
VMX
2025
VETERINARY MEETING & EXPO
Festival of the HeARTS
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JANUARY 25-29
ORLANDO, FLORIDA
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Hidden Heartbreak: Diagnosing Early Cardiac Disease

Dr. Allison Spake, DVM, DACVIM (Cardiology)

VMX 2025 VETERINARY MEETING & EXPO

Conflict of Interest Disclosure:

I have financial interest, arrangement or affiliation with:

IDEXX: Full time employee & own IDEXX stock.

VMX 2025 VETERINARY MEETING & EXPO

Agenda

- Overview of most common screening tests for cardiac diseases in dogs and cats
- Overview of most common diseases in dogs and cats and how to screen for these diseases
- Case examples

CARDIAC EDUCATION group

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Cardiac Education Group

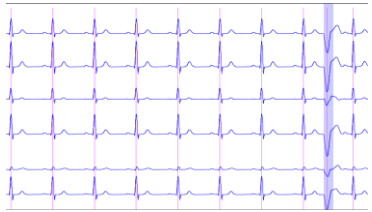
Is a not-for-profit group of board-certified veterinary cardiologists from both academia and private practice that offers independent recommendations to veterinary practitioners for the evaluation and treatment of canine and feline heart disease.

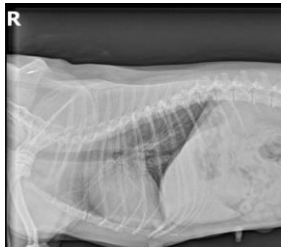
LEARN MORE

Cardiaceducationgroup.org

Screening tests

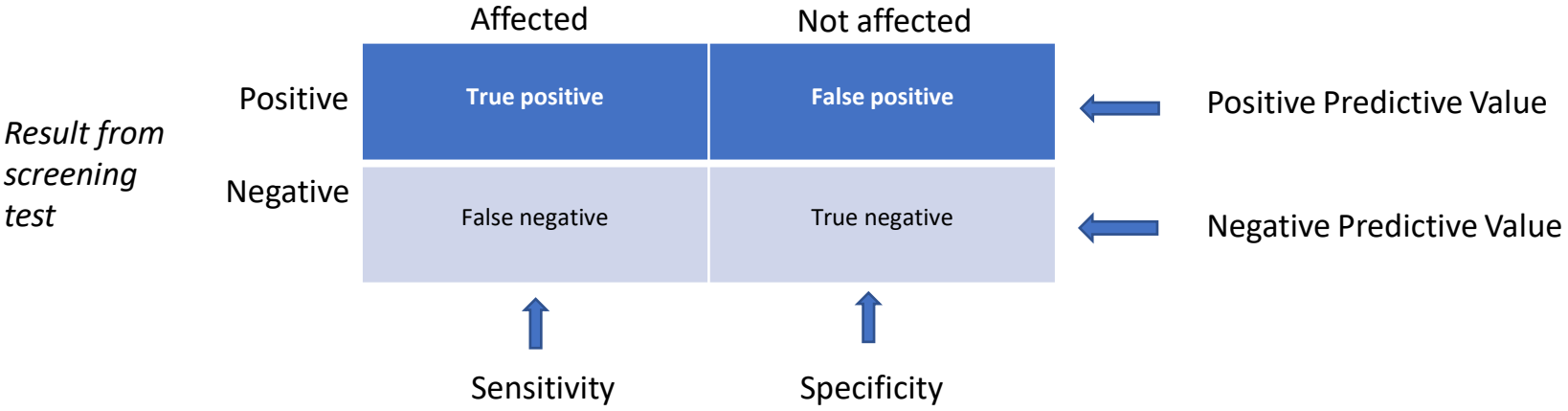
- Widely available
- Inexpensive
- Non-invasive
- Reliable





What happens when you screen all healthy patients?

Status of patient according to reference standard



Sensitivity = (True positive/True positive + False negative) x 100

Specificity = (True negative/False positive + True negative) x 100

Positive PV = (True positive/True positive + False positive) x 100

Negative PV = (True negative/True negative + False negative x 100

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.

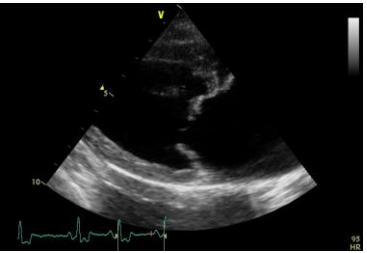
		Affected	Not affected	
Positive	(25*0.68)	17.0	27.0	Sensitivity: 68.0
Negative		8.0	48.0	Specificity: 64.0
Increase to 25% prevalence				PPV: **38.6**
Total patients: 100.0		25.0	75.0	NPV: **85.7**

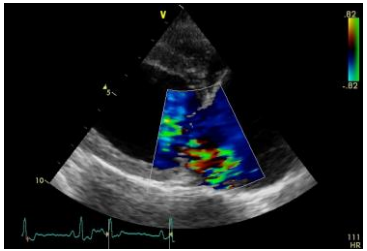
PPV = 17 / (17+27)
PPV = 38.6

Screening tests for cardiac disease

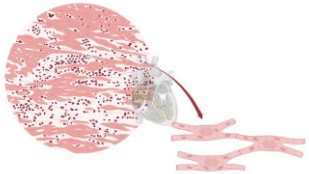
- HISTORY: response to previous anesthetic events? Known medical conditions? Previous adverse drug responses? Medication list? History of syncope? Coughing? Tachypnea?
- PHYSICAL EXAM: Murmur or arrhythmia?
- ECG
- Biomarkers: Nt-Pro BNP, Troponin
- Thoracic Radiographs
- Genetic Testing

BNP Refresher

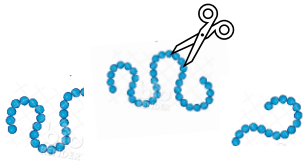




Increased Wall Stress



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

Images generated from biorender.com

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
- 5 centers
- Significant differences within breed and between breeds
- Labs and NF highest
- Dachshunds lowest
- Limitation - young adult to middle-aged dogs

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

ELSEVIER

Journal of Veterinary Cardiology
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]

CrossMark

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

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

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

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.

