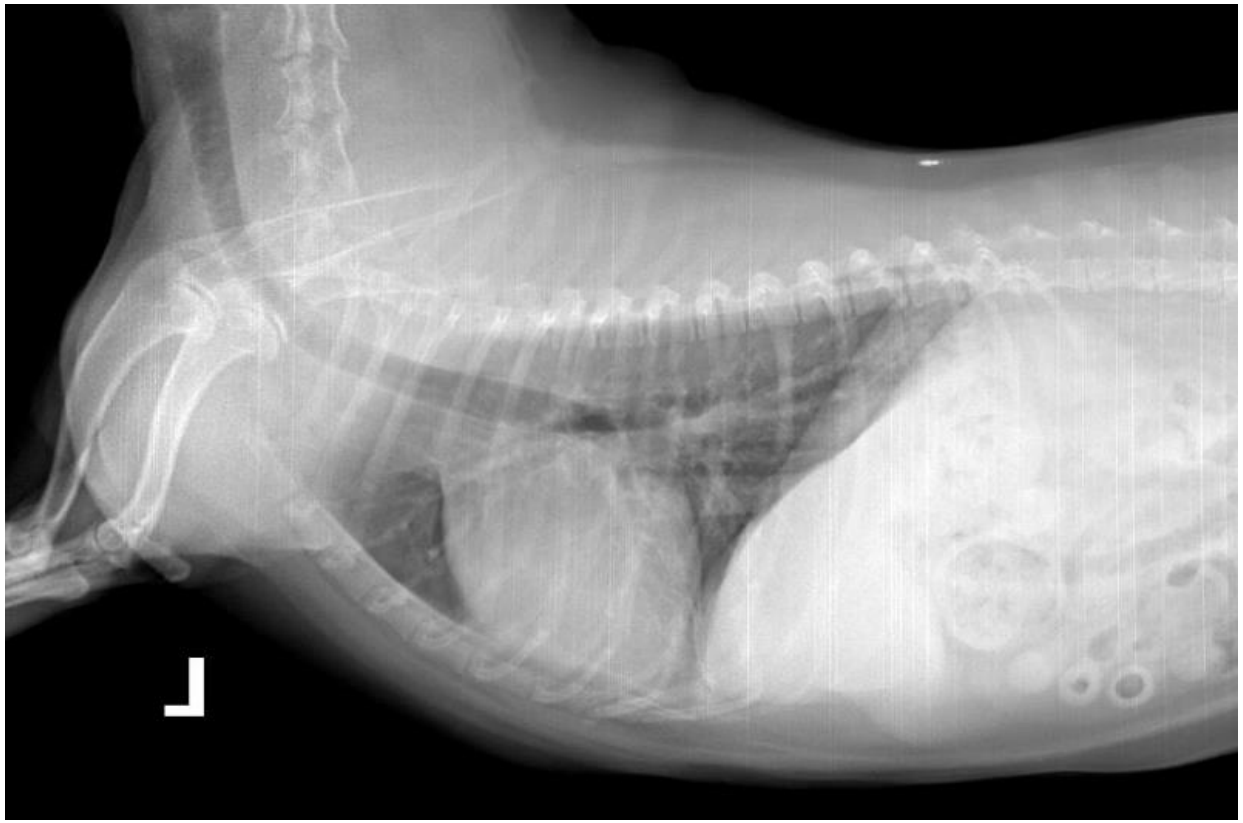
- Three view thorax is standard (RL / LL / DV or VD)
- Technique and positioning matter!
- Cardiac silhouette is combination of blood and walls, so cannot determine if concentric hypertrophy present on radiographs alone
- Congestive heart failure is a radiographic diagnosis
    - An echo cannot easily determine if pulmonary edema is present

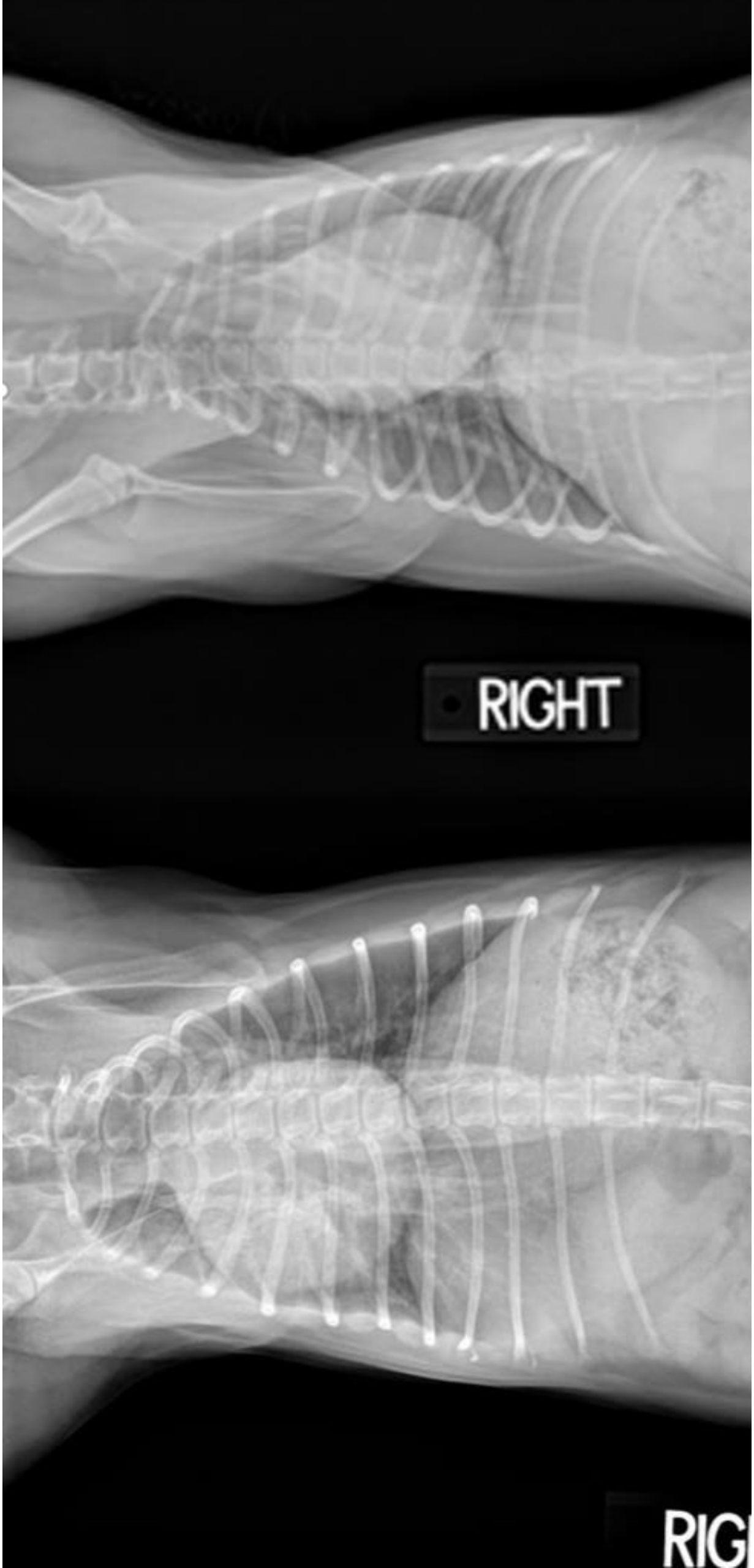
In patients with known heart disease undergoing anesthesia, my recommendations are a chest radiograph and bloodwork (at least a PCV / TS). Everyone always wants an echo, but radiographs are more important as you need to see their lungs / trachea and heart size before they inevitably start coughing after their dental.

A Note on Positioning and Technique

Same Dogs, Same day






RIGHT
RIG

ECG / Holter Monitor

Helpful Tips / Reminders

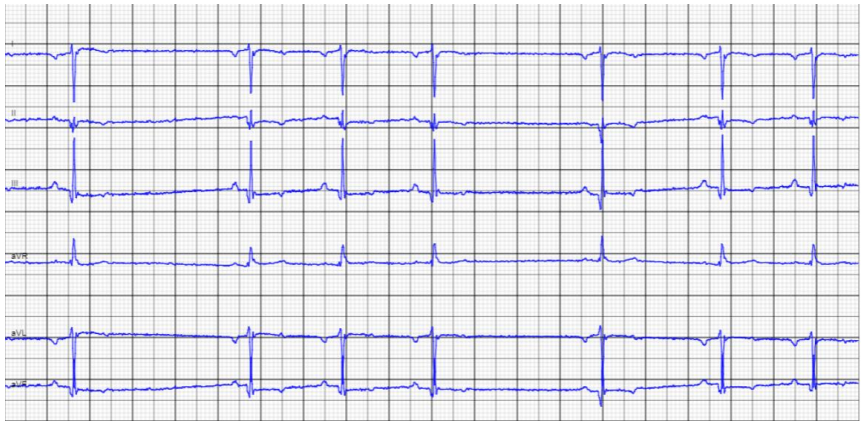
- ECGs are diagnostic for heart rate and rhythm and only supportive of / suggestive of cardiac chamber enlargement
- ECG axis only valid if the patient is in right lateral recumbency AND if the clips are applied to the correct limbs.

Image generated with chatGPT

Helpful Tips / Reminders – Lead Placement

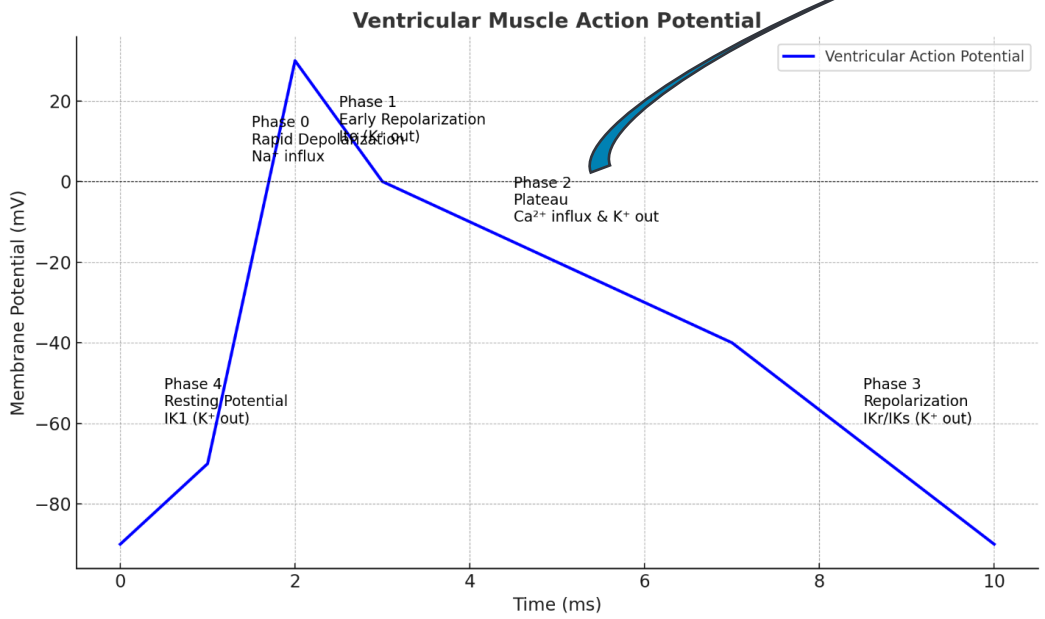
<u>Front limbs</u>
Read the newspaper with front limbs (white and black FL)
White rhymes with right
Snow on ground (white on RF)

<u>Rear limbs</u>
Christmas at end of year (green and red RL)
Grass grows on ground (green on RR)

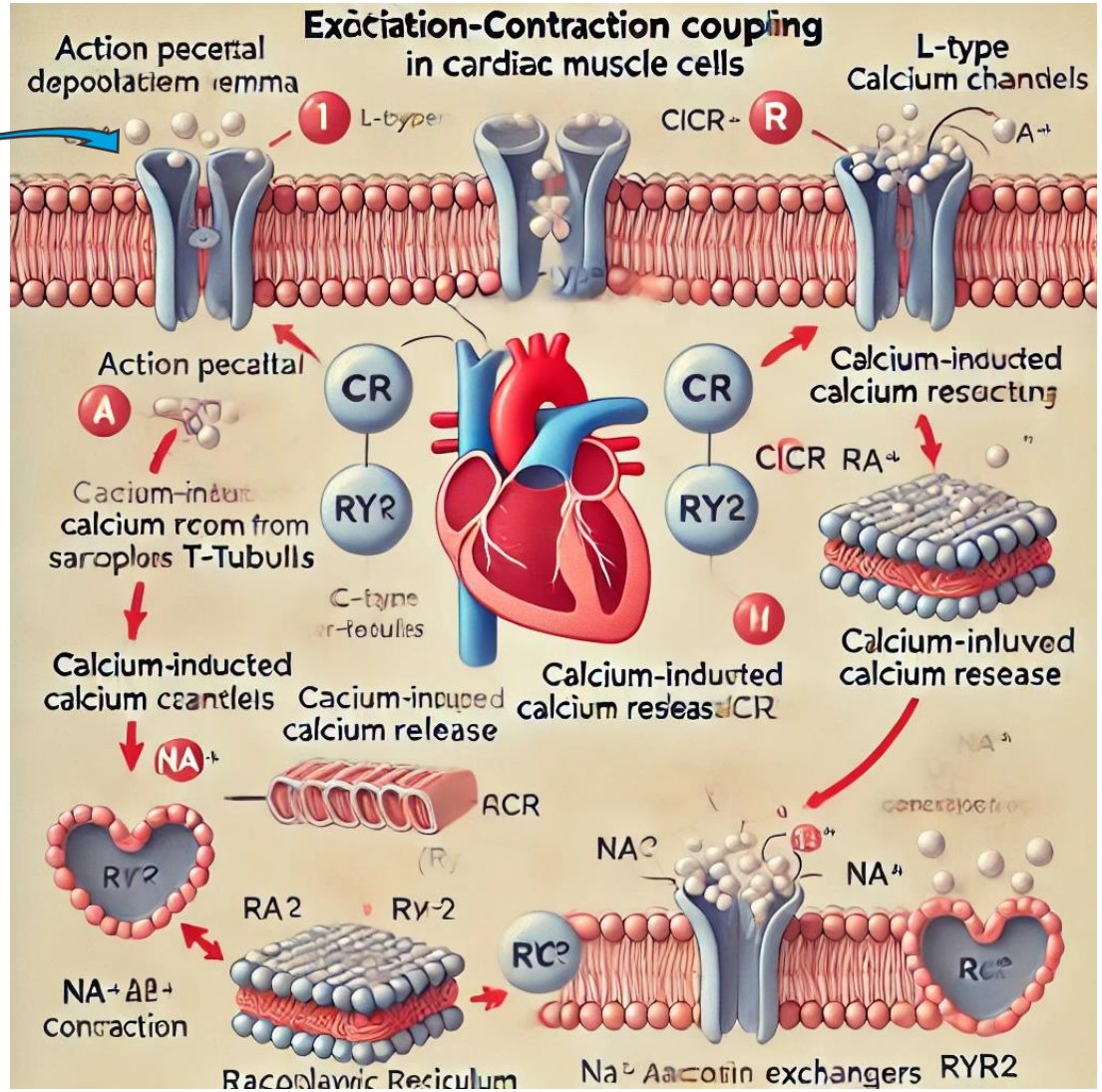


LA / RA reversal:
- Right axis deviation
- P waves negative in lead I, positive in inferior leads
- Lead II and III switched
- aVL and aVR switched

Shout-Out to Physiology



For dogs and cats, this happens **40-250 times per minute!!!**



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Introduction

Electrocardiograms serve as a primary diagnostic tool for the identification of arrhythmias and as a screening tool for structural heart disease.

Arrhythmias may increase morbidity and mortality in both dog and cat patients. This study aimed to describe the occurrence of arrhythmias in dog and cat patients from general practice settings.

To the authors' knowledge, this is the first study of its kind to include this type of sample size and to draw patients from outside of a specialty hospital or university.

Methods

A cross sectional, retrospective, cohort design was used in the study. ECGs were obtained from the IDEXX Database System between May 2020 and September of 2020.

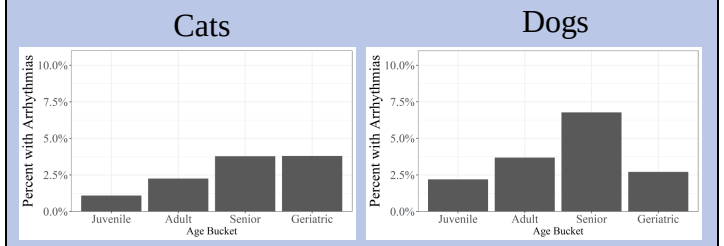
A total of 53,708 electrocardiograms were included from 108 different dog breeds and 9,440 electrocardiograms were included from 16 different cat breeds. Exclusion criteria included treatment with anti-arrhythmic drugs, recent atropine administration, recent sedation (including alpha-2 agonists), missing weight, sex or age.

Odds of having an arrhythmia were calculated. Two Firth's logistic regression models (one for each species) was performed with arrhythmia (present or absent) as the dependent variable and breed, age, weight (for dogs), and sex as independent variables. Due to the high number of comparisons, the false discovery rate (FDR) method was used to adjust p-values for multiplicity.

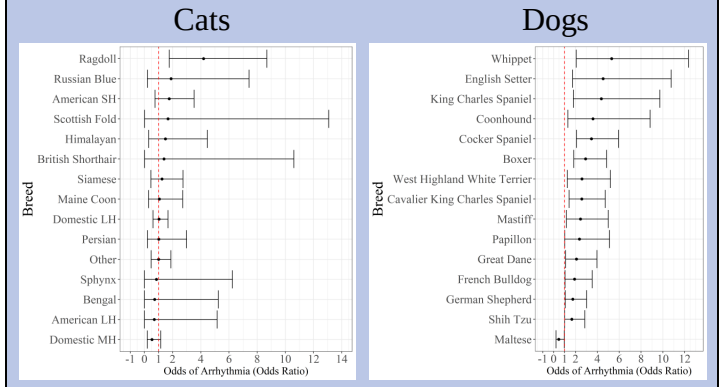
Conflict of Interest Statement

Three of the authors (DS, JG-S, AS) have an affiliation to the commercial funders of this research, as employees of IDEXX Laboratories. The work presented in this study was funded by IDEXX Laboratories, Inc. Westbrook, ME, USA.

Arrhythmia Distribution by Life Stage



Odds of Arrythmia by Breed



Whiskers represent the 95% confidence interval of the Odds ratios from the Firth Regression models

Relationship between neutered status and Arrhythmia

In both dogs and cats, neutered animals had a higher proportion of arrythmias than animals that were not neutered. Spayed female cats had a higher proportion of arrythmias than intact female cats (2.89% vs. 1.30%, P <0.004). Neutered male cats had a higher proportion of arrythmias than intact male cats (3.80% vs. 1.68%, P <0.001). Spayed female dogs had a higher proportion of arrythmias than intact female dogs (3.51% vs. 2.77%, P <0.001). Neutered male dogs had a higher proportion of arrythmias than intact male dogs (3.96% vs. 2.46%, P <0.001).

Top 5 Arrythmias in Dogs

Arrhythmia Types	%	n
Overall	3.27	1758
Ventricular premature beats	1.38	740
Supraventricular premature beats	0.71	380
First degree AV block	0.63	337
Second degree AV block	0.44	238
Sinus arrest	0.10	54

Top 5 Arrhythmias in Cats

Arrhythmia Types	%	n
Overall	2.64	249
Ventricular premature beats	1.63	154
Sinus bradycardia	0.36	34
Supraventricular premature beats	0.35	33
Complete AV block	0.16	15
Second degree AV block	0.10	9

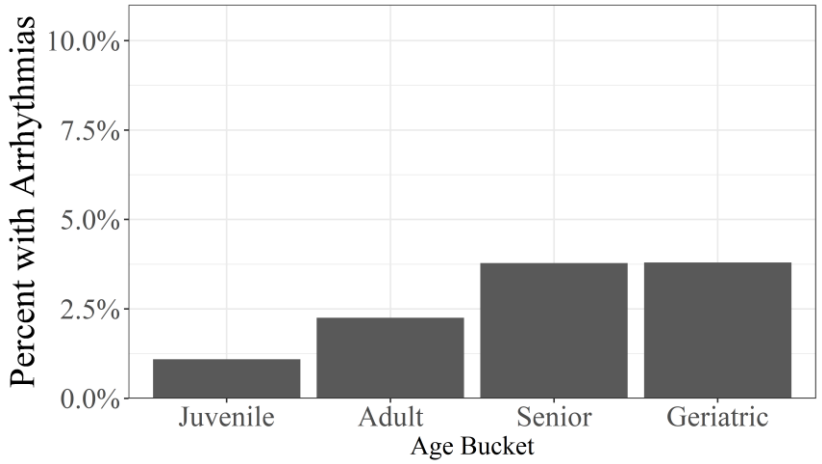
Discussion

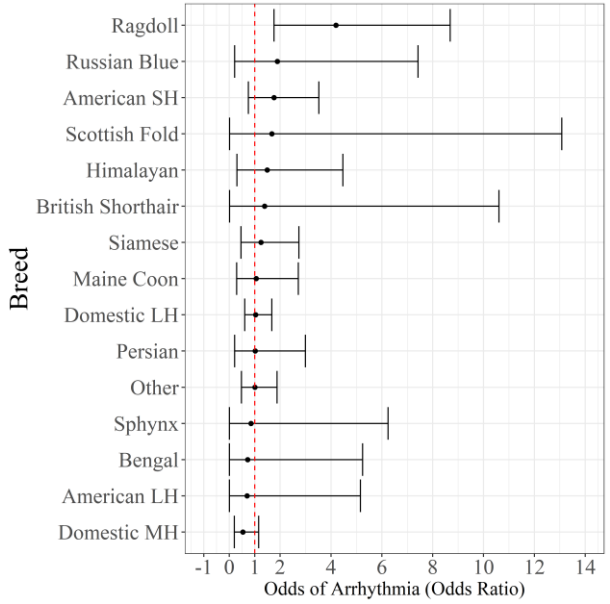
Our study identifies the most common arrhythmias identified in a general practice population and show the usefulness of screening for arrhythmias, particularly in at-risk ages and breeds. In cats, arrythmias are more prevalent in the senior and geriatric life stage. In contrast, arrythmias were observed to be more prevalent in senior dogs than geriatric dogs. We believe this effect might be due to "survivability bias" where senior and adult dogs with arrhythmias and associated comorbidities are dying prior to reaching the geriatric life stage.

