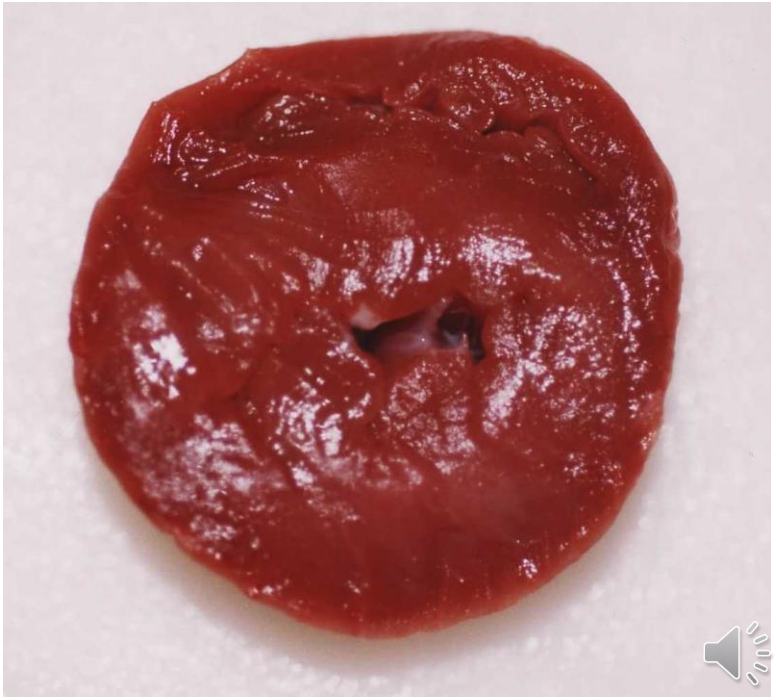
# Hypertrophic Cardiomyopathy and Other Feline Myocardial Diseases

# Hypertrophic Cardiomyopathy
## Main Pathologic Features

- Concentric or asymmetric LV hypertrophy
  - ♥ Thickening of the LVFW and IVS
  - ♥ Small LV internal cavity
  - ♥ Papillary muscle hypertrophy
  - ♥ Myocardial fiber disarray
  - ♥ Fibrosis
  - ♥ Coronary arteriosclerosis
    - ♥ Small coronary arteries
- Left atrial enlargement
- Right heart enlargement



# Hypertrophic Cardiomyopathy
## Pathophysiology

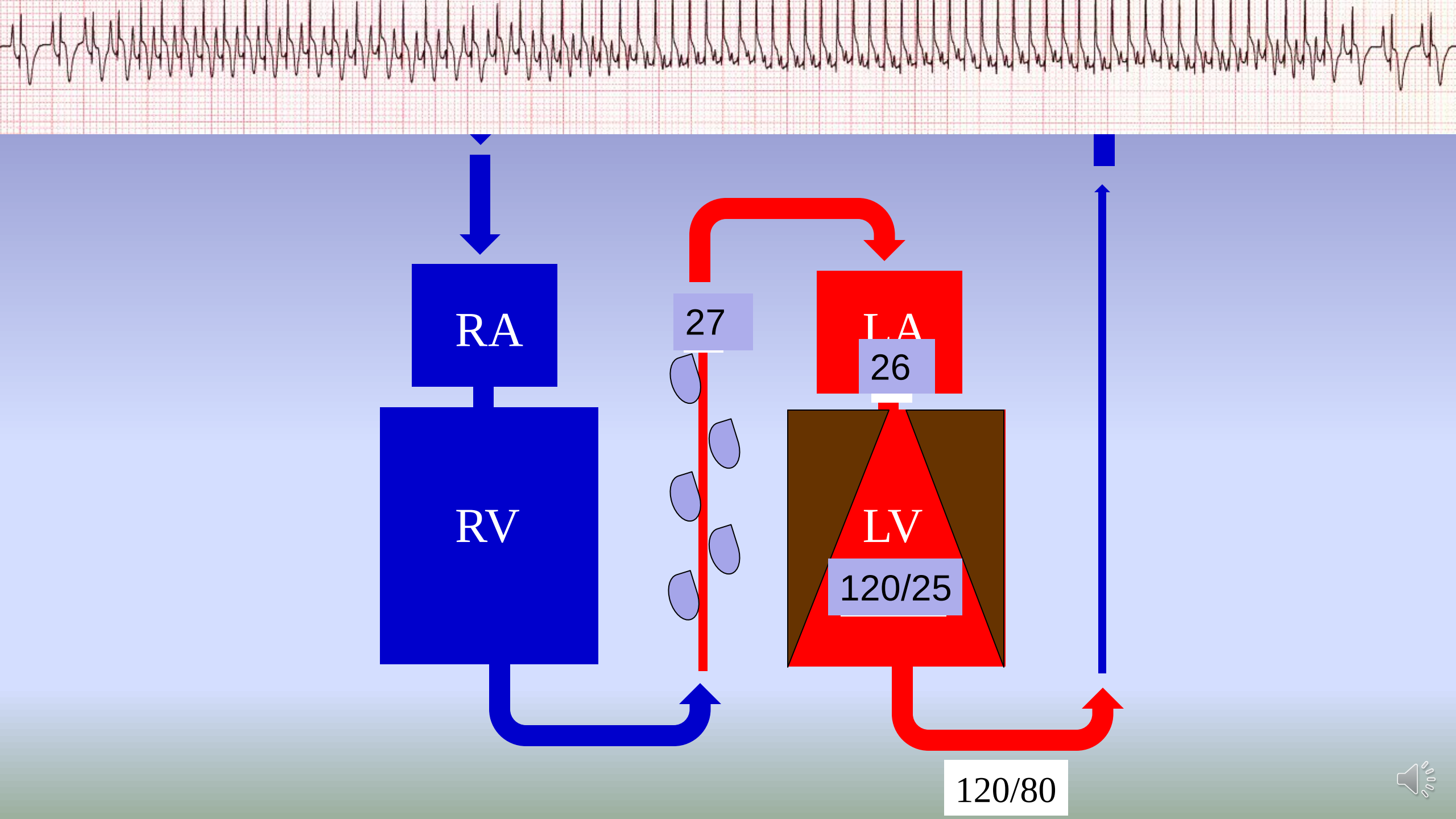
- Hypertrophy leads to reduced LV cavity size
- Diastolic filling is compromised
- Most coronary flow occurs during diastole
- Tachycardia shortens the duration of diastole
- Tachycardia therefore limits coronary flow to a hypertrophied myocardium
  - ♥ The myocardium gets “stiffer” following tachycardia
- Reduced LV compliance leads to LA enlargement
- Myocardial hypoxia/ischemia leads to arrhythmias

# Canine Hypertrophic Cardiomyopathy

- Very uncommon
- German Shorthaired Pointers +/- German Shepherds, Shi Tzu?
- Genetic basis in German Shorthaired Pointer (?)
- Conduction abnormalities, 3º AV block, ventricular arrhythmias
- CHF may develop
- Sudden death first sign in some cases

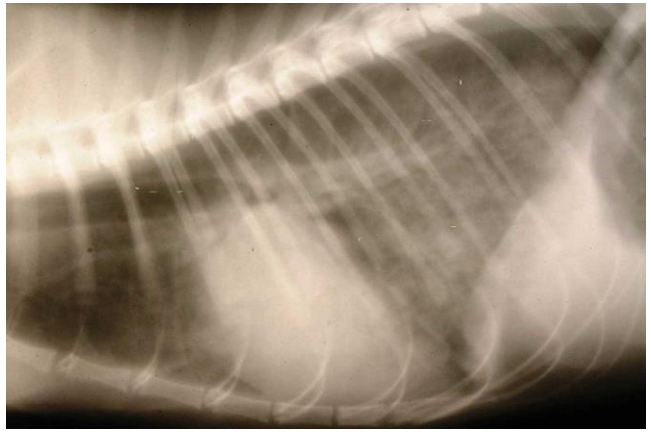
# Feline Hypertrophic Cardiomyopathy

- Most common cardiovascular disease in the cat
- Most common feline cause of:
  - ♥ CHF
  - ♥ Arterial thromboembolism
  - ♥ Syncope
  - ♥ Sudden death
  - ♥ Unexpected anesthesia death
    - ➢1:1000-2000 to 1:100?