Radiographs

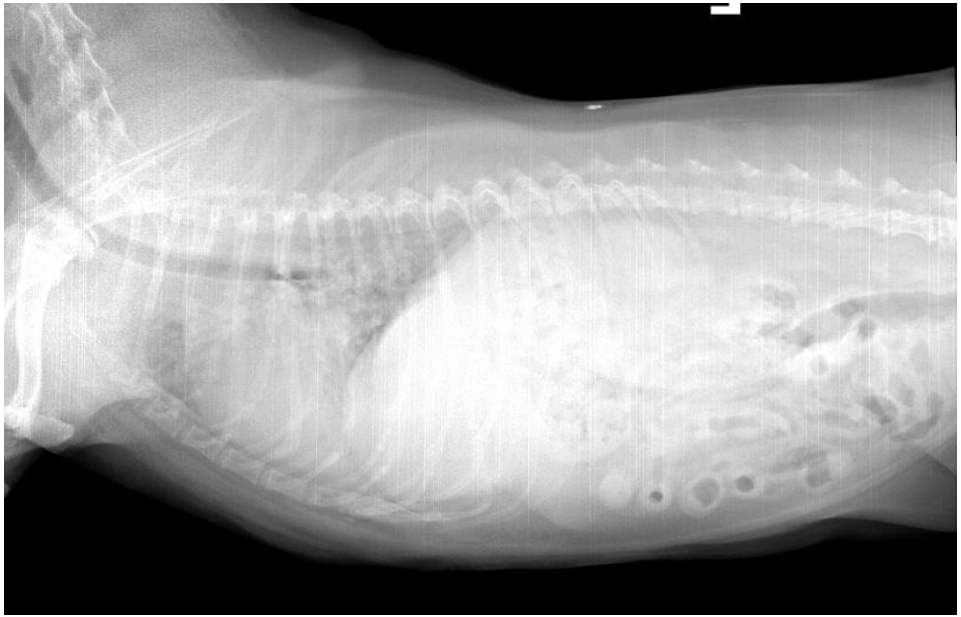
Subtitle

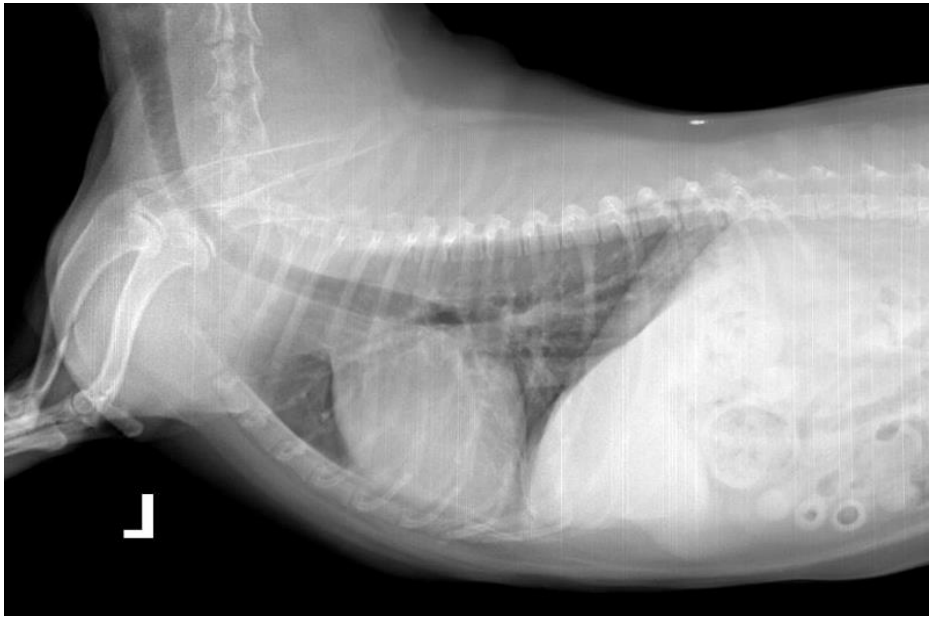
Helpful Reminders

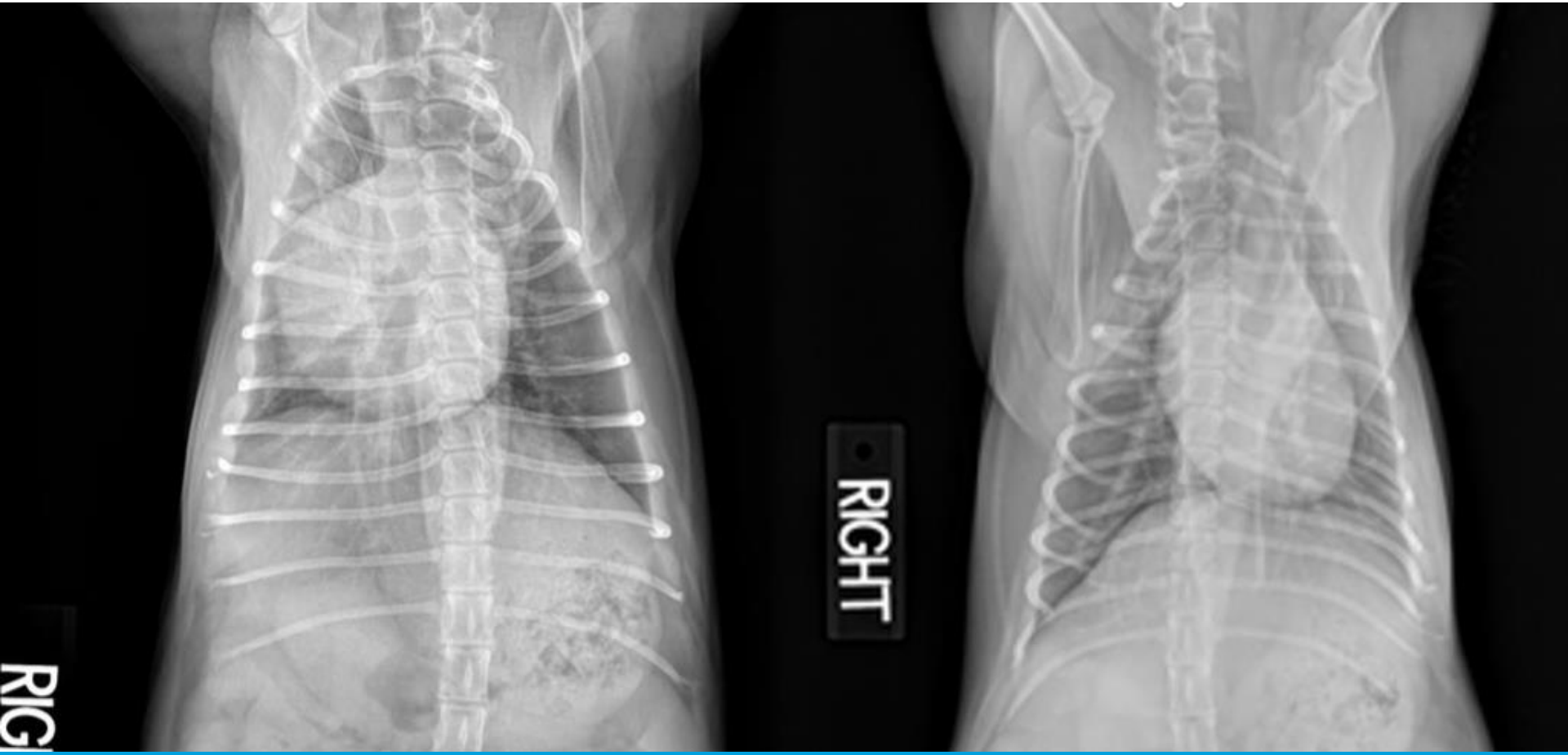
- Three view thorax is standard (RL / LL / DV or VD)
- Technique and positioning matter!
- Cardiac silhouette is combination of blood and walls, so cannot determine if concentric hypertrophy present on radiographs alone
- Congestive heart failure is a radiographic diagnosis
  - An echo cannot easily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

A note on positioning and technique

Same Dogs, Same day






RIGHT

ECG / Holter Monitor

Subtitle

Some 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.

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.

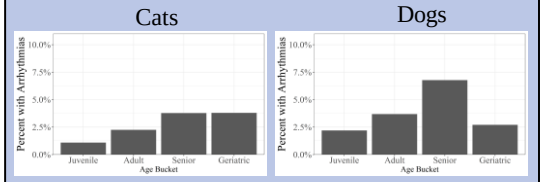
A total of 53,708 electrocardiograms were included from 108 different dog breeds and 9,440 electrocardiograms were included from 16 different cat breeds. Exclusion criteria included treatment with anti-arrhythmic drugs, recent atropine administration, recent sedation (including alpha-2 agonists), missing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

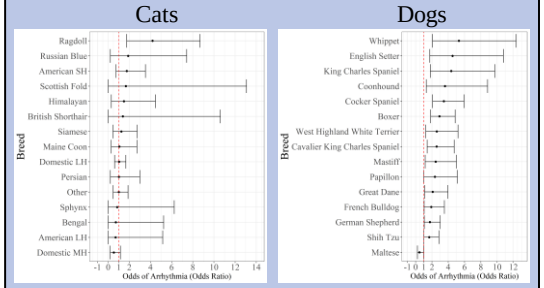
Conflict of Interest Statement

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.

Arrythmia 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

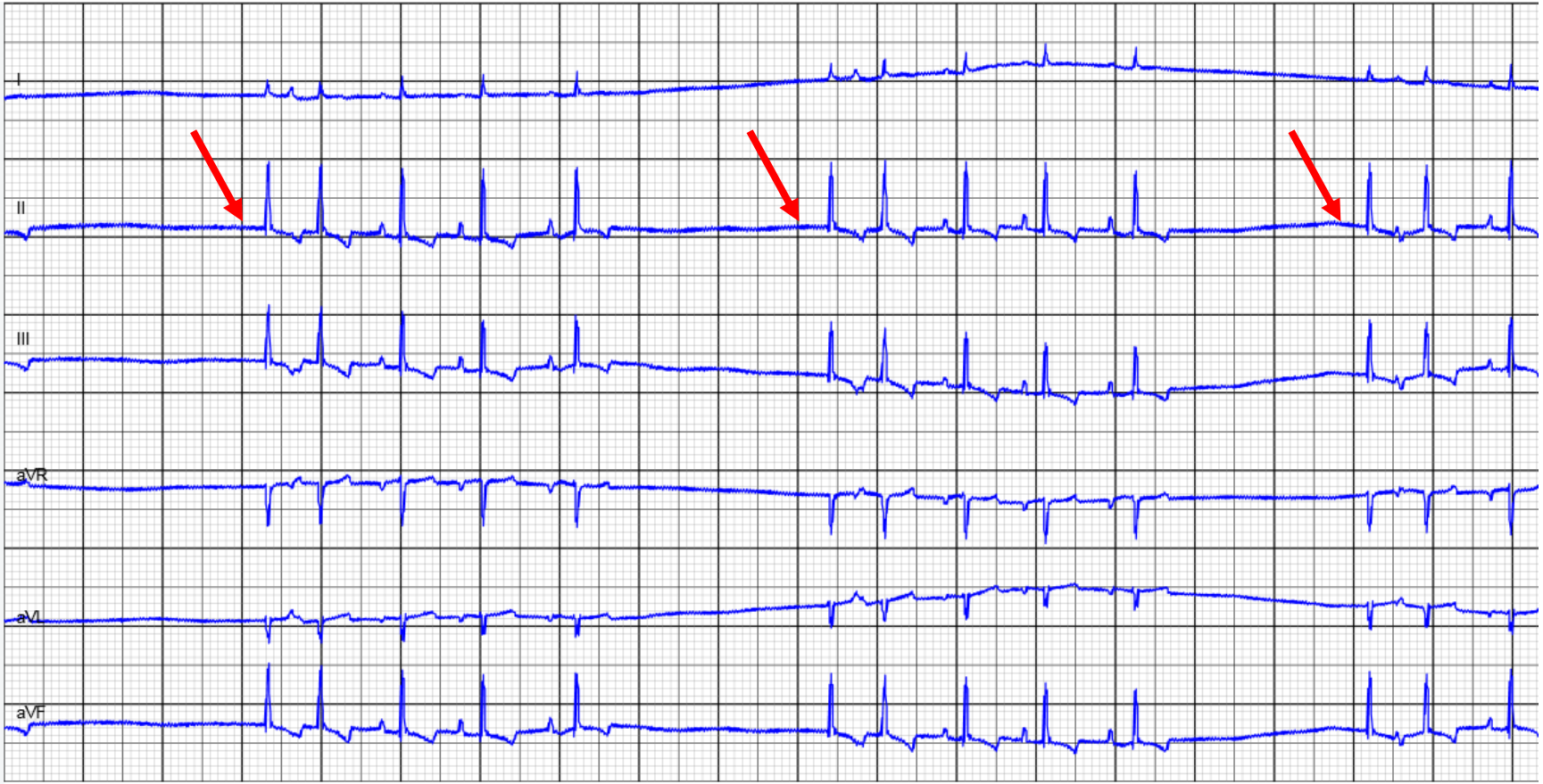
These findings demonstrated the value of including electrocardiograms in screening protocols for dog and cat patients, especially those in at-risk age brackets and breeds, to create suitable anesthetic protocols and guide further diagnostics and treatment.