Summary and Conclusions

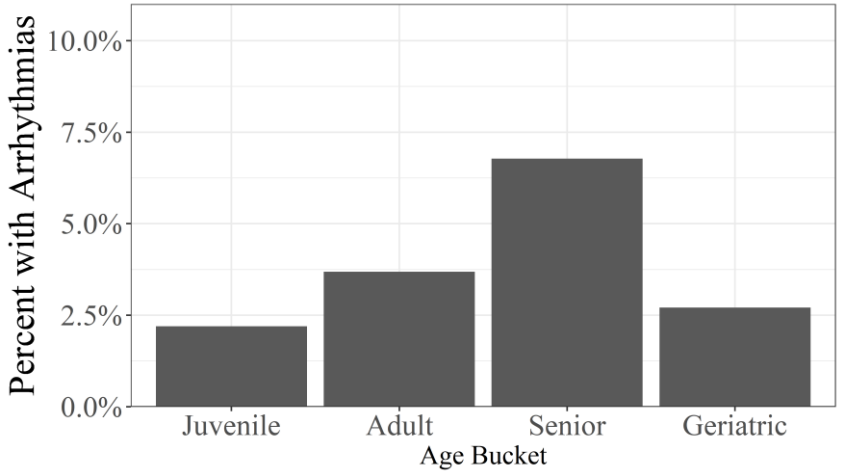
These findings demonstrated the value of including electrocardiograms in screening protocols for dog and cat patients, especially those in at-risk age brackets and breeds, to create suitable anesthetic protocols and guide further diagnostics and treatment.

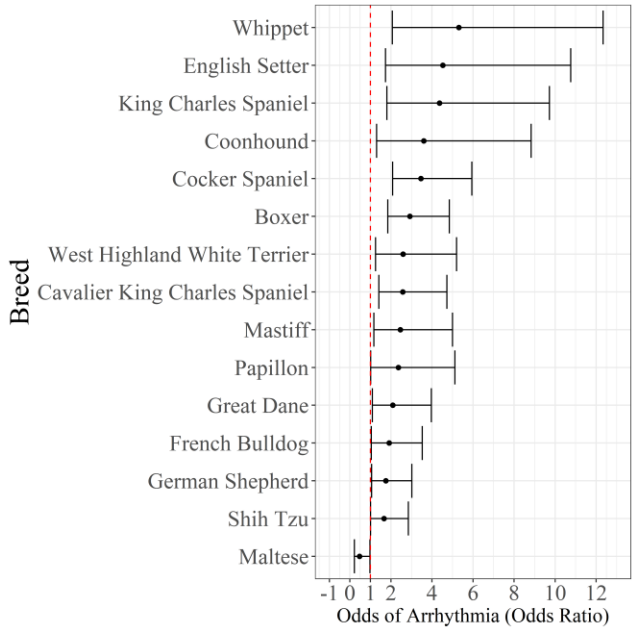
Cats





Dogs





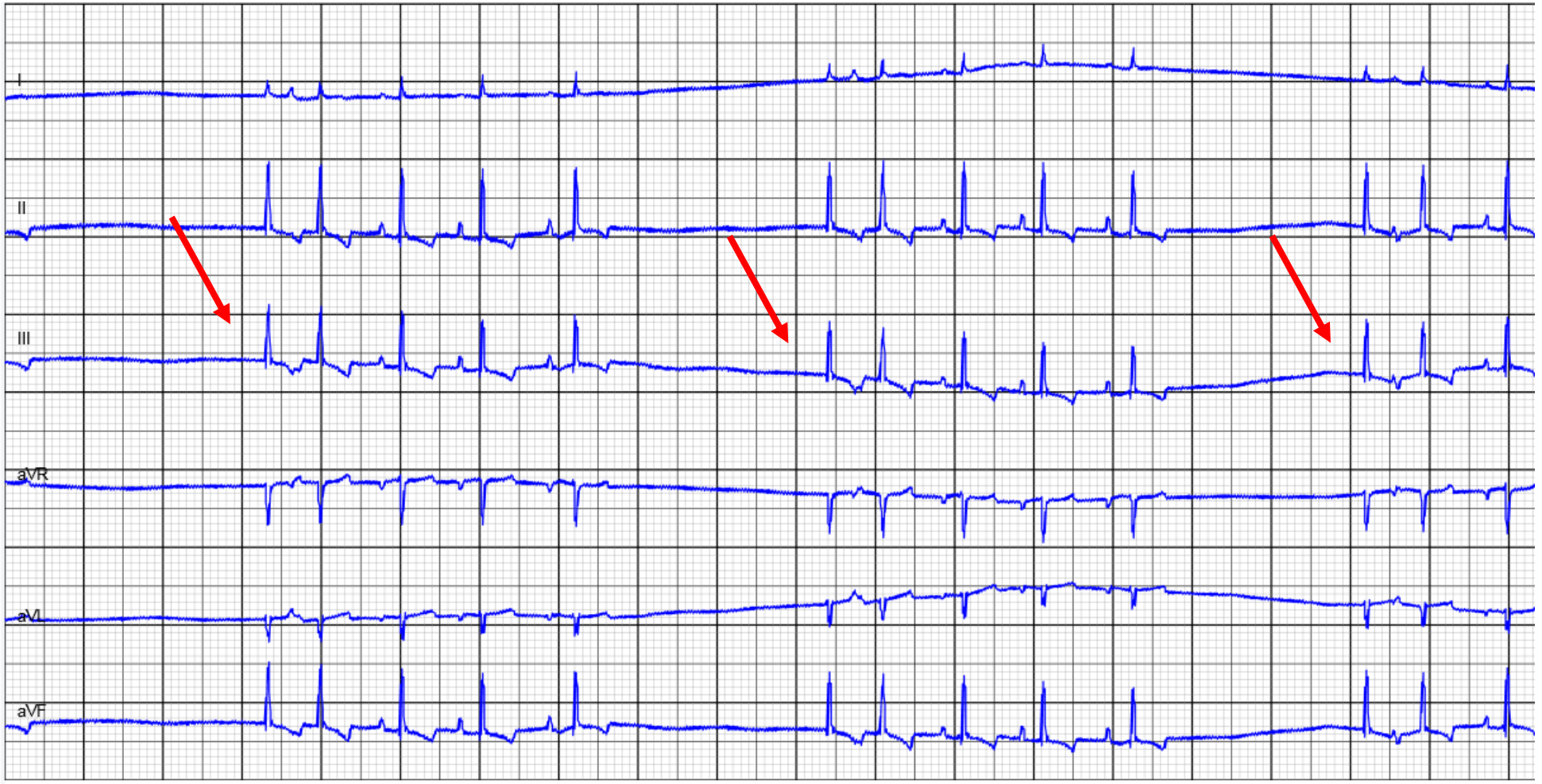
D.A. Szlosek, E.L. Castaneda, D.A. Grimaldi, A.K. Spake, A.H. Estrada, J. Gentile-Solomon, *Frequency of arrhythmias detected in 9440 feline electrocardiograms by breed, age, and sex,* J Vet Cardio, V 51,Pgs 116-123

9 yo FS Schnauzer

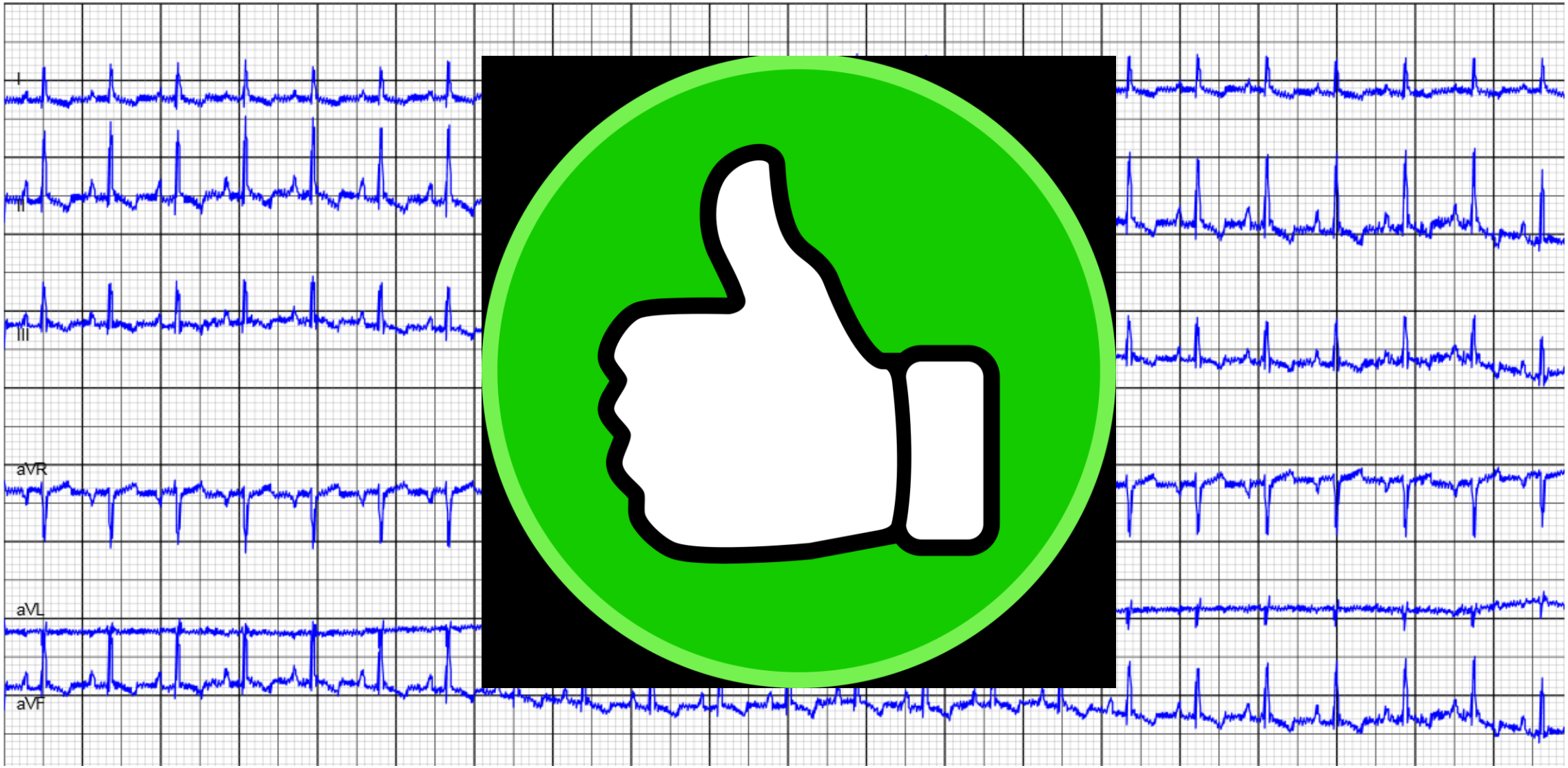
+ Presenting for a dental procedure.
+ Prominent sinus arrhythmia on PE.

Knowing the signalment and history, what would be your next diagnostic step?

Schnauzers, especially females, are pre-disposed to development of sick sinus syndrome. Therefore, an ECG would be indicated in this patient



Sinus rhythm interrupted by short periods of sinus arrest, punctuated by junctional escape beats.
Is this from sick sinus syndrome or high vagal tone?

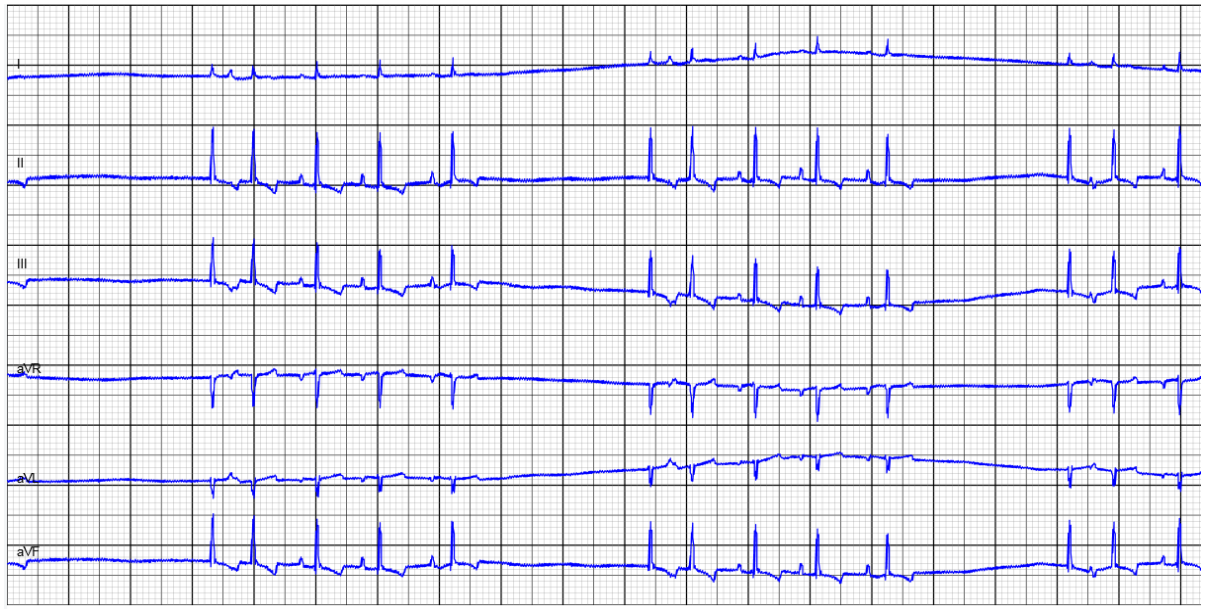


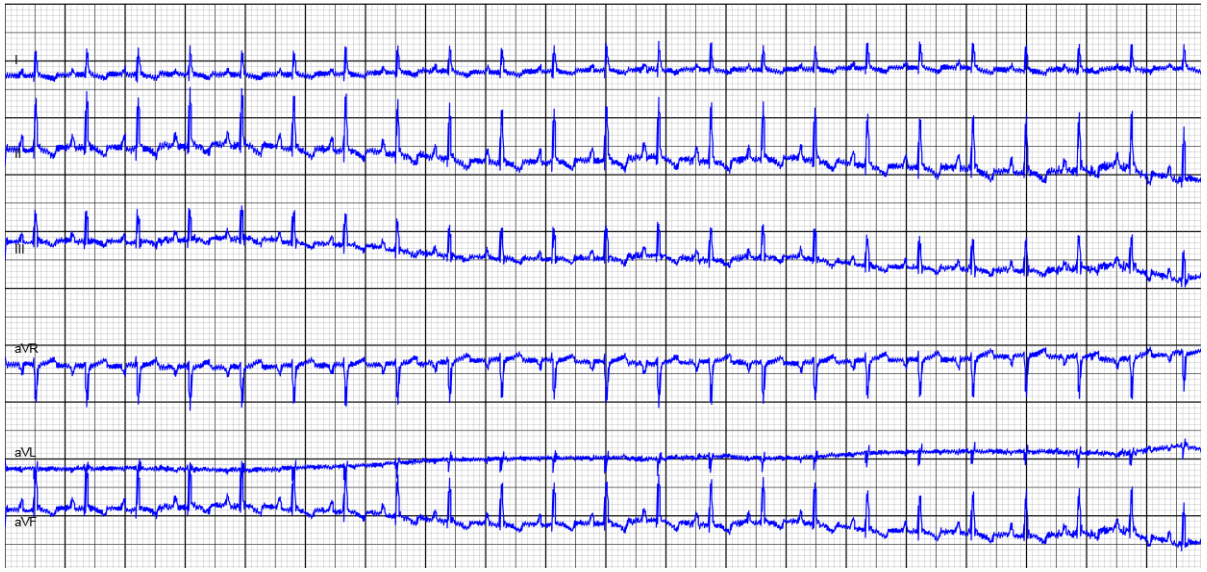
Post Atropine ECG

Conclusion

Signalment and physical exam prompted appropriate diagnostic

While Atropine response was appropriate, given signalment, would recommend yearly exam with ECG +/- Holter monitoring



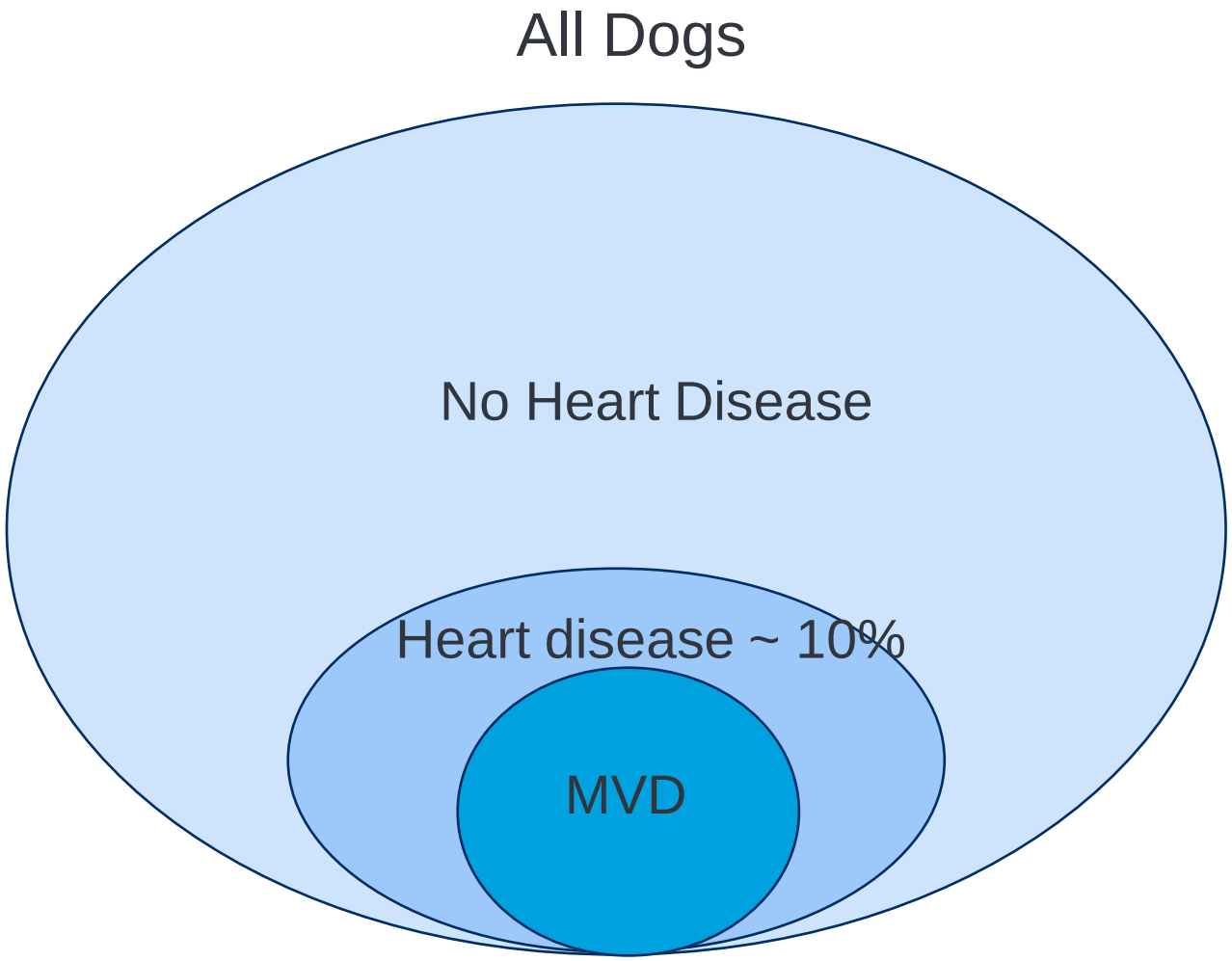


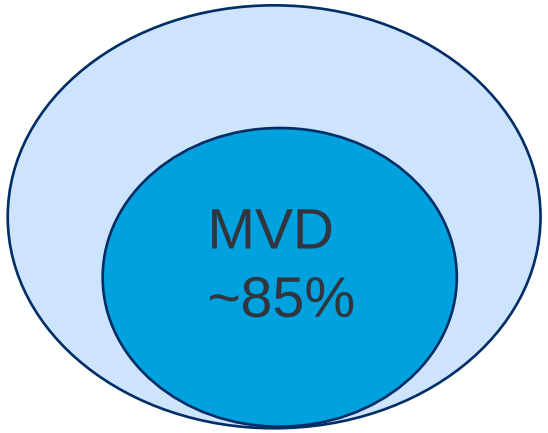
Mitral Valve Disease

Myxomatous Mitral Valve Degeneration

- Synonymous with: Degenerative mitral valve disease, mitral endocardiosis, atrioventricular valvular insufficiency (AVVI)
- In some reports, males 1.5 times more likely to develop disease than females
- Prevalence much higher in dogs < 20 kg, although can affect larger dogs
- CKCS 8 times more likely to develop MMVD than other insured breeds
- Cause: suspected heritable