RA
RV
27
LA
26
LV
120/25
120/80

# Tachycardia-induced CHF in cats with subclinical HCM

- 6 year old cat
- Previously asymptomatic
- II/VI murmur noted on last exam
- Laceration required anesthesia for sutures
- 2 days later respiratory distress
- Radiographs – pulmonary edema



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# Feline Hypertrophic Cardiomyopathy
## Differential Diagnosis

- Hypertrophic cardiomyopathy
- Systemic hypertension
  - ♥ Hypertensive heart disease
- Congenital aortic stenosis
- Hyperthyroidism
  - ♥ Hyperthyroid heart disease
- Other feline myocardial disease

# Feline Hypertrophic Cardiomyopathy

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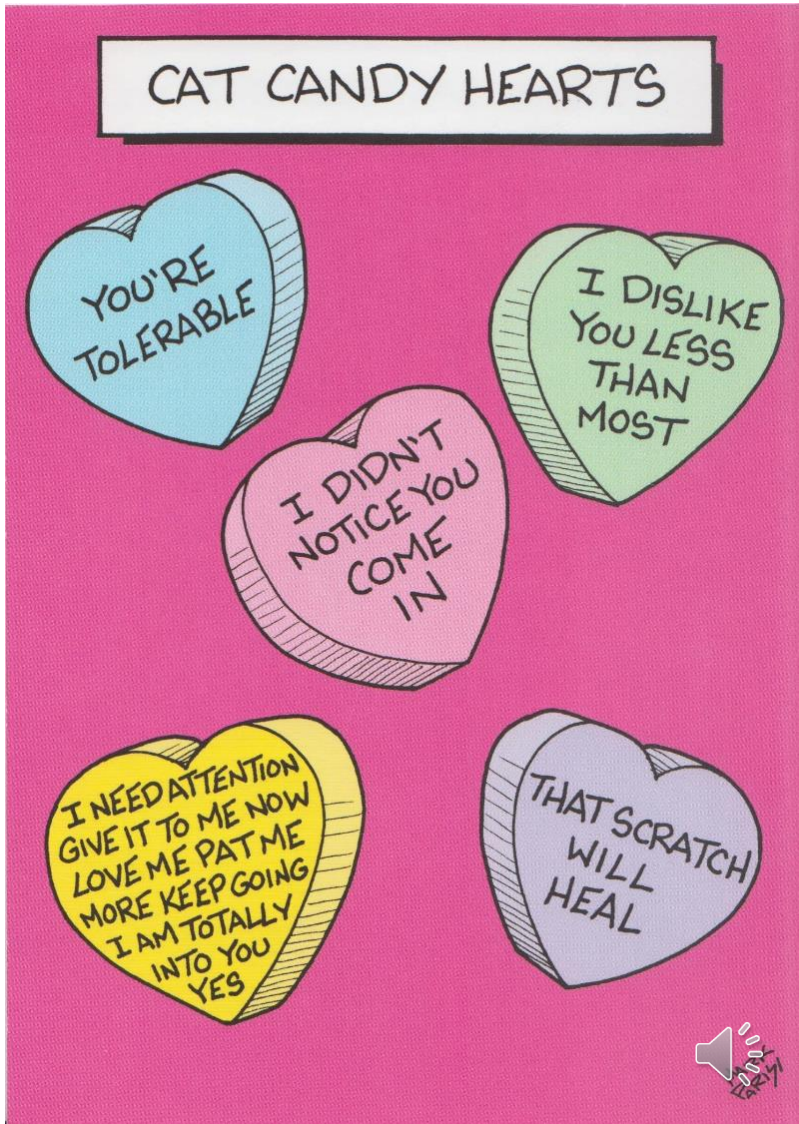

# Differential Diagnosis for Cardiac Murmurs in Cats

- Cardiomyopathy (HCM, DCM, RCM, UMC)
- Dynamic right ventricular outflow tract obstruction
  - ♥ Benign cause of murmur
- Systemic hypertension
- Hyperthyroidism
- Anemia
- Congenital heart disease

# What Causes Feline HCM?

## Sarcomeric proteins – Missense mutations

## Abnormalities identified in humans

- B-Myosin heavy chain
- Troponin T
- Alpha-Tropomyosin
- Myosin binding protein C
- Myosin light chains
- > 460 specific mutations identified

## Abnormalities in cats

- Myosin binding protein C in
  - Maine Coon cats, Ragdoll cats

## Role of the environment?

- Large or overweight cats more likely to get HCM?

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# Hypertrophic Cardiomyopathy Disease Manifestations

- Congestive Heart Failure (CHF)
- Arterial Thromboembolism (ATE)
- Syncope
- Sudden Death

The first clinical manifestation of cardiac disease is usually a “crisis” event

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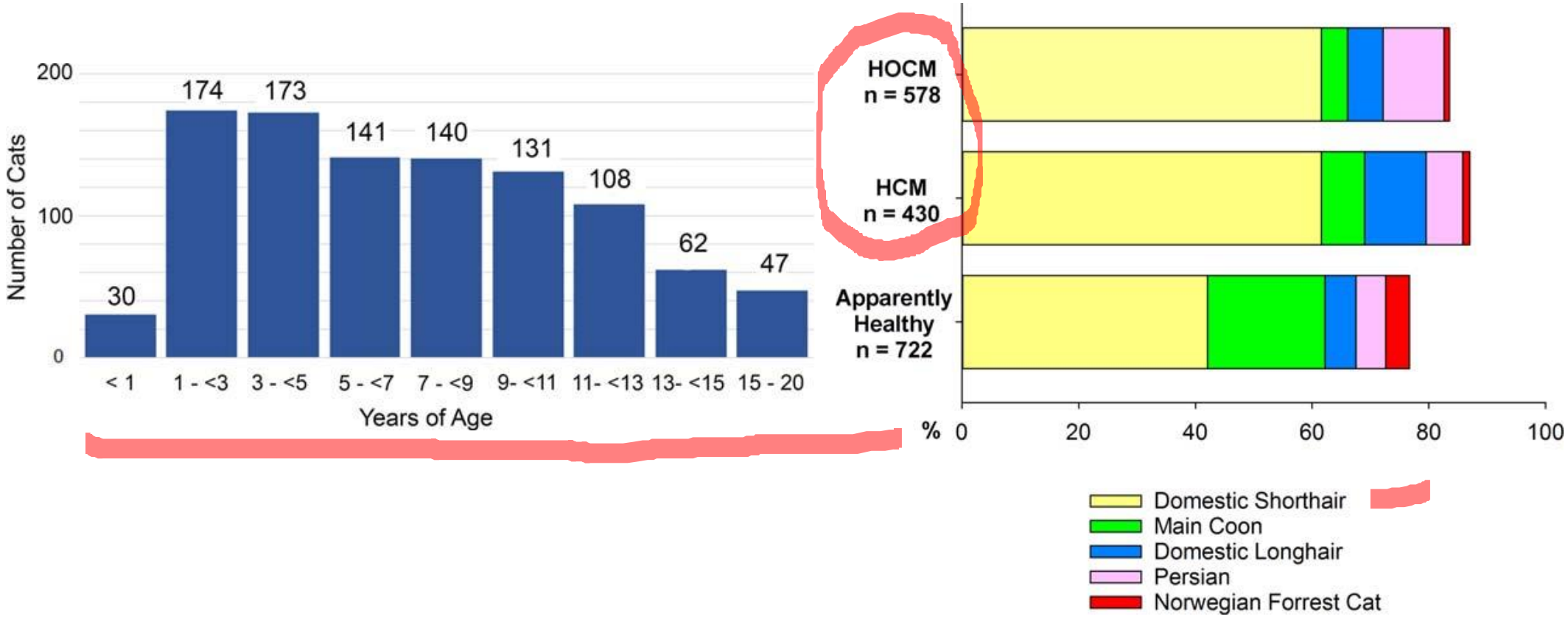
# Feline Hypertrophic Cardiomyopathy
## History