9 yo FS Schnauzer

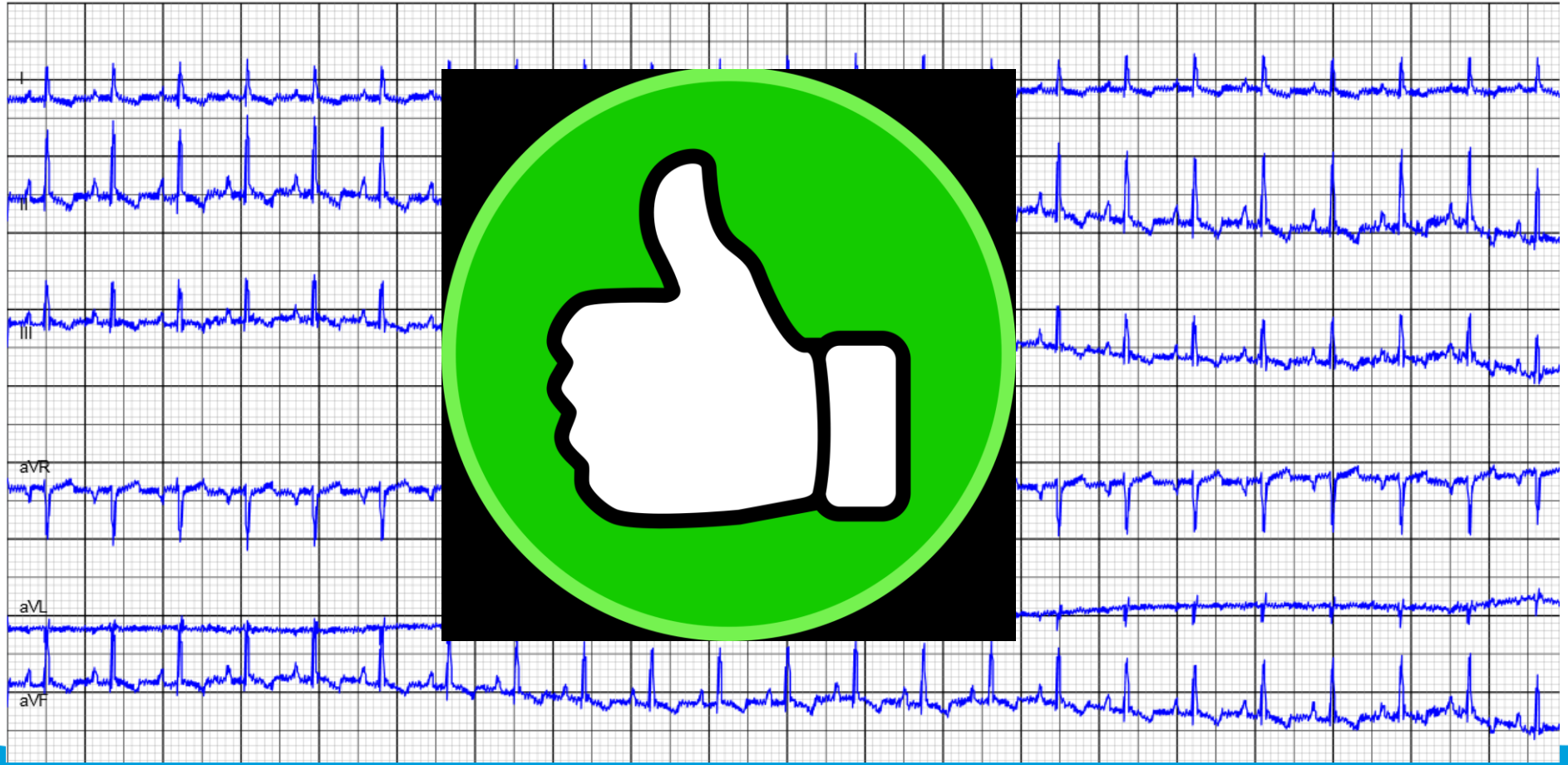
- Presenting for a dental procedure.
- Prominent sinus arrhythmia on PE.

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?

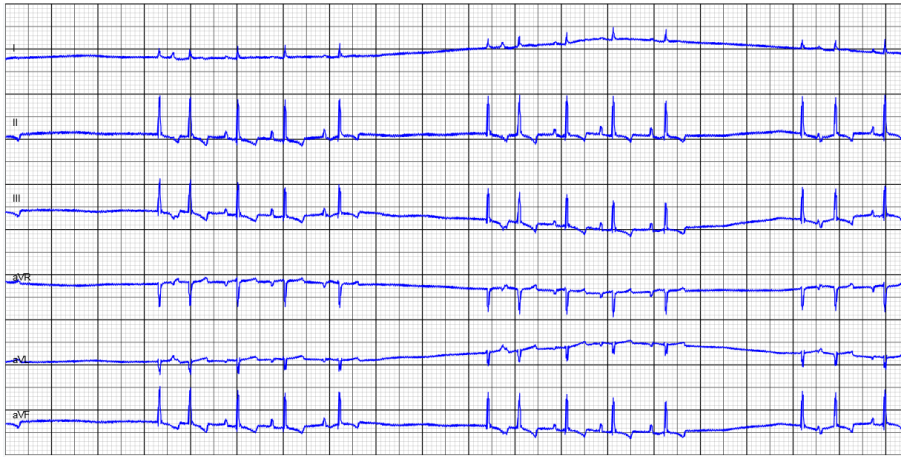


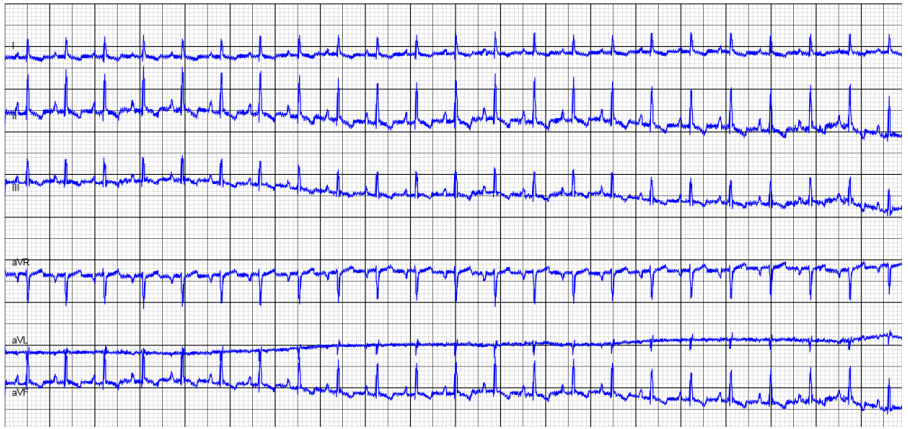
Post Atropine ECG

Conclusions

Signalment and physical exam prompted appropriate diagnostic

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



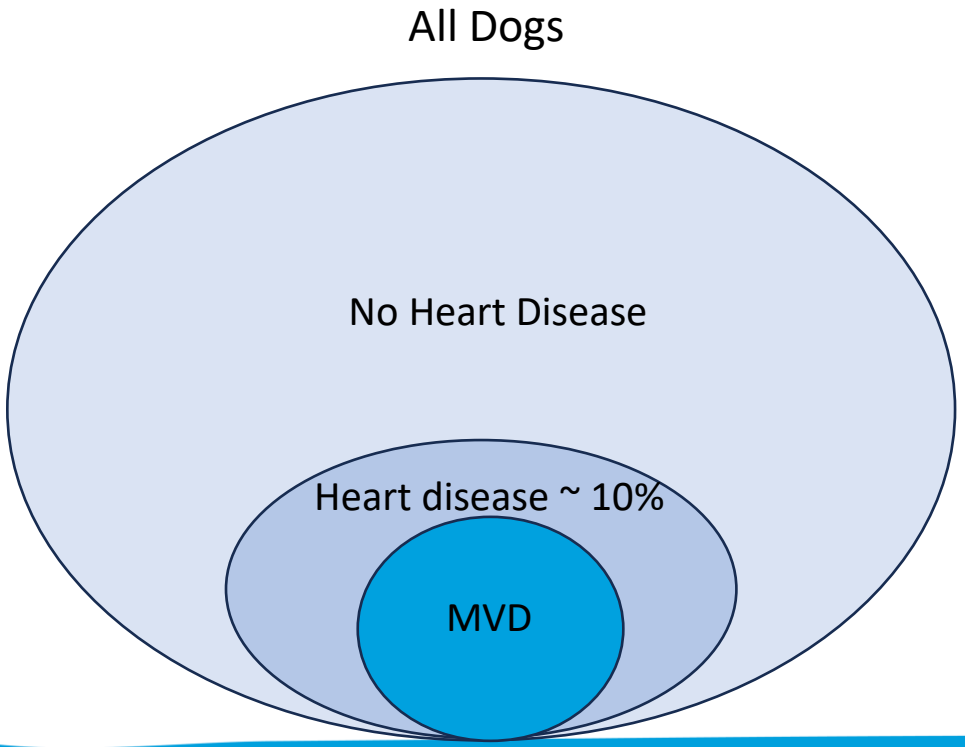


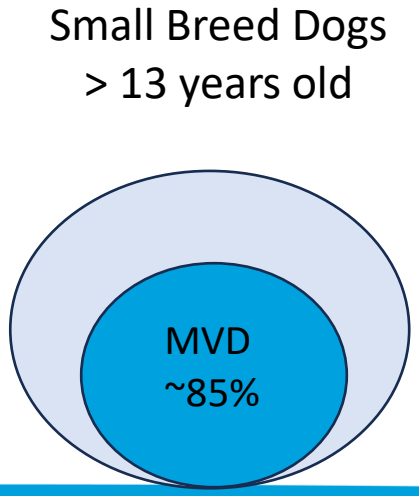
Mitral Valve Disease

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





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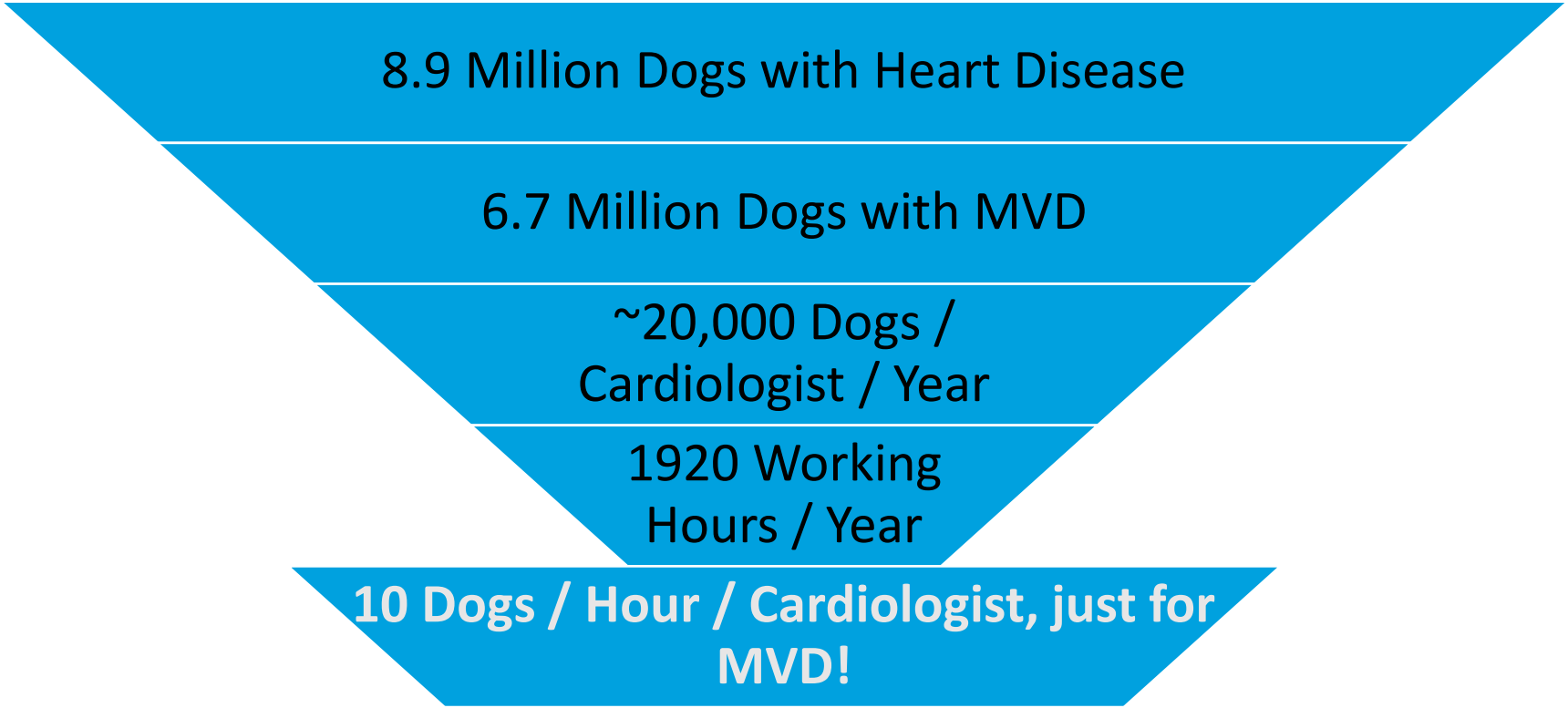
Buchanan JW. Chronic valvular disease (endocardiosis) in dogs. *Adv Vet Sci Comp Med*. 1977; **21**: 75-106