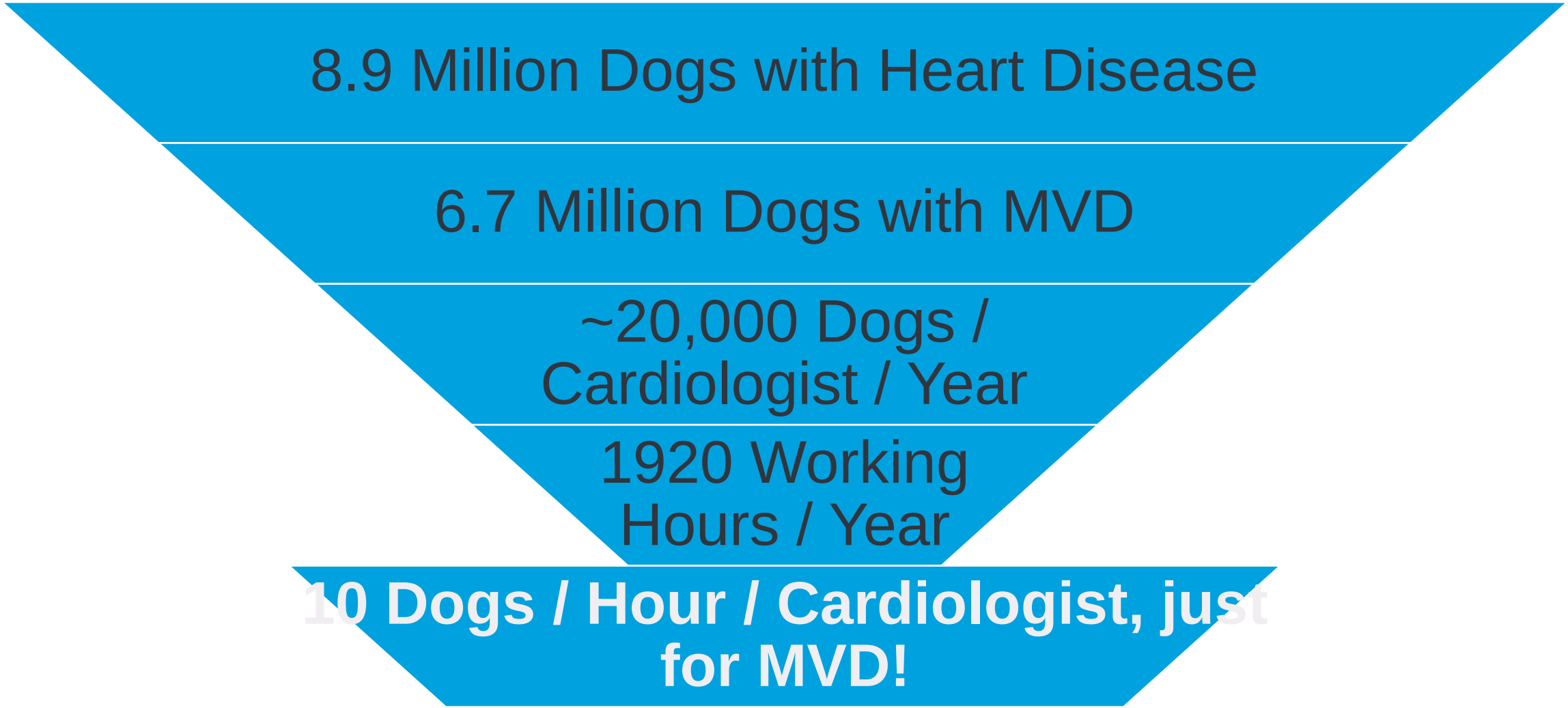
Prevalence of Heart Disease in Dogs





Keene BW, Atkins CE, Bonagura JD, et al. ACVIM consensus guidelines for the diagnosis and treatment of myxomatous mitral valve disease in dogs. *J Vet Intern Med*. 2019; 33: 1127–1140. https://doi.org/10.1111/jvim.15488

Buchanan JW. Chronic valvular disease (endocardiosis) in dogs. *Adv Vet Sci Comp Med*. 1977; **21**: 75-106



[1] AVMA 2022 Pet Ownership and Demographic Sourcebook
[2] https://www.avma.org/resources-tools/reports-statistics/veterinary-specialists-2020
[3] Keene BW et al. ACVIM consensus guidelines for the diagnosis and treatment of myxomatou mitral valve disease in dogs. *J Vet Intern Med* 2019;33:1127-1140

ACVIM Consensus Statement: ABCD

- **Stage A**: High risk for developing heart disease
  - CKCS, Dachshunds, Poodles, all small breed dogs
- **Stage B**: Structural heart disease but no clinical signs
  - B1: No remodeling
  - B2: Remodeling defined as LAE or LV dilation (echo, VHS, VLAS)
- **Stage C:** Past or current clinical signs of CHF
  - Inpatient vs. Outpatient
- **Stage D**: End stage disease. CHF refractory to ‘standard therapy’
  - Inpatient vs. outpatient

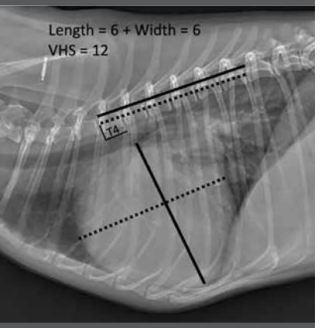
Hidden heartbreak

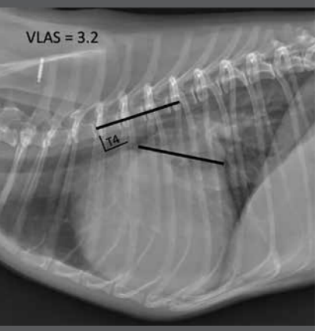
B

STAGES OF MYXOMATOUS MITRAL VALVE DISEASE (MMVD)

Dogs with structural heart disease that have not yet developed clinical signs of heart failure.

DIAGNOSTICS: STAGE B1 & B2 MMVD





- **Patient history**[3]
- **Cardiac and pulmonary auscultation**[4]
- **Echocardiography**[5, 6]
- **Thoracic radiographs**[7, 8]
  - **Measure Vertebral Heart Size (VHS)**
  - **Measure Vertebral Left Atrial Size (VLAS)**
- **Blood pressure**
- **Electrocardiogram (ECG) when cardiac arrhythmia is evident during clinical examination.**
- NT-proBNP[9] increases over time are associated with progression of MMVD.
- Clinical lab tests: serum biochemistries, PCV/TS (or CBC) and urinalysis to establish baseline values in older patients.

KEY:	**Red text:** High priority	**Black text:** Lower priority

B

STAGES OF MYXOMATOUS MITRAL VALVE DISEASE (MMVD)

Dogs with structural heart disease that have not yet developed clinical signs of heart failure.

Stage B valve disease can be divided into Stage B1 and Stage B2 disease.

Dogs with Stage B MMVD have no clinical signs of heart failure. This stage includes:

- **Stage B1:** Dogs with no radiographic or echocardiographic evidence of cardiac remodeling (heart enlargement) or remodeling that is not severe enough to meet current clinical trial criteria used to determine initiation of treatment.
- **Stage B2:** Dogs with remodeling that is severe enough to support initiation of treatment.

Diagnostics are required to differentiate B1 from B2.

- Echocardiography is the test of choice to differentiate Stage B1 MMVD from Stage B2 MMVD. Echocardiographic enlargement indicative of Stage B2 includes both LA:Ao ≥ 1.6 and LVIDDN ≥ 1.7[1]. Details of diagnostic approach can be found here.
- Radiographic criteria may be used to help identify MMVD patients likely to meet echocardiographic criteria for Stage B2 when echocardiographic examination is not possible.
- In dogs with left apical systolic heart murmurs ≥ grade 3/6, radiographic criteria to identify likely Stage B2 dogs includes vertebral heart size (VHS) ≥ 11.5 or vertebral left atrial size (VLAS) ≥ 3 measured on a lateral radiograph.
- In cases where an echocardiogram cannot be obtained for staging, serial radiography (with consecutive examinations separated by 6 to 12 months) can offer a practical substitute[2].