- Any breed
  - ♥ DSH, Maine coon, American shorthair, Persian, Himalayan,
  - ♥ Norwegian forest cat, Birman
- Any age
- Male > female
- History of prior murmur or gallop
- Cough is typically absent (Ddx - asthma, HW, others)
- Dyspnea, open mouth breathing
- Lethargy, weakness, hiding, anorexia, vomiting
- Seizure (actually syncope)
- Limb weakness/paralysis
- Recent stress, anesthesia, fluids, steroids

# Retrospective Study of Asymptomatic Cats




Fox et al 2018
JVIM

# Retrospective Study of Asymptomatic Cats

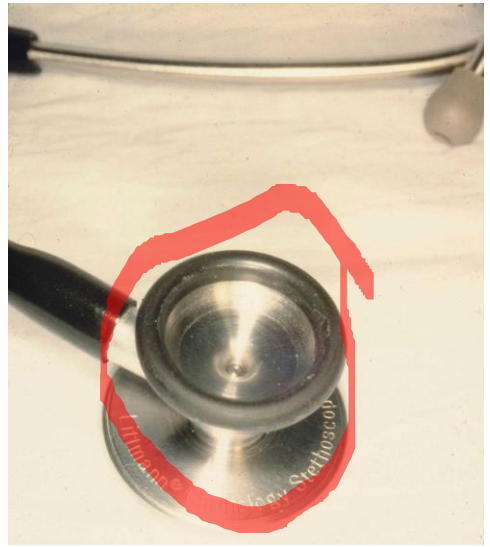
**TABLE 2** Prevalence of systolic heart murmurs in feline study populations

| Number of cats with heart murmurs | Study Population (n = 1730) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | AH (n = 722) | | HCM (n = 430) | | HOCM (n = 578) | | HCM/HOCM (n = 1008) | |
| | 335 | % 46.4 | 294 | % 68.4 | 537 | % 92.9 | 831 | % 82.4 |
| Heart murmur grade | | | | | | | | |
| 1 | 60 | 8.3 | 25 | 5.8 | 13 | 2.3 | 38 | 3.8 |
| 2 | 168 | 23.3 | 109 | 25.3 | 91 | 15.7 | 200 | 19.8 |
| 3 | 91 | 12.6 | 120 | 27.9 | 271 | 46.9 | 391 | 38.8 |
| 4 | 16 | 2.2 | 39 | 9.1 | 157 | 27.2 | 196 | 19.4 |
| 5 | 0 | 0.0 | 1 | 0.2 | 5 | 0.9 | 6 | 0.6 |

Abbreviations: HCM, nonobstructive hypertrophic cardiomyopathy; HOCM, obstructive hypertrophic cardiomyopathy.

Fox et al 2018
JVIM

# Physical Examination



- Cardiac murmur - sternal borders
- Cardiac gallop (S4) - Try the bell!
- Arrhythmia
- Respiratory distress
  - ♥ Pulmonary crackles (edema)
  - ♥ Dull lungs ventrally, expanded chest cavity
- Jugular vein distention (Pleural effusion, hepatomegaly)
- Variable MM, CRT, weak arterial pulses
- Hypothermia if CHF or ATE
  - ♥ HR and Temperature related
- Signs of ATE

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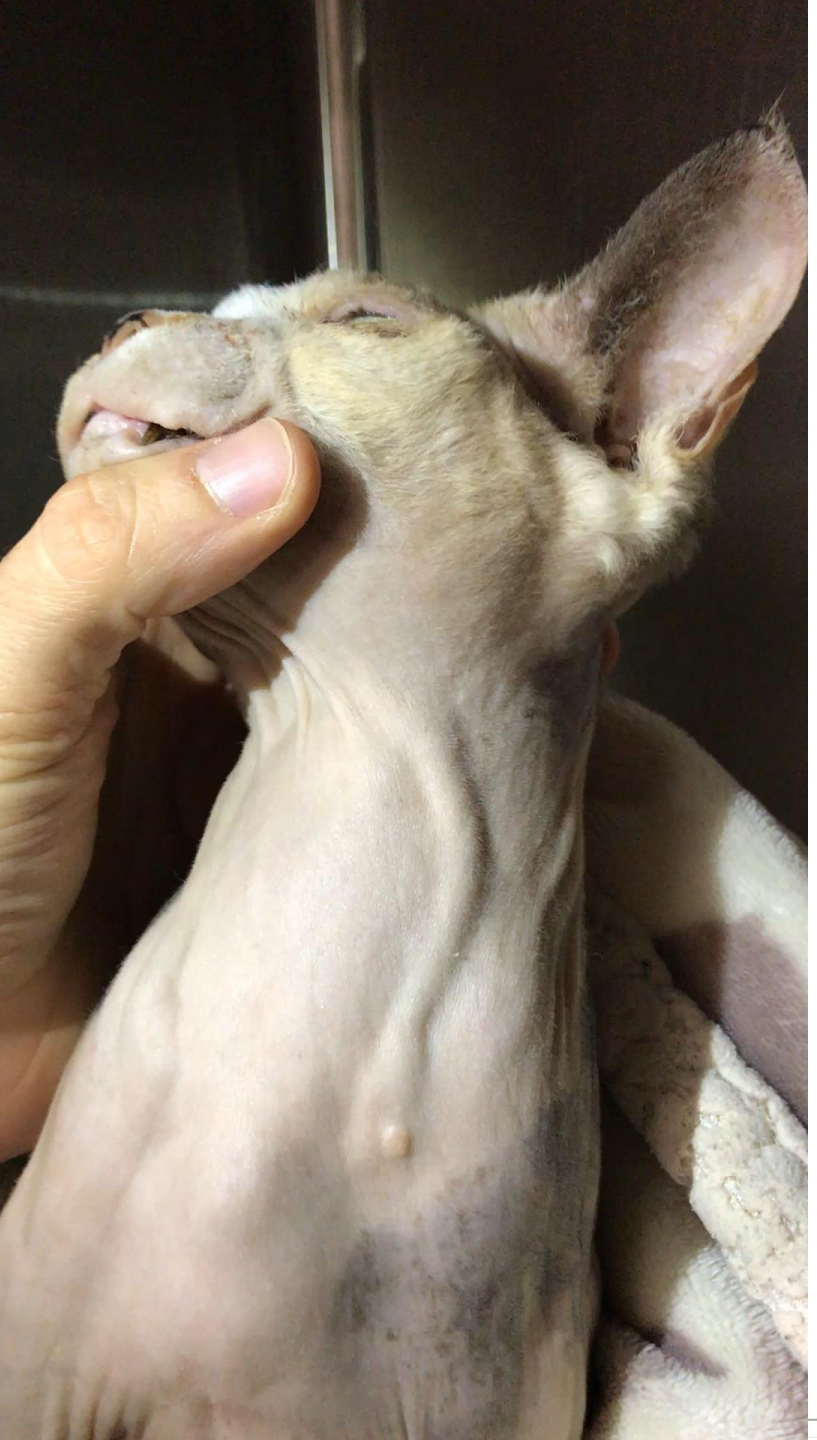

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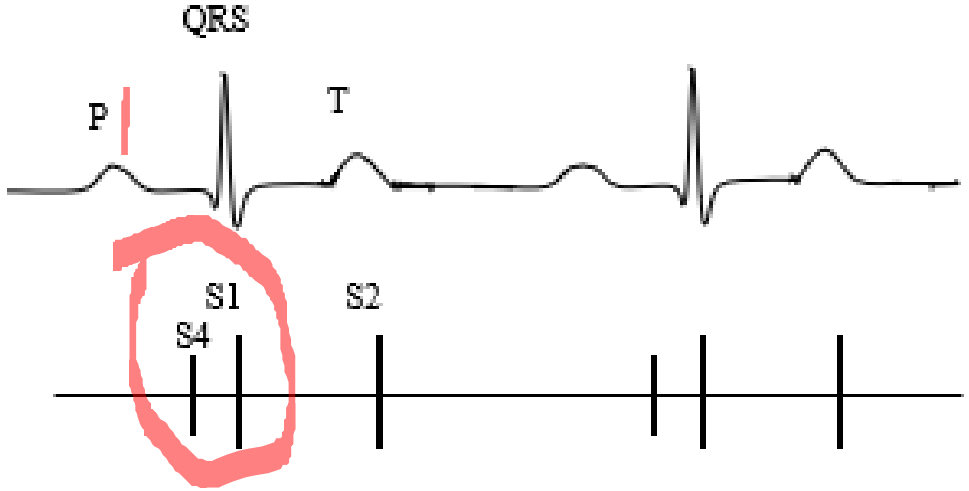
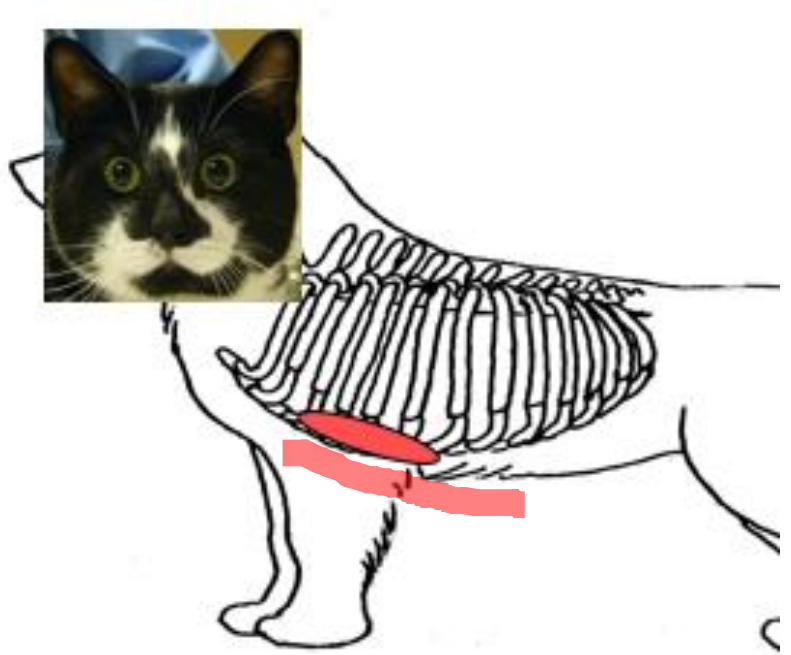



HSS gallop comes and goes

Cat murmur heard best at end of recording



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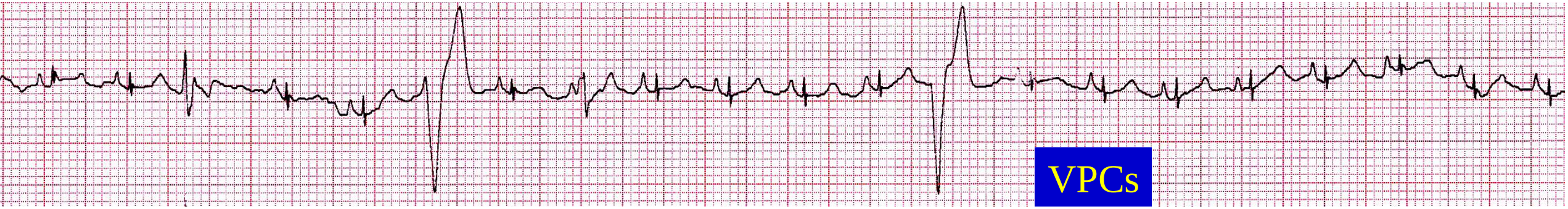
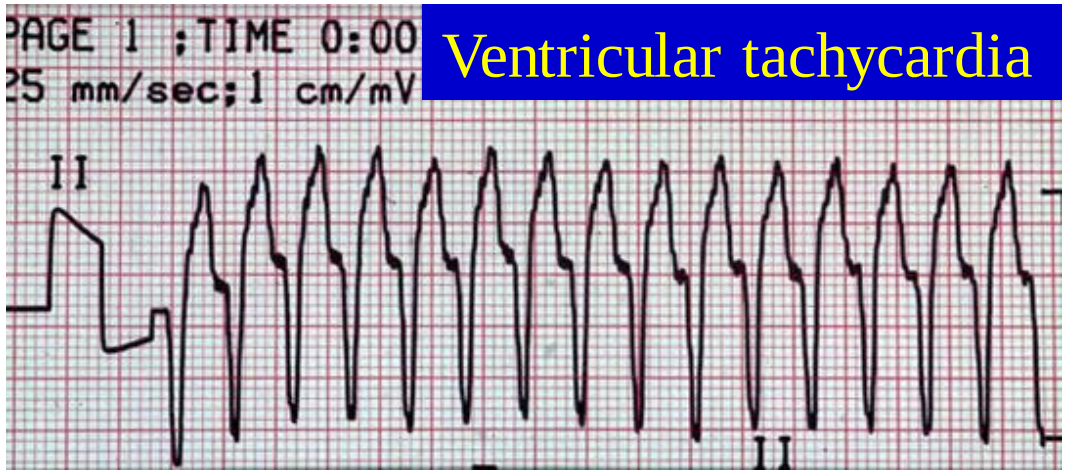
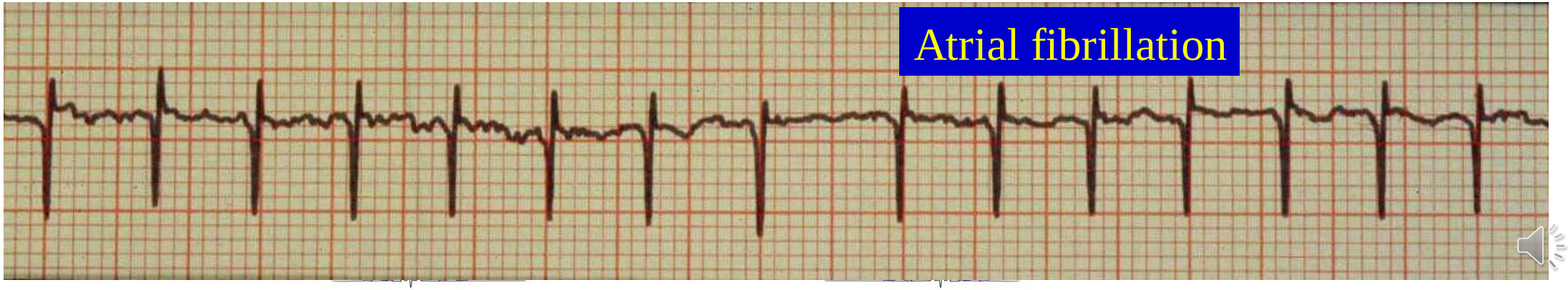
# Electrocardiography

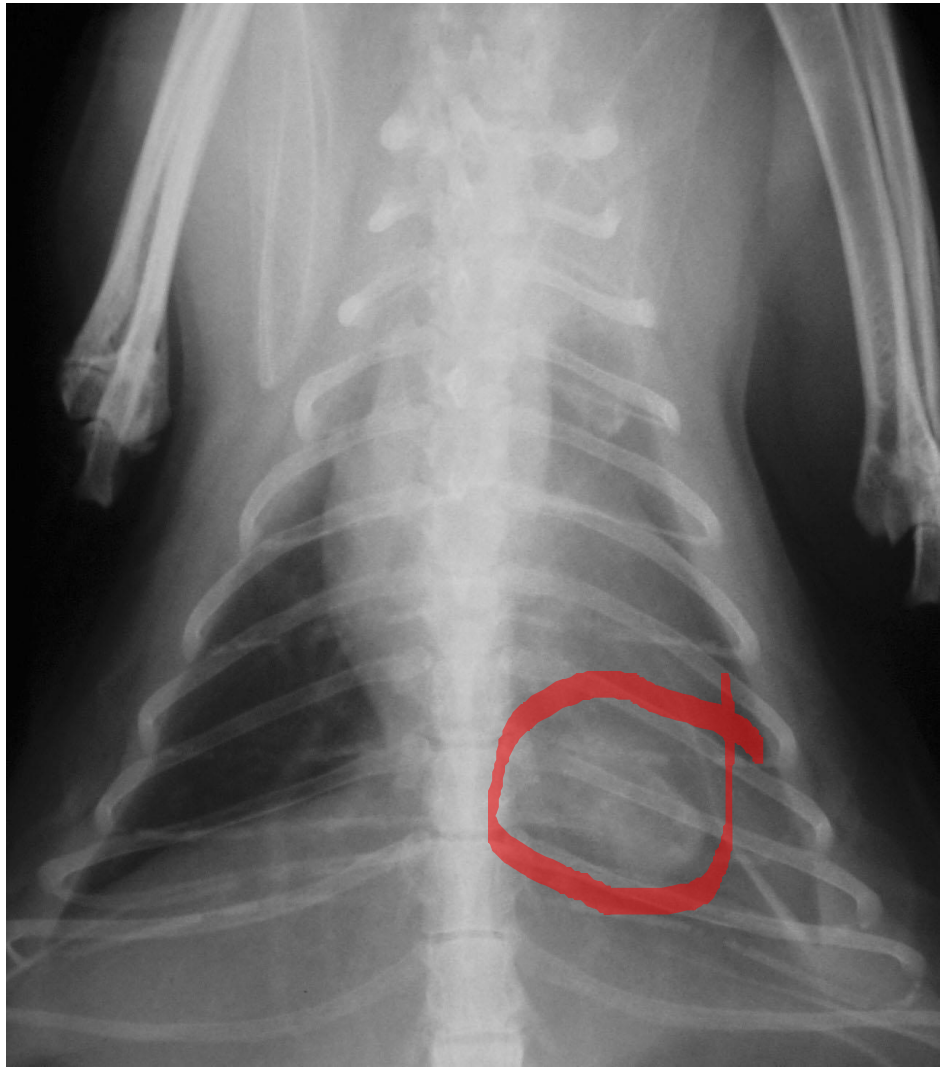


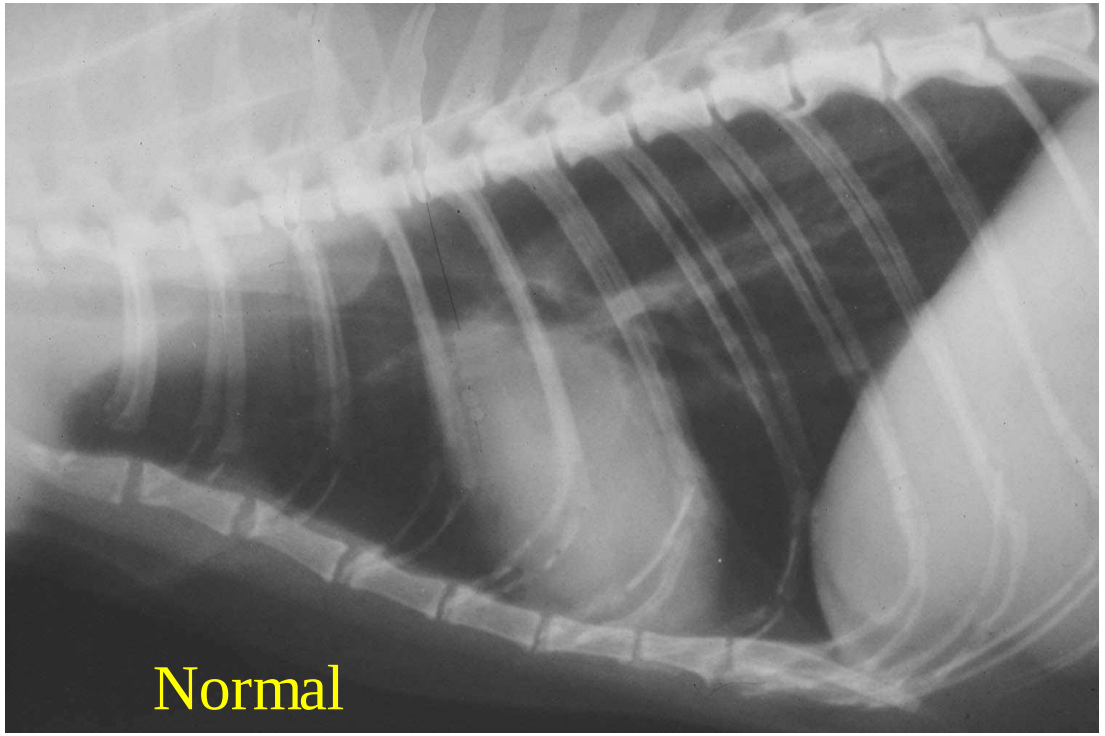



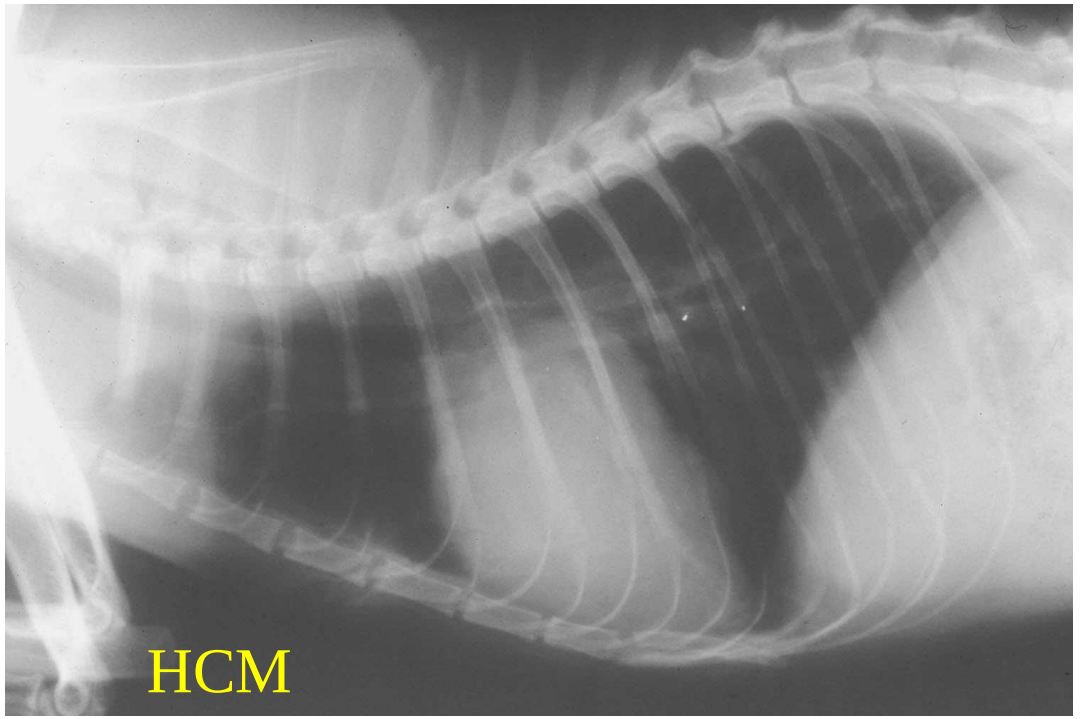
# Thoracic Radiographs

- Identify cardiomegaly
- Determine whether CHF exists
- Identify other thoracic diseases



# Thoracic Radiographs




VHS generally < 8.1v in normal cats

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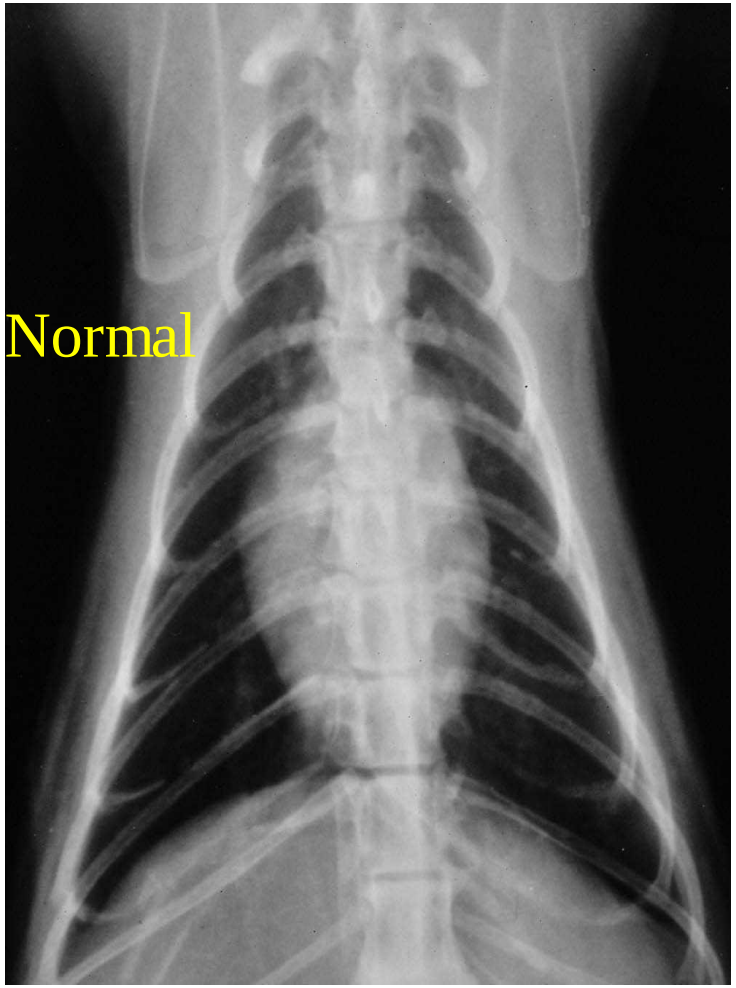
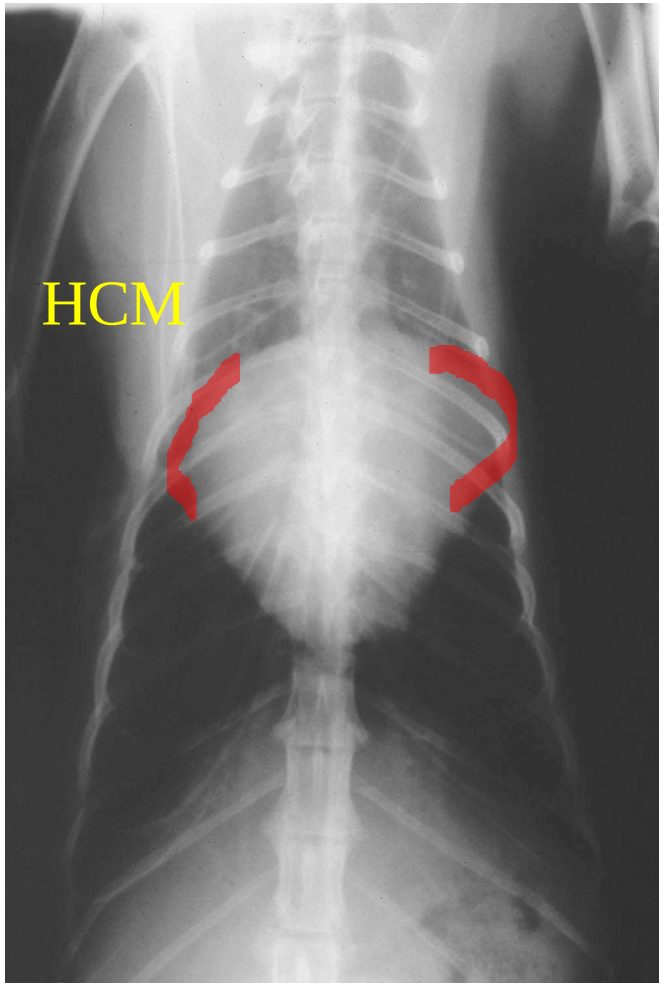
# Thoracic Radiographs



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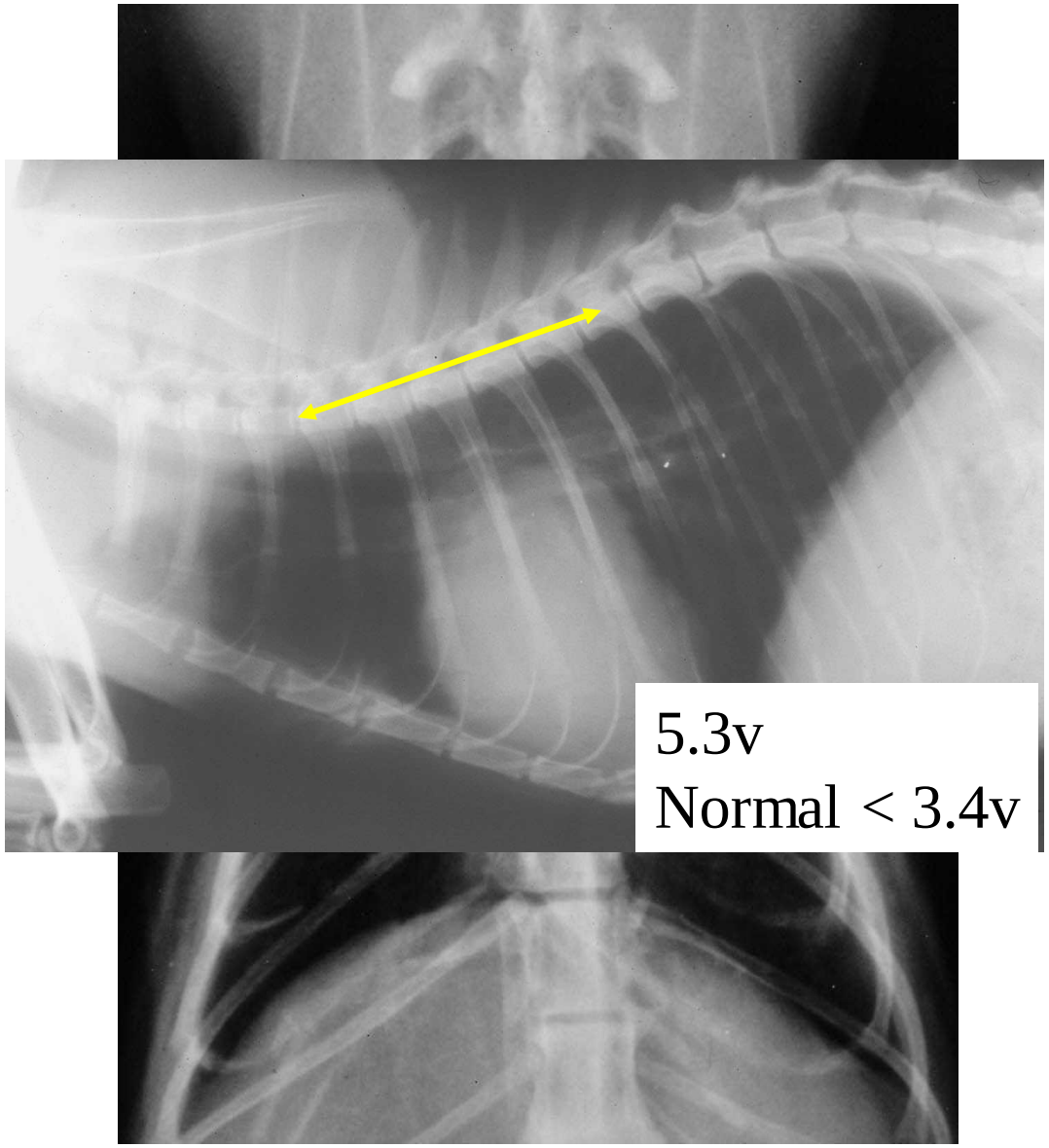
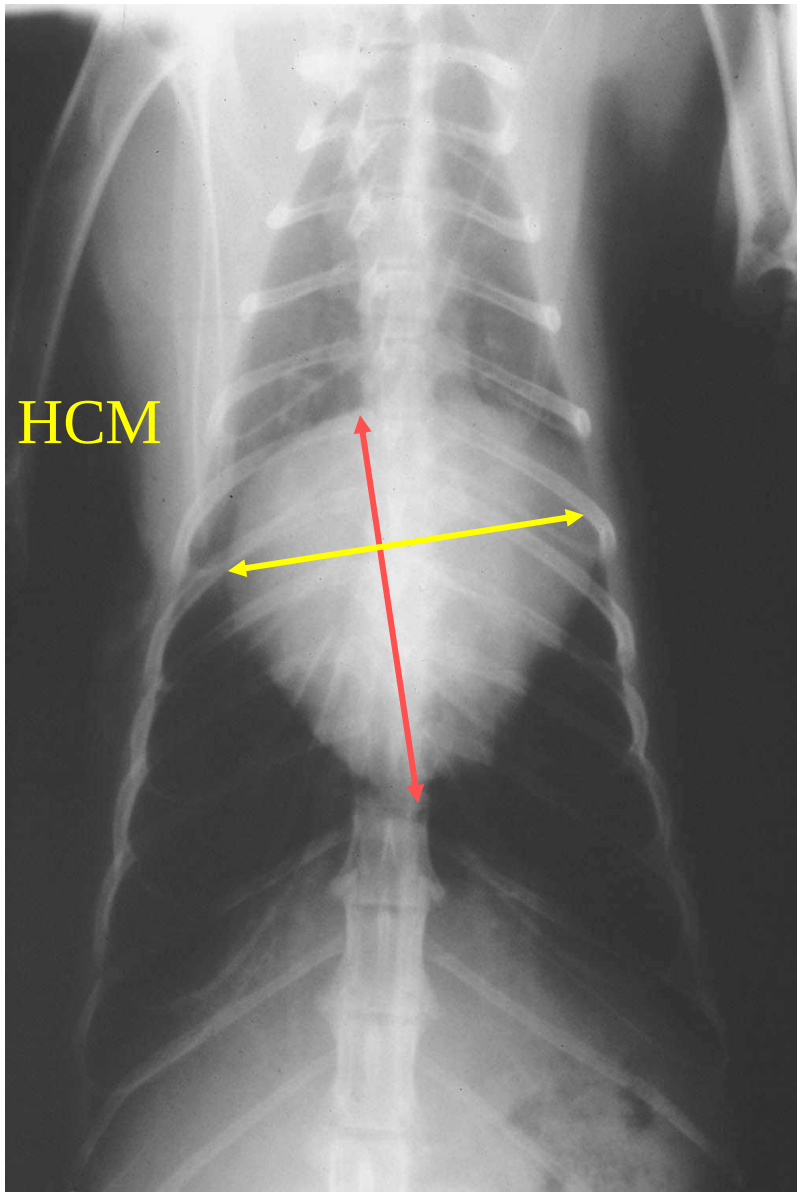
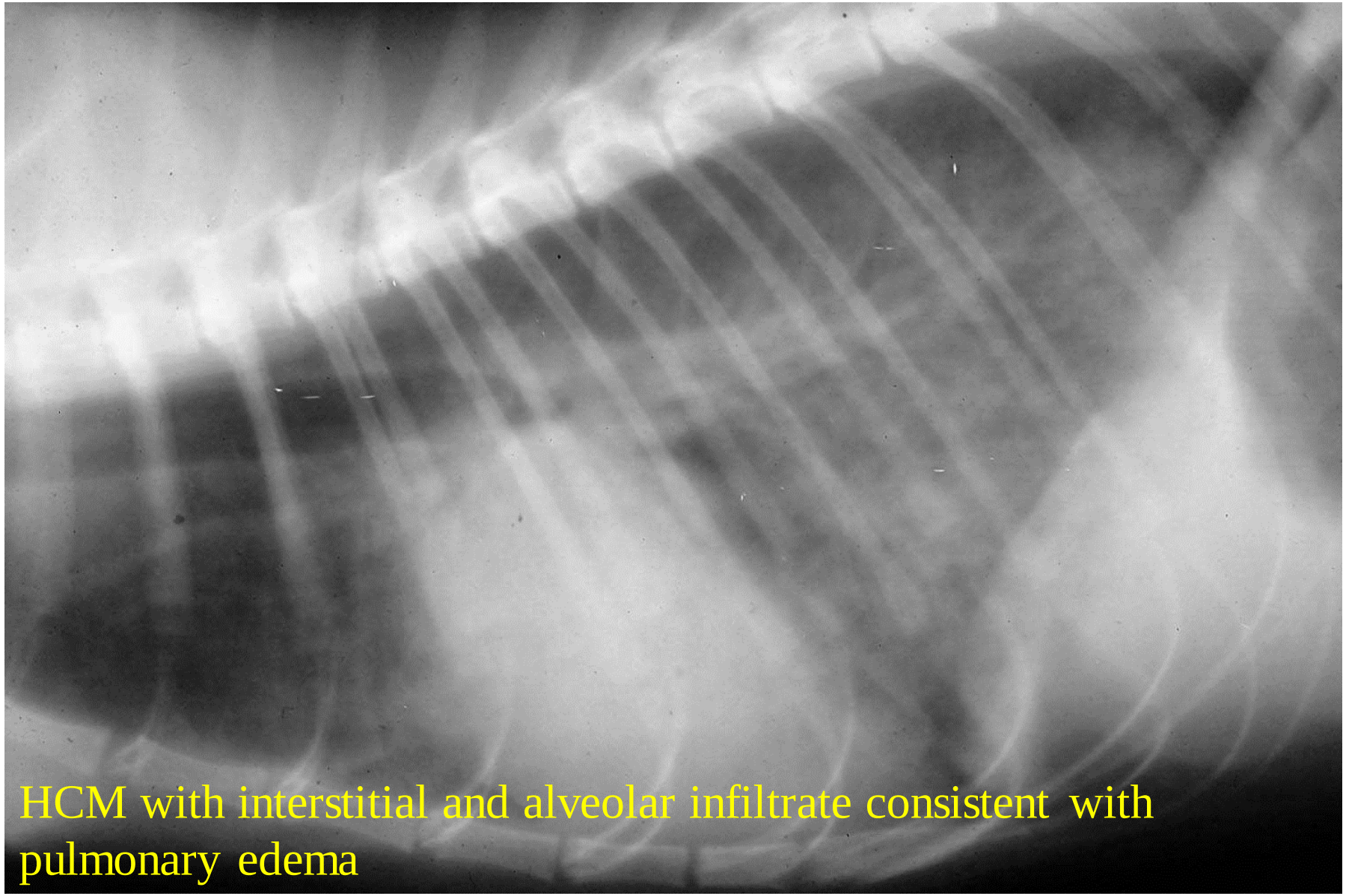
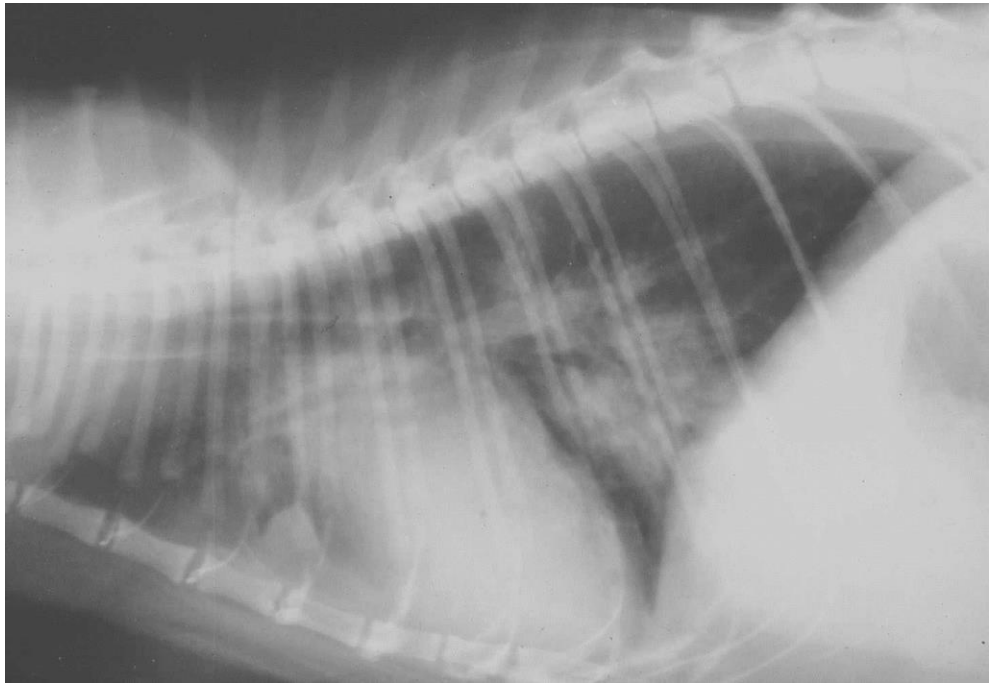
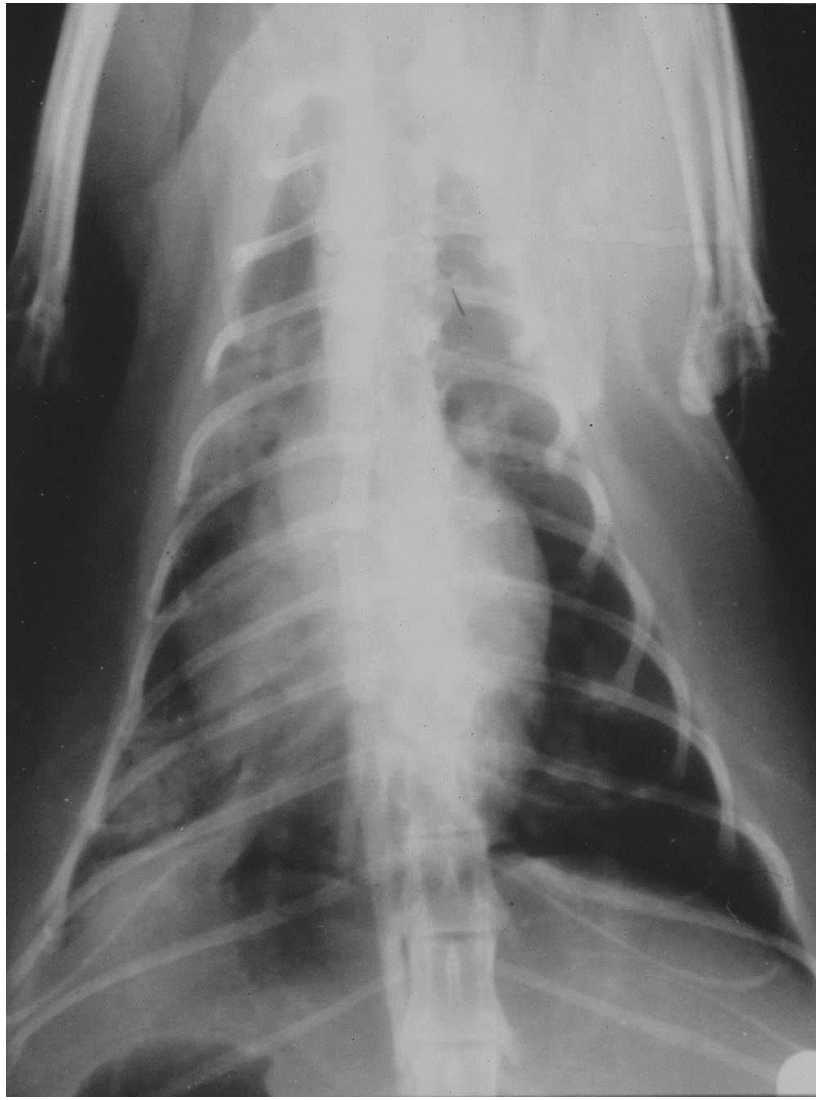