[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 myxomatous mitral valve disease in dogs. *J Vet Intern Med* 2019;33:1127-1140

VMX 2025 VETERINARY MEETING & EXPO

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

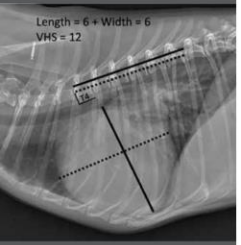
Hidden heartbreak

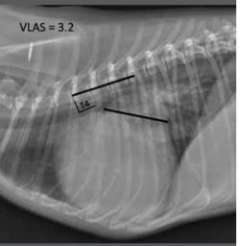
B

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:

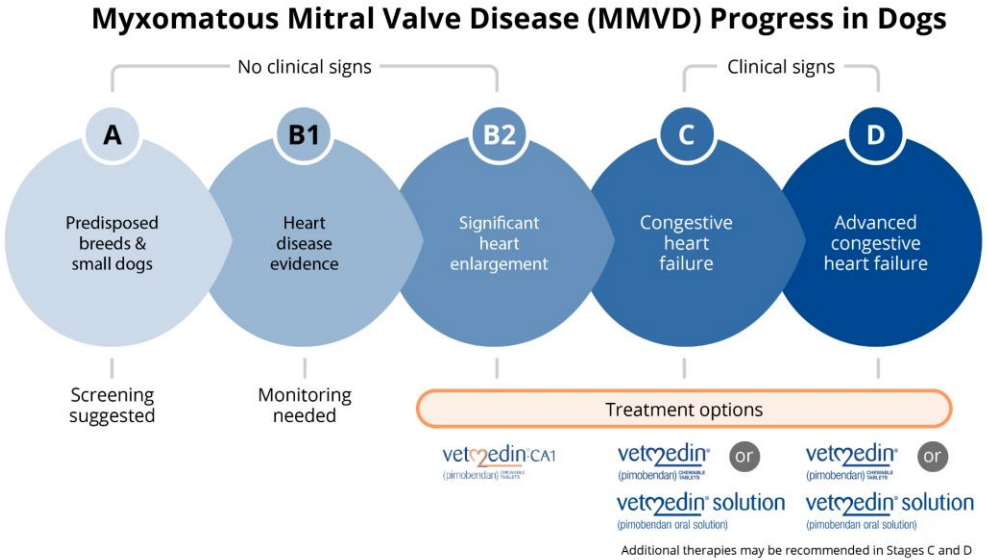
- **Stage B1:** Dogs with no radiographic or echocardiographic evidence of cardiac remodeling (heart enlargement) or remodeling that is not severe enough to meet current clinical trial criteria used to determine initiation of treatment.
- **Stage B2:** Dogs with remodeling that is severe enough to support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

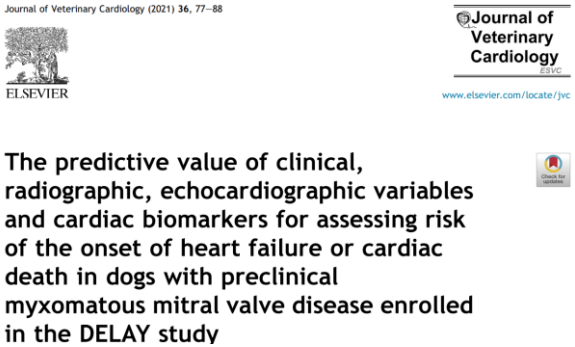
1. Echocardiography – gold standard
   LA:Ao >/= 1.6 AND LVIDDN >/=1.7
2. Radiographs with >/= 3/6 murmur
   VHS >/= 11.5 or VLAS >/= 3



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

LVEDDn, LA:Ao and NTproBNP strong predictors for heart failure



Journal of Veterinary Cardiology (2021) 36, 77–88

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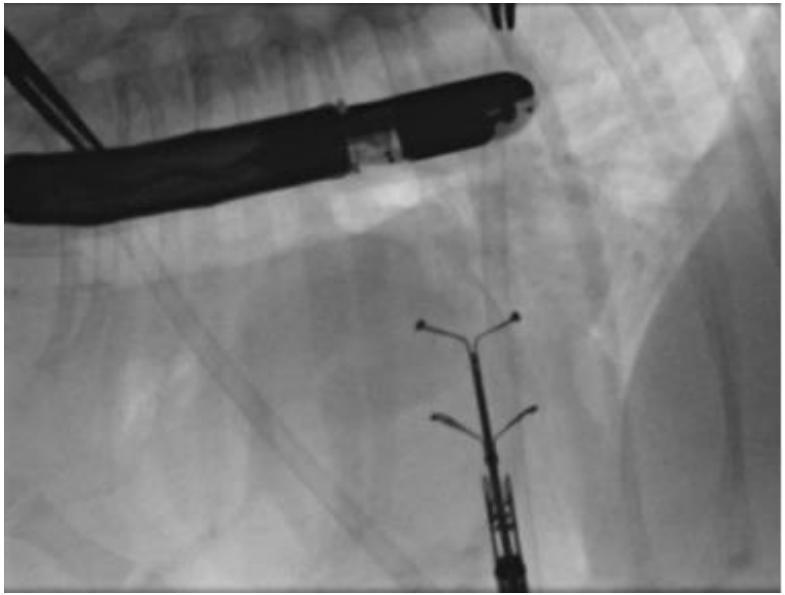
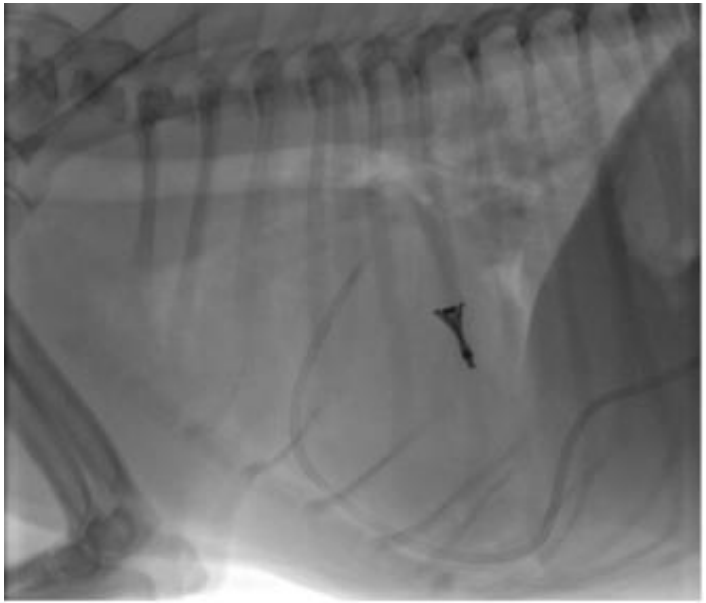
The predictive value of clinical, radiographic, echocardiographic variables and cardiac biomarkers for assessing risk of the onset of heart failure or cardiac death in dogs with preclinical myxomatous mitral valve disease enrolled in the DELAY study

DELAY study gave insight into factors predicting time to CHF in this group such as BNP, LA:Ao, LVEDDn

M. Borgarelli, L. Ferasin, K. Lamb, D. Chiavegato, C. Bussadori, G. D'Agnolo, F. Migliorini, M. Poggi, R.A. Santilli, E. Guillot, C. Garelli-Paar, R. Toschi Corneliani, F. Farina, A. Zani, M. Dirven, P. Smets, C. Guglielmini, P. Oliveira, M. Di Marcello, F. Porciello, S. Crosara, P. Ciaramella, D. Piantedosi, S. Smith, S. Vannini, E. Dall'Aglio, P. Savarino, C. Quintavalla, M. Patteson, J. Silva, C. Locatelli, M. Baron Toaldo, The predictive value of clinical, radiographic, echocardiographic variables and cardiac biomarkers for assessing risk of the onset of heart failure or cardiac death in dogs with preclinical myxomatous mitral valve disease enrolled in the DELAY study, Journal of Veterinary Cardiology, Volume 36, 2021, Pages 77-88

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 high amounts of 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]
- 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.
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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 (5 min)
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

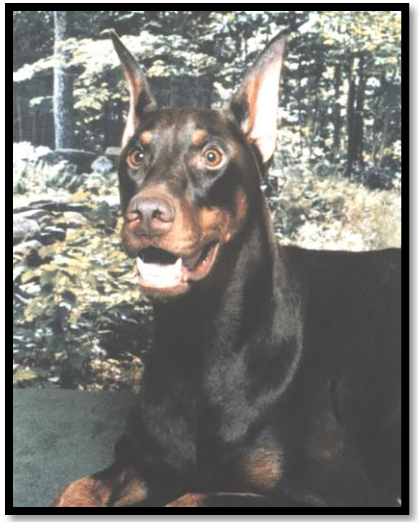
11. Blood pressure assessment is used to document normal blood pressure and rule out systemic hypertension.
12. Thoracic radiographs serve as baseline for future comparison if signs consistent with CHF develop. In addition, when an echocardiogram is not available, radiographic cardiomegaly, in particular 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)

Troponin in occult Doberman DCM

Wess JVIM 2010



Wess, G., Simak, J., Mahling, M. and Hartmann, K. (2010), Cardiac Troponin I in Doberman Pinschers with Cardiomyopathy. Journal of Veterinary Internal Medicine, 24: 843-849

Journal of Veterinary Cardiology (2023) 47, 1–13

ELSEVIER

ww

Long-term outcome and troponin I concentrations in Great Danes screened for dilated cardiomyopathy: an observational retrospective epidemiological study☆

S. El Sharkawy, PhD[a,b], J. Dukes-McEwan, PhD[a], H. Abdelrahman, PhD[c], H. Stephenson, BVMS[a,d,*]

124 Great Danes

J Vet Cardiol. 2022 Apr:40:69-83. doi: 10.1016/j.jvc.2022.01.004. Epub 2022 Feb 2.

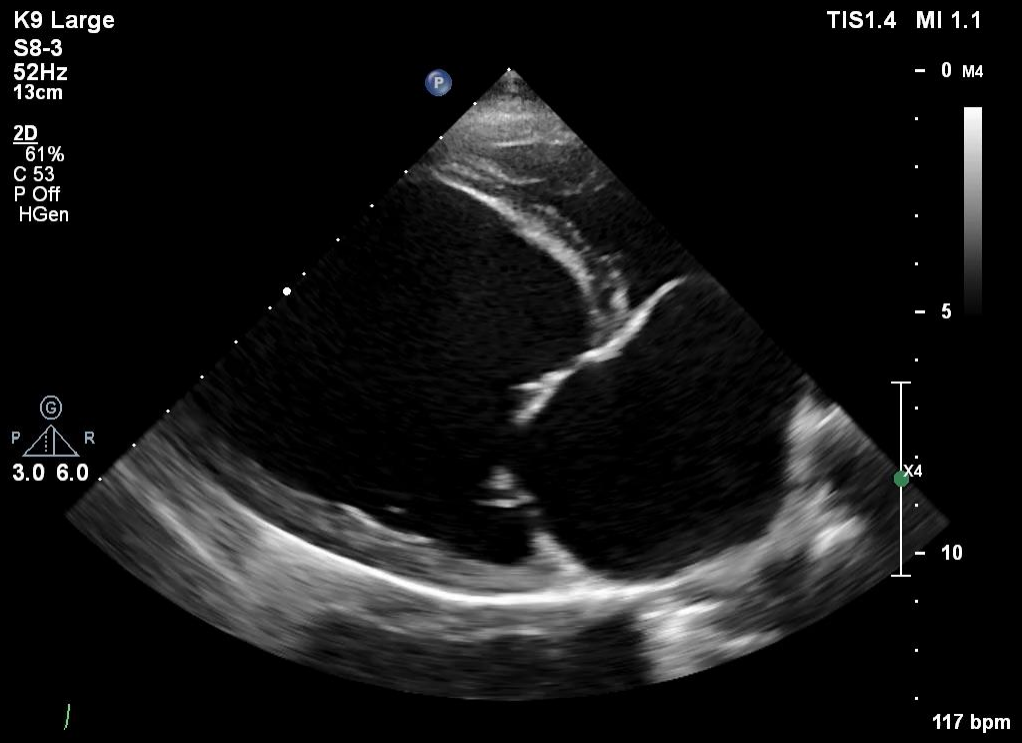
Prospective evaluation of the combined value of physical examination and biomarker variables in screening for preclinical dilated cardiomyopathy in Doberman Pinschers

S G Gordon [1], S Wesselowski [2], A H Estrada [3], L Braz-Ruivo [4], N Morris [5], J Häggström [6], M R O'Grady [7], E Malcolm [2]

NTproBNP cut-off ≥548 pmol/L - 100% Se & 77.3% Sp for detecting PC-DCM-Echo.

6 Year Old, FS American Staffordshire Terrier

- Lethargic 1 week
- Anorexic 1 day
- 3/6 left and right sided systolic murmur
- Grain free diet
- NTproBNP > 10,000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52Hz
13cm
2D
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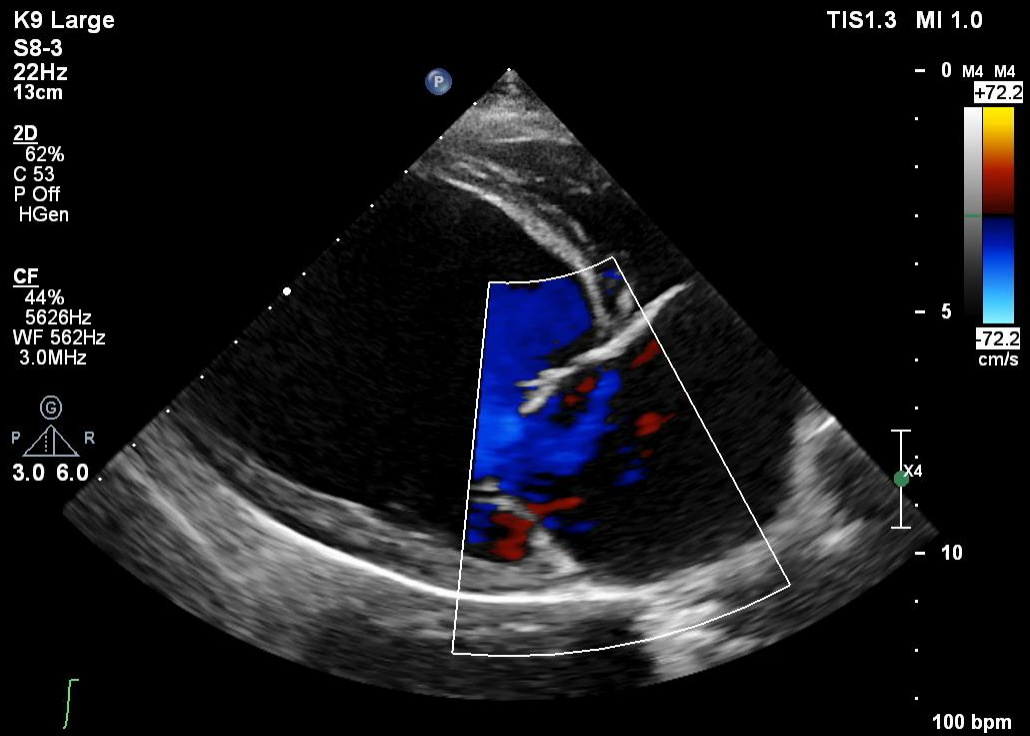
C 53
P Off
HGen
TIS1.4 MI 1.1
0 M4
5
10
117 bpm
P
R
3.0 6.0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5626Hz
WF 562Hz
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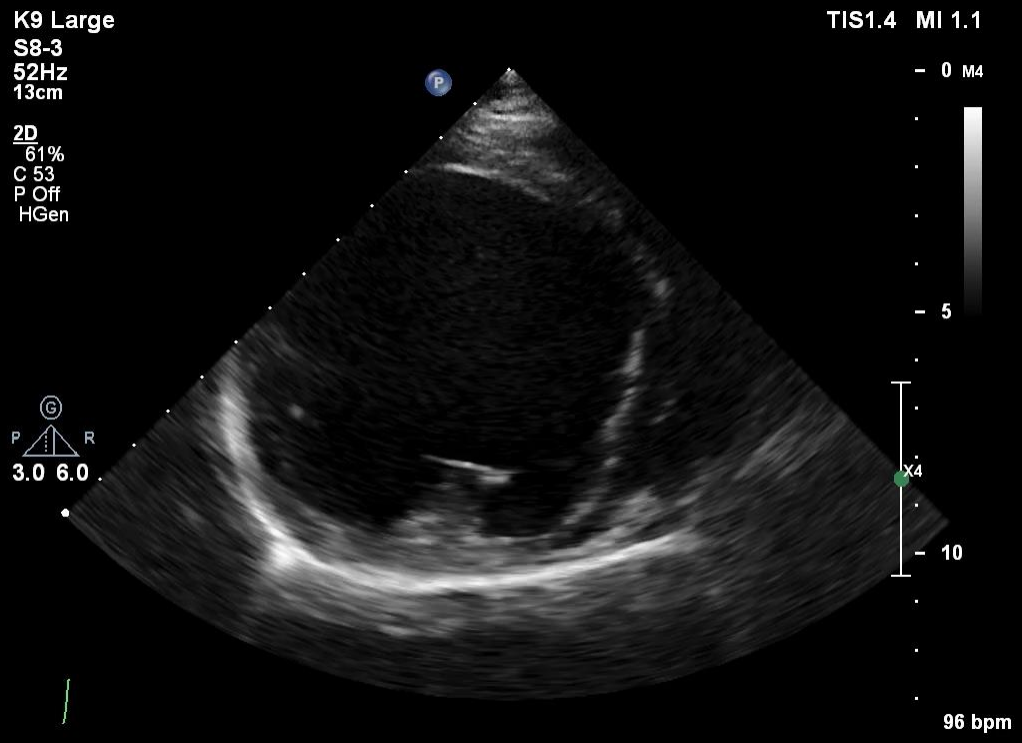
0
M4 M4
+72.2
5
-72.2
cm/s
10
100 bpm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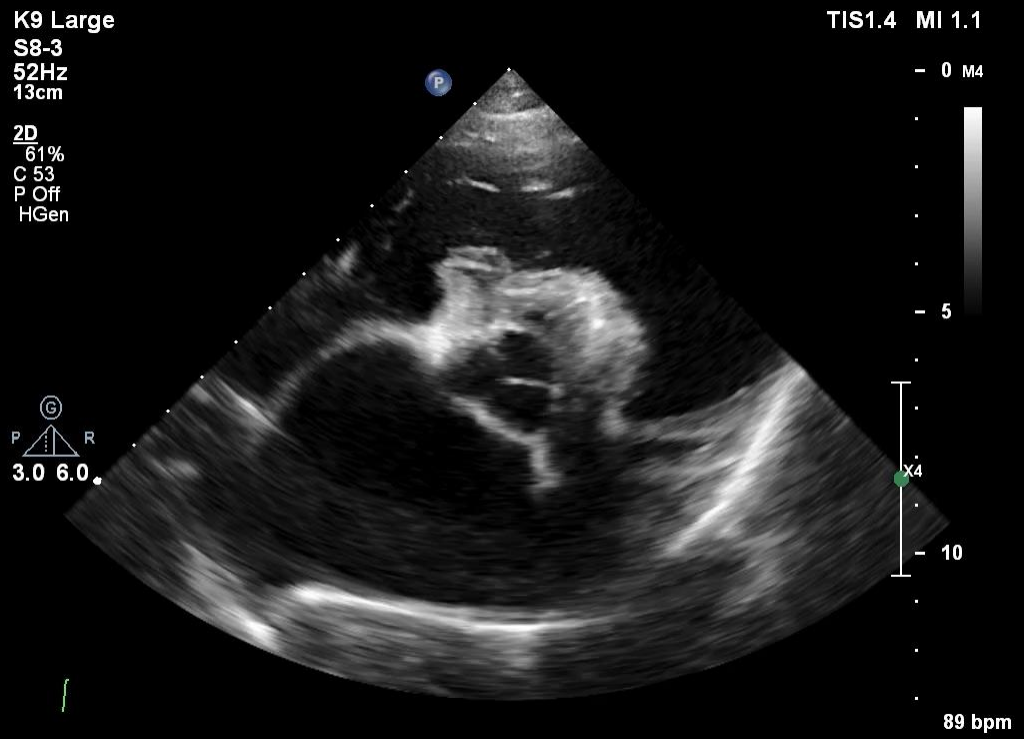
3.0 6.0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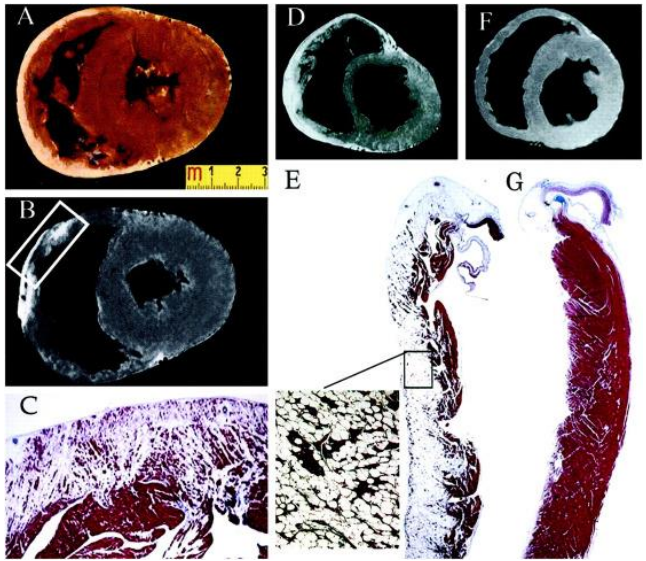
Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC)



Hereditary, adult-onset disease (~6 years)

Replacement of myocytes with fatty or fibrofatty infiltrates

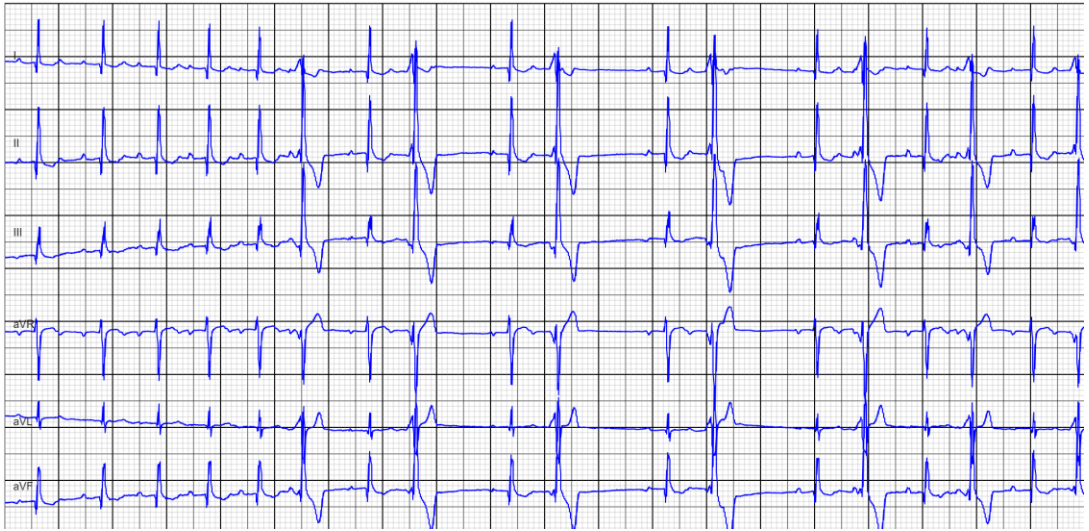
Typical VPCs: Left bundle branch block morphology" because originate in the RV

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.

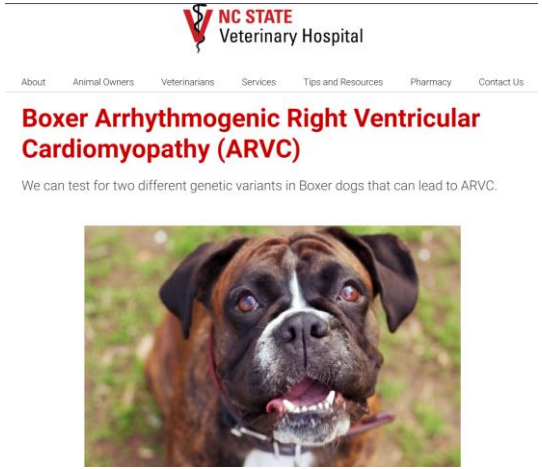
ARVC — Right Ventricular Origin VPCs



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]

HCM Phenotype

15% prevalence in feline population

Up to 29% prevalence in older population.

5-year mortality 23%.

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

Many cats with murmurs have physiologic flow murmurs, and some cats without murmurs have cardiomyopathy

Payne JR, Brodbelt DC, Luis Fuentes V. Cardiomyopathy prevalence in 780 apparently healthy cats in rehoming centres (the CatScan study). J Vet Cardiol. 2015 Dec;17 Suppl 1:S244-57. doi: 10.1016/j.jvc.2015.03.008. PMID: 26776583.

Paige CF, Abbott JA, Fo E, et al. Prevalence of cardiomyopathy in apparently healthy cats. J Am Vet Med Assoc. 2009;234:1398-1403. 15.

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

BNP can help identify and risk stratify cats with heart disease

	Normal	Abnormal	
SNAP Feline proBNP Test	 Sample spot is lighter than reference spot.	 Sample spot is the same color as reference spot.	 Sample spot is darker than reference spot.
Cardiopet proBNP Test	<150 pmol/L	150–200 pmol/L	>200 pmol/L

Ranges: Sensitivity (65%-84%) and Specificity (83%-100%)

Hanas et al, JVIM 2020
Harris et al, JVIM 2017
Machen et al, JVC 2014

Cats can get pushed in heart failure/volume overload

- 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

Journal of Veterinary Cardiology (2014) 16, 245—255

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Journal of Veterinary Cardiology
ESVC

www.elsevier.com/locate/jvc

Multi-centered investigation of a point-of-care NT-proBNP ELISA assay to detect moderate to severe occult (pre-clinical) feline heart disease in cats referred for cardiac evaluation

Maggie C. Machen, DVM [a], Mark A. Oyama, DVM [a,*], Sonya G. Gordon, DVM, DVSc [b], John E. Rush, DVM, MS [c], Sarah E. Achen, DVM [d], Rebecca L. Stepien, DVM [e], Philip R. Fox, DVM [f], Ashley B. Saunders, DVM [b], Suzanne M. Cunningham, DVM [c], Pamela M. Lee, DVM [f], Heidi B. Kellihan, DVM [e]

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 healthy cats
- 21 GPs
- 217 cats without overtly apparent physical signs of heart disease,
- 49 (23%) had abnormal echos
- Sensitivity 43%, Sp 96%.

ELISA vs. POC ProBNP

139 cats: 100 healthy and 39 HCM cats

Hanas et al, JVIM 2020

POC ProBNP helpful to ID cats with moderate to severe heart disease

- 146 asymptomatic cats
- Heart murmur, gallop rhythm, arrhythmia, or cardiomegaly.
- PE, BP, Echo, proBNP
- 43 normals, 16 equivocal HD, 50 mild OcHD, 31 moderate OcHD, 6 severe OcHD

POC ELISA differentiated cats with moderate or severe OcHD with sensitivity/specificity of 83.8%/82.6% and overall accuracy of 82.9%.

Journal of Veterinary Cardiology (2014) 16, 245–255

Algorithm for identifying heart disease in asymptomatic cats

For cats with cardiac disease risk factors (murmur, arrhythmia, gallop, breed, history) and healthy adult cats as part of a chemistry or preanesthetic profile

↓

SNAP® Feline proBNP Test

↓

Normal

Moderate to severe heart disease is unlikely at this time.

↓

Because heart disease can develop at any time, consider retesting next year.

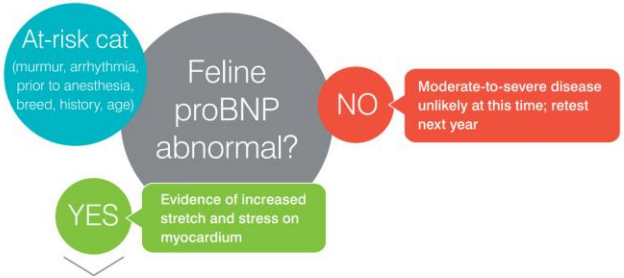
Abnormal

There is evidence of increased stretch and stress on the myocardium. Additional diagnostics are recommended:*

- Cardiopet® proBNP Test (quantitative)
- Chemistry profile with total T_4
- Evaluate blood pressure
- Echocardiogram for diagnosis of cardiac disease

*Hyperthyroidism and systemic hypertension can have secondary effects on the heart and lead to increases in NT-proBNP concentrations. The presence of severe azotemia consistent with IRIS CKD Stage 3 disease could also result in increased NT-proBNP concentrations due to reduced renal clearance of the peptide. Echocardiography is recommended for the diagnosis and management in the cat. Thoracic radiographs and ECG may also be considered.

Identifying heart disease in cats



Investigate

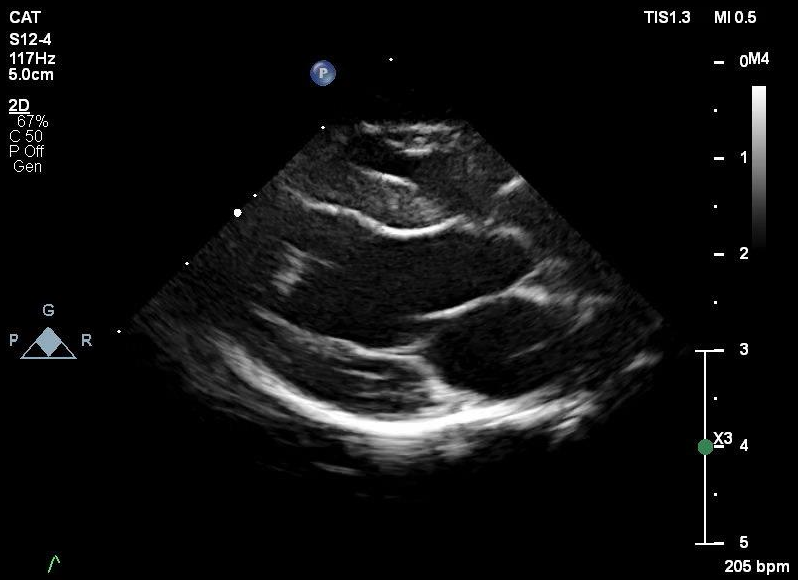
- Additional diagnostics required
  - Evaluate for diseases affecting the heart (hyperthyroidism, hypertension) or reducing the excretion of NT-proBNP (severe renal disease)
  - Quantitative Cardiopet® proBNP Test (test code 2666)
  - Echocardiogram for diagnosis
  - Radiographs (optional)

Manage

- Treatment based upon echocardiographic findings and diagnosis

Monitor

- Educate client on home monitoring
  - Resting respiratory rate
- Recheck using Cardiopet proBNP Test every 6–12 months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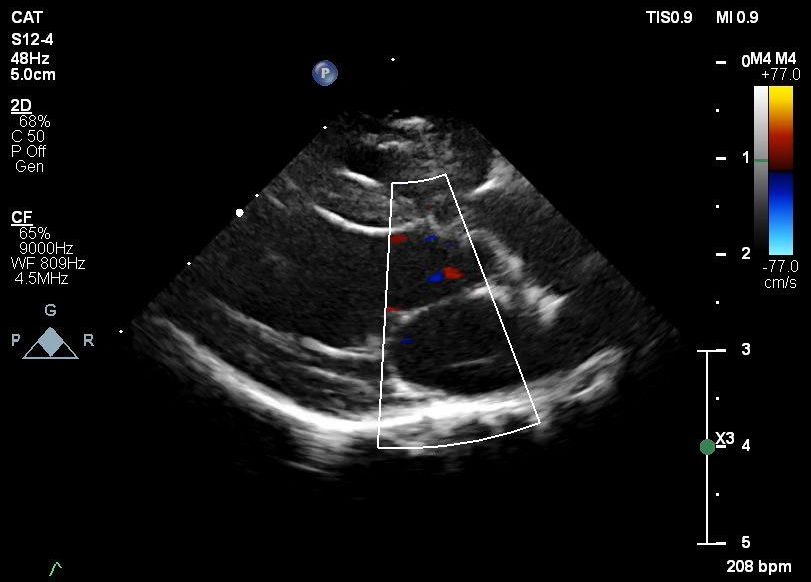
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cm/s
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X3
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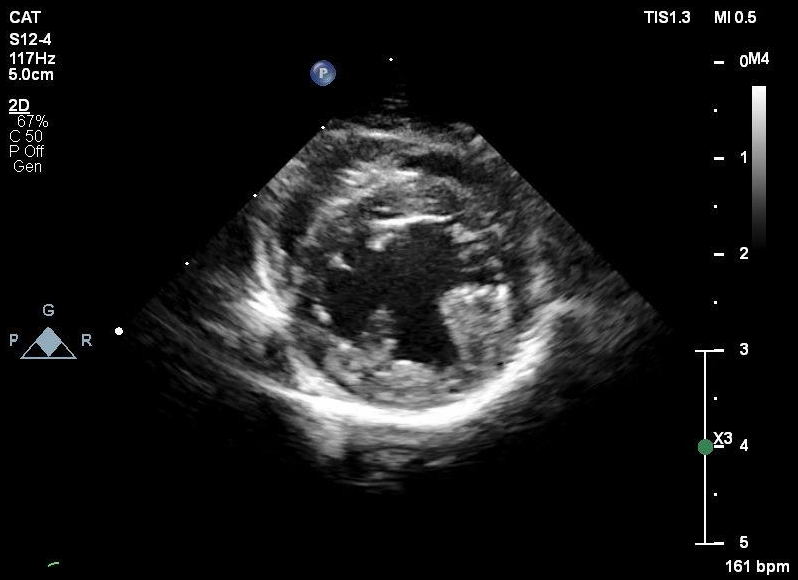
208 bpm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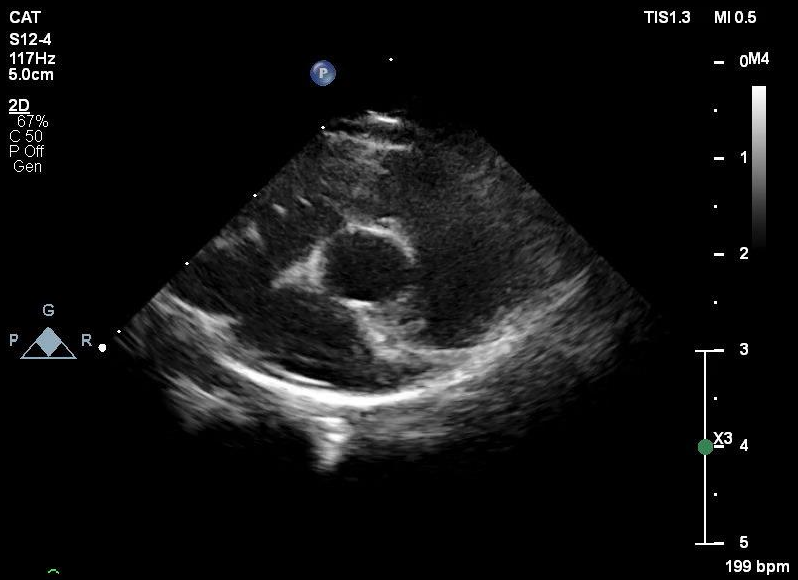
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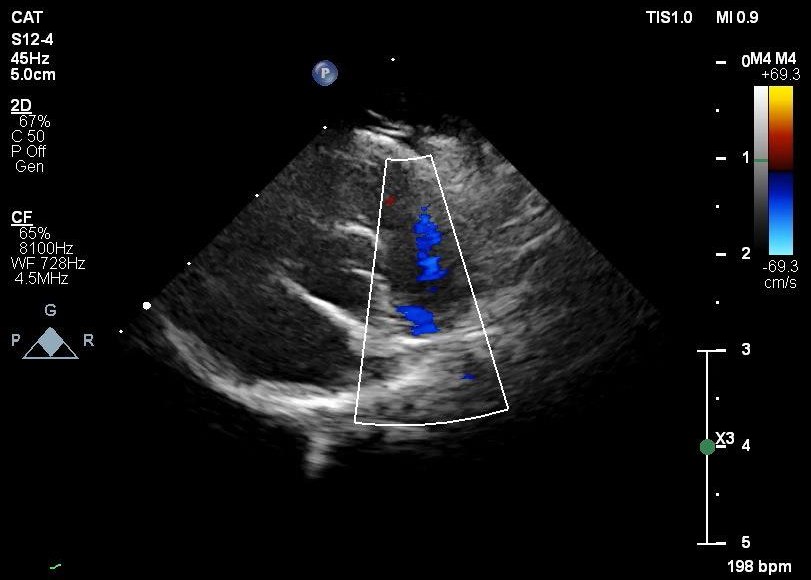
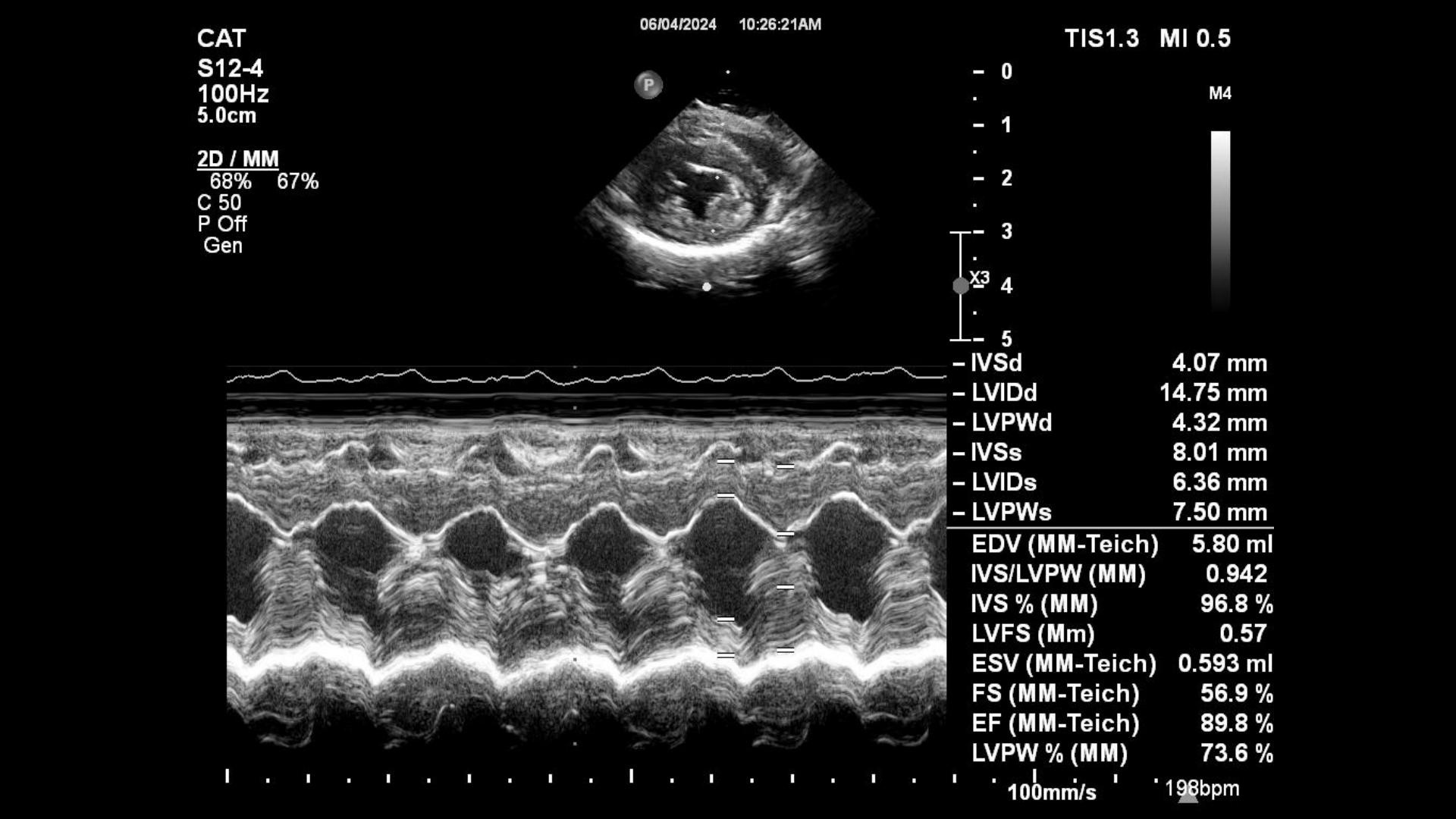
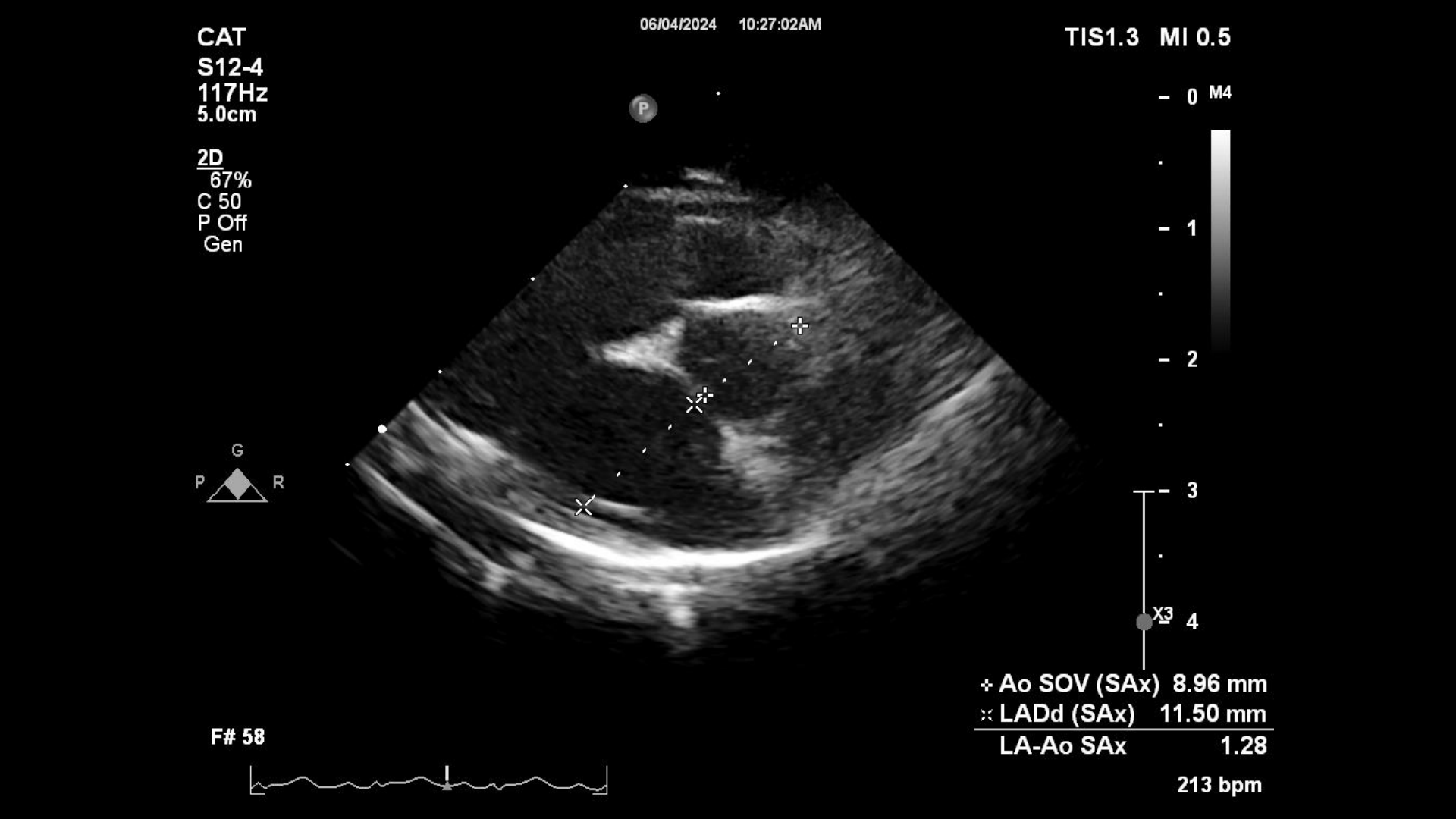
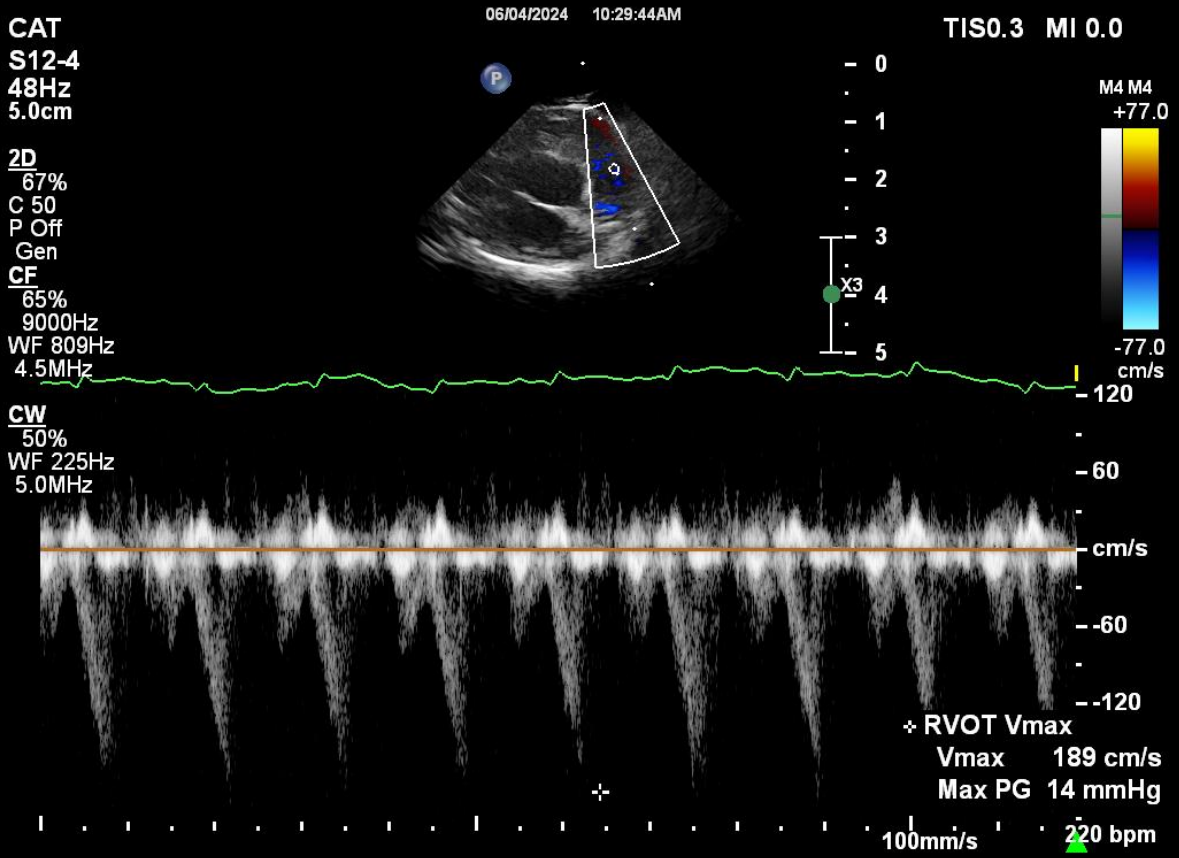
X3
199 bpm
G
P
R


CAT
S12-4
45Hz
5.0cm
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


CAT
S12-4
100Hz
5.0cm
2D / MM
68% 67%
C 50
P Off
Gen
06/04/2024 10:26:21AM
TIS1.3 MI 0.5
M4
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
X3
G
P
R
Ao SOV (SAx) 8.96 mm
LADd (SAx) 11.50 mm
LA-Ao SAx 1.28
213 bpm
F# 58


CAT
S12-4
48Hz
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

Conflict of Interest Disclosure:

I have no relevant financial interest, arrangement or affiliation with any company or organization.

Conflict of Interest Disclosure:

I have financial interest, arrangement or affiliation with:

Name of Organization	Relationship
Company A	Employee, honorarium, grant, consultant, own stock, etc.
Company B	Employee, honorarium, grant, consultant, own stock, etc.
Company C	Employee, honorarium, grant, consultant, own stock, etc.
Company D	Employee, honorarium, grant, consultant, own stock, etc.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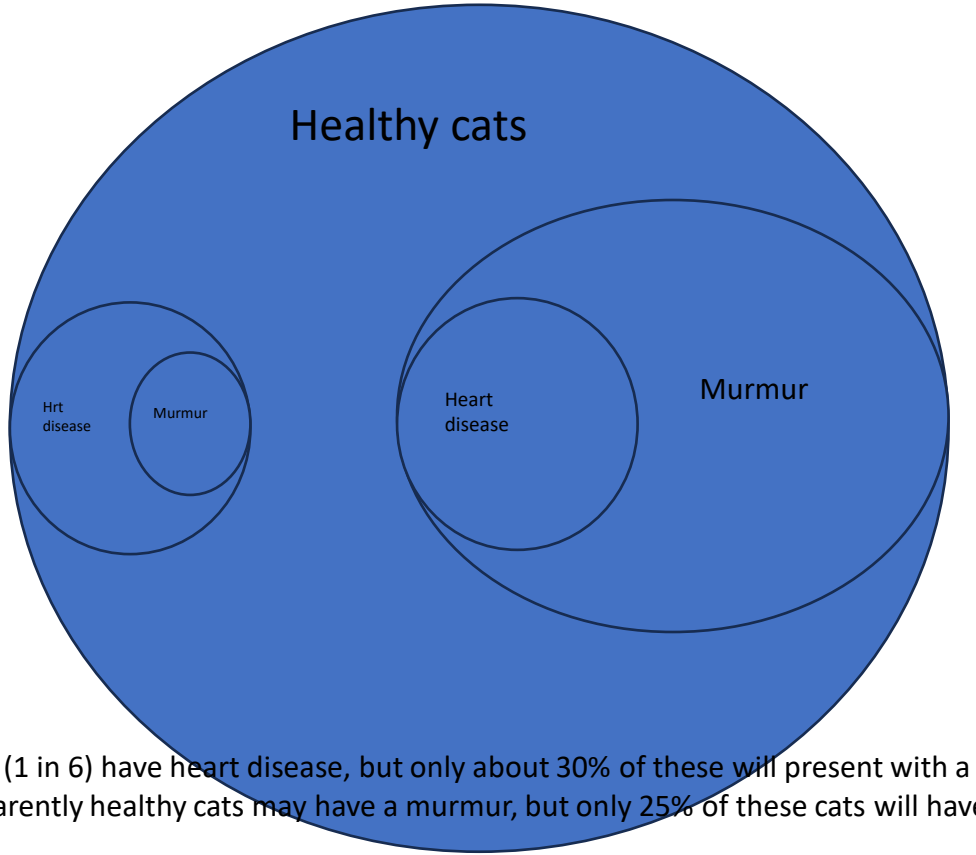
Does a murmur matter in a cat?



Approximately 15% of cats (1 in 6) have heart disease, but only about 30% of these will present with a heart murmur.3,4 On the other hand, 1 out of 4 apparently healthy cats may have a murmur, but only 25% of these cats will have evidence of cardiomyopathy by echocardiogram