Diagnostics to differentiate B1 vs B2

1. Echocardiography – gold standard

   LA:Ao >/= 1.6 AND LVIDDN >/=1.7

2. Radiographs with >/= 3/6 murmur

   VHS >/= 11.5 or VLAS >/= 3

9 yo FS CKCS

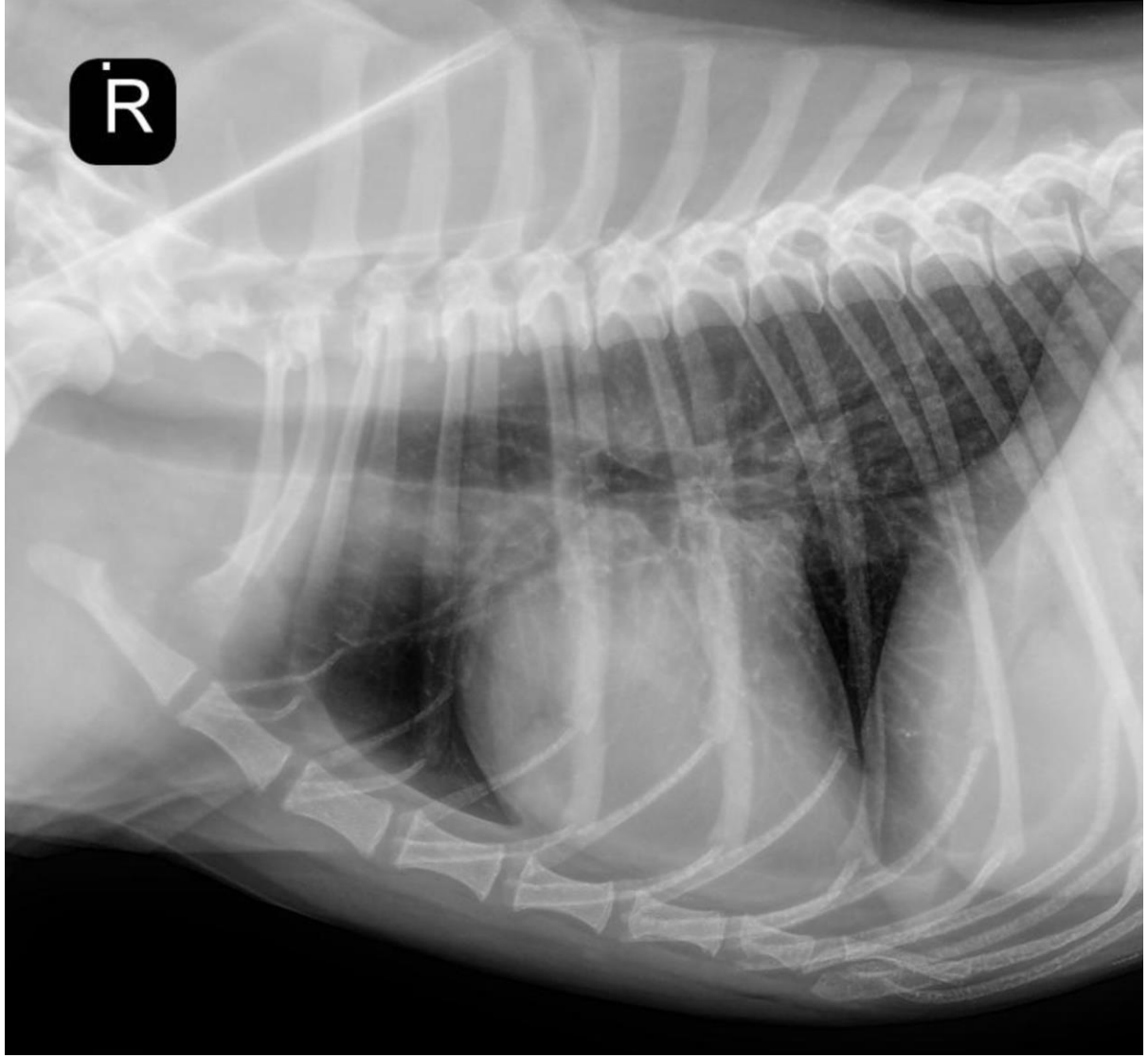
PC: Dental

Relevant history: MMVD B1, diagnosed in April

Meds: None

C/S/V/D: None

PE: 5/6 murmur (3/6 in April)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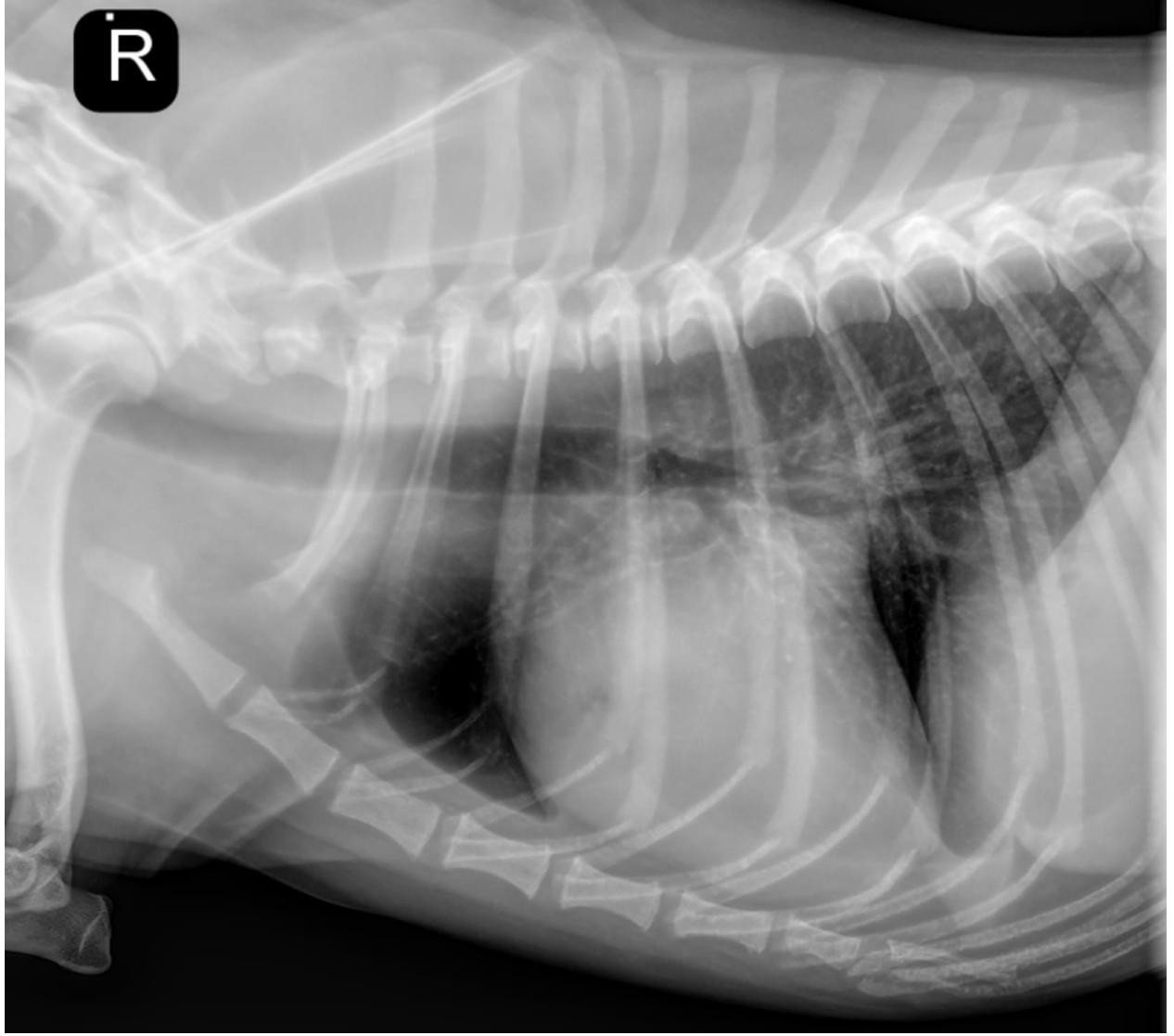
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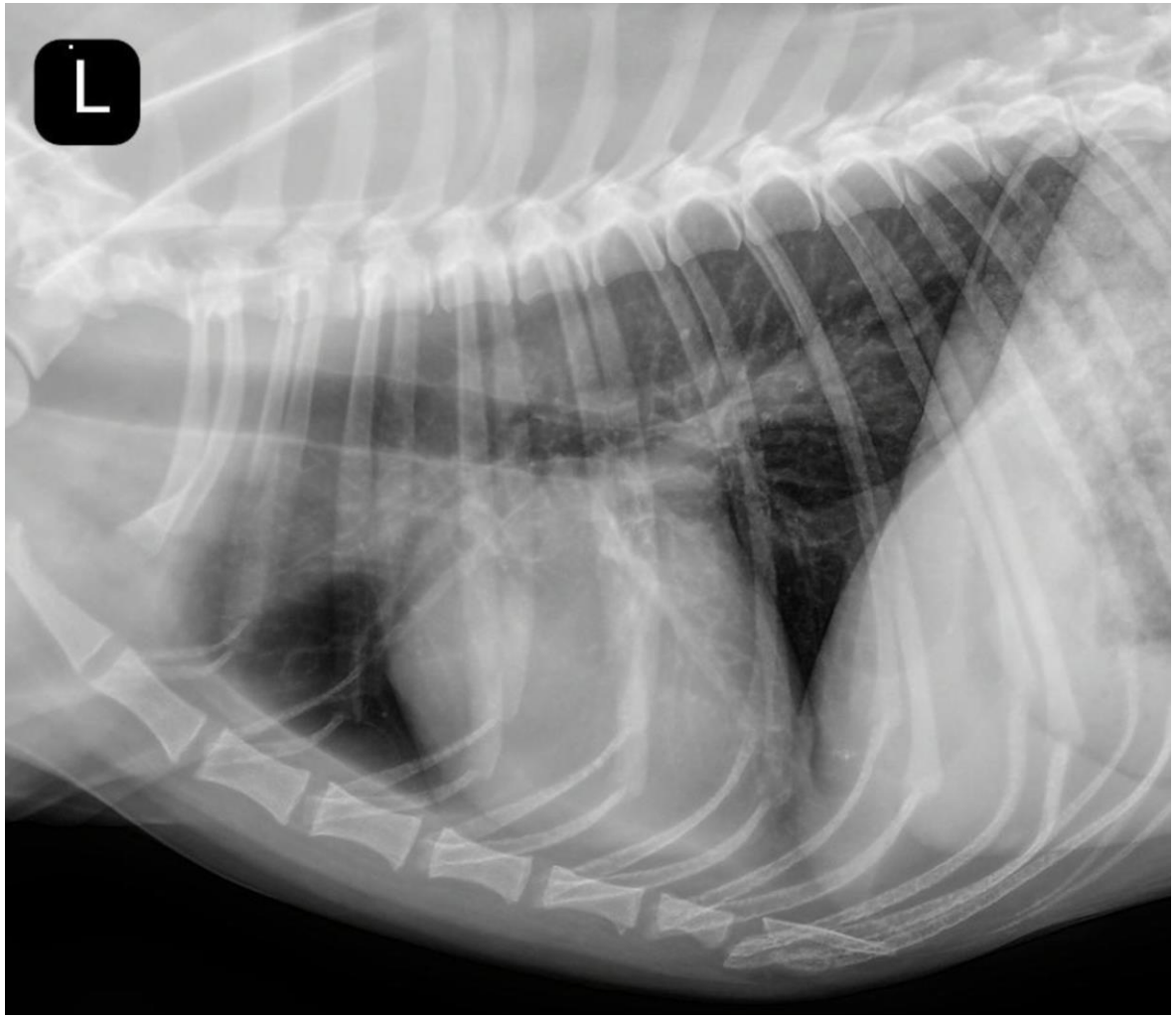
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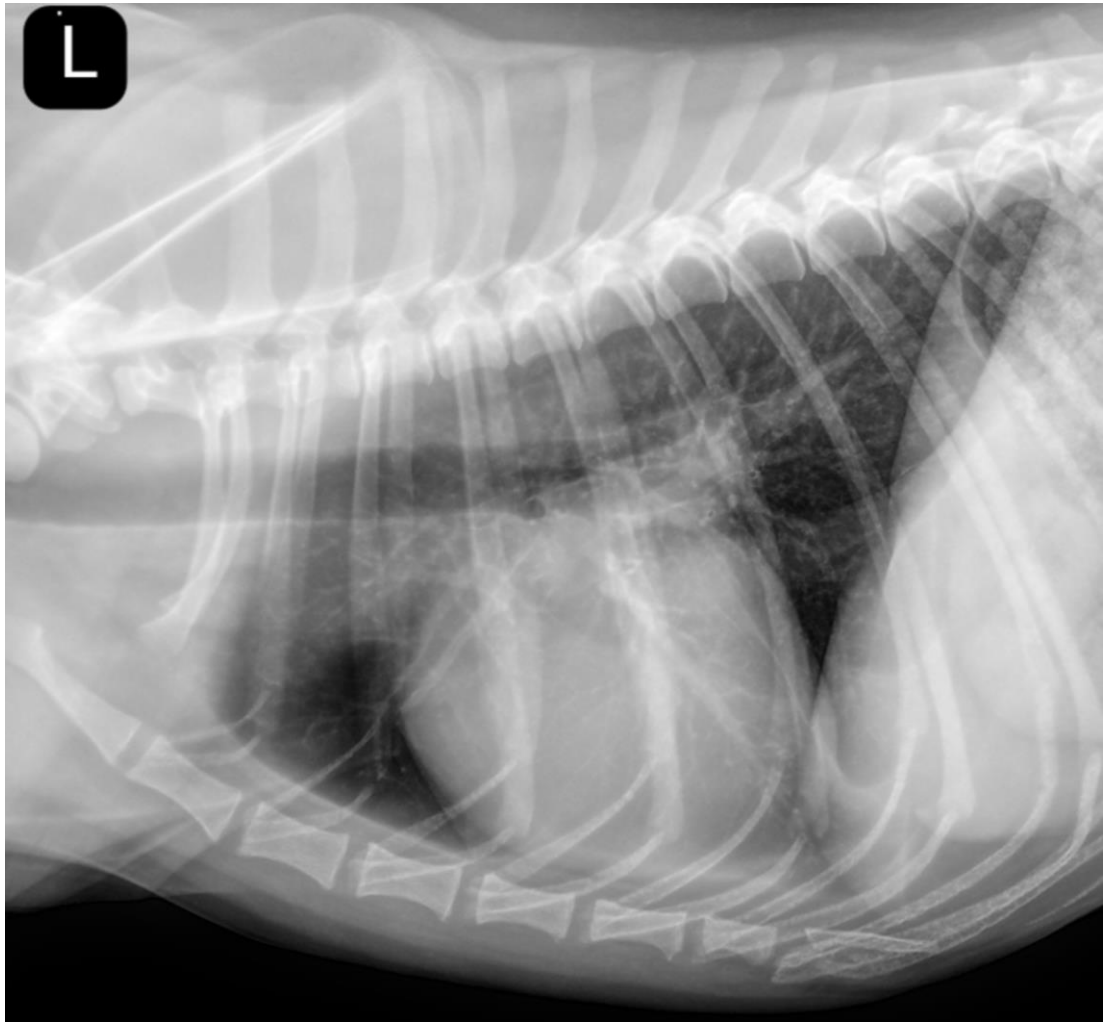
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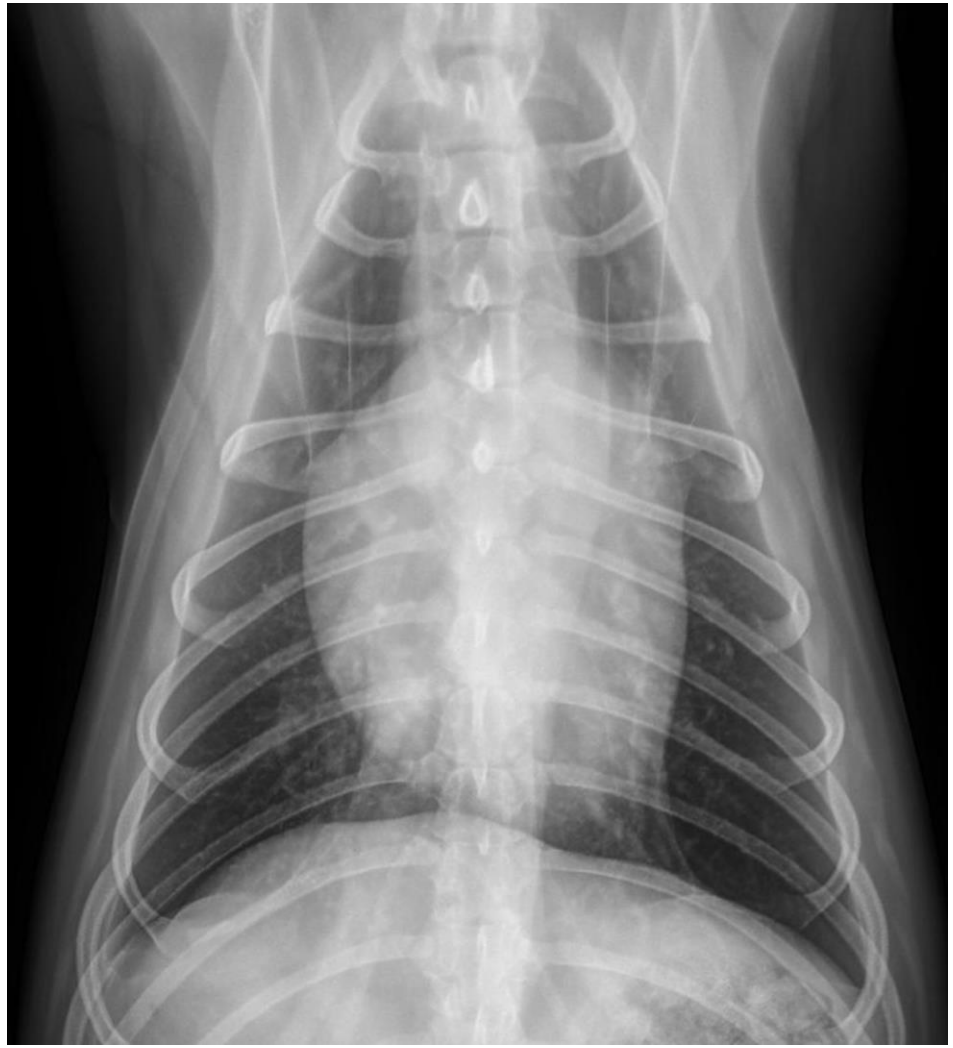
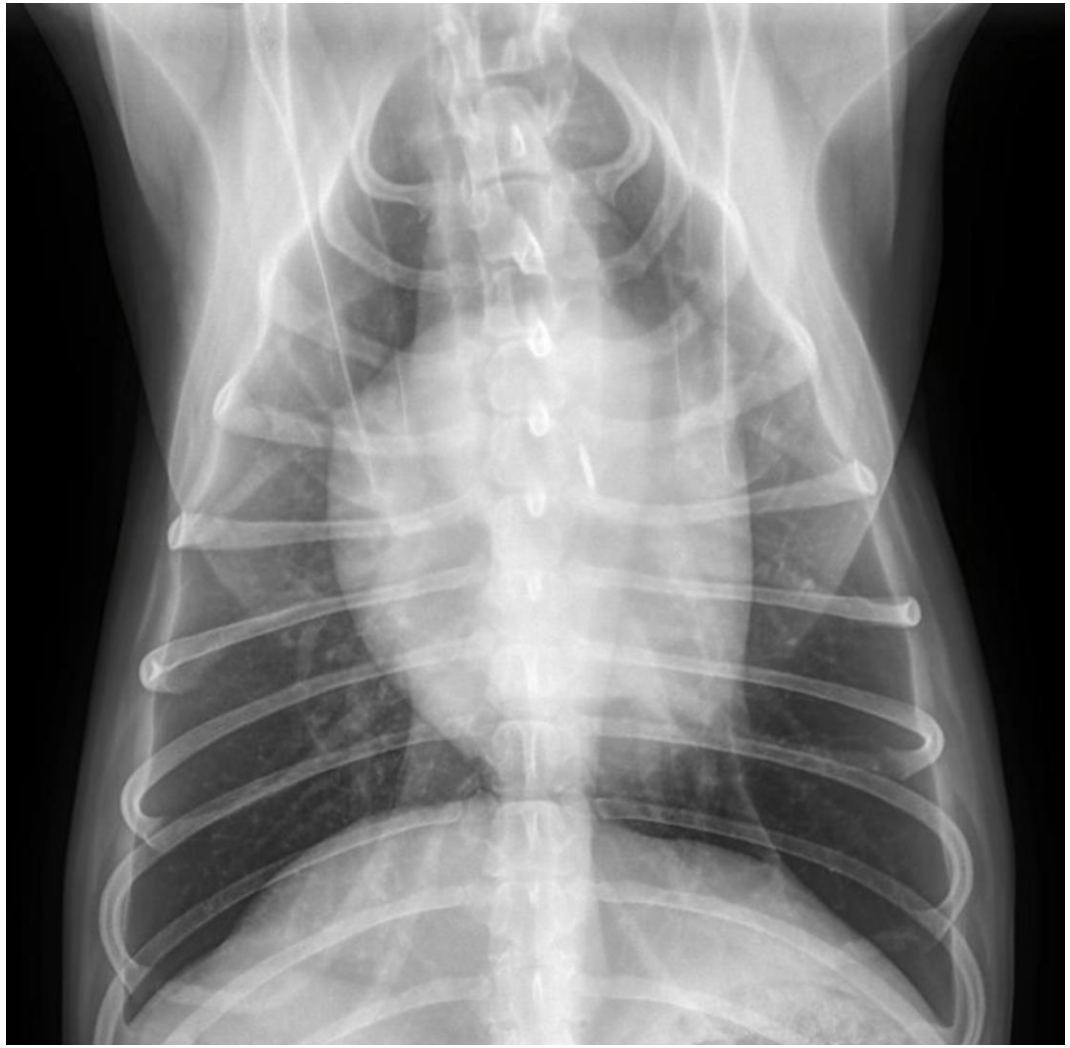
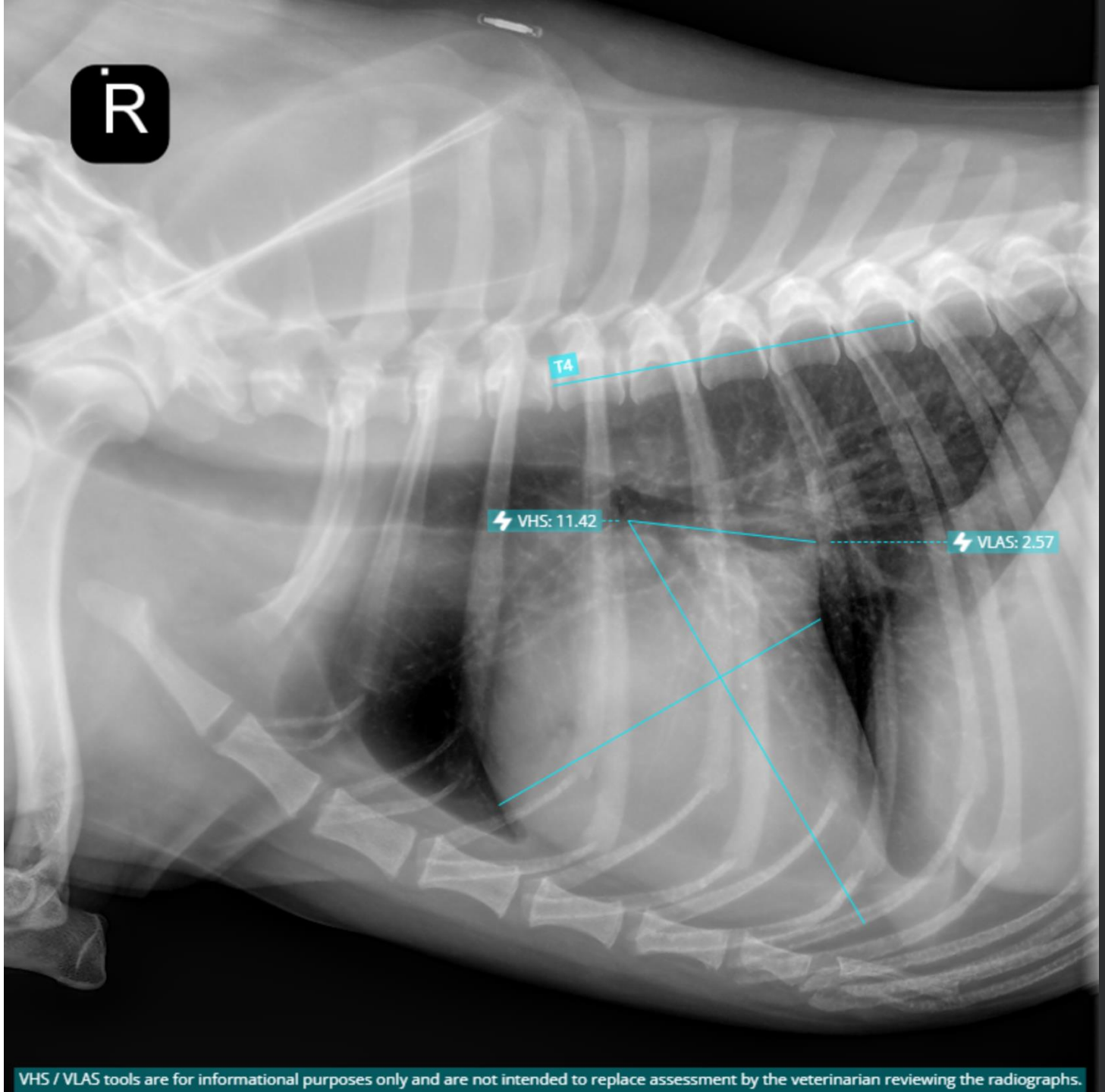
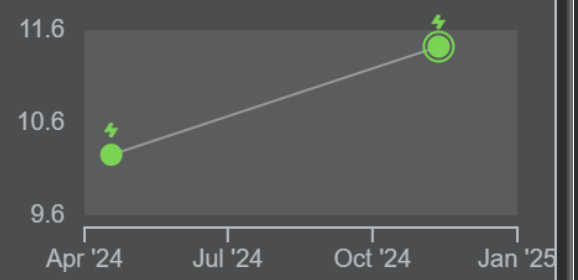






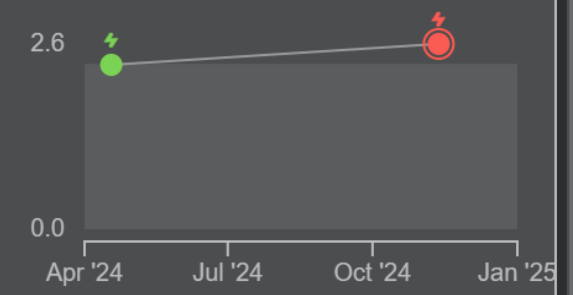
VHS / VLAS tools are for informational purposes only and are not intended to replace assessment by the veterinarian reviewing the radiographs.

VHS: 11.42



Reference Range
Canine: 8.7 - 10.7
Cavalier King Charles Spaniel: 9.6 - 11.6

VLAS: 2.57

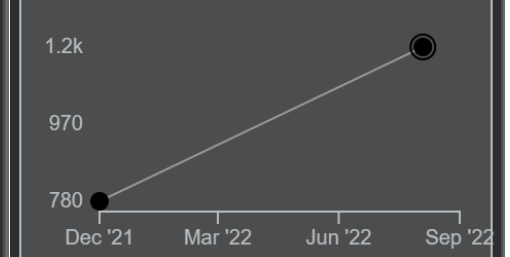


A score of 2.3 vertebrae or higher suggests the presence of left atrial enlargement.

Why VLAS

Related Results

NT-ProBNP: 1,153 pmol/L



Reference Range
0-900 pmol/L in canines <20 kg
0-735 pmol/L for Dobermans

Reference ranges have not been established for all breeds of canines >20 kg

April

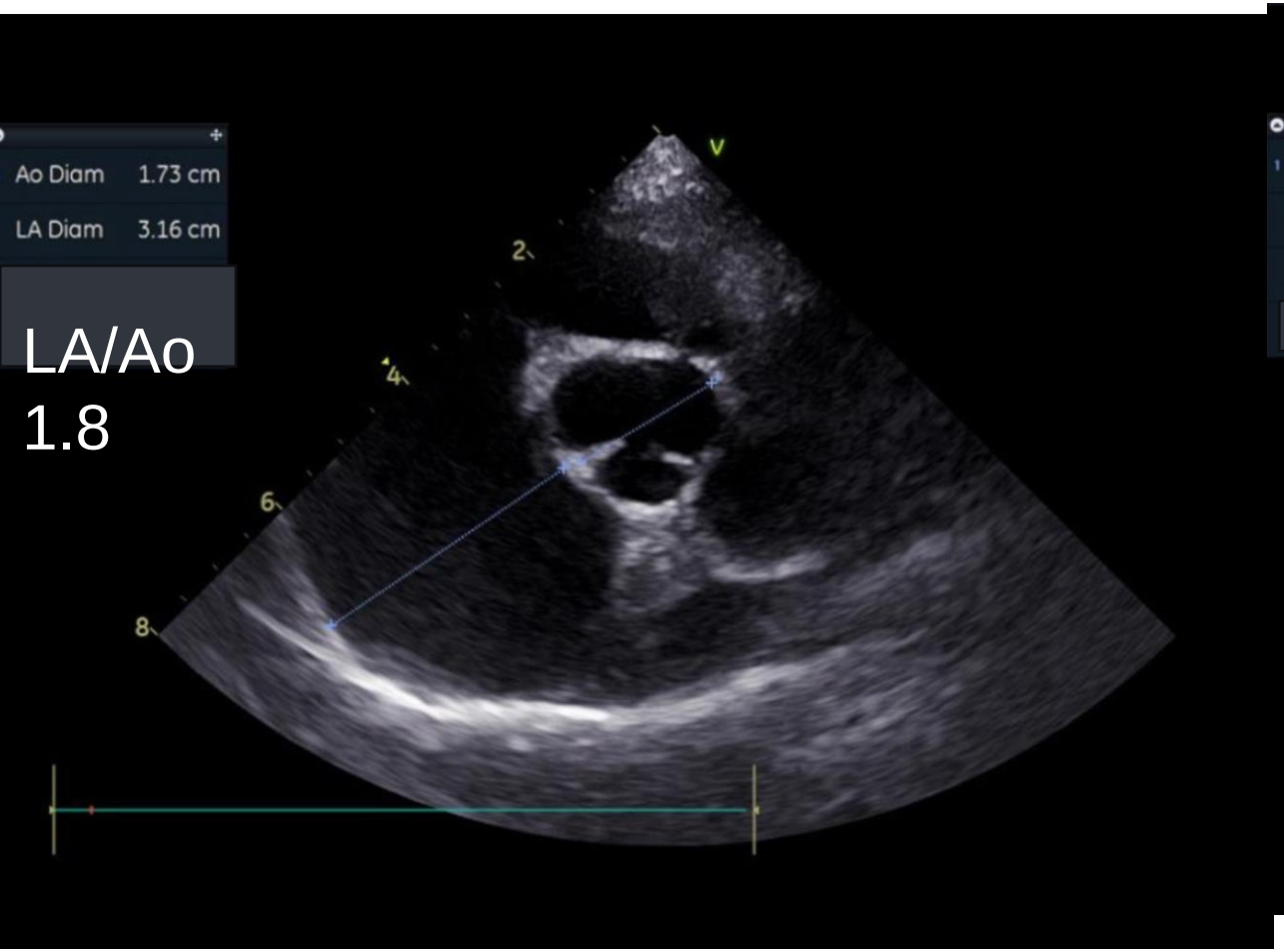
Important Information

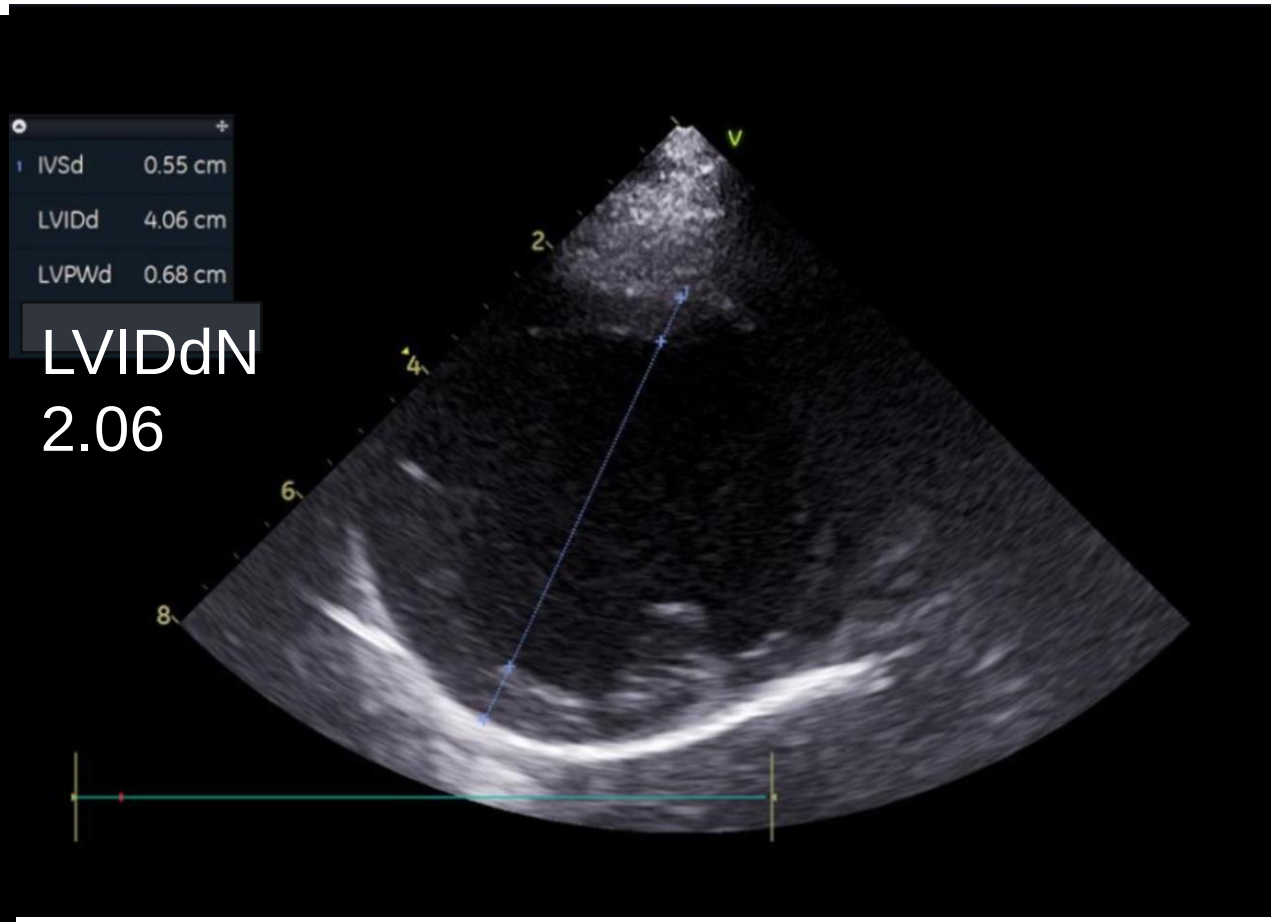
Vertebral Heart Score

- VHS Announcement
- VHS Positioning Guide
- VHS Results and Trending

Vertebral Left Atrial Score

- VLAS Announcement
- VLAS Positioning Guide
- Cardiac Tools


Ao Diam 1.73 cm
LA Diam 3.16 cm
LA/Ao
1.8


IVSd 0.55 cm
LVIDd 4.06 cm
LVPWd 0.68 cm
LVIDdN
2.06

Plan:
This patient is currently classified as a stage B2 (i.e., asymptomatic with hemodynamically significant regurgitation).

Pimobendan (i.e., Vetmedin) has been shown to delay the onset of CHF in dogs with confirmed stage B2 degenerative valve disease. Based on these results, pimobendan (0.2-0.3 mg/kg PO q12h) is likely indicated for this patient. An ACE-inhibitor (e.g., enalapril or benazepril 0.25-0.5 mg/kg PO q12h) is also an option, although evidence of efficacy has not been definitively established in dogs with stage B2 CDVD. If the ace-inhibitor is started ideally rechecking renal parameters and blood pressure in 1 week. The medications are usually well tolerated although pimobendan can occasionally cause GI upset.

The degree of cardiomegaly indicates that this patient is at risk of developing congestive heart failure in the future. Consequently, the owner should be asked to monitor and record the sleeping respiratory rate. Normal rates are < 30 breaths/min. If the sleeping respiratory rate increases from an established baseline, or consistently exceeds 35 breaths/min, this patient warrants immediate repeat thoracic radiographs to determine if left-sided congestive heart failure has developed. If congestive heart failure is identified radiographically recommend adding in furosemide 1-2 mg/kg orally twice daily and recheck radiographs and renal function in 1 week.

Thoracic radiographs should be repeated every 6 months to monitor for progression of the heart disease. A repeat echocardiogram is recommended yearly or sooner if clinical signs are seen, progression is noted, or additional cardiac therapy is contemplated.

Anesthetic risk is moderately increased, and recommendations would include the avoidance of ketamine, telazol, dexdomitor (or other alpha-2 agonists), and acepromazine. Consider premedication with an opioid/benzodiazepine and induction with Propofol, Etomidate or Alfaxan. Recommend reduction in IV fluid rates to 1/4 surgical rates. Monitor cardiovascular parameters while under anesthesia and during recovery (ECG, BP, SPO2 and ETCO2)

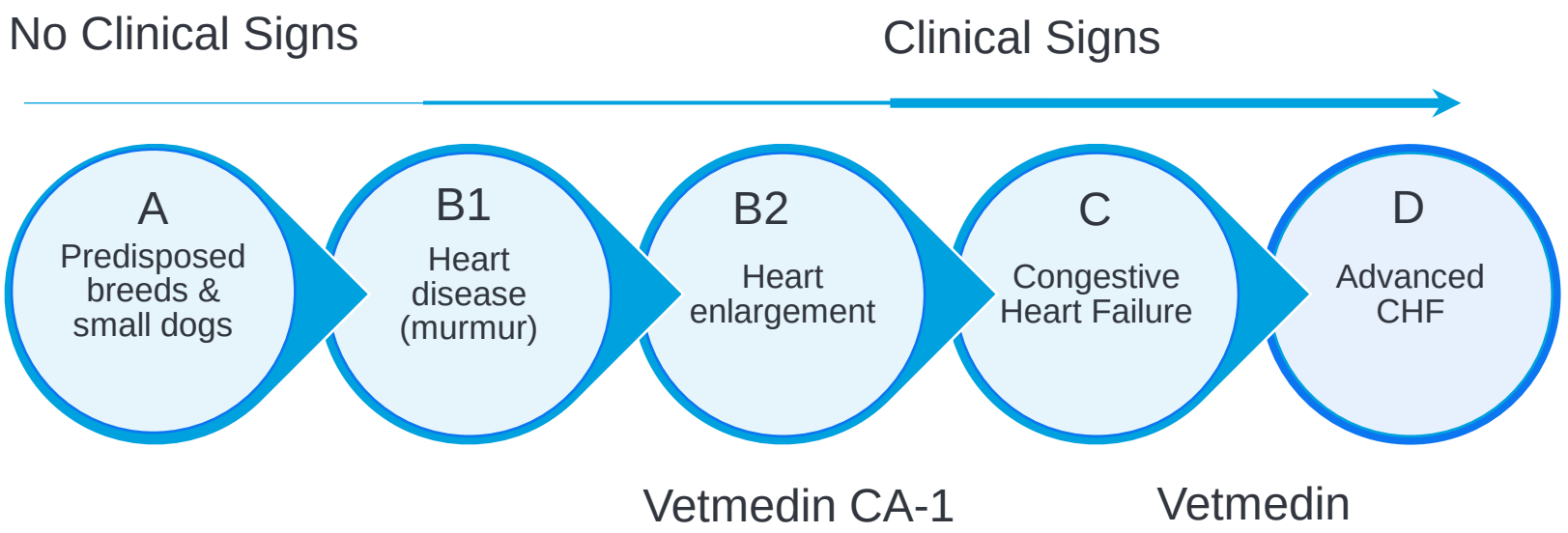
Actionable Recommendations in Report

Start Vetmedin CA-1 +/- Ace inhibitor

Monitor RR at rest, recheck rads if > 35 bpm

Recheck radiographs every 6 months. Recheck echo yearly.

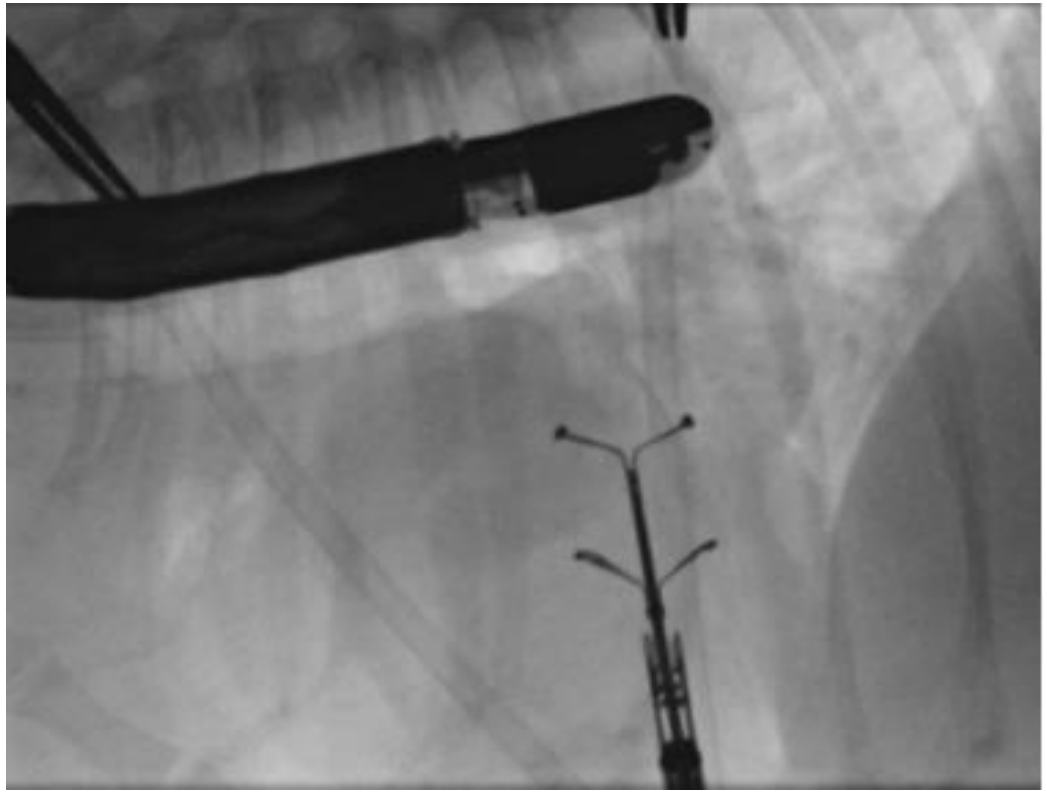
Anesthetic risk and recommendations discussed.

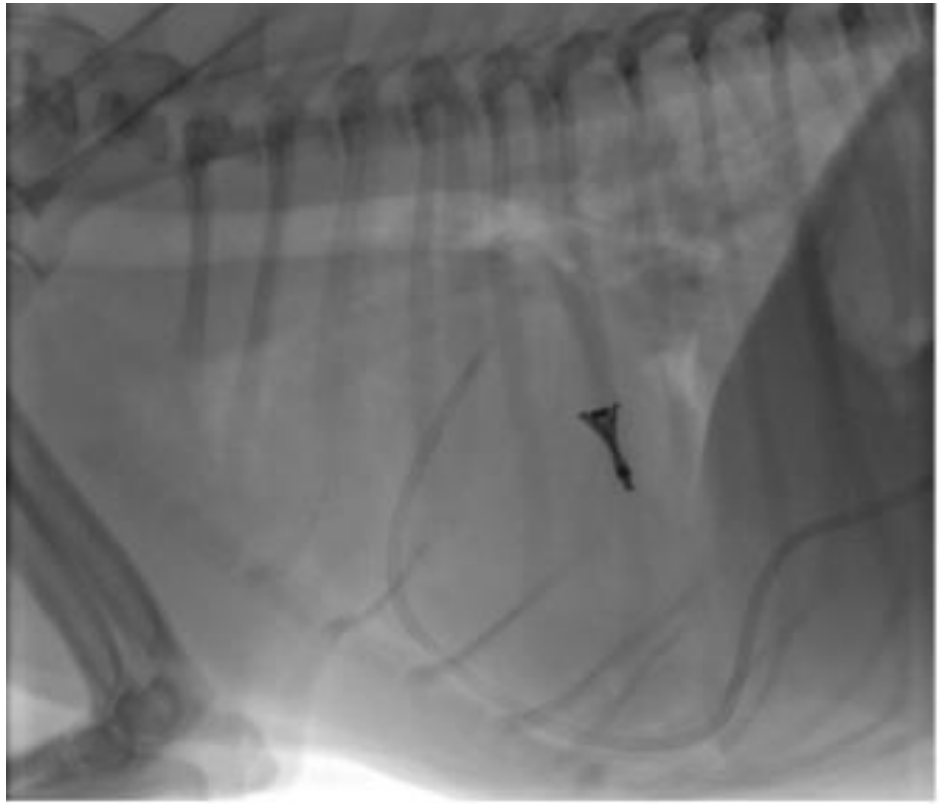


For dogs that meet all the inclusion criteria of the EPIC trial, the data suggest that dogs that receive pimobendan will, on average, remain **asymptomatic for ~15 months longer** and **live for ~5 months longer** when compared to dogs that do not.

https://healthyhabitsforpets.com/vetmedin

Mitral V-Clamp: TEER procedure





Dilated Cardiomyopathy

STAGE

A

CANINE CARDIOMYOPATHY

STAGE A

Dogs that are predisposed to cardiomyopathy (CM) but currently have no clinical evidence of heart disease

Canine cardiomyopathy is a myocardial disease that is characterized by some combination of ventricular dilation, decreased systolic function or arrhythmia.

Cardiomyopathy can be familial, idiopathic or have defined underlying cause(s).

CEG DIAGNOSTIC RECOMMENDATIONS: STAGE A

- Patient history[1]
  - Obtain diet history[2]
  - Confirm the absence of exercise intolerance, increased respiratory rate or effort, syncope, collapse and unintended weight loss
  - Investigate regional origin or travel history[3]
- Yearly auscultation[4]
- Screening echocardiography for predisposed breed[5] or dogs consuming nontraditional diets[2]
- 24-hour ambulatory (Holter) ECG for predisposed breeds[5]
- Genetic tests[6] are available for Doberman pinschers, Boxers and Standard Schnauzers
- Cardiac biomarkers (NT-proBNP and cardiac troponin-I)
  - Elevated concentrations may be used to identify Doberman pinschers (NT-proBNP > 500 pmol/l, cTnI >0.112 ng/ml) that may benefit from further diagnostic evaluation
  - The utility of these assessments in other breeds for this indication is currently unknown

CEG TREATMENT RECOMMENDATIONS: STAGE A

- No treatment
- Client education
  - Diet change for dogs eating diets associated with CM
- Annual reevaluation

Red text: High priority
Black text: Lower priority

Abbreviations: CM-cardiomyopathy, CHF-congestive heart failure, SCD-sudden cardiac death, ECG-electrocardiogram

1. CM may be suspected in a dog with a history of syncope, collapse, exercise intolerance or unintended weight loss (reduction in body condition score or muscle condition score), or when a murmur, gallop or tachyarrhythmia is detected on physical examination. However, many dogs with preclinical (Stage B1 and B2) CM will have a normal history and physical examination.
2. Diet-associated CM can mimic or complicate the diagnosis of idiopathic dilated CM. Dogs eating non-traditional diets associated with development of CM may benefit from a diet change and/or additional screening. Breeds considered at increased risk for diet-associated CM include golden retrievers, Newfoundland dogs, American cocker spaniels, Irish wolfhounds, Saint Bernards and English setters. Higher-risk diets include those that do not meet the World Small Animal Veterinary Association recommendations: WSAVA Global Nutrition Committee Tool Kit and WSAVA Global Nutrition Committee: Guidelines on Selecting Pet Food
3. Dogs originating from or traveling to specific regions may have an increased risk of exposure to infectious agents that can cause myocarditis (e.g., Chagas disease and tick-borne diseases).
4. The absence of a heart murmur or arrhythmia does not exclude the possibility of preclinical CM.
5. Breeds commonly affected include Doberman pinschers, boxers, Great Danes, Irish wolfhounds and Scottish deerhounds Typically, screening is initiated at 2-3 years of age or prior to breeding.
6. Genetic tests do not replace the need for phenotypic screening such as echocardiographic and Holter screening. Genetic testing may be a higher priority in dogs used for breeding.

Breed Predisposition / Genetic

Doberman, Great Dane, Boxer, Cocker Spaniels, Labs, other giant breed dogs

Nutritional

Boutique / exotic / grain free diets with pulses
Taurine deficiency
Carnitine deficiency

Infectious

Chagas
Parvovirus

Tachycardia Induced CM

Prolonged SVT or VT

Toxins

Doxorubicin

STAGE

A

CANINE CARDIOMYOPATHY

STAGE A

Dogs that are predisposed to cardiomyopathy (CM) but currently have no clinical evidence of heart disease

Canine cardiomyopathy is a myocardial disease that is characterized by some combination of ventricular dilation, decreased systolic function or arrhythmia.

Cardiomyopathy can be familial, idiopathic or have defined underlying cause(s).

CEG DIAGNOSTIC RECOMMENDATIONS: STAGE A

- Patient history[1]
  - Obtain diet history[2]
  - Confirm the absence of exercise intolerance, increased respiratory rate or effort, syncope, collapse and unintended weight loss
  - Investigate regional origin or travel history[3]
- Yearly auscultation[4]
- Screening echocardiography for predisposed breed[5] or dogs consuming nontraditional diets[2]
- 24-hour ambulatory (Holter) ECG for predisposed breeds[5]
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CEG TREATMENT RECOMMENDATIONS: STAGE A

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- Client education
  - Diet change for dogs eating diets associated with CM
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2. Diet-associated CM can mimic or complicate the diagnosis of idiopathic dilated CM. Dogs eating non-traditional diets associated with development of CM may benefit from a diet change and/or additional screening. Breeds considered at increased risk for diet-associated CM include golden retrievers, Newfoundland dogs, American cocker spaniels, Irish wolfhounds, Saint Bernards and English setters. Higher-risk diets include those that do not meet the World Small Animal Veterinary Association recommendations: WSAVA Global Nutrition Committee Tool Kit and WSAVA Global Nutrition Committee: Guidelines on Selecting Pet Food
3. Dogs originating from or traveling to specific regions may have an increased risk of exposure to infectious agents that can cause myocarditis (e.g., Chagas disease and tick-borne diseases).
4. The absence of a heart murmur or arrhythmia does not exclude the possibility of preclinical CM.
5. Breeds commonly affected include Doberman pinschers, boxers, Great Danes, Irish wolfhounds and Scottish deerhounds Typically, screening is initiated at 2-3 years of age or prior to breeding.
6. Genetic tests do not replace the need for phenotypic screening such as echocardiographic and Holter screening. Genetic testing may be a higher priority in dogs used for breeding.

Diagnostics for screening

1. History, including diet history
2. Echocardiogram
3. 24-hour Holter monitor
   In House ECG if not feasible
4. Genetic Testing (Doberman, Boxer, Std Schnauzer)
5. NT-proBNP and Troponin-I

STAGE

B

CANINE CARDIOMYOPATHY

STAGES B1 AND B2

Dogs with CM that do not have active or previous clinical signs of congestive heart failure (CHF) or clinically important arrhythmias

CEG DIAGNOSTIC RECOMMENDATIONS: STAGES B1 and B2

- Confirmation of a diagnosis of Stage B CM requires an echocardiogram and evaluation of cardiac rhythm. If an echocardiogram is not available or declined, other tests (NT-proBNP, cTnI, thoracic radiographs) can be used to encourage compliance for confirmatory testing
  - Blood pressure[11]
  - Thoracic radiographs[12]
- Cardiac biomarkers (NT-proBNP and cardiac troponin-I)
  - Elevated concentrations may be used to identify Doberman pinschers (NT-proBNP > 500 pmol/l, cTnI >0.112 ng/ml) that may benefit from further diagnostic evaluation
  - The utility of these assessments in other breeds for this indication is currently unknown, but substantially elevated concentrations for the breed can be considered an indication for confirmatory diagnostic testing[8]
  - Cardiac troponin is recommended when myocarditis is suspected and in septic patients[3]
- Clinical laboratory tests: serum biochemistries, PCV/TS (or CBC), urinalysis (prior to initiating any therapy in B2 patients)
- Evaluation of whole blood or plasma taurine concentrations in dogs with suspected diet-associated CM[13]

Red text: High priority
Black text: Lower priority

Abbreviations: CM-cardiomyopathy, CHF-congestive heart failure, SCD-sudden cardiac death, ECG-electrocardiogram, NT-proBNP, cTnI, PCV/TS, CBC

11. Blood pressure assessment is used to document normal blood pressure and rule out systemic hypertension.

12. Thoracic radiographs serve as baseline for future comparison if signs consistent with CHF develop. In addition, when an echocardiogram is not available, radiographic cardiomegaly, in particular a VHS > 11.5, identifies many dogs at high risk of heart disease and can be used to encourage clients to pursue an echocardiogram or be used to track progressive cardiomegaly. A normal VHS does not rule out cardiac disease. Evaluating Heart Size on Radiograph.

13. Decreased taurine concentrations may be associated with a dilated CM phenotype and respond to supplementation but diet-associated CM cannot be ruled out in dogs based on a normal taurine concentration.

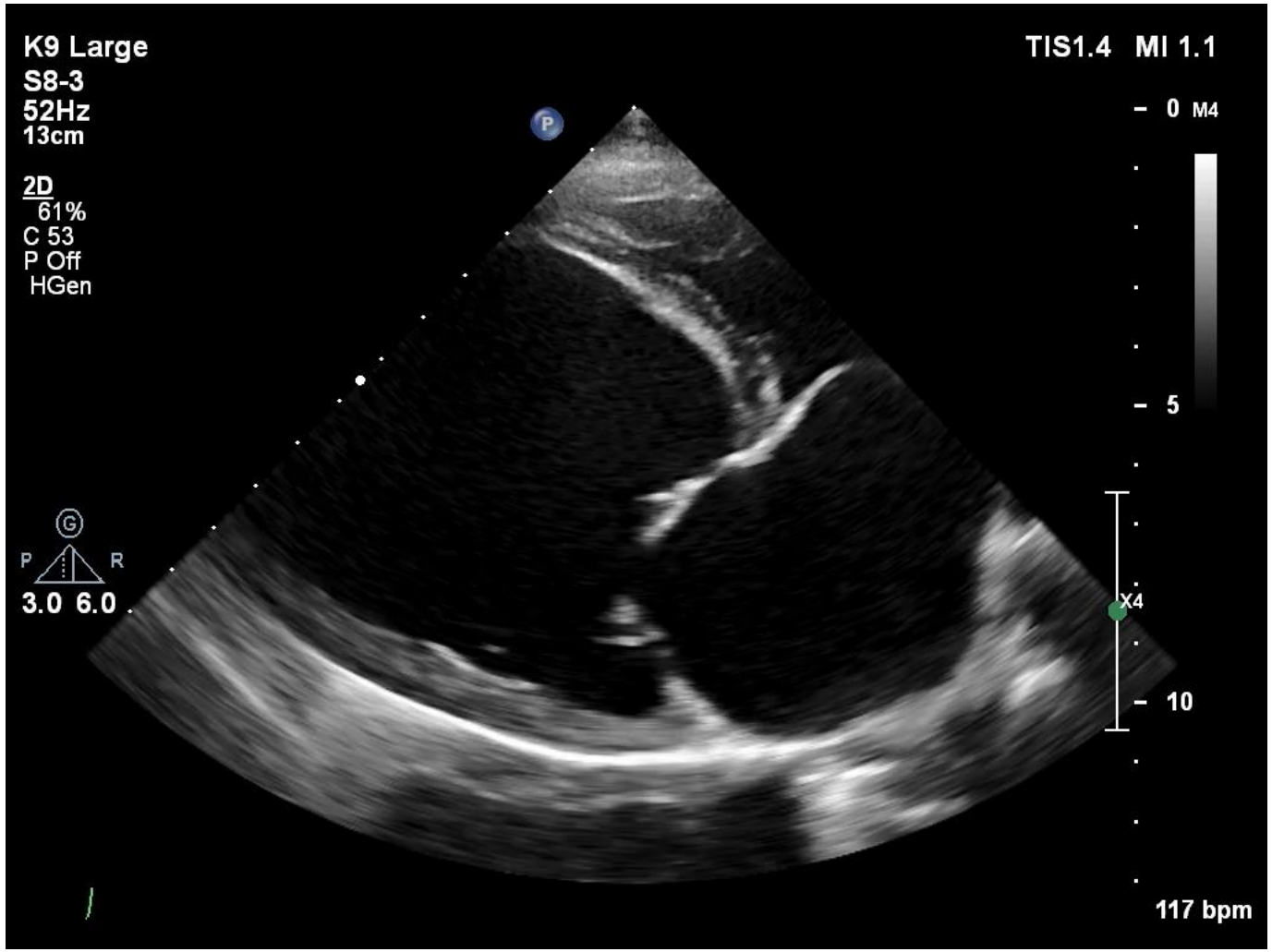
Diagnostics to differentiate stage B1 vs B2

1. Echocardiogram
2. Thoracic Radiographs
3. NT-proBNP & Troponin-I (Doberman)

Early detection of cardiomyopathy in dogs is hard because they usually don’t have a loud murmur. But it is important to find it so you can educate your clients on what to watch for – resting respiratory rate is particularly important.

6 Year Old, FS American Staffordshire Terrier

+ Lethargic 1 week
+ Anorexic 1 day
+ 3/6 left and right sided systolic murmu
+ Grain free diet
+ NT proBNP > 10,000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2D
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C 53
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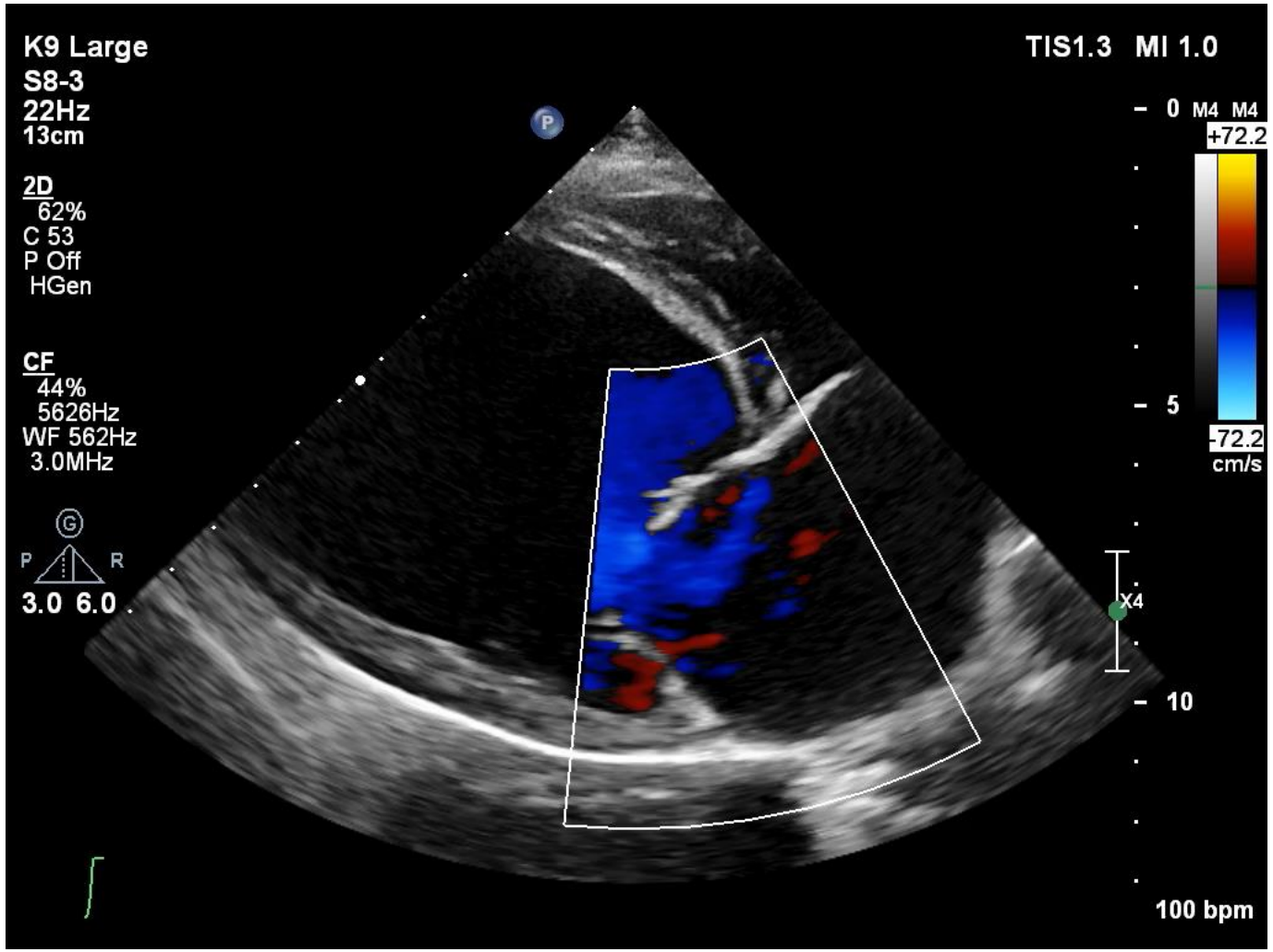
HGen
TIS1.4 MI 1.1
0 M4
5
10
X4
117 bpm
P
R
3.0 6.0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C 53
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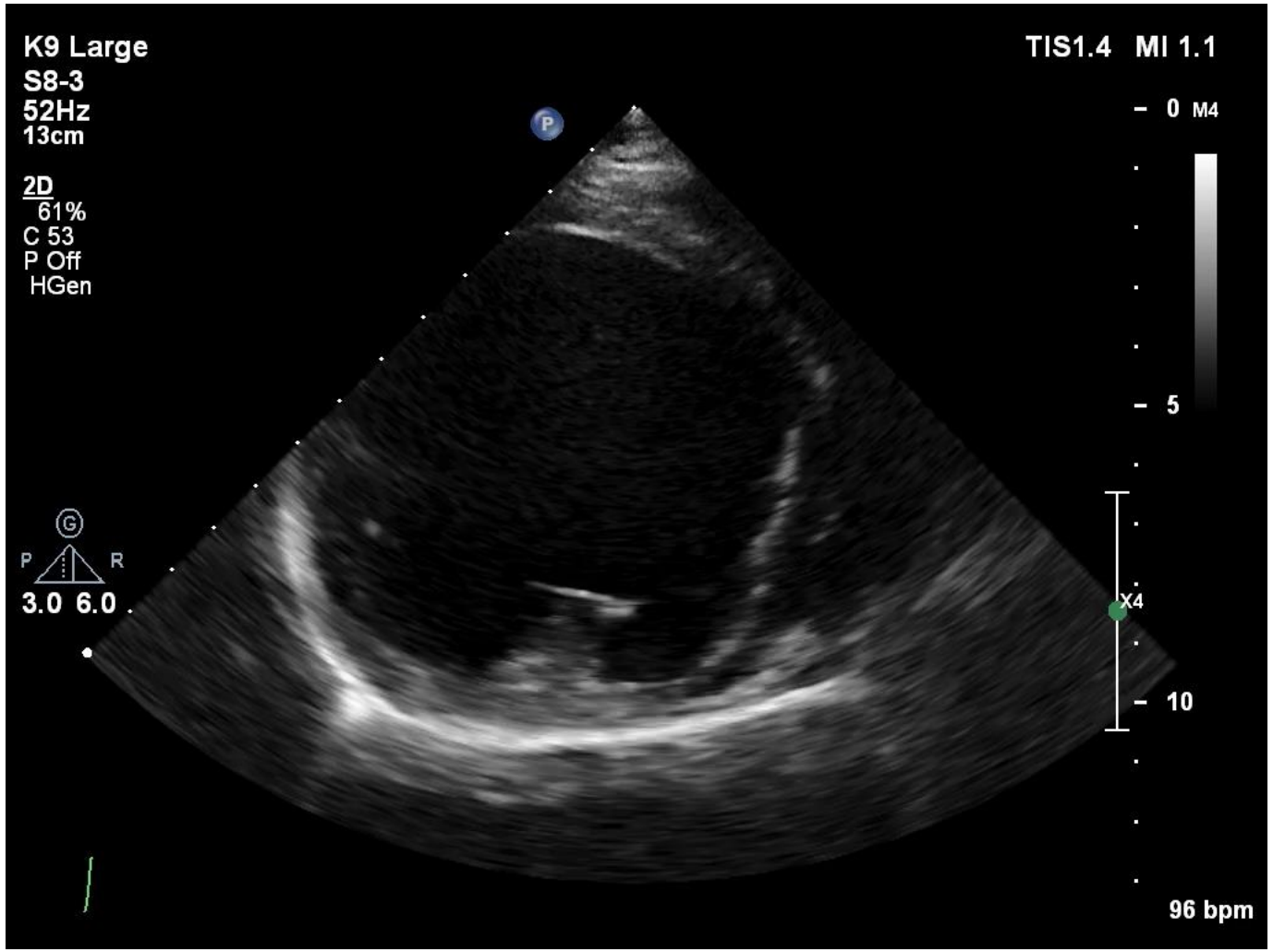
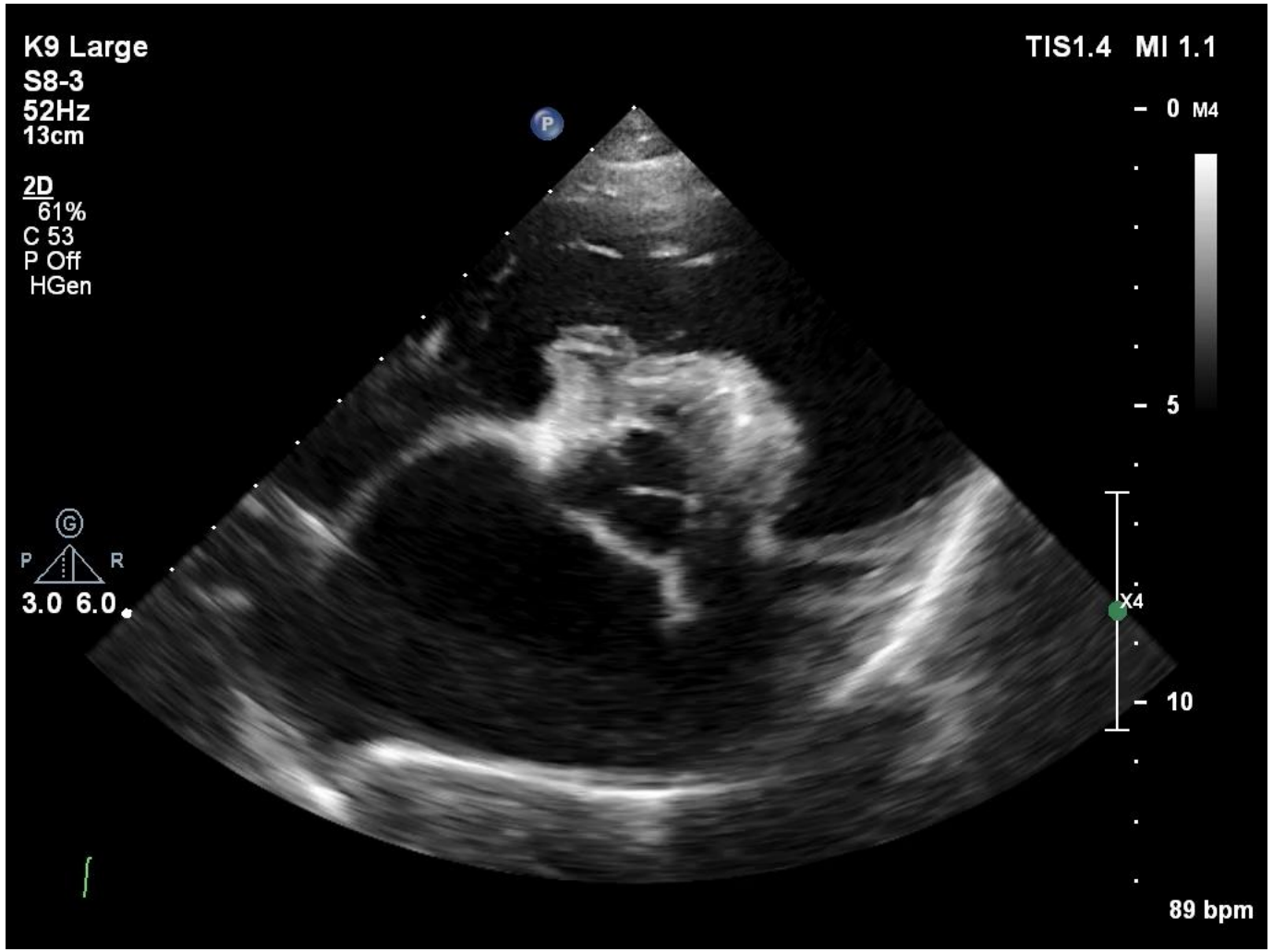
HGen
CF
44%
5626Hz
WF 562Hz
3.0MHz
3.0 6.0
TIS1.3 MI 1.0
0
M4 M4
+72.2
5
-72.2
cm/s
X4
10
100 bpm

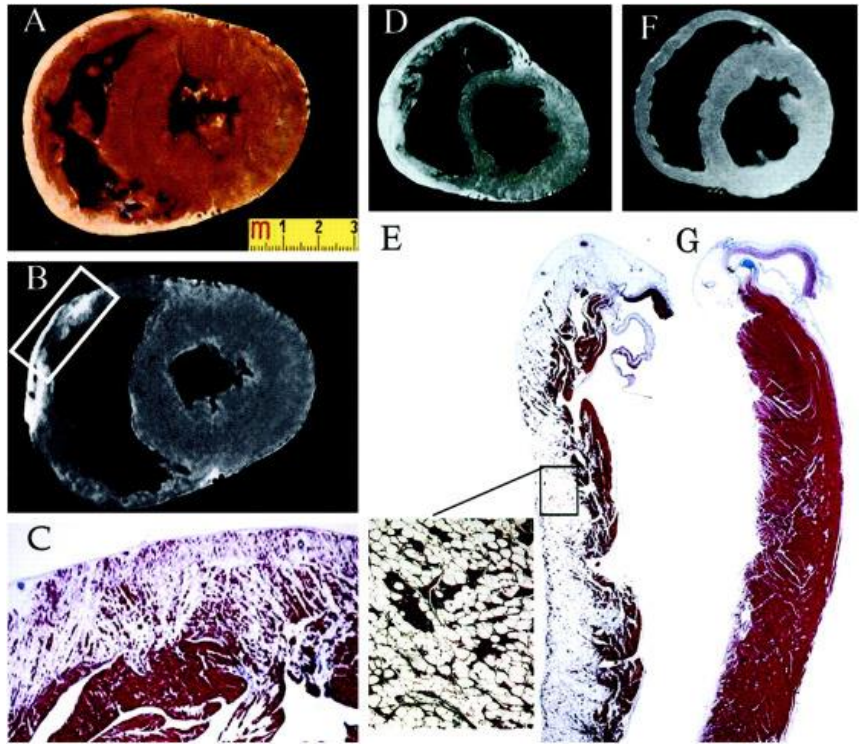

K9 Large
S8-3
52Hz
13cm
2D
61%
C 53
P Off
HGen
TIS1.4 MI 1.1
0 M4
5
10
X4
P
R
G
3.0 6.0
96 bpm


K9 Large
S8-3
52Hz
13cm
2D
61%
C 53
P Off
HGen
TIS1.4 MI 1.1
0 M4
5
10
X4
89 bpm
P
R
3.0 6.0

I feel like we see less nutritional DCM than we did 2019-2021. Reasonable to screen with BNP, if high, come in for echo.

Not all grain free diets are bad. Pulses (lentils, peas, chickpeas) seem to be the culprit – try to avoid diets with those in first 5 ingredients.

Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC)



Hereditary, adult-onset disease (~6 years)

Replacement of myocytes with fatty or fibrofatty infiltrates

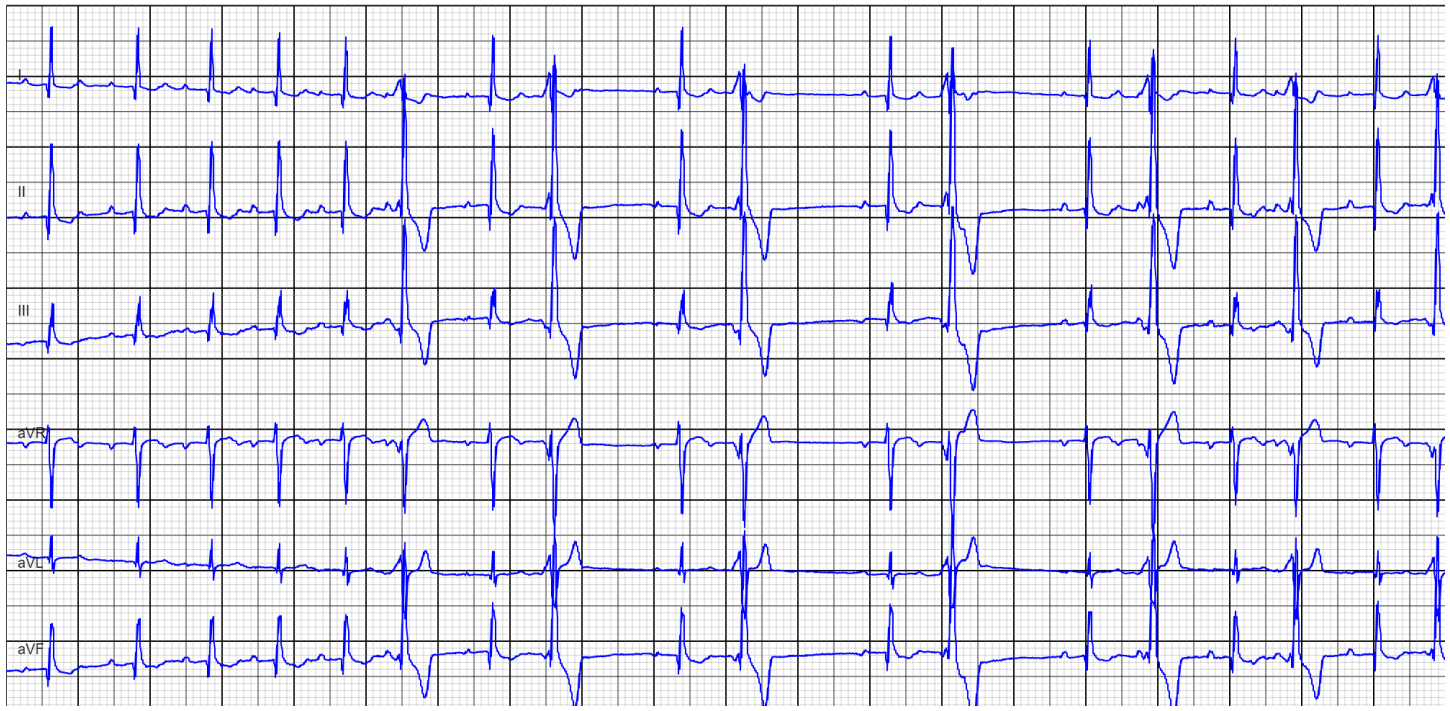
Typical VPCs: Left bundle branch block morphology" because originate in the RV

Clinical signs: Asymptomatic → syncope → sudden death

Can progress to RV and LV dilation and CHF

S.M. Cunningham, L. Dos Santos, Arrhythmogenic right ventricular cardiomyopathy in dogs, JVC,
Volume 40, 2022, Pages 156-169.

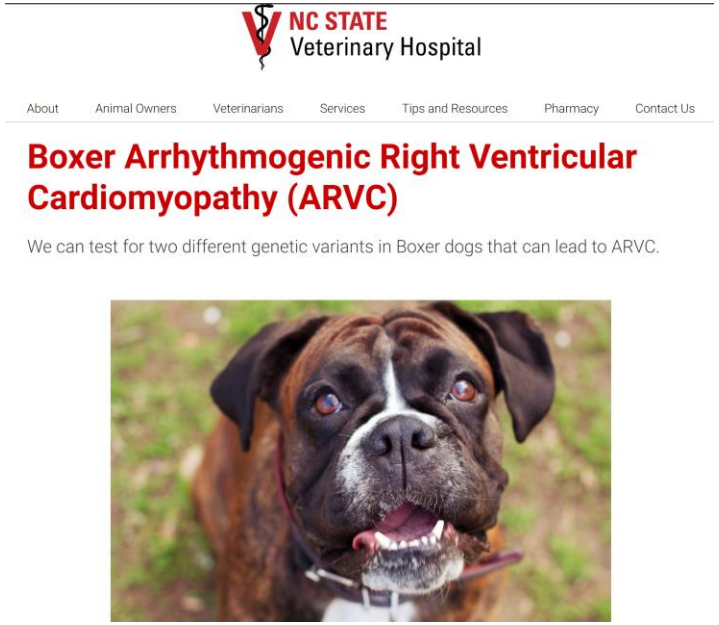
ARVC —
Right Ventricular Origin VPCs



Note: Upright, wide and bizarre QRS complexes of a different configuration of the normal sinus beats without associated P waves

ARVC Screening Recommendations

- Yearly 24-hour Holter monitor for Boxers, starting at 3 years of age
  - If holter not feasible, recommend yearly ECG testing and an ECG prior to any anesthetic event
- Genetic testing through NCSU



Feline Cardiomyopathy

Received: 8 January 2020 | Accepted: 14 February 2020
DOI: 10.1111/jvim.15745

CONSENSUS STATEMENT

Journal of Veterinary Internal Medicine Open Access
ACVIM American College of Veterinary Internal Medicine

Consensus Statements of the American College of Veterinary Internal Medicine (ACVIM) provide the veterinary community with up-to-date information on the pathophysiology, diagnosis, and treatment of clinically important animal diseases. The ACVIM Board of Regents oversees selection of relevant topics, identification of panel members with the expertise to draft the statements, and other aspects of assuring the integrity of the process. The statements are derived from evidence-based medicine whenever possible and the panel offers interpretive comments when such evidence is inadequate or contradictory. A draft is prepared by the panel, followed by solicitation of input by the ACVIM membership that may be incorporated into the statement. It is then submitted to the Journal of Veterinary Internal Medicine, where it is edited before publication. The authors are solely responsible for the content of the statements.

ACVIM consensus statement guidelines for the classification, diagnosis, and management of cardiomyopathies in cats

Virginia Luis Fuentes[1] | Jonathan Abbott[2] | Valérie Chetboul[3] | Etienne Côté[4] | Philip R. Fox[5] | Jens Häggström[6] | Mark D. Kittleson[7] | Karsten Schober[8] | Joshua A. Stern[7]

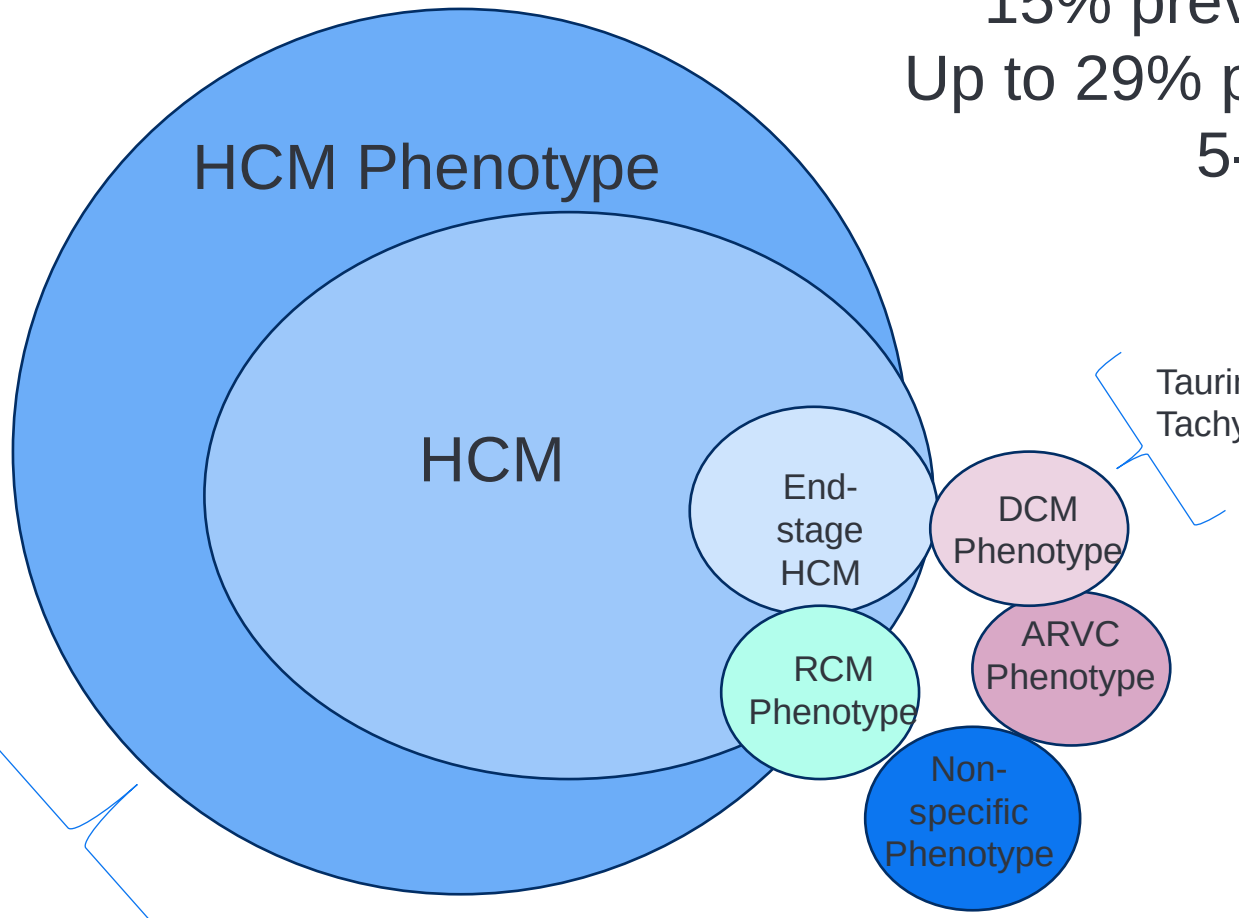
Phenotype	Definition
Hypertrophic Cardiomyopathy (HCM)	Diffuse or regional increase LV wall thickness with a nondilated LV chamber
Restrictive Cardiomyopathy (RCM)	Endomyocardial form: prominent endocardiac scar that bridges IVS and LVFW, may cause mid-LV obstruction. Normal LV dimensions with LA or biatrial enlargement
Dilated Cardiomyopathy (DCM)	LV systolic dysfunction with progressive increase in LV dimensions, normal or reduced LV wall thickness & atrial dilation
Arrhythmogenic cardiomyopathy (AC) or arrhythmogenic right ventricular cardiomyopathy (ARVC)	Severe RA and RV dilation +/- RV systolic dysfunction and wall thinning. Arrhythmias and RCHF common.
Nonspecific phenotype	Not adequately described by the other categories

HCM Phenotype

15% prevalence in feline population

Up to 29% prevalence in older population

5-year mortality 23%



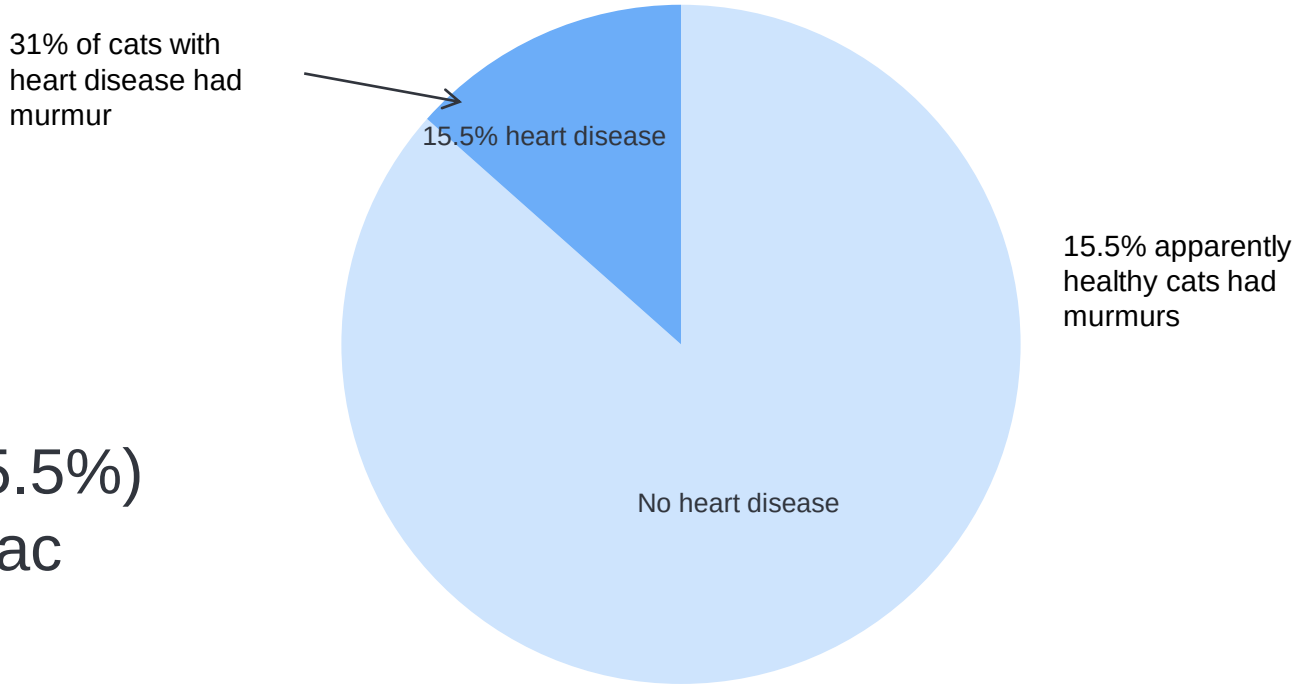
Taurine deficiency
Tachycardia induced

Hypertension
Hyperthyroidism
Acromegaly
Neoplastic
Pseudohypertrophy

Luis Fuentes V, Abbott J, Chetboul V, et al. ACVIM consensus statement guidelines for the classification, diagnosis, and management of cardiomyopathies in cats. *J Vet Intern Med*. 2020; 34: 1062–1077

Fox PR, Keene BW, Lamb K, et al. International collaborative study to assess cardiovascular risk and evaluate long-term health in cats with preclinical hypertrophic cardiomyopathy and apparently healthy cats: the REVEAL study. *J Vet Intern Med.* 2018;32:930-943

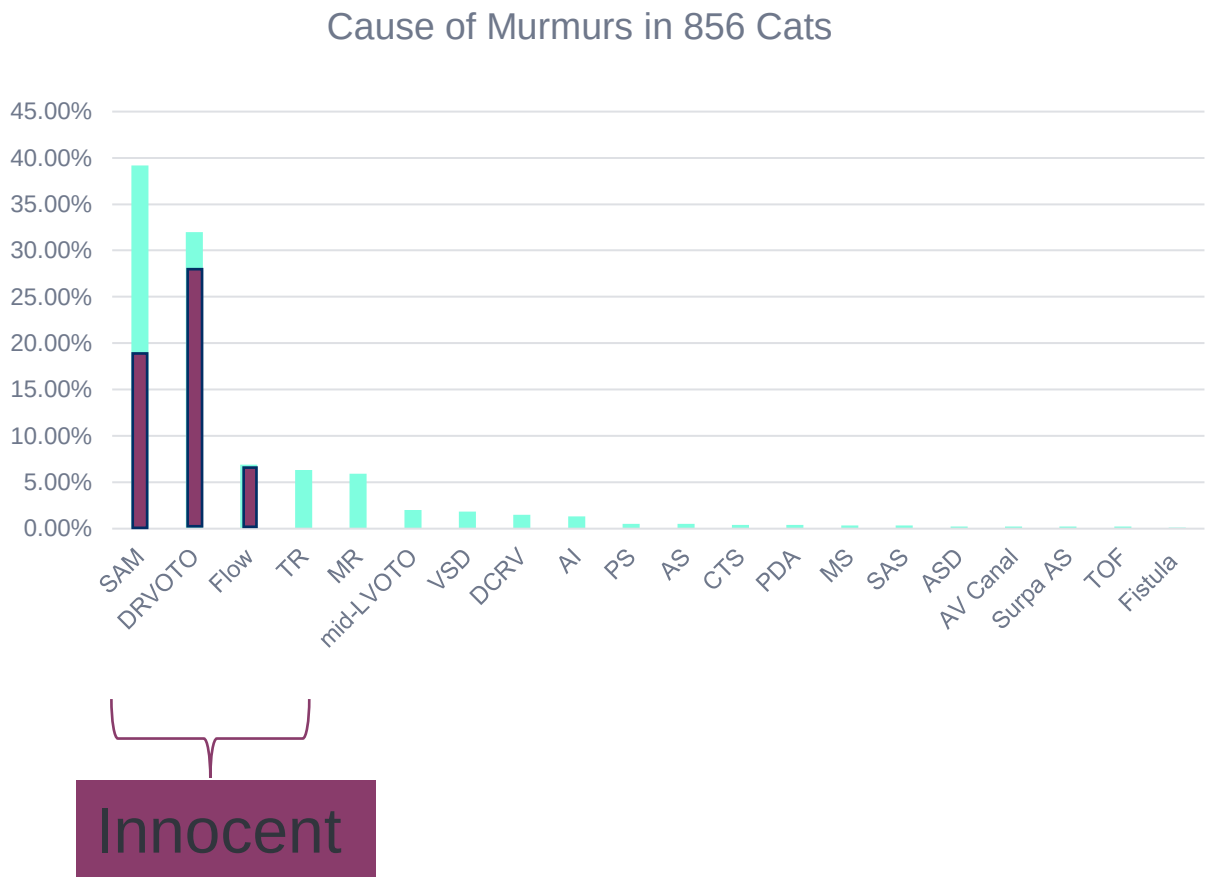
Prevalence of cardiomyopathy in apparently healthy cats



<u>103 cats examined</u>
16 heart murmurs (15.5%)
5/16 had cardiac disease

Sensitivity of auscultation for detection of cardiac disease 31%; 87% specific

Paige CF, Abbott JA, Elvinger F, Pyle RL. Prevalence of cardiomyopathy in apparently healthy cats. *JAVMA*. 2009;234(11):1398–1403.

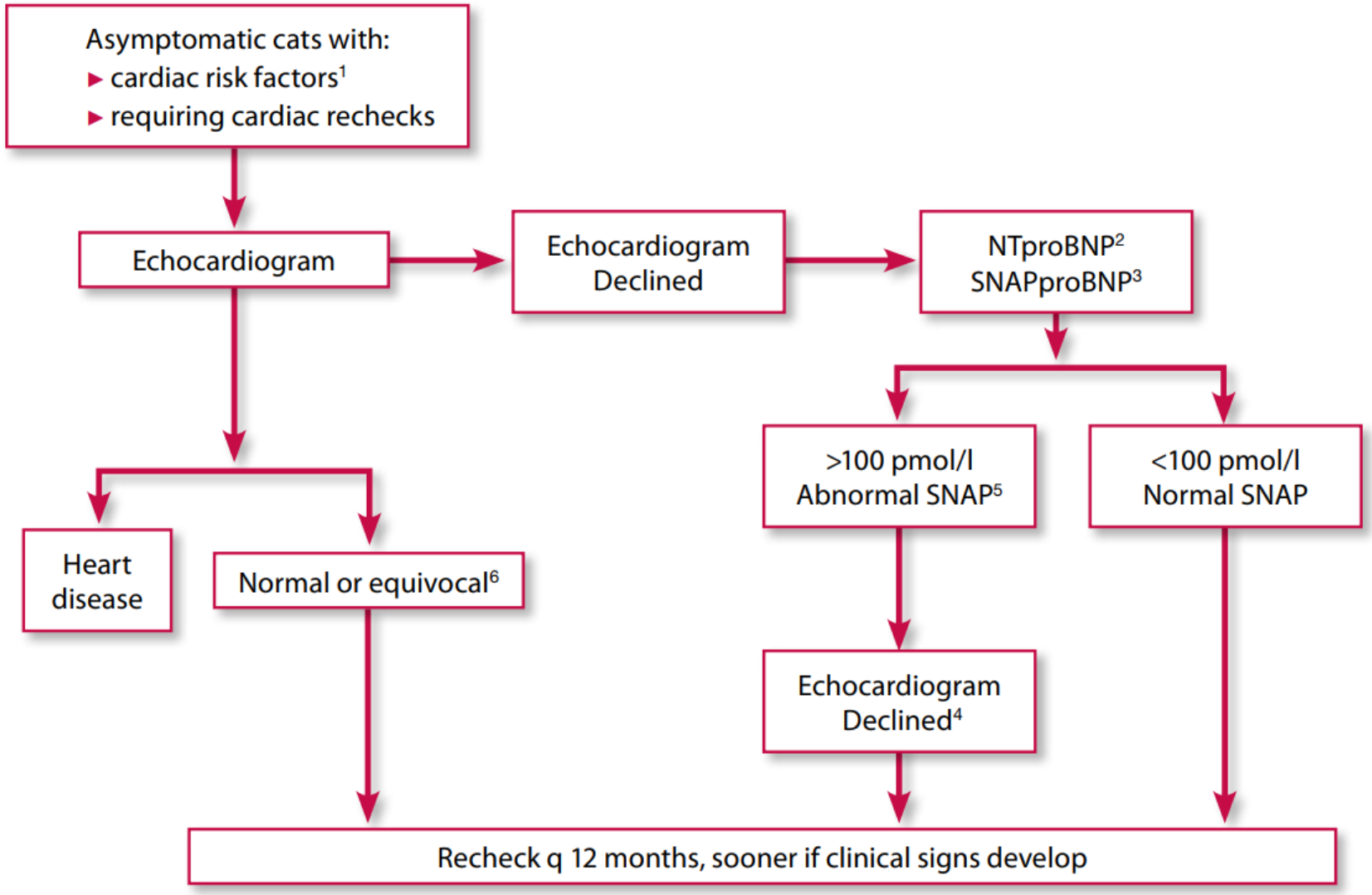


Ferasin L, Ferasin H, Cala A, Creelman N. Prevalence and Clinical Significance of Heart Murmurs Detected on Cardiac Auscultation in 856 Cats. Vet Sci. 2022 Oct 13;9(10):564.

Dynamic RV Outflow Tract Obstruction (DRVOTO)

- Common cause of a physiologic heart murmur
- Considered a benign heart murmur in cats
- Turbulent systolic jet located within the right ventricular (RV) outflow region
- Heard best at high heart rates ventrally over sternum or right sternal border
- Dynamic murmur and often goes away when the cat is calm and has a slower heart rate

For cats, we screen with BNP (SNAP) if there is a family history, breed predisposition or murmur /gallop arrhythmia. I think BNP is a great test in a cat. We may miss mild cases. But if it is high, the cat should get an echo. If it is a breeding cat, they need an echo.



Legend

1 Cardiac risk factors: murmur, gallop, rrhythmia or conduction

2 Cardiopet®proBNP

3 SNAP® Feline proBNP

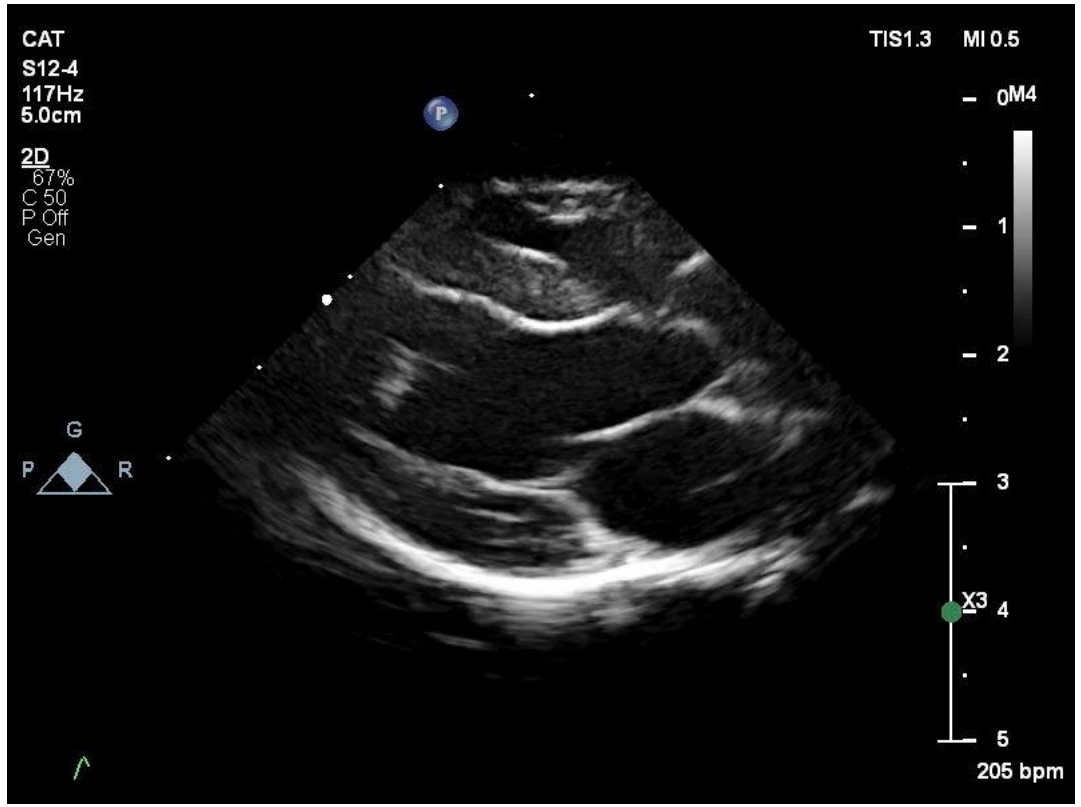
4 If echocardiogram declined in cat with NTproBNP >100 or an Abnormal SNAP consider baseline thoracic radiographs

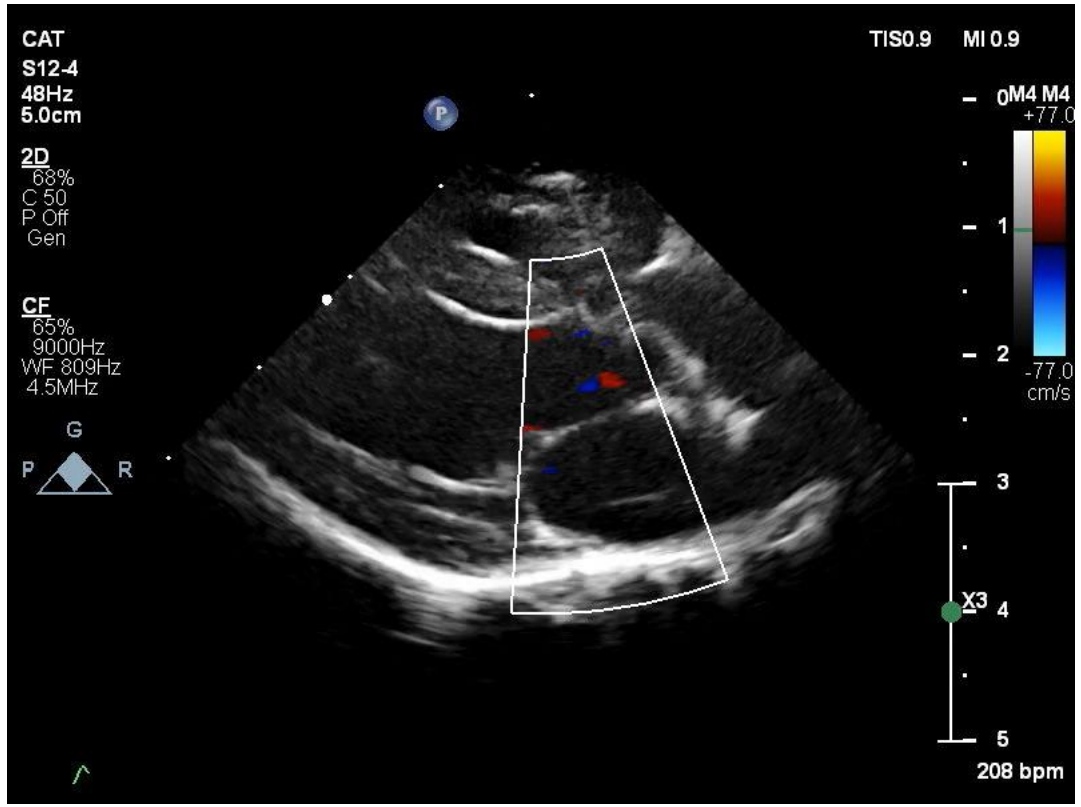
5 Consider an NTproBNP in cats with an abnormal SNAPproBNP for potential future comparison especially if an echocardiogram is declined at this time

6 Consider a baseline NTproBNP test for future comparison in cats where the recommended follow-up echocardiogram is declined

Knowledge of Underlying Cardiac Disease in Cats Can Alter Treatment of Other Disease

- Stressful event
  - Vet visit, anesthesia, etc.
- Steroid - induced HF
  - avoid long acting injectable if possible
- SQ/IV fluids or blood transfusion to cat with silent heart disease
- Systemic diseases
  - Sepsis, Normovolemic anemia, Hyperglobulinemia


CAT
S12-4
117Hz
5.0cm
2D
67%
C 50
P Off
Gen
TIS1.3
MI 0.5
0M4
1
2
3
X3
4
5
205 bpm
G
P
R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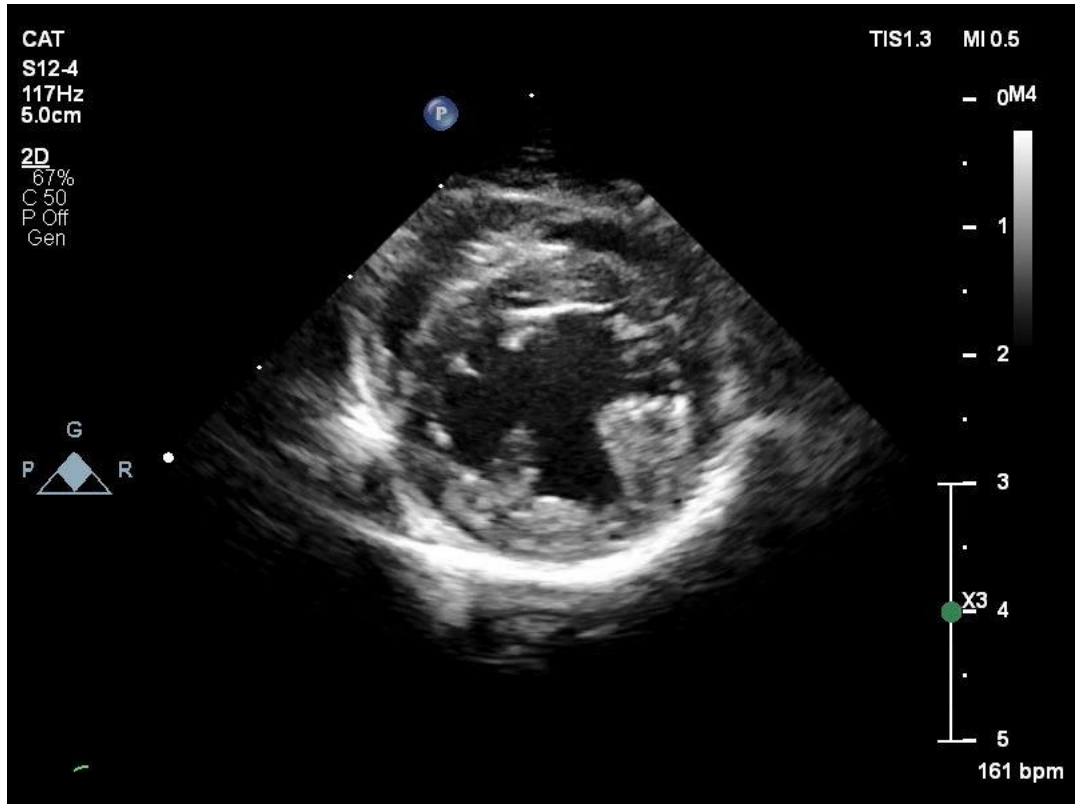
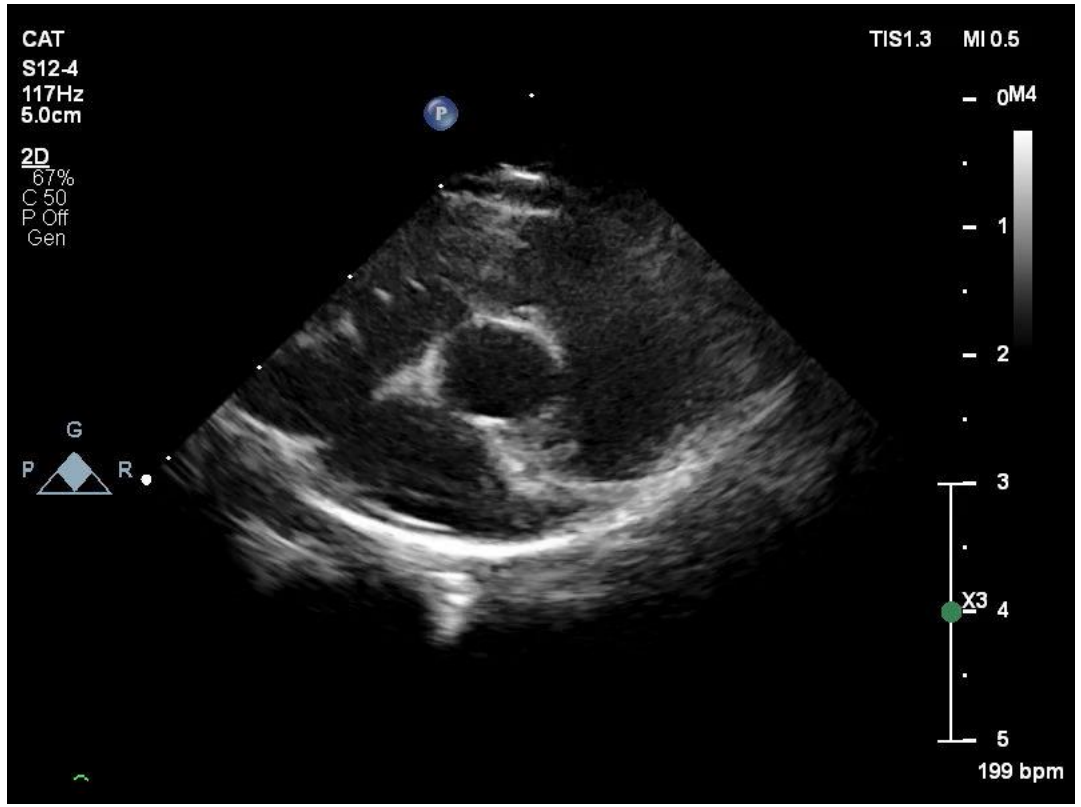
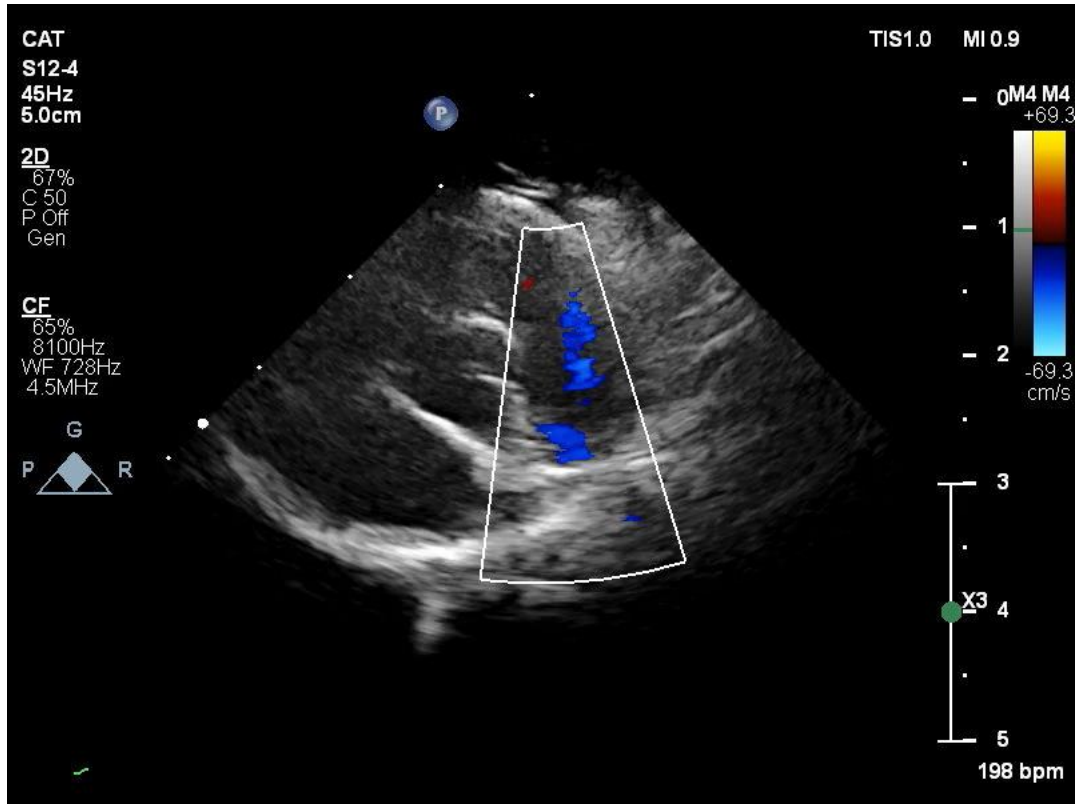
S12-4
48Hz
5.0cm
2D
68%
C 50
P Off
Gen
CF
65%
9000Hz
WF 809Hz
4.5MHz
G
P
R
TIS0.9
MI 0.9
0M4 M4
+77.0
1
2
-77.0
cm/s
3
X3
4
5
208 bpm


CAT
S12-4
117Hz
5.0cm
2D
67%
C 50
P Off
Gen
TIS1.3
MI 0.5
0M4
1
2
3
4
5
X3
G
P
R
161 bpm


CAT
S12-4
117Hz
5.0cm
2D
67%
C 50
P Off
Gen
TIS1.3 MI 0.5
0M4
1
2
3
X3
4
5
199 bpm
G
P
R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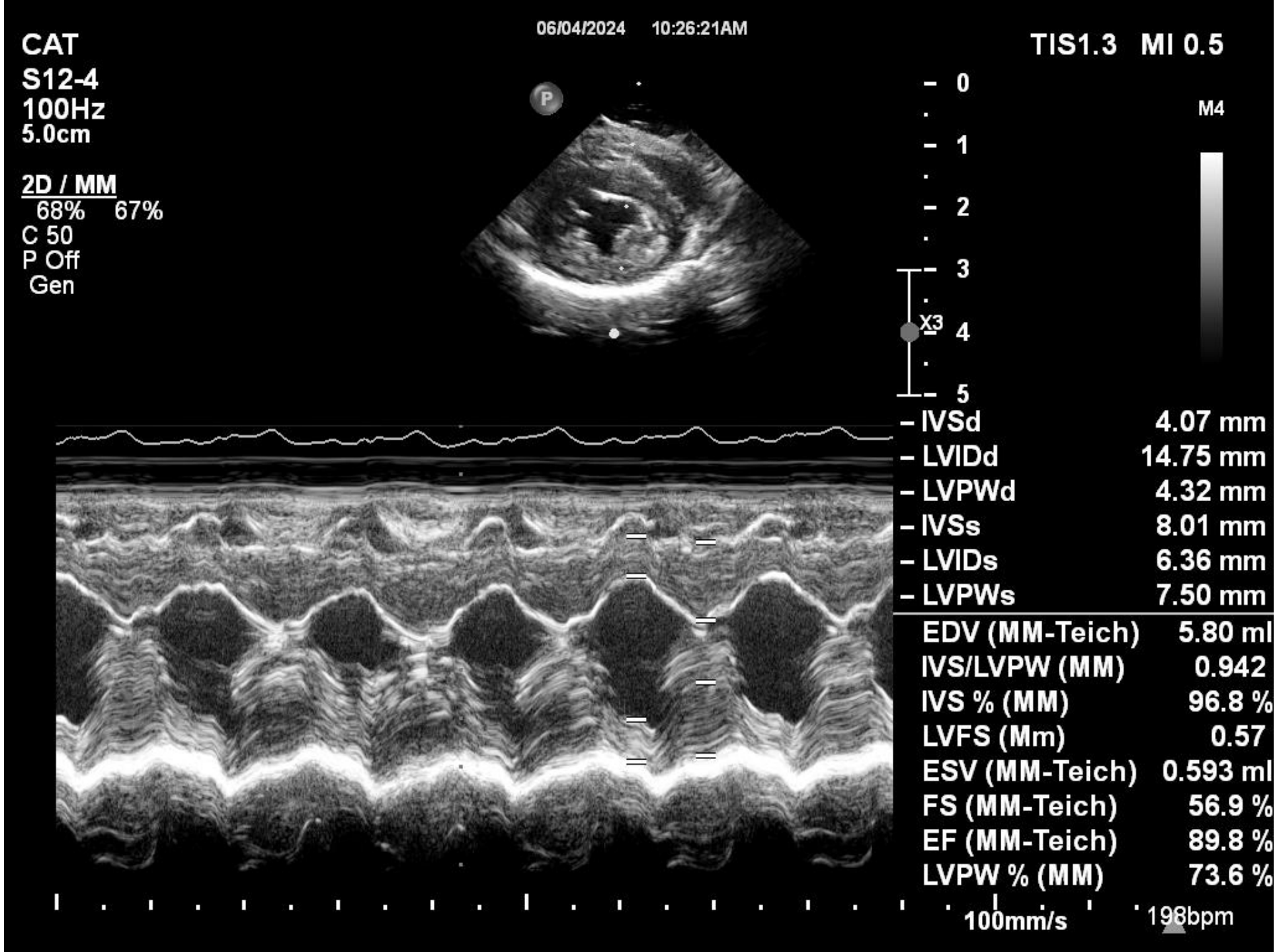
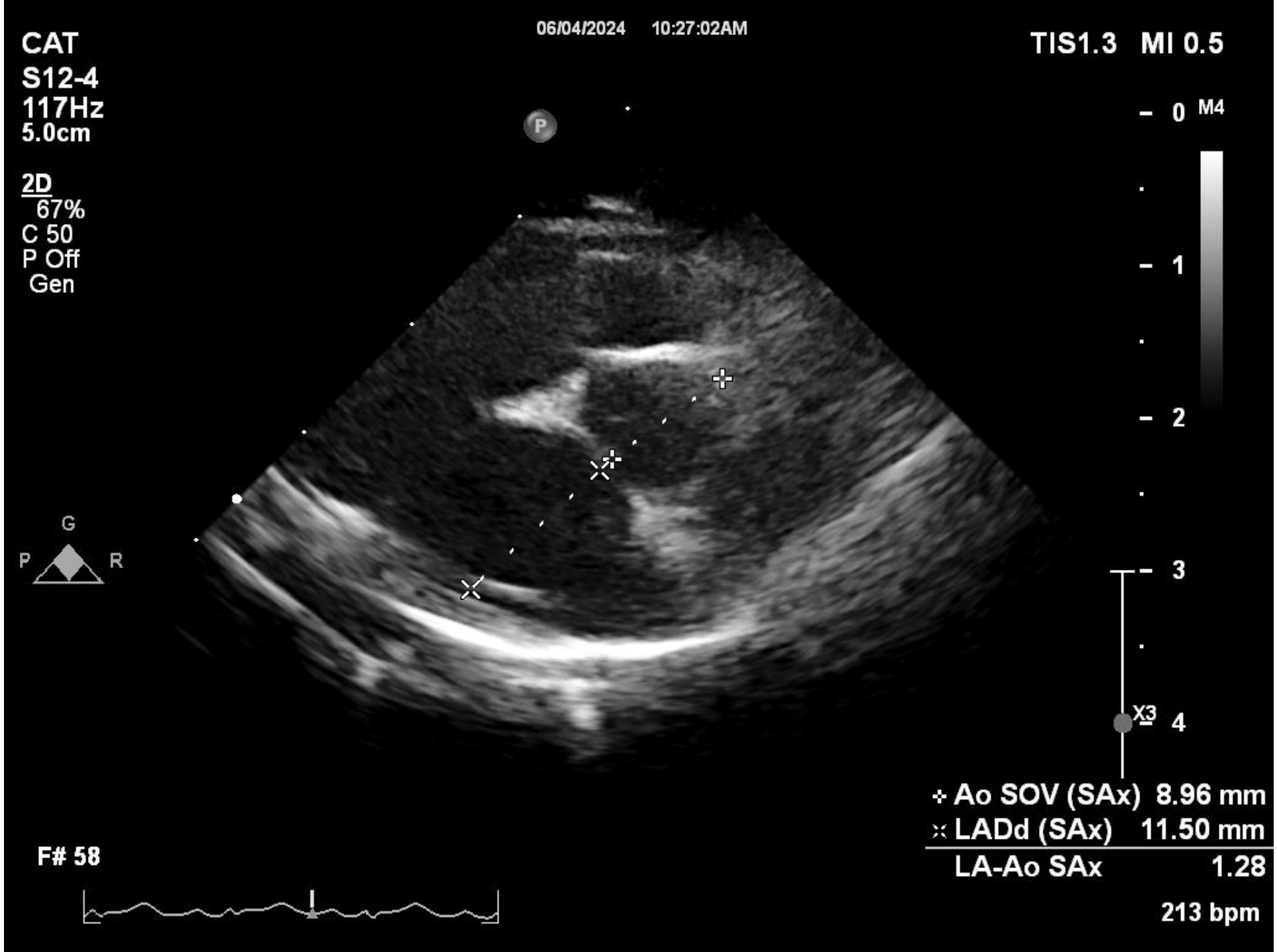
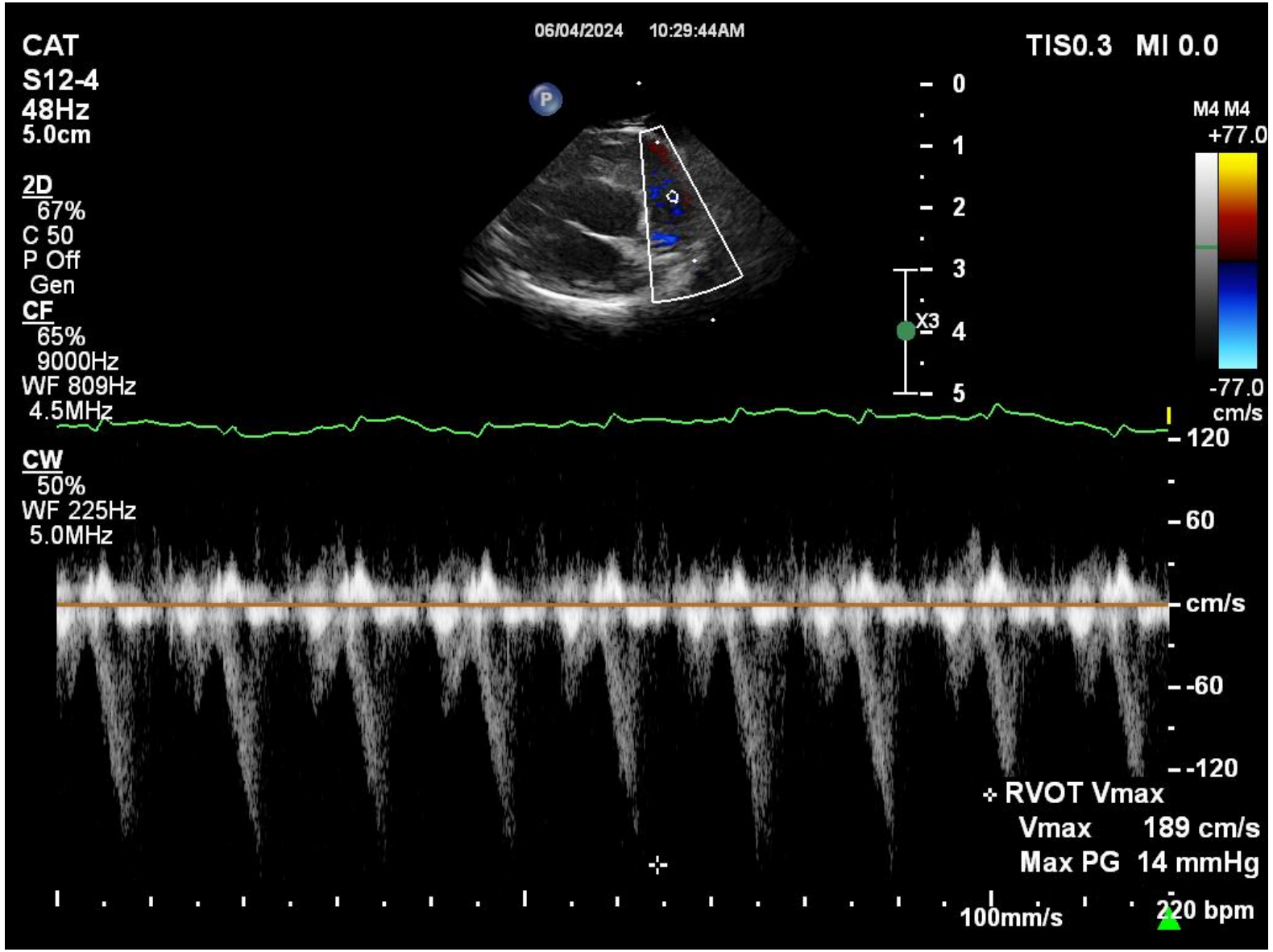
2D
67%
C 50
P Off
Gen
CF
65%
8100Hz
WF 728Hz
4.5MHz
G
P
R
TIS1.0
MI 0.9
0M4 M4
+69.3
1
2
-69.3
cm/s
3
X3
4
5
198 bpm


06/04/2024 10:26:21AM
CAT
S12-4
100Hz
5.0cm
2D / MM
68% 67%
C 50
P Off
Gen
TIS1.3 MI 0.5
M4
0
1
2
3
4
5
X3
IVSd 4.07 mm
LVIDd 14.75 mm
LVPWd 4.32 mm
IVSs 8.01 mm
LVIDs 6.36 mm
LVPWs 7.50 mm
EDV (MM-Teich) 5.80 ml
IVS/LVPW (MM) 0.942
IVS % (MM) 96.8 %
LVFS (Mm) 0.57
ESV (MM-Teich) 0.593 ml
FS (MM-Teich) 56.9 %
EF (MM-Teich) 89.8 %
LVPW % (MM) 73.6 %
100mm/s
198bpm


CAT
S12-4
117Hz
5.0cm
2D
67%
C 50
P Off
Gen
06/04/2024 10:27:02AM
TIS1.3 MI 0.5
M4
0
1
2
3
4
G
P
R
Ao SOV (SAx) 8.96 mm
LADd (SAx) 11.50 mm
LA-Ao SAx 1.28
213 bpm
F# 58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5.0cm
2D
67%
C 50
P Off
Gen
CF
65%
9000Hz
WF 809Hz
4.5MHz
CW
50%
WF 225Hz
5.0MHz
06/04/2024 10:29:44AM
TIS0.3 MI 0.0
M4 M4
+77.0
-77.0
cm/s
120
60
cm/s
-60
-120
RVOT Vmax
Vmax 189 cm/s
Max PG 14 mmHg
100mm/s
220 bpm

Outcome

+ Physiologic murmur due to dynamic right ventricular outflow tract obstruction
+ Normal BNP (25)
+ No medications
+ Follow with serial BNP rather than echos.

Summary

- Screening tests are generally more useful in at risk populations, or in populations with a higher prevalence of disease
- Early identification of disease does not always mean we can change the course of disease, but we can adjust client expectations, anesthetic protocols, medication adjustments and customer education.
- There is not one test to screen for all cardiac diseases.