Hidden Heartbreak: Diagnosing Early Cardiac Disease

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Conflict of Interest Disclosure:

Employee of the University of Edinburgh

I have received consultancy fees from Idexx

This talk is sponsored by Idexx

Thank you to Alison Spake for providing these slides (they have been adapted).

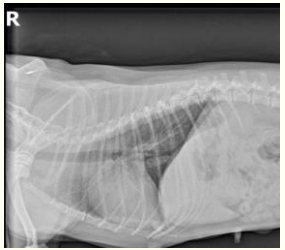
The information contained herein is intended to provide general guidance only. As with any diagnosis or treatment you should use clinical discretion with each patient based on a complete evaluation of the patient, including history, physical exam and presentation, and laboratory data. With respect to any drug therapy or monitoring program, you should refer to a product insert, for complete description of dosage, indications, interactions, and cations, Diagnosis, treatment, and monitoring should be patient specific and is the responsibility of the veterinarian providing primary care.

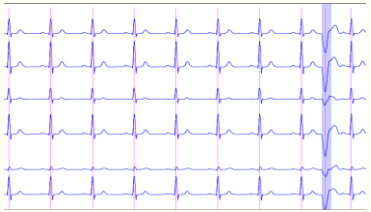
Agenda

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

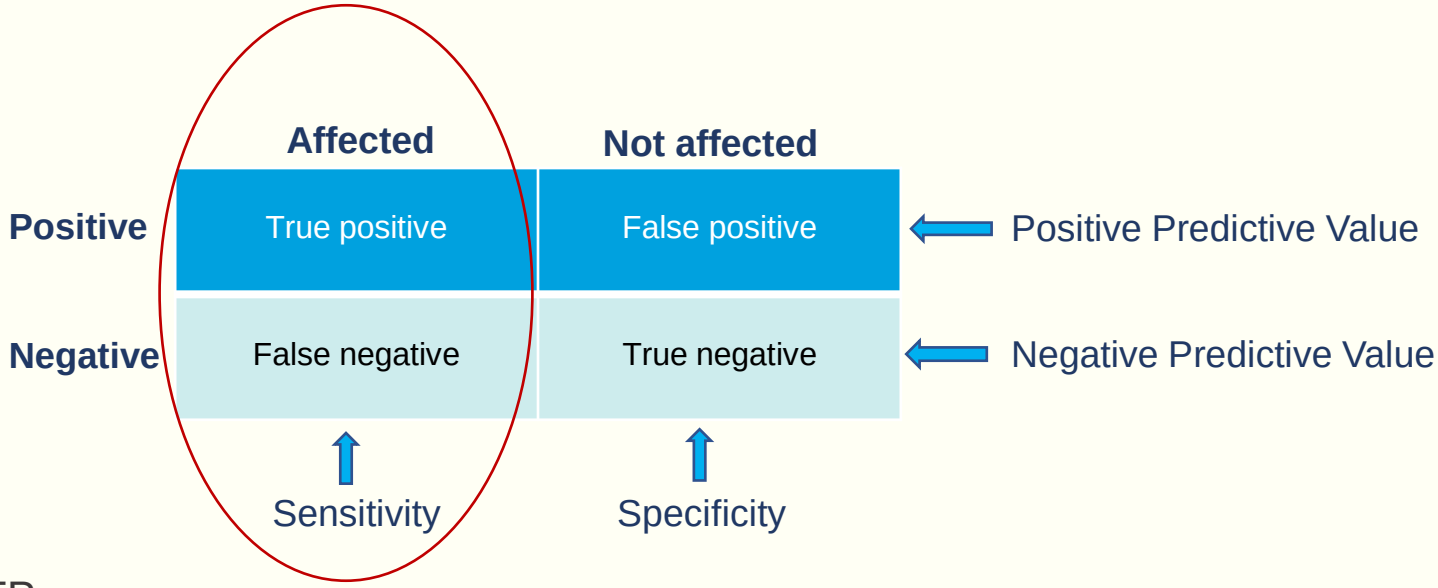
Screening tests

- Widely available
- Inexpensive
- Non-invasive
- Reliable





What happens when you screen all healthy patients?

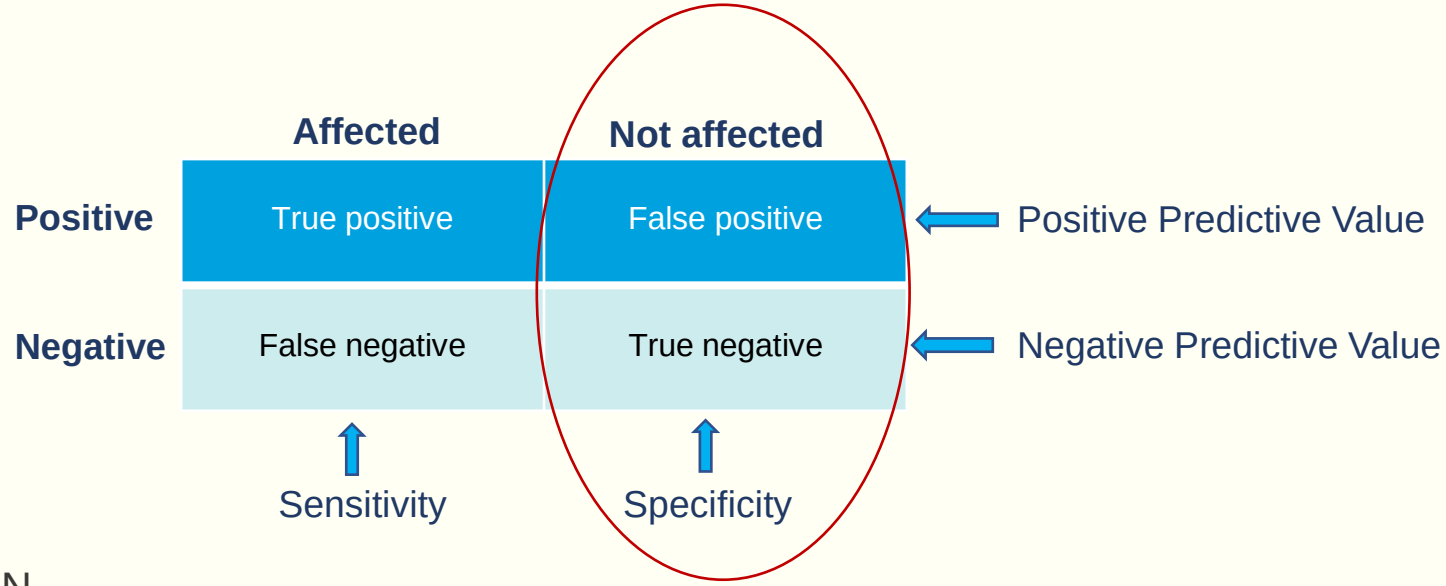


Sensitivity = $\frac{TP}{TP+FN}$

Proportion of patients **with** a disease who test **positive**

100% sensitivity means all patients who have the disease will test positive and a negative results **rules out** the disease (SNout)

False positive results may occur

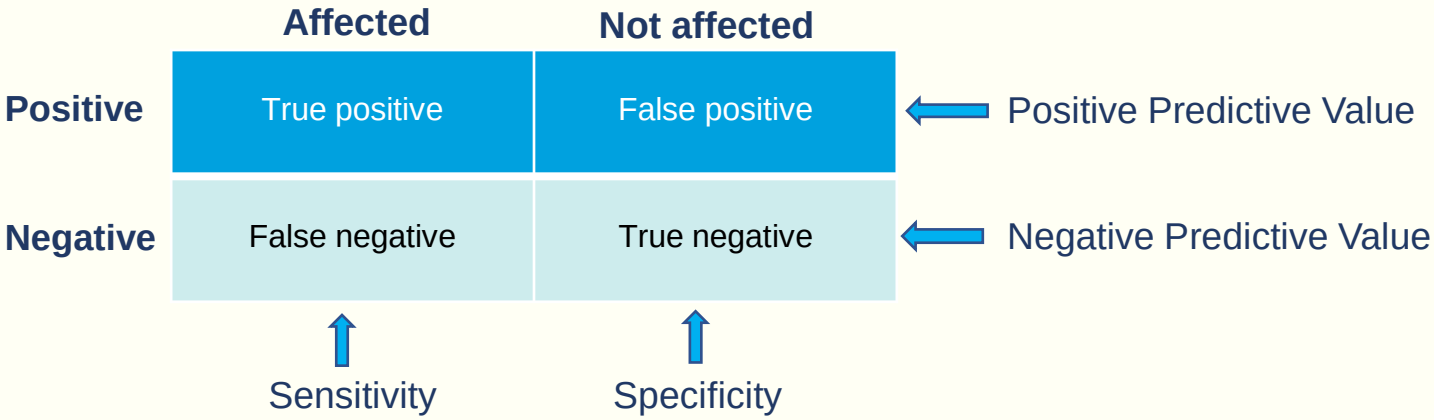


Specificity = $\frac{TN}{TN+FP}$

Proportion of patients **without** a disease who test **negative**

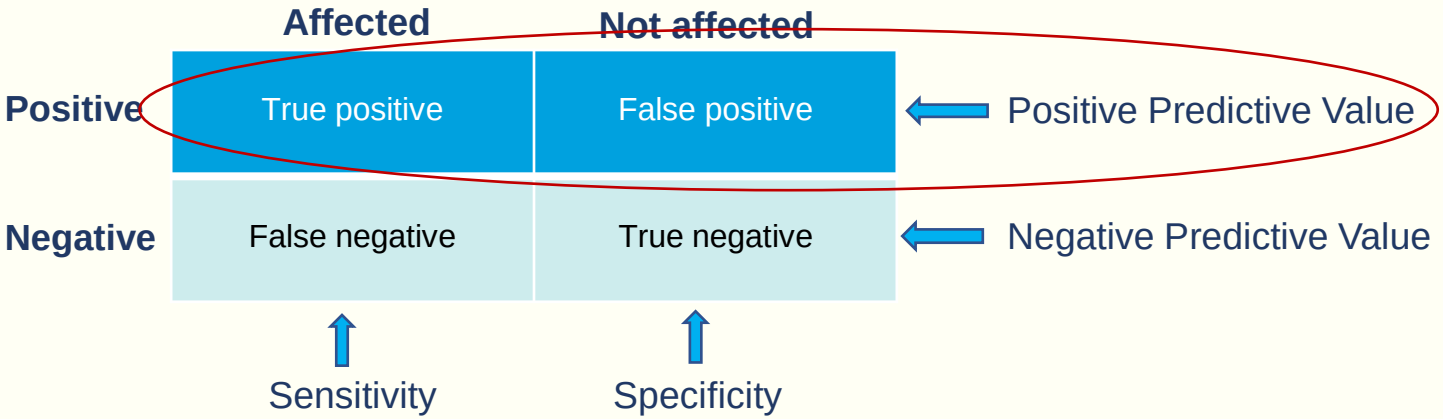
100% specificity means all patients who do not have the disease will test negative and a positive results **rules in** the disease (SPin)

False negative results may occur



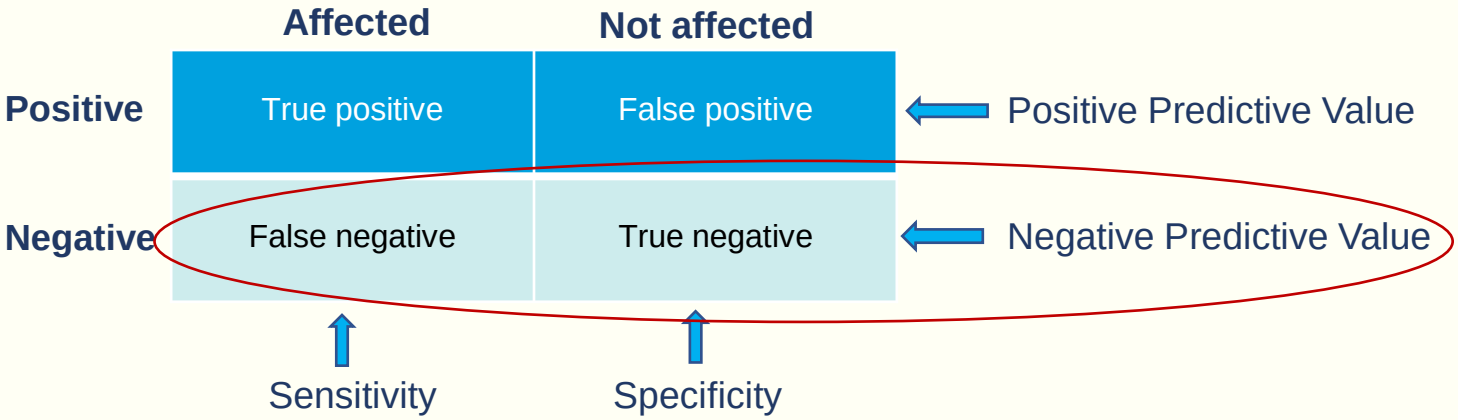
Most tests don’t have 100% sensitivity or specificity

Sensitivity and specificity don’t take into account prevalence of disease



Positive Predictive Value = $\frac{TP}{TP+FP}$

Proportion of patients with a **positive test** who are **affected**



Negative Predictive Value $= \frac{TN}{TN+FN}$

Proportion of patients with a **negative test** who are **unaffected**

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 (90*.64)	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 (75*0.64)	Specificity: 64.0
Increase to 25% prevalence			PPV: **38.6**
Total patients: 100.0	25.0	75.0	NPV: **85.7**

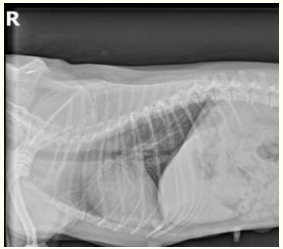
PPV = 17 / (17+27)

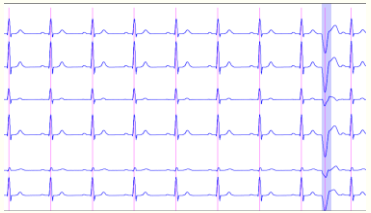
PPV = 38.6

IDEXX internal white paper

Screening tests for cardiac disease

- ❑History
- ❑Physical exam
- ❑Blood based biomarkers
- ❑Thoracic Radiographs
- ❑Genetic Testing
- ❑ECG





Physical examination

Most dogs with heart disease have a murmur

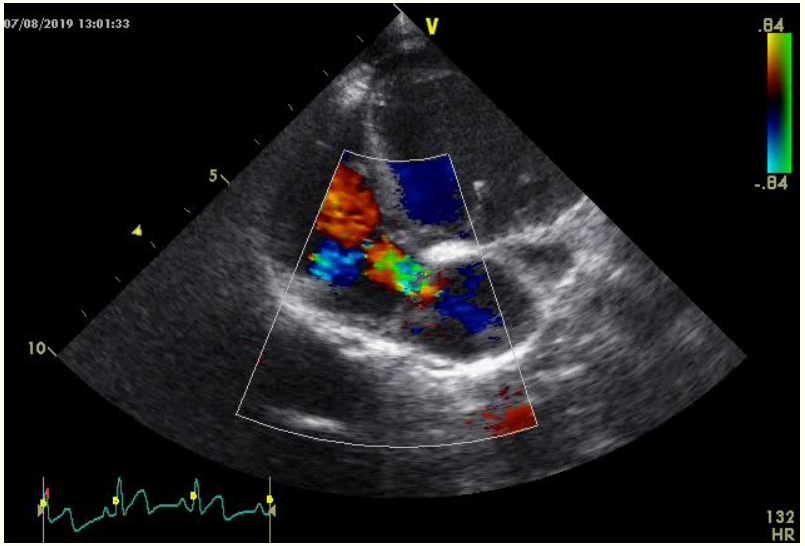
- Grade of murmur usually correlates with severity of disease
  - **MMVD:** Louder murmur correlates with larger left atrium and increased likelihood of CHF
  - **Pulmonic and subaortic stenosis:** Soft murmurs all had mild stenosis, loud murmurs usually had severe stenosis.

Ljungvall, I., Rishniw, M., Porciello, F., Ferasin, L. and Ohad, D.G. (2014), Murmur intensity in small-breed dogs with myxomatous mitral valve disease reflects disease severity. J Small Anim Pract, 55: 545-550. https://doi.org/10.1111/jsap.12265

Caivano, D., Dickson, D., Martin, M. and Rishniw, M. (2018), Murmur intensity in adult dogs with pulmonic and subaortic stenosis reflects disease severity. J Small Anim Pract, 59: 161-166. https://doi.org/10.1111/jsap.12760

Cardiac disease can be present with no murmur

- DCM
- Large VSD
- Cor triatriatum dexter
- R-L shunting PDA
- ASD



Not always sensitive

Innocent murmurs can occur in dogs

- **“Innocent”/”flow”/”physiologic”/”non-pathological”** murmur
  - 15-28% of puppies
  - 6-12% young adults had a low-grade, systolic, basal murmur: 27-50% were physiologic

- Grade I-II/VI
- Left basal
- Mid-systolic
- No radiation

Not always specific

Murmurs are not such a good screening test in cats

- Localisation is difficult
- Dynamic murmur does not help to differentiate
- Grade of murmur may not correlate with severity of disease
- Cats with severe heart disease may have no murmur
- Compression of the thorax can cause a murmur

Gallop sound or arrhythmia is more accurate for detecting heart disease in cats

Blood-based biomarkers

Natriuretic Peptides

- **BNP** (brain or B-type natriuretic peptide)
  - Atrial and ventricular myocytes
  - Disease mainly ventricles
  - Stress (volume overload, pressure overload, ischaemia)
- **ANP** (atrial natriuretic peptide)
  - Atrial myocytes
  - Disease ventricles can also release
  - Stretch

ATII, endothelin and catecholamines can also stimulate release

Natriuretic Peptides

- **CNP** (C-type natriuretic peptide)
  - Bone growth
- **DNP** (dendroaspis natriuretic peptide)
  - Venom of the green mamba snake
- **VNP** (ventricular natriuretic peptide)
  - Primitive myocytes, mainly in fish
- **Urodilatin**
  - Distal renal tubule

Natriuretic Peptides

Preprohormone (stored) → **Pro**hormone (proANP, proBNP)

Cleaved once released

C-terminal
- C-BNP, C-ANP
- Active

N-terminal
- NT-proBNP, NT-proANP
- Inactive

NPR-A receptor
- Natriuresis
- Vasodilation
- Inhibit RAAS
- Overall effect is to reduce blood volume and blood pressure

Measured as biomarker

~~Renin Angiotensin~~

Which Natriuretic Peptide to Measure?

- T ½
  - BNP > ANP
  - N-terminal > C-terminal

- **NT-proBNP**

- C-terminal ANP and N-terminal ANP used experimentally but not commercially available
- C-terminal BNP commercially available in USA but not Europe

NT proBNP assay

- First generation
  - EDTA plasma, frozen.
- Second generation
  - EDTA plasma, not frozen unless >48 hours delay.
- POC snap test (cats)
  - Serum or EDTA plasma.
  - Results in 10 minutes so more practical.
  - Becomes positive between 100-200pmol/l.

Feline Cardiopet® proBNP Assay
SNAP® Feline proBNP, IDEXX Laboratories Inc., Westbrook (ME))

NT-proBNP	Lighter	Equal	Darker
			
Evaluation	Normal	Abnormal	Abnormal
NT-proBNP concentration (pmol/L)	24 (24-31)[a]	162 (100-217)[b]	505 (336-1312)[c]
No of POCT	108	6	25

Effect of feline characteristics on plasma N-terminal-prohormone B-type natriuretic peptide concentration and comparison of a point-of-care test and an ELISA test. Veterinary Internal Medici ne, Volume: 34, Issue: 3, Pages: 1187-1197, First published: 22 March 2020, DOI: (10.1111/jvim.15754)

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

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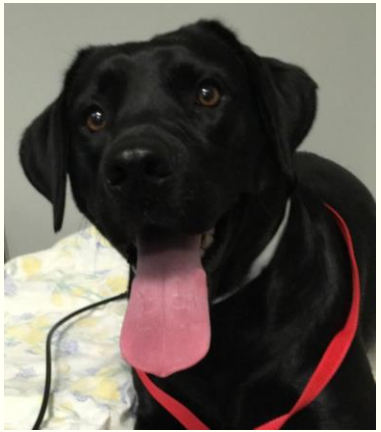


- **Labs and Newfoundland highest (3X higher than Dachshunds)**
- **Dachshunds lowest**

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]

	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 - 67.5%)

28 dogs with MMVD and 10 healthy controls.

NTproBNP was measured hourly, daily, and weekly x 6 wk (272 observations)

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

Biologic variability of N-terminal pro-brain natriuretic peptide in adult healthy cats

Journal of Feline Medicine and Surgery
2017, Vol. 19(2) 216–223

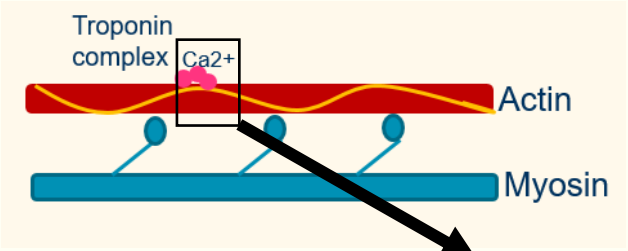
DOI: 10.1177/1098612X15623825
jfms.com
SAGE

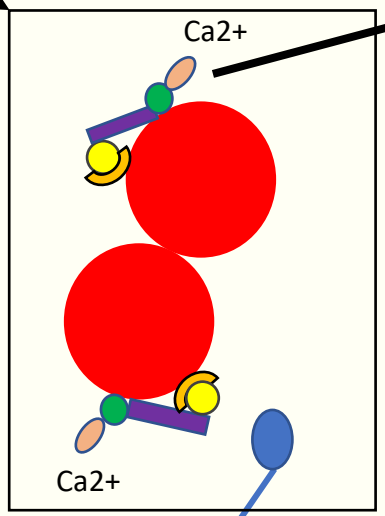
Autumn N Harris[1], Amara H Estrada[1], Alexander E Gallagher[1], Brandy Winter[1], Kenneth E Lamb[2], Mary Bohannon[1], Jancy Hanscom[3] and Celine A Mainville[3]

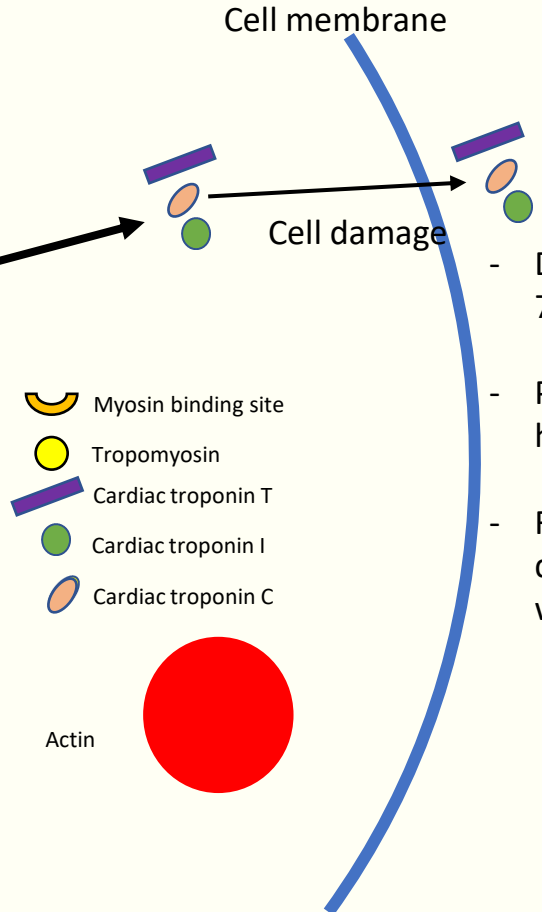
A change of 39.8% between days and 60.5% between weekly measurements is required to be considered significant in the cat

- **Comorbid conditions**
  - Renal disease (seems to be associated with related hypertension rather than reduced GFR)
  - Systemic hypertension
  - Hyperthyroidism
  - Pulmonary hypertension (cor pulmonale)
- Males higher NT-proBNP than females
- Higher in SAM than without SAM

Cardiac troponins







- Detected 2-7 hours
- Peak 18-48 hours
- Reduce days to weeks

Which troponin to measure?

- ~~**Cardiac troponin C** structurally similar to skeletal troponin C~~
- ~~**Cardiac troponin T** tightly bound~~
- **Cardiac troponin I**

Available assays

- Over 15 different assays with antibodies to different isotopes
- In theory shouldn’t compare measurements from different assays
- Not all validated for veterinary use

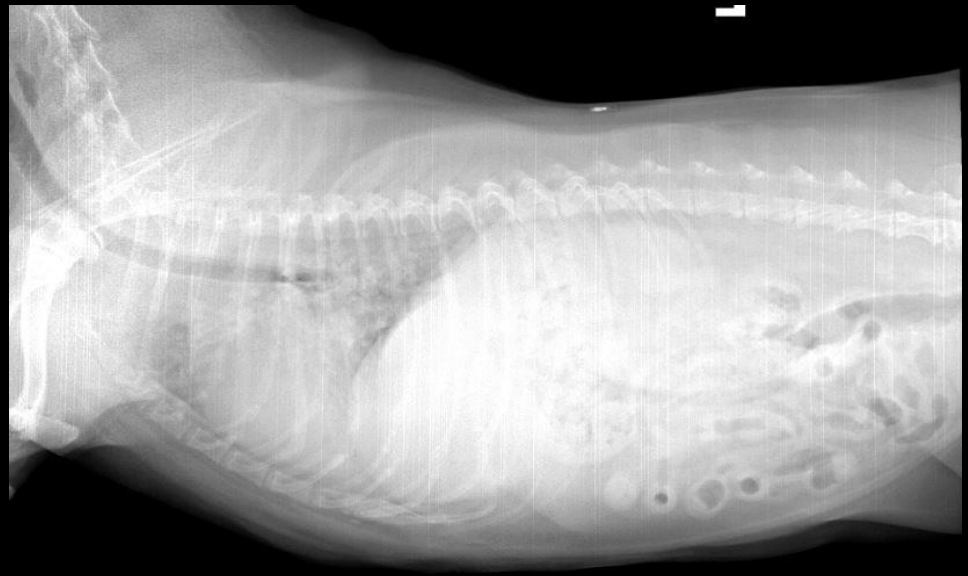
Radiographs

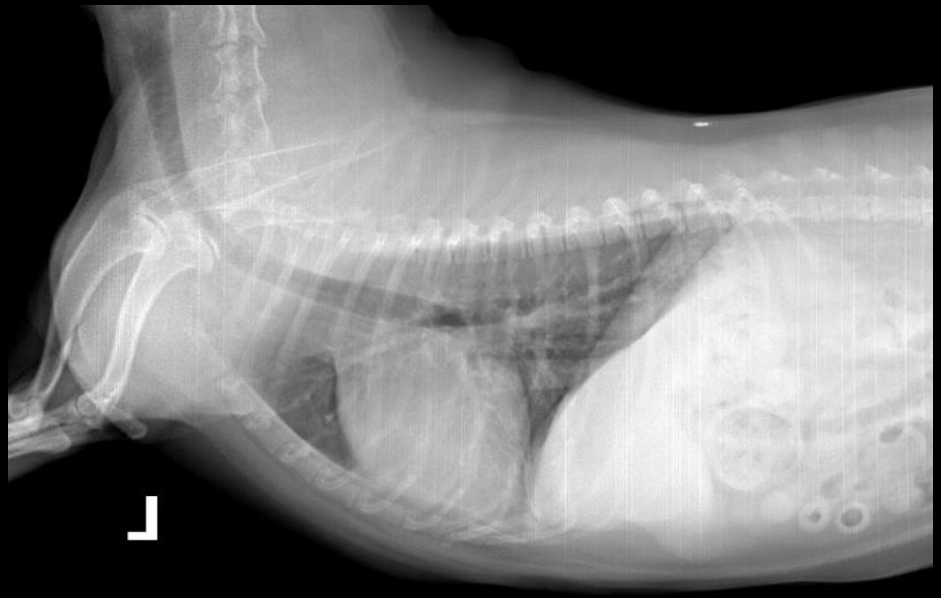
Helpful Reminders

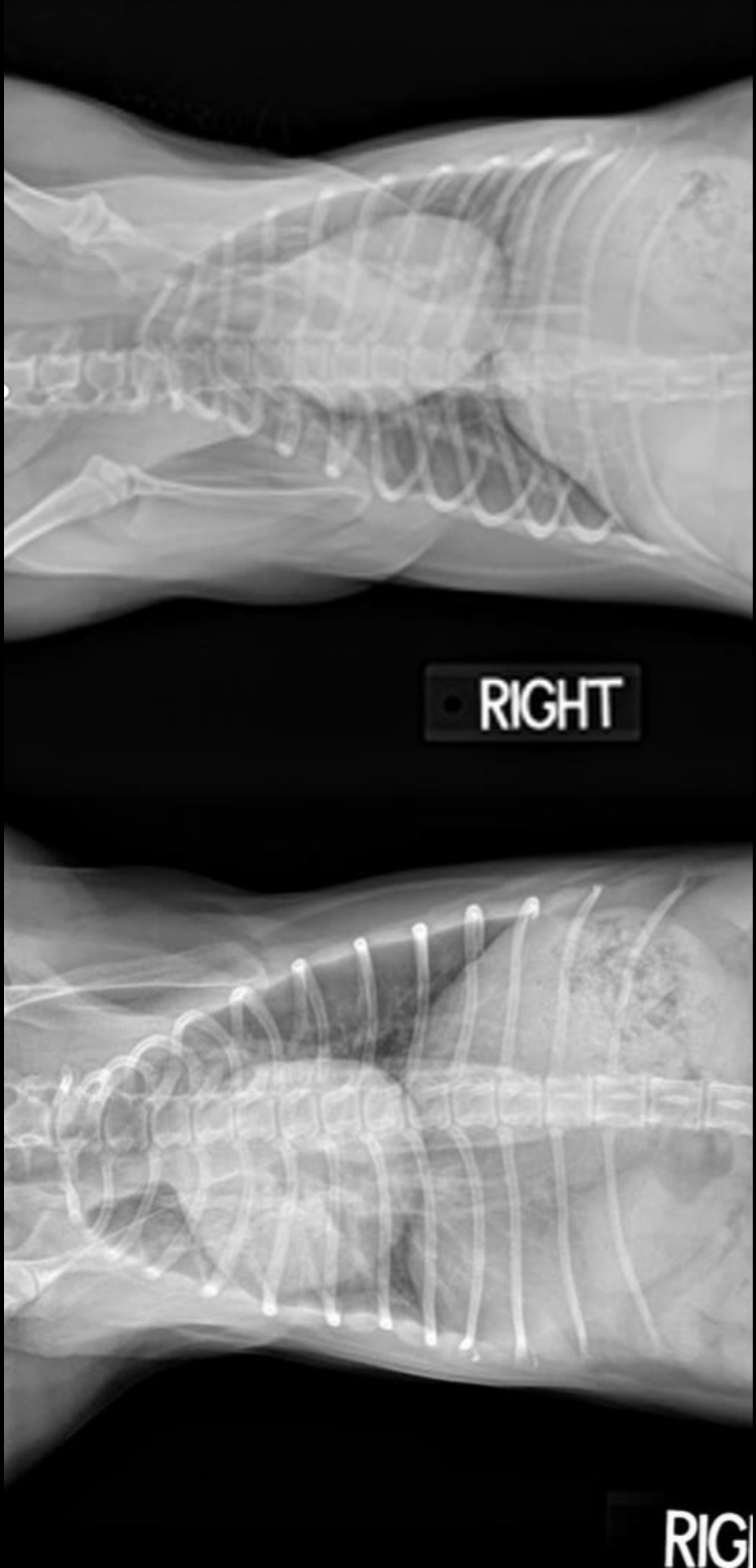
- Three view thorax is standard (RL / LL / DV or VD)
- Adequate positioning and technique is very important
- Only detects cardiomegaly, not cardiac disease
- Radiographs diagnose CHF, not echocardiography
- **VHS**
  - Useful but use breed reference ranges if possible

A Note on Positioning and Technique

Same Dogs, Same day






RIGHT
RIG

VHS in different dog breeds

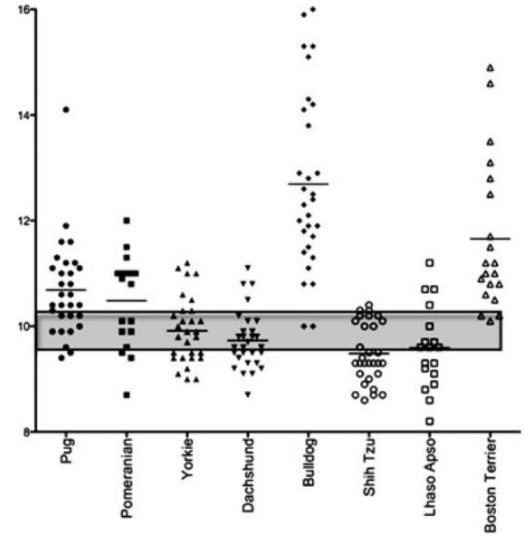


FIG. 3. Graphical representation of VHS measurements, with mean of each breed represented by the individual black lines. The highlighted box represents the reference value of 9.7 ± 0.5.

Jepsen-Grant K, Pollard RE, Johnson LR. Vertebral heart scores in eight dog breeds. Vet Radiol Ultrasound. 2013 Jan-Feb;54(1):3-8. doi:10.1111/j.1740-8261.2012.01976.x. Epub 2012 Sep 21.

PMID:22994206.

ECG/Holter Monitor

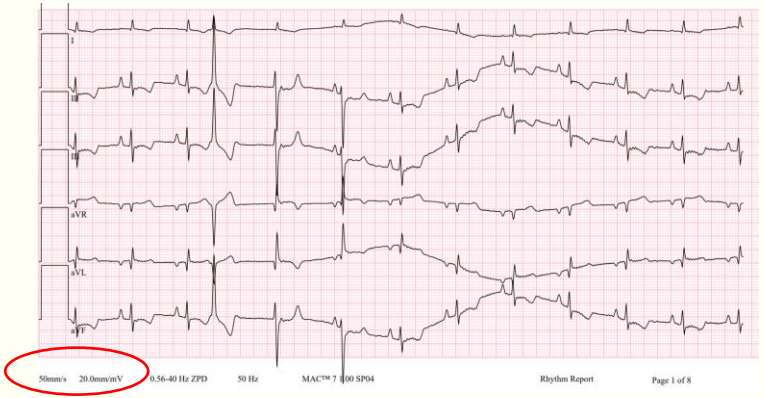
Helpful Reminders

- ECGs are diagnostic for **heart rate and rhythm** and only supportive of / suggestive of cardiac chamber enlargement

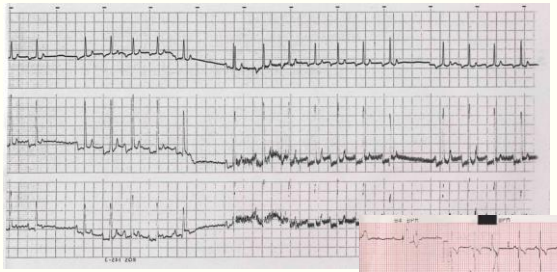
- ECG axis only valid if the patient is in right lateral recumbency AND if the clips are applied to the correct limbs.

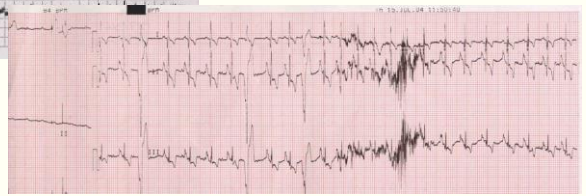
Helpful Reminders

- Lead II for measurements
  - 50mm/s and 10mm/mV
  - Can change settings if needed

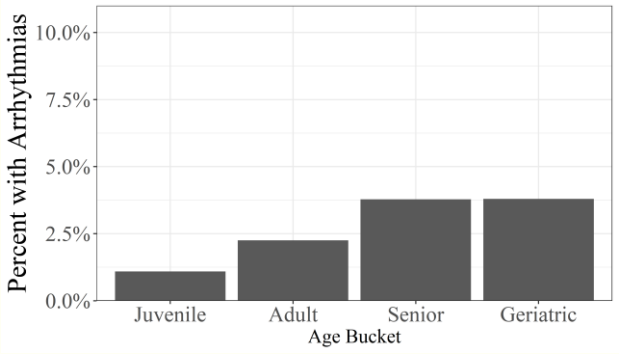


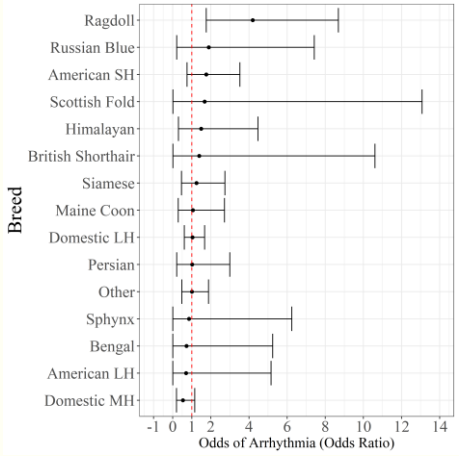
- Good quality trace with little/ no artefact
  - Movement/ electrical/ purring/ respiration



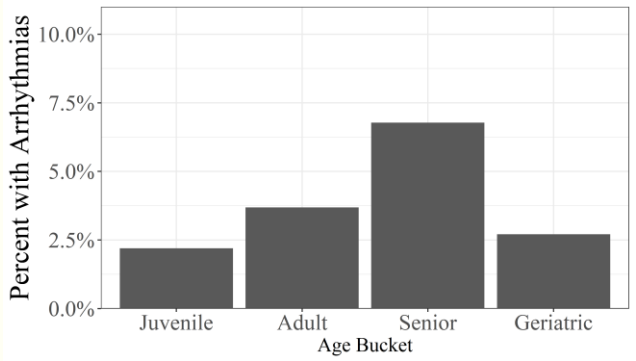


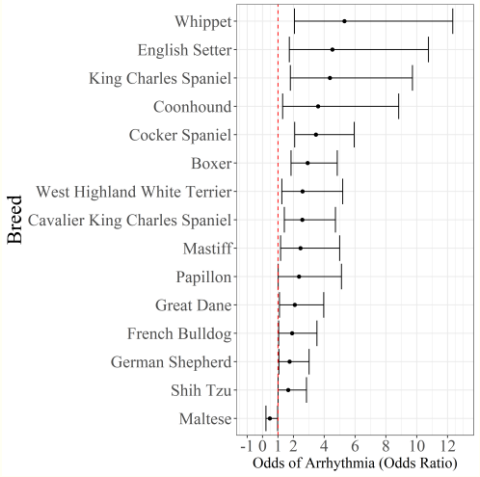
Cats





Dogs

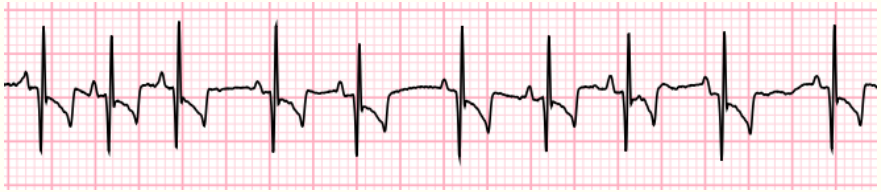




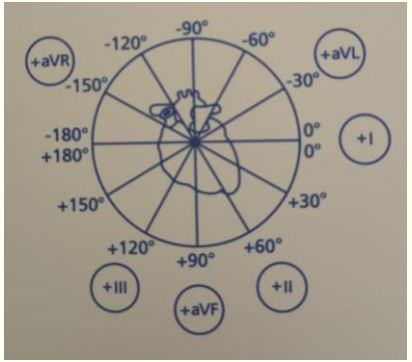
D.A. Szlosek, E.L. Castaneda, D.A. Grimaldi, A.K. Spake, A.H. Estrada, J. Gentile-Solomon, *Frequency of arrhythmias detected in 9440 feline electrocardiograms by breed, age, and sex,* J Vet Cardio, V 51,Pgs 116-123

Using the ECG to detect cardiac chamber enlargement

- P wave duration for detection of LA enlargement
  - Sens 75% Spec 67.6% **PPV 52.7%** NPV 84.9%
- QRS duration for detection of L-sided enlargement
  - Sens 71.2% Spec 70.4% **PPV 53.6%** NPV 83.5%



- Healthy Doberman Pinscher, French Bulldogs, Pugs and English Bulldogs can have left axis shift



Ogawa M, Ogi H, Miyakawa H, Hsu HH, Miyagawa Y, Takemura N. Evaluation of the association between electrocardiogram parameters and left cardiac remodeling in dogs with myxomatous mitral valve disease. Vet World. 2022 Aug;15(8):2072-2083. doi: 10.14202/vetworld.2022.2072-2083. Epub 2022 Aug 27. PMID: 36313845; PMCID: PMC9615506.

Echocardiography

What about echo in practice?

Hezzell et al., **Teaching vets to be EPIC: Validation of a focussed echocardiographic training program for general practitioners - The FEET-FIRST Study** [abstract]. In: 31st ECVIM-CA Online Congress; 2021.

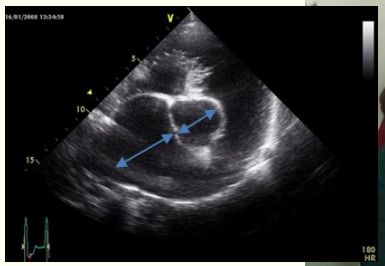
- LA:Ao the same as cardiologists
- LVIDdN statistically smaller than cardiologists but clinically insignificant
- Classified EPIC class correctly in 47/52 dogs.

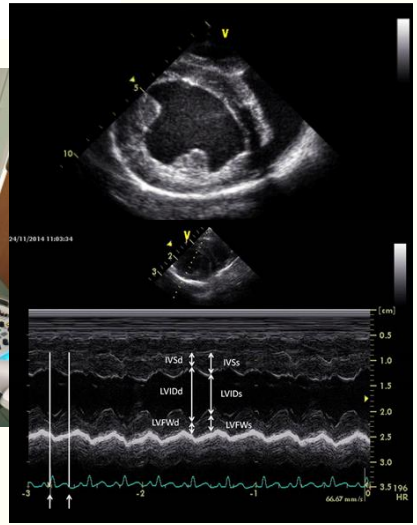
J Vet Emerg Crit Care (San Antonio). 2013 May-Jun;23(3):268-73. doi: 10.1111/vec.12056. Epub 2013 May 6.

Evaluation of a training course in focused echocardiography for noncardiology house officers.

Tse YC[1], Rush JE, Cunningham SM, Bulmer BJ, Freeman LM, Rozanski EA.

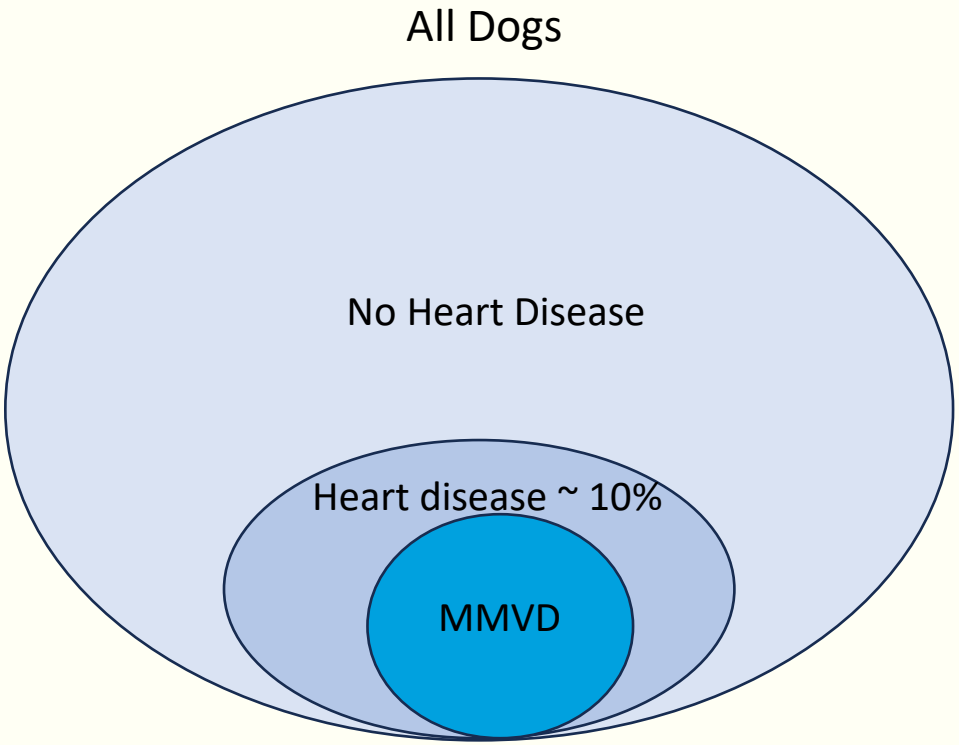
- Good at detecting
  - Pleural effusion
  - Pericardial effusion
  - Big vs. normal left atrial size
- Not so good at accurately assessing
  - Cardiac masses
  - Volume status
  - Ventricular enlargement or hypertrophy
  - Congenital heart disease

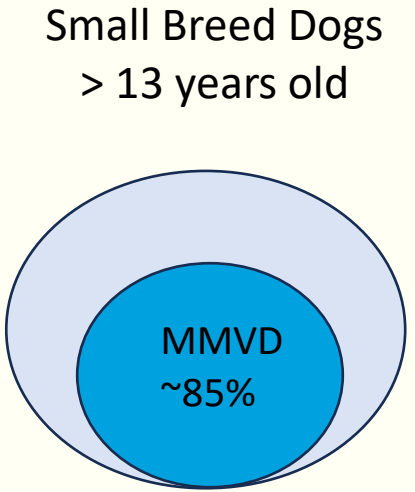




Myxomatous Mitral Valve Disease

Prevalence of Heart Disease in Dogs



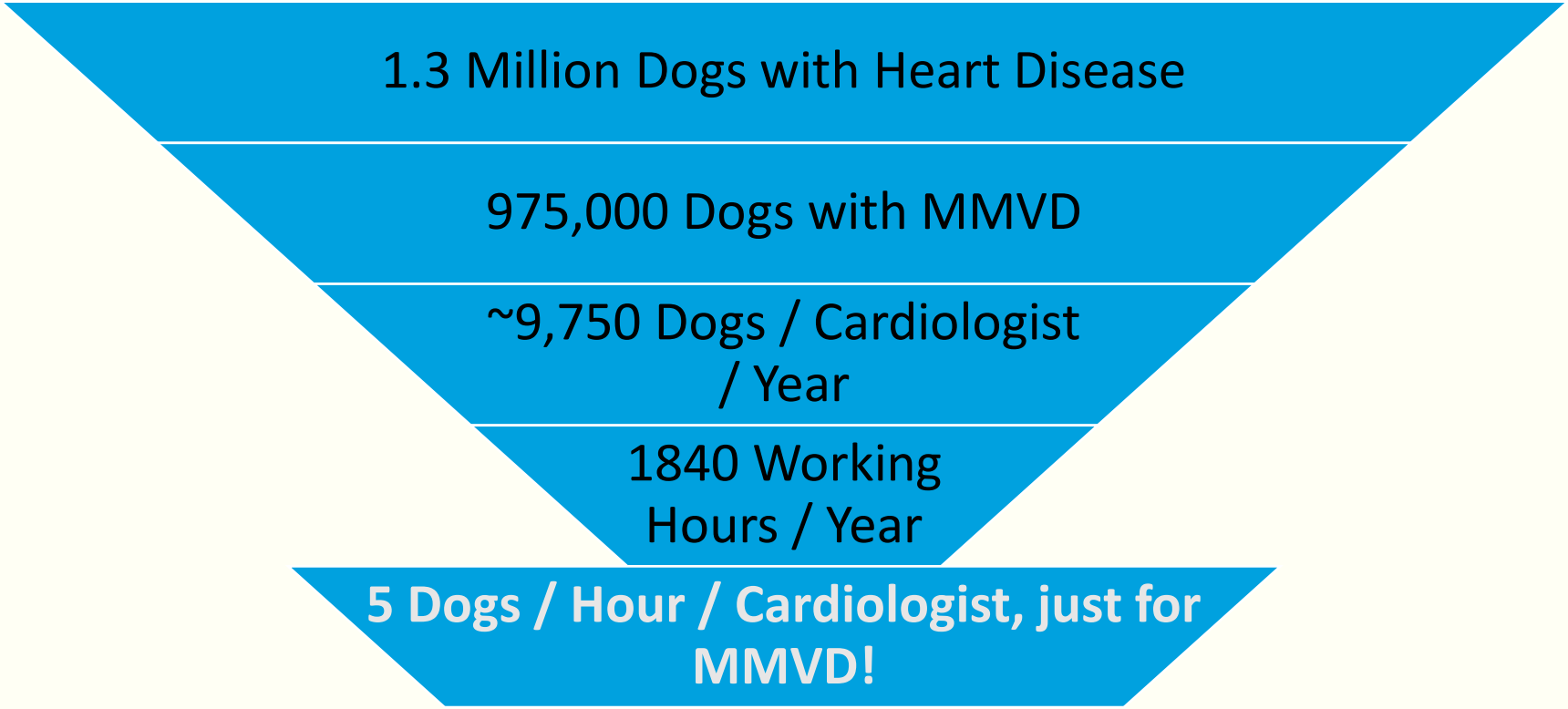


Keene BW, Atkins CE, Bonagura JD, et al. ACVIM consensus guidelines for the diagnosis and treatment of myxomatous mitral valve disease in dogs. *J Vet Intern Med*. 2019; 33: 1127–1140. https://doi.org/10.1111/jvim.15488

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

ACVIM Consensus Statement

- **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 and LV dilation (LA:Ao, LVIDdN, VHS)
- **Stage C:** Past or current clinical signs of CHF
- **Stage D**: End stage disease. CHF refractory to ‘standard therapy’


1.3 Million Dogs with Heart Disease
975,000 Dogs with MMVD
~9,750 Dogs / Cardiologist / Year
1840 Working Hours / Year
5 Dogs / Hour / Cardiologist, just for MMVD!

Which dogs to screen?

- **Breed**
- **Age**
- **Heart murmur**
  - Grade I or II/VI suggests disease is likely stage B1
  - ≥ Grade III/VI murmur is one of the criteria for stage B2 disease

Criteria for Stage B2 Disease

J Vet Intern Med 2016;30:1765–1779

Effect of Pimobendan in Dogs with Preclinical Myxomatous Mitral Valve Disease and Cardiomegaly: The EPIC Study—A Randomized Clinical Trial

A. Boswood, J. Häggström, S.G. Gordon, G. Wess, R.L. Stepien, M.A. Oyama, B.W. Keene, J. Bonagura, K.A. MacDonald, M. Patteson, S. Smith, P.R. Fox, K. Sanderson, R. Woolley, V. Szatmári, P. Menaut, W.M. Church, M. L. O'Sullivan, J.-P. Jaudon, J.-G. Kresken, J. Rush, K.A. Barrett, S.L. Rosenthal, A.B. Saunders, I. Ljungvall, M. Deinert, E. Bomassi, A.H. Estrada, M.J. Fernandez Del Palacio, N.S. Moise, J.A. Abbott, Y. Fujii, A. Spier, M.W. Luethy, R.A. Santilli, M. Uechi, A. Tidholm, and P. Watson

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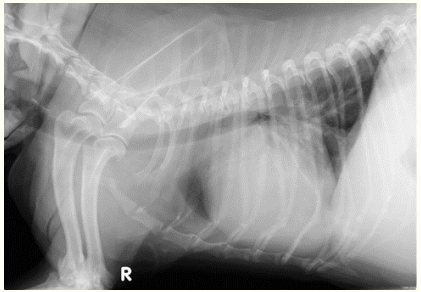
Animals: 360 client-owned dogs with MMVD with left atrial-to-aortic ratio ≥1.6, normalized left ventricular internal diameter in diastole ≥1.7, and vertebral heart sum >10.5.

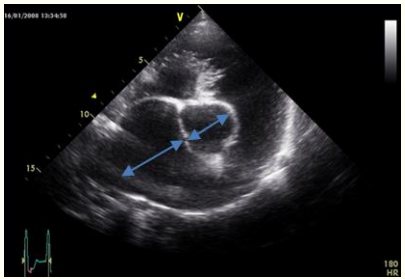
Methods: Prospective, randomized, placebo-controlled, blinded, multicenter clinical trial. Primary outcome variable was time to a composite of the onset of CHF, cardiac-related death, or euthanasia.

Results: Median time to primary endpoint was 1228 days (95% CI: 856–NA) in the pimobendan group and 766 days (95% CI: 667–875) in the placebo group ($P = .0038$). Hazard ratio for the pimobendan group was 0.64 (95% CI: 0.47–0.87) compared with the placebo group. The benefit persisted after adjustment for other variables. Adverse events were not different between treatment groups. Dogs in the pimobendan group lived longer (median survival time was 1059 days (95% CI: 952–NA) in the pimobendan group and 902 days (95% CI: 747–1061) in the placebo group) ($P = .012$).

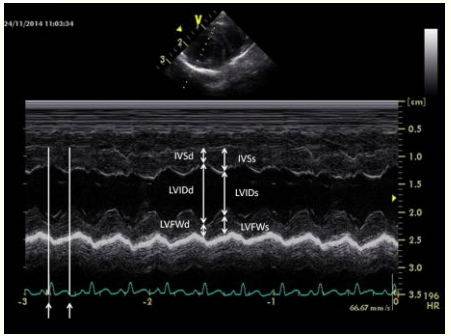
Conclusions and Clinical Importance: Administration of pimobendan to dogs with MMVD and echocardiographic and radiographic evidence of cardiomegaly results in prolongation of preclinical period and is safe and well tolerated. Prolongation of preclinical period by approximately 15 months represents substantial clinical benefit.



VHS>10.5v



LA:Ao≥1.6



LVIDDN≥1.7

ACVIM consensus guidelines for the diagnosis and treatment of myxomatous mitral valve disease in dogs

Bruce W. Keene[1] | Clarke E. Atkins[1] | John D. Bonagura[1,2] | Philip R. Fox[3] | Jens Häggström[4] | Virginia Luis Fuentes[5] | Mark A. Oyama[6] | John E. Rush[7] | Rebecca Stepien[8] | Masami Uechi[9]

J Vet Intern Med. 2019; 33: 1127– 1140

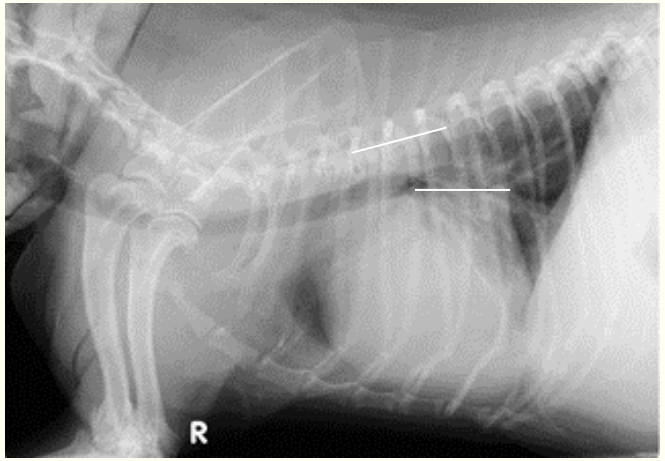
*"In the absence of echocardiographic measurements, clear radiographic evidence of cardiomegaly (eg, a general breed **VHS≥11.5**, or a comparable breed-adjusted VHS in cases where breed-specific VHS normal values are available) **or evidence of accelerating (increasing) interval change** in radiographic or echocardiographic cardiac enlargement patterns can substitute for quantitative echocardiography to identify Stage B2. **(LOE expert opinion)"***

VLAS

- Malcolm, EL et al., *JAVMA* 2018;253(8):1038-1045.
  - **VLAS ≥ 2.3** vertebrae was a useful predictor of LA enlargement

- Mikawa S et al., *J Vet Cardiol* 2020;30:92-99.
  - **VLAS ≥ 2.6** provided the greatest diagnostic accuracy for identification of dogs with ACVIM stage B2 MMVD
  - **VLAS ≥ 2.5** exhibited the highest sensitivity
  - **VLAS ≥ 3.1** exhibited the highest specificity

- Stepien RL et al., *JAVMA* 2020;256(10):1129-1136.
  - **VLAS ≥ 2.5** greatest accuracy
  - **VLAS ≥ 3** highest specificity



Accuracy of history, physical examination, cardiac biomarkers, and biochemical variables in identifying dogs with stage B2 degenerative mitral valve disease

Jenny Wilshaw[1] | Steven L. Rosenthal[2] | Gerhard Wess[3] | Dave Dickson[4] | Luca Bevilacqua[5] | Emily Dutton[6] | Michael Deinert[7] | Ricardo Abrantes[8] | Ingo Schneider[9] | Mark A. Oyama[10] | Sonya G. Gordon[11] | Jonathan Elliott[12] | Dong Xia[13] | Adrian Boswood[1]

J Vet Intern Med. 2021; 35: 755– 770

- NT-proBNP↑
- Murmur intensity↑
- Appetite↓
- Body condition ≤3
- Serum creatinine concentration ↓

- Age 8-10 years
- Serum ALT↑

Use of physical examination, electrocardiography, radiography, and biomarkers to predict echocardiographic stage B2 myxomatous mitral valve disease in preclinical Cavalier King Charles Spaniels☆

S. Wesselowski, DVM, MS[a,*], S.G. Gordon, DVM, DVSc[a], R. Fries, DVM[b], A.B. Saunders, DVM[a], K.T. Sykes, DVM[a], J. Vitt, DVM[b], B. Boutet, DVM[c], J. Häggström, DVM[d], S. Kadotani, DVM, MS[b], J. Stack, DVM[b], B.G. Barnett, DVM[a]

J Vet Cardiol. 2023; 50: 1-16

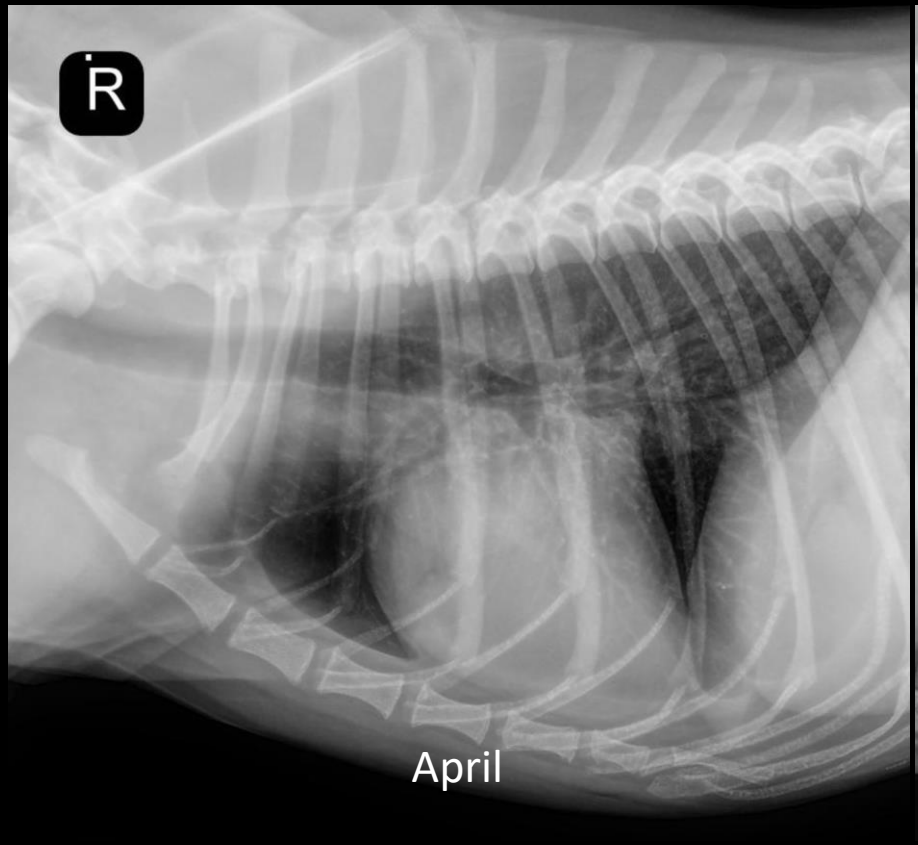
- NT-proBNP > 1138 pmol/L
- VHS > 11.5

- Prediction models using multiple tests are best at discriminating (murmur grade, HR, p and QRS duration)

9 yo FS CKCS

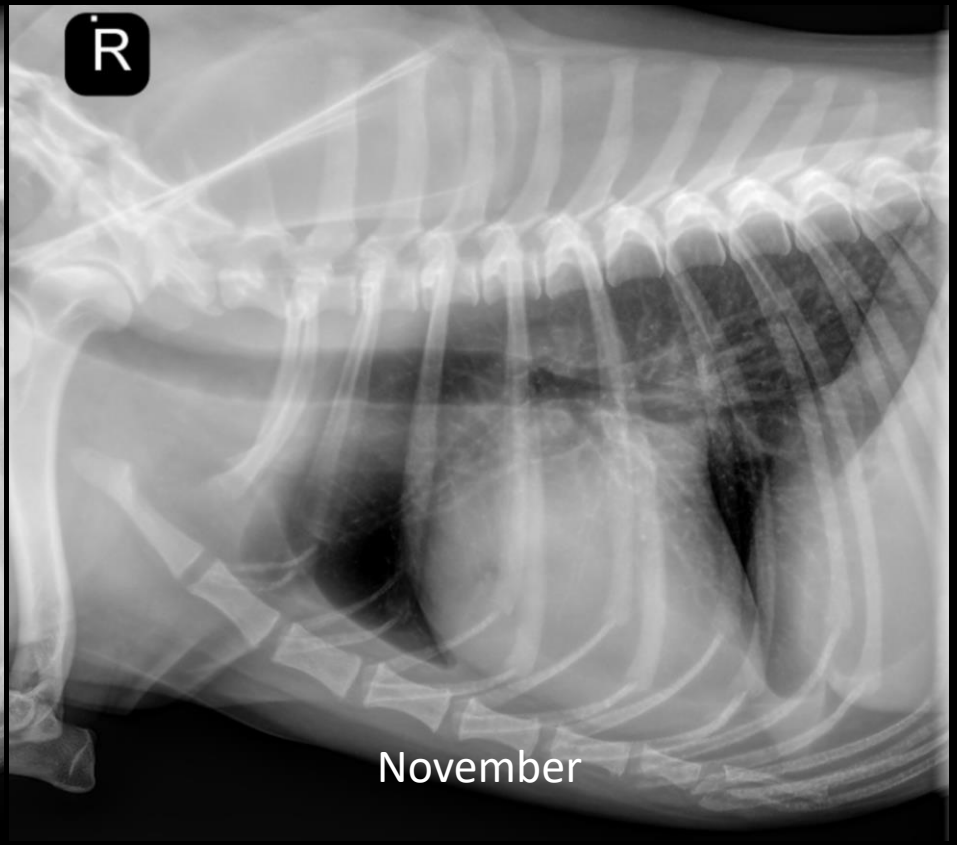
Presenting complaint: Dental

Physical exam: Grade V/VI left apical systolic murmur (III/VI 6 months prior)



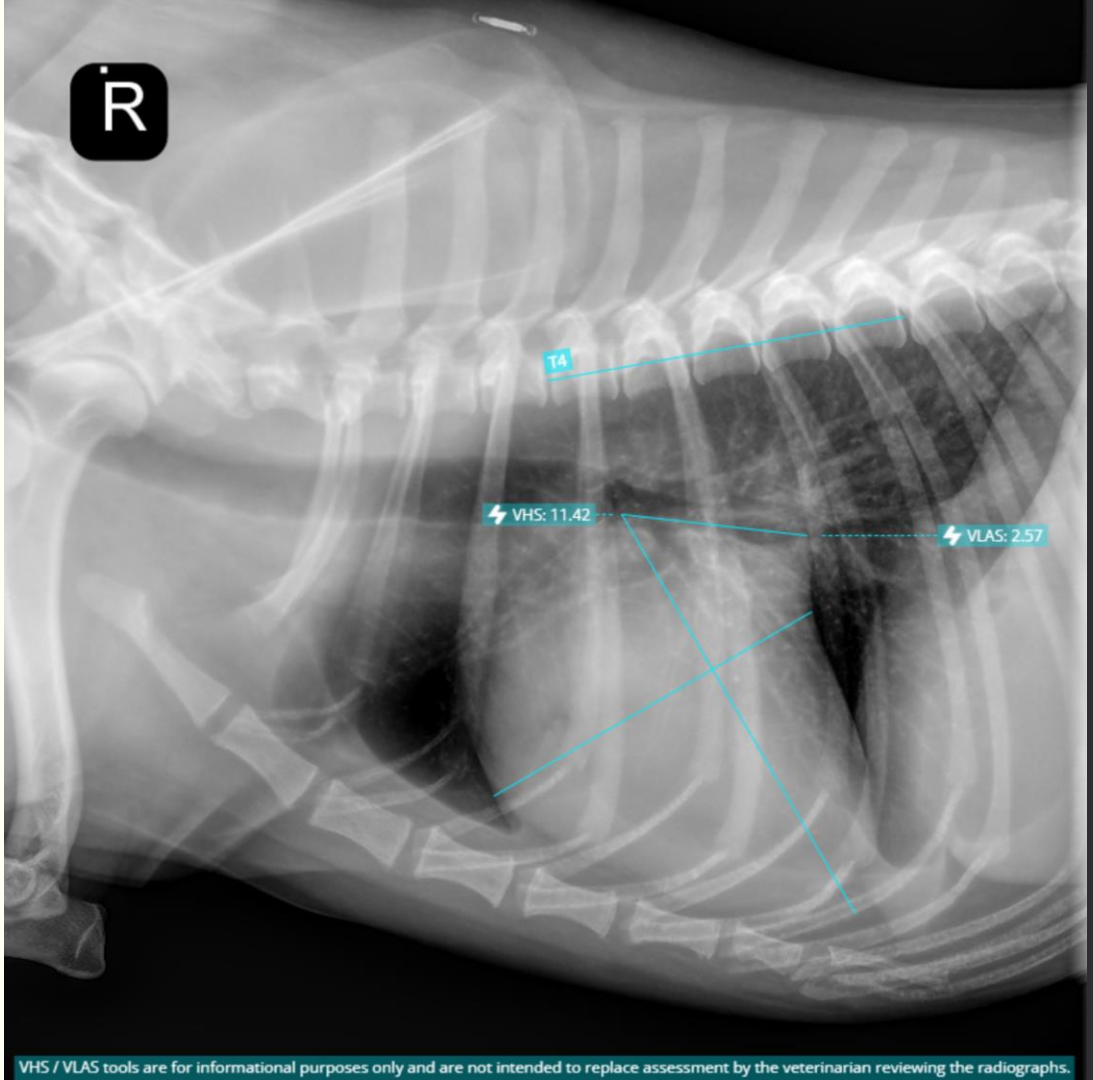
April

VHS 10.2



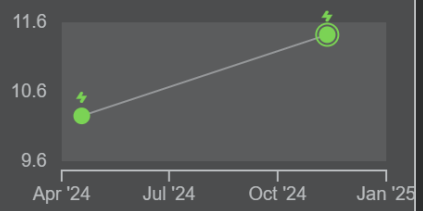
November

VHS 11.42



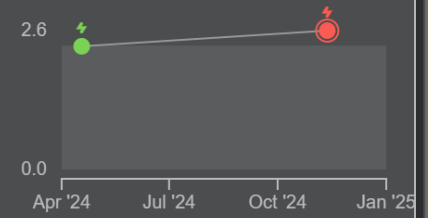
VHS / VLAS tools are for informational purposes only and are not intended to replace assessment by the veterinarian reviewing the radiographs.

VHS: 11.42



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

VLAS: 2.57

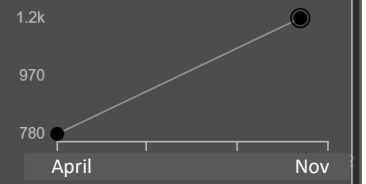


A score of 2.3 vertebrae or higher suggests the presence of left atrial enlargement.

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

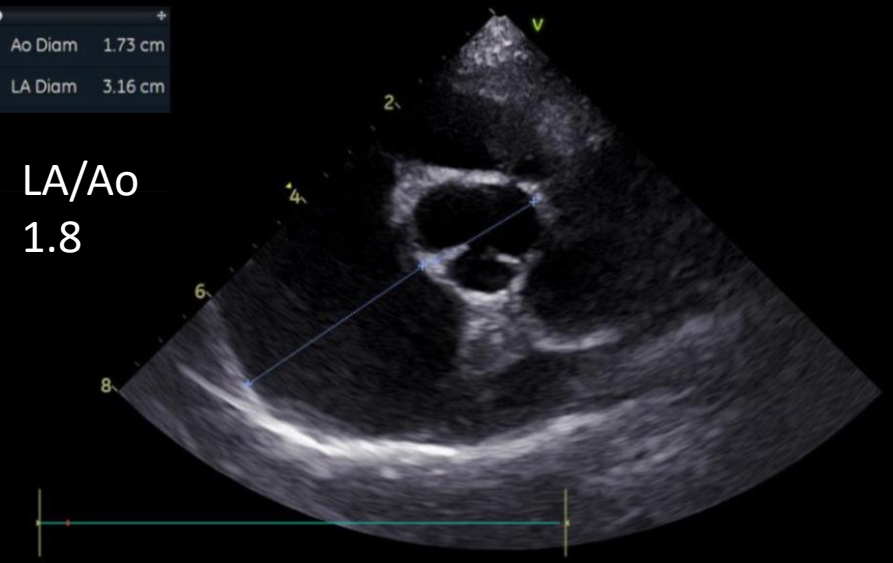
Important Information

Vertebral Heart Score

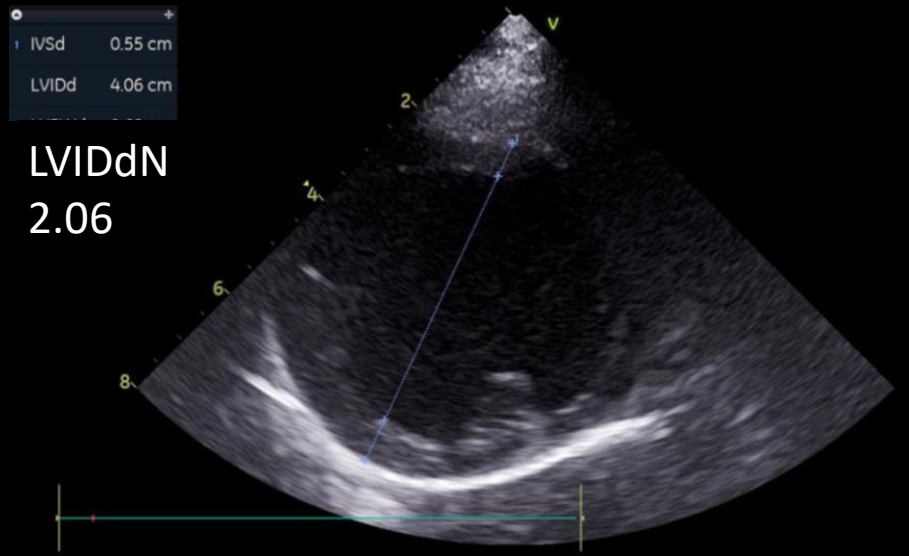
- VHS Announcement
- VHS Positioning Guide
- VHS Results and Trending

Vertebral Left Atrial Score

- VLAS Announcement
- VLAS Positioning Guide
- Cardiac Tools



LA/Ao
1.8



LVIDdN
2.06

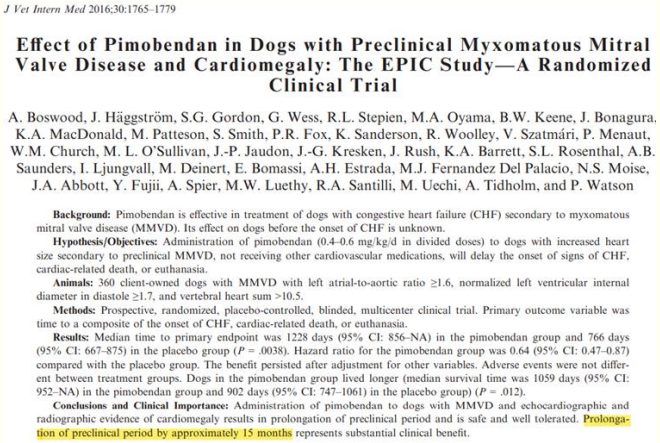
Recommendations

- Start pimobendan

- Monitor RR at rest, recheck radiographs if >30bpm

- Recheck physical examination, blood pressure, radiographs, bodyweight, echocardiography every 6 months

- Anesthetic risk considerations



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Conclusions and Clinical Importance: Administration of pimobendan to dogs with MMVD and echocardiographic and radiographic evidence of cardiomegaly results in prolongation of preclinical period and is safe and well tolerated. Prolongation of preclinical period by approximately 15 months represents substantial clinical benefit.

Summary for MMVD screening (B1 vs B2)

Gold standard

- Murmur grade
  - ≥ III/VI
- Echocardiography
  - LA:Ao ≥ 1.6
  - LVIDd ≥ 1.7
- Thoracic radiographs
  - VHS > 10.5v

Alternative

- Murmur grade
  - ≥ III/VI
- Thoracic radiographs
  - VHS > 11.6v
  - VLAS > 3.0v
- NT pro BNP
  - 1138 pmol/L

Dilated Cardiomyopathy

Which dogs to screen?

Start once 3 years old
Every 1-2 years

Primary DCM

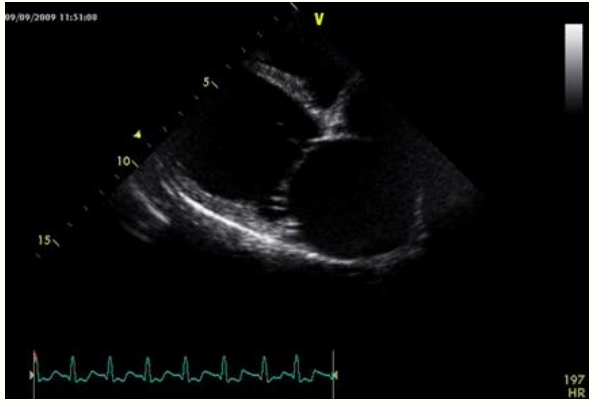
- Doberman 58.2%
- Newfoundland 17.6%
- Irish Wolfhound 24.2%
- Scottish Deerhound 21.6%
- Great Dane 35.6%
- Cocker Spaniel

Secondary DCM

- “BEG” diets – Boutique, Exotic, Grain-free
- Tachycardia induced
- Toxins (eg. doxorubicin)
- Endocrinoapthies
- Infectious disease

Physical exam

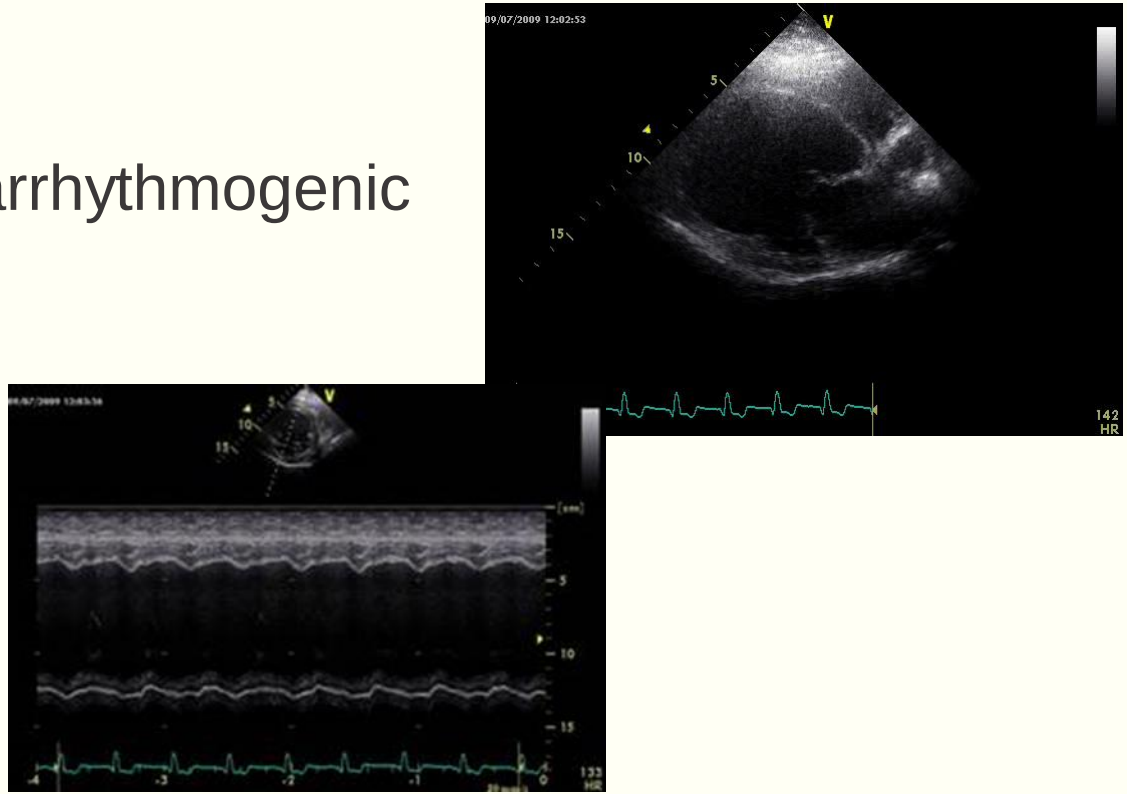
- Murmur
- Gallop
- Arrhythmia



- Often no physical exam findings with DCM

Echocardiography

- Gold standard
- May not detect arrhythmogenic DCM



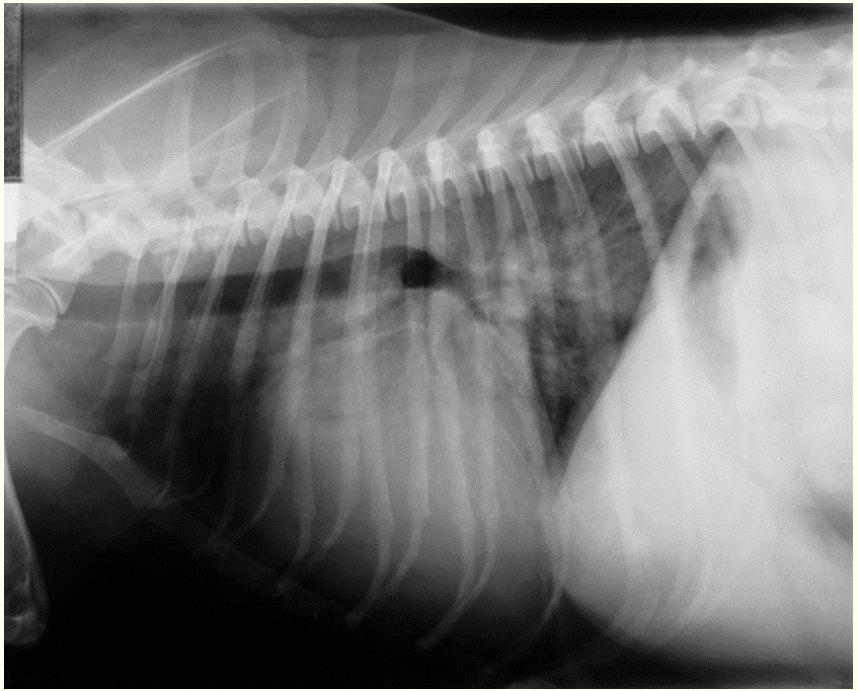
Holter monitor

- In combination with echocardiography
- Doberman: >300 VPCs in 24 hours or between 50-300 VPCs on two separate Holter monitors within a year.

- Rule out systemic disease

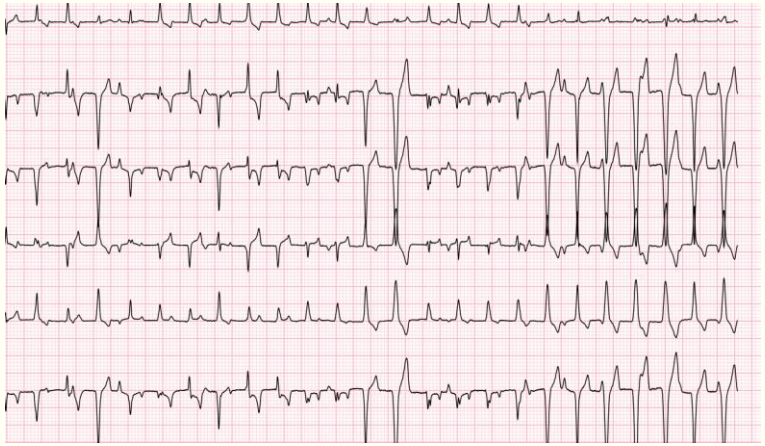
Thoracic radiographs

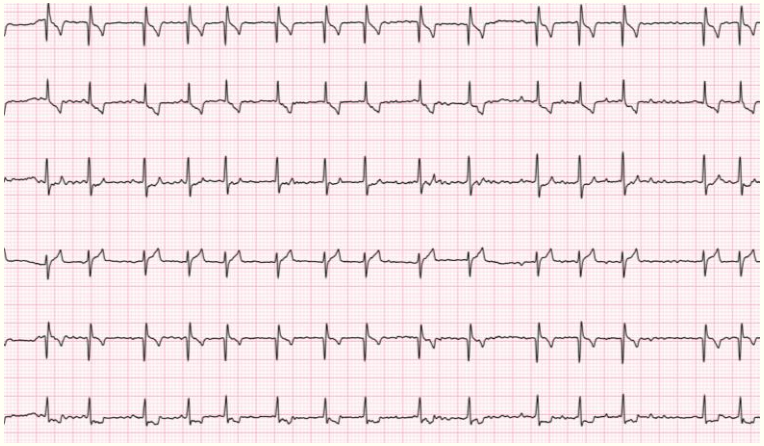
- Not very sensitive or specific



ECG

One VPC in 5 minutes suggests >100 VPCs in 24 hours
PPV 85.6% NPV 89.9%
Prevalence of 23.3%





Blood-based biomarkers

- NT pro BNP
  - **>626 pmol/L**: PPV 72%, NPV 83% (Dukes-McEwan, J et al., *J Small Anim Pract* 2022;63:275-285)
  - **>550 pmol/L:** Sens 78.6%, spec 90.4% (Wess et al., JAVMA 2010;73(5))
  - **>400 pmol/L:** Sens 90.0%, spec 75.0% (Wess et al., JAVMA 2010;73(5))
  - Does not detect arrhythmic DCM
- Cardiac troponin I
  - **>0.22 ng/mL:** Sens 79.5%, spec 84.4%(Wess et al., J Vet Intern Med 2010;24:843-849)
  - **> 0.113 ng/mL:** Sens 81.2%, spec 73.2%(Kluser et al., J Vet Intern Med 2019;33:54-63)
  - **> 0.056 ng/mL:** Sens 84%, spec 84%(Dukes-McEwan et al., J Small Anim Pract 2022;63(4):275-285)
- Taurine

Genetic Screening

Useful as screening for breeding animals but not individual risk of development of DCM

PDK4 gene: US population
Titin gene
Others proposed

Several **SNPs**

By Udo Tjalsma - Own work, CC0, https://commons.wikimedia.org/w/index.php?curid=8960691

Phospholamban gene

User:Challkhmc, Public domain, via Wikimedia Commonshttps://commons.wikimedia.org/wiki/File:Portugueuse_Water_Dog_in_snow.jpg

Locus on **chromosome 8**

RNA-binding motif protein 20 gene

Summary for DCM

Gold standard

- Echocardiography
- 24-hour Holter monitor

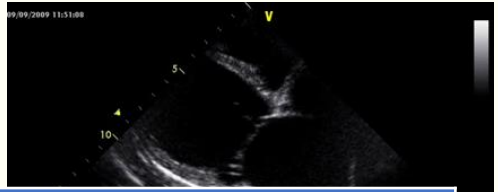
Alternative

- NT-pro BNP
- 5-minute ECG
- Cardiac troponin I

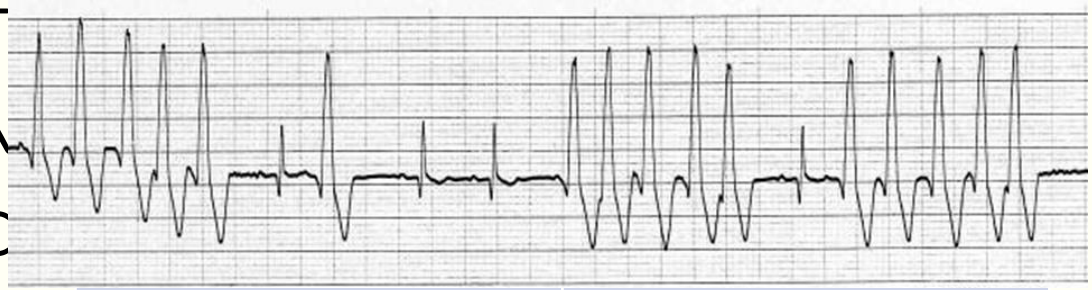
Arrhythmogenic Right Ventricular Cardiomyopathy

Screening Recommendations are Similar to DCM

- Start once 3-4 years, repeat annually
- Echocardiography
- Holter monitor
- ECG
- T
- N
- C
- Genetic Screening: **Striatin**

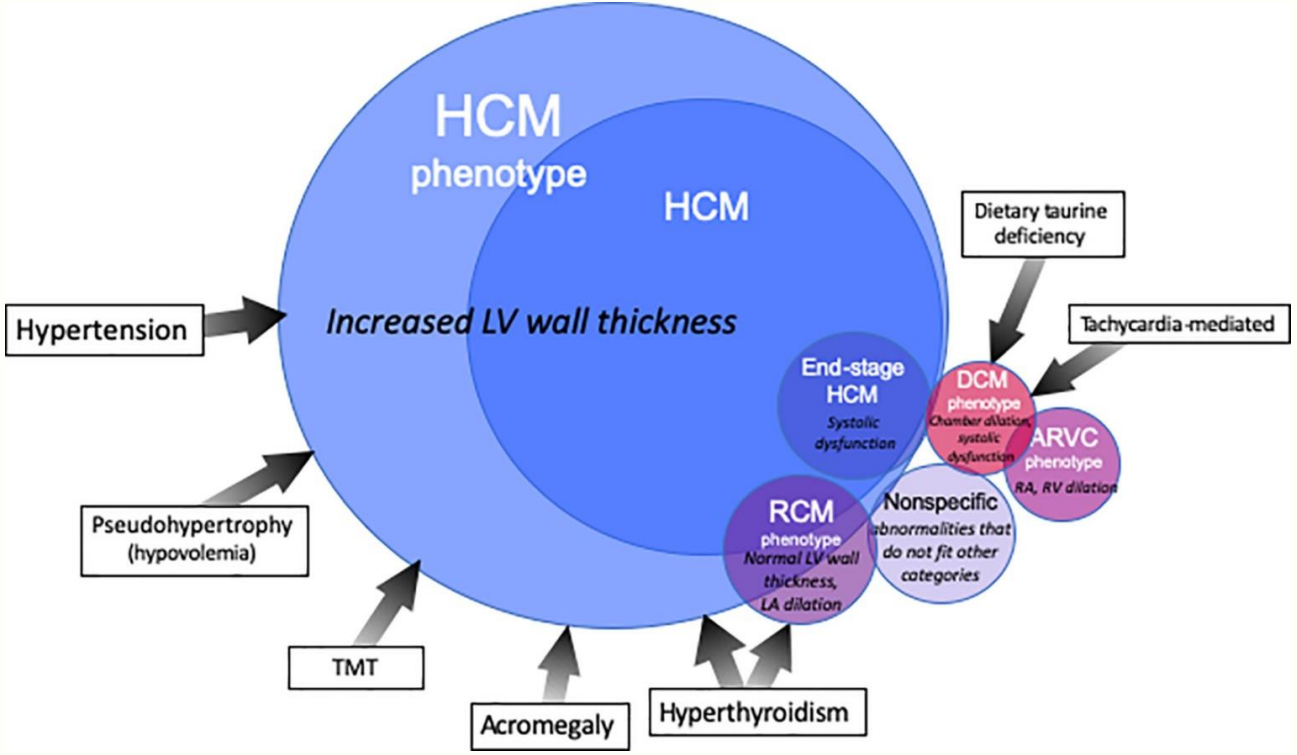


VPCs/24h	Interpretation
0-20	Normal



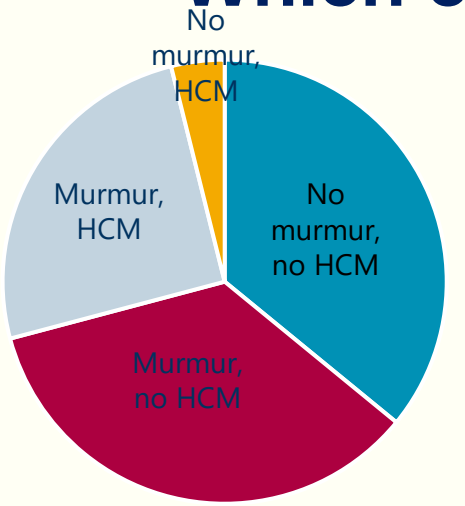
Feline Cardiomyopathy

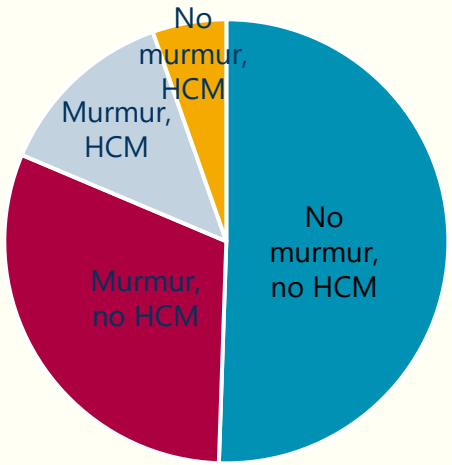
ACVIM consensus statement guidelines for the classification, diagnosis, and management of cardiomyopathies in cats



Journal of Veterinary Internal Medicine, Volume: 34, Issue: 3, Pages: 1062-1077, First published: 03 April 2020, DOI: (10.1111/jvim.15745)

Which cats should we screen?



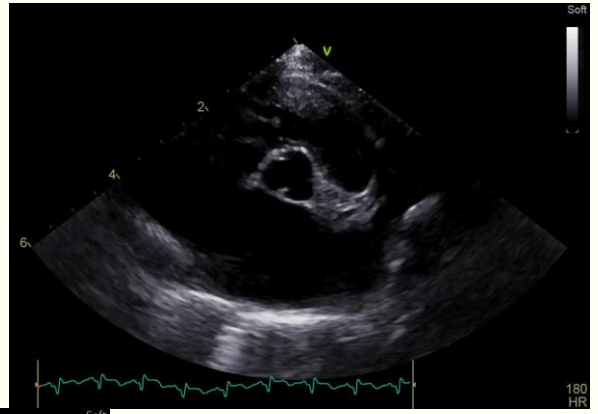


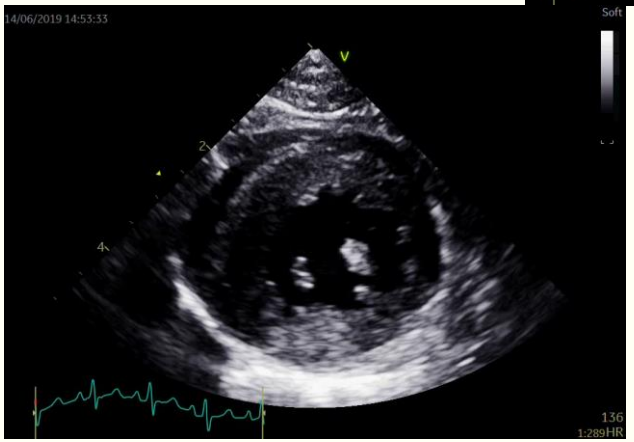
>9 years	**Cats 3-9 years**
• Murmur prevalence 59.8%	44.1%
• HCM prevalence 29.4%	18.6%
• Sens 86.7%	71.1%
• Spec 51.4%	62.1%
• PPV 42.6%	30.1%
• NPV 90.2%	90.4%

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.

Echocardiography

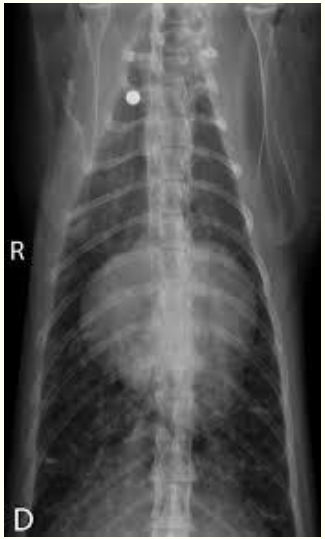
- Gold standard
- POCUS can detect stage B2

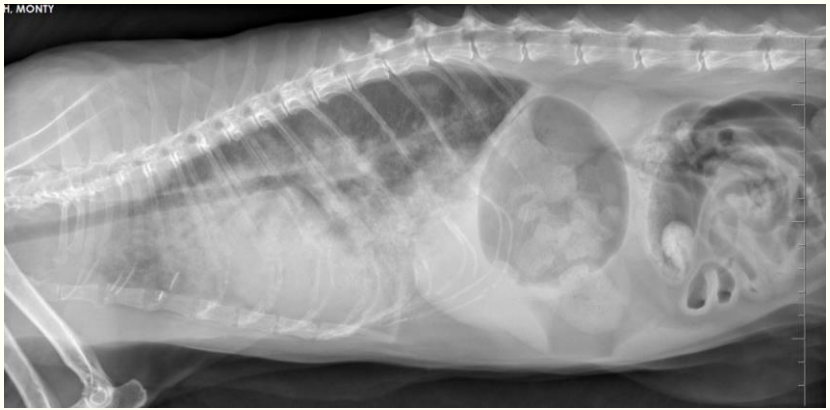




Radiographs in cats

- **VHS ≤8.1** suggest absence of cardiomegaly but not necessarily absence of cardiac disease.
- **“Valentine” heart** on DV/VD suggests cardiac disease BUT 7-12% have normal echo.
- Low sensitivity but high specificity for LA enlargement overall





NT pro BNP

- Mild disease
  - Insensitive
- Moderate or severe disease
  - Good negative predictive value
  - Moderate positive predictive value
- Use to decide if need further testing

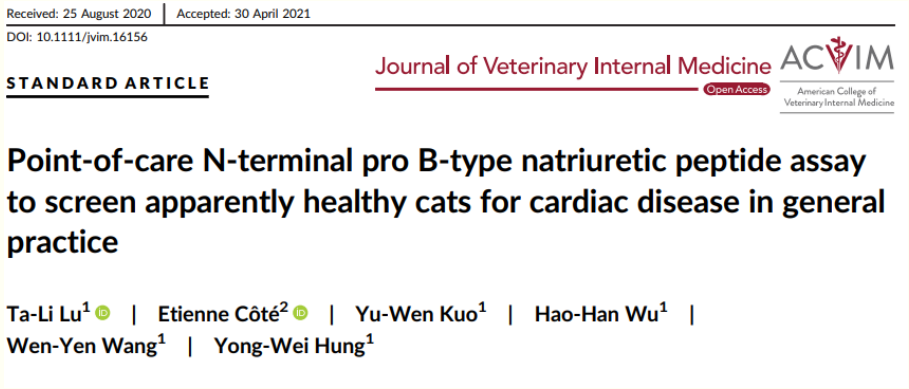
Cut-off values recommend by IDEXX using the Feline Cardiopet® proBNP Assay*	
<100pmol/l	Clinically significant cardiomyopathy is unlikely
100-270pmol/l	Clinically significant cardiomyopathy is unlikely but early disease may be present. Consider repeating NT-proBNP in 3–6 months or an echocardiogram.
>270pmol/l	Clinically significant cardiomyopathy is highly likely. Further cardiac work-up including an echocardiogram is recommended.

IDEXX Laboratories Inc., Westbrook (ME)

NT-proBNP	Lighter	Equal	Darker
			
Evaluation	Normal	Abnormal	Abnormal
NT-proBNP concentration (pmol/L)	24 (24-31)[a]	162 (100-217)[b]	505 (336-1312)[c]
No of POCT	108	6	25

Normal or mild heart disease likely

Moderate to severe heart disease likely



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STANDARD ARTICLE

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ACVIM American College of Veterinary Internal Medicine

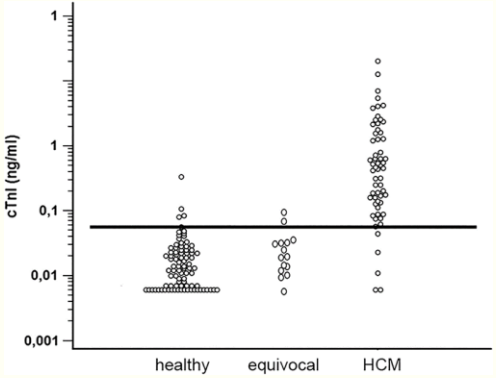
Point-of-care N-terminal pro B-type natriuretic peptide assay to screen apparently healthy cats for cardiac disease in general practice

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 apparent physical signs of heart disease
- 49 (23%) had abnormal echos
- Sensitivity 43%, Specificity 96%, **PPV 78%, NPV 85%**
- With murmur, Sensitivity 71%, Specificity 92%, **PPV 91%, NPV 75%**

Cardiac Troponin I

- Cutoff of >0.06 ng/mL
  - Sensitivity 87.8%
  - Specificity 95.4%
- Higher if SAM present
- Use to decide if need further testing



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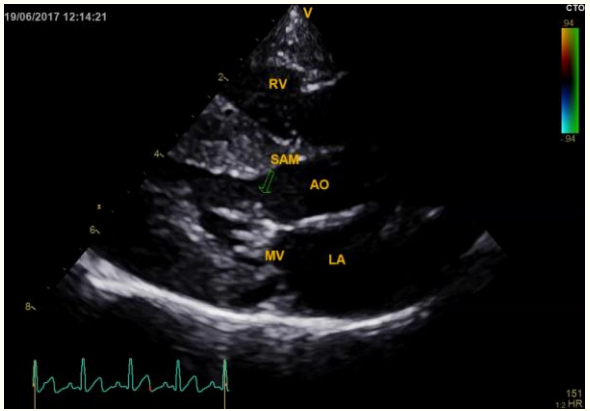
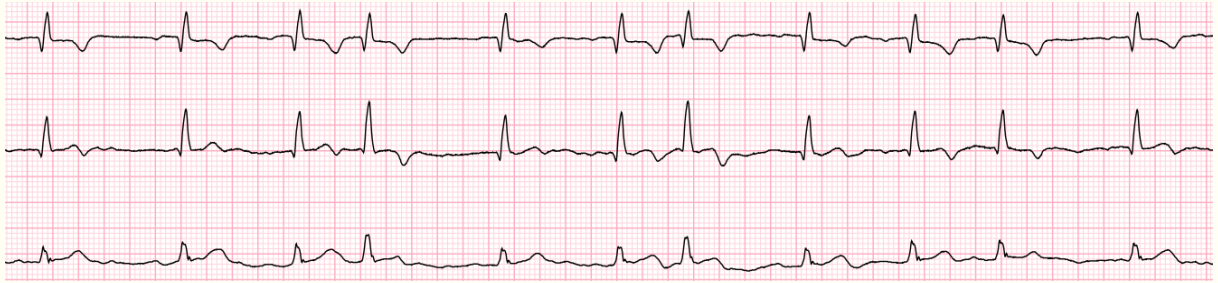


ECG

Arrhythmia very suggestive of cardiomyopathy in cats (only 4/106 cats with a ventricular arrhythmia had normal echo)

*"Sensitivity of a 6-lead ECG for detecting LV hypertrophy or LA enlargement is low and ECG is **not recommended as a screening method** for cardiomyopathies in cats"*



Summary for HCM

Gold standard

- Echocardiography

Alternative

- NT proBNP
- Thoracic radiographs

Summary

- Screen at risk populations

- Early identification of disease
  - Treatment
  - Client expectations and education
  - Anesthetic protocols
  - Alter treatment of concurrent diseases
  - Monitoring

Questions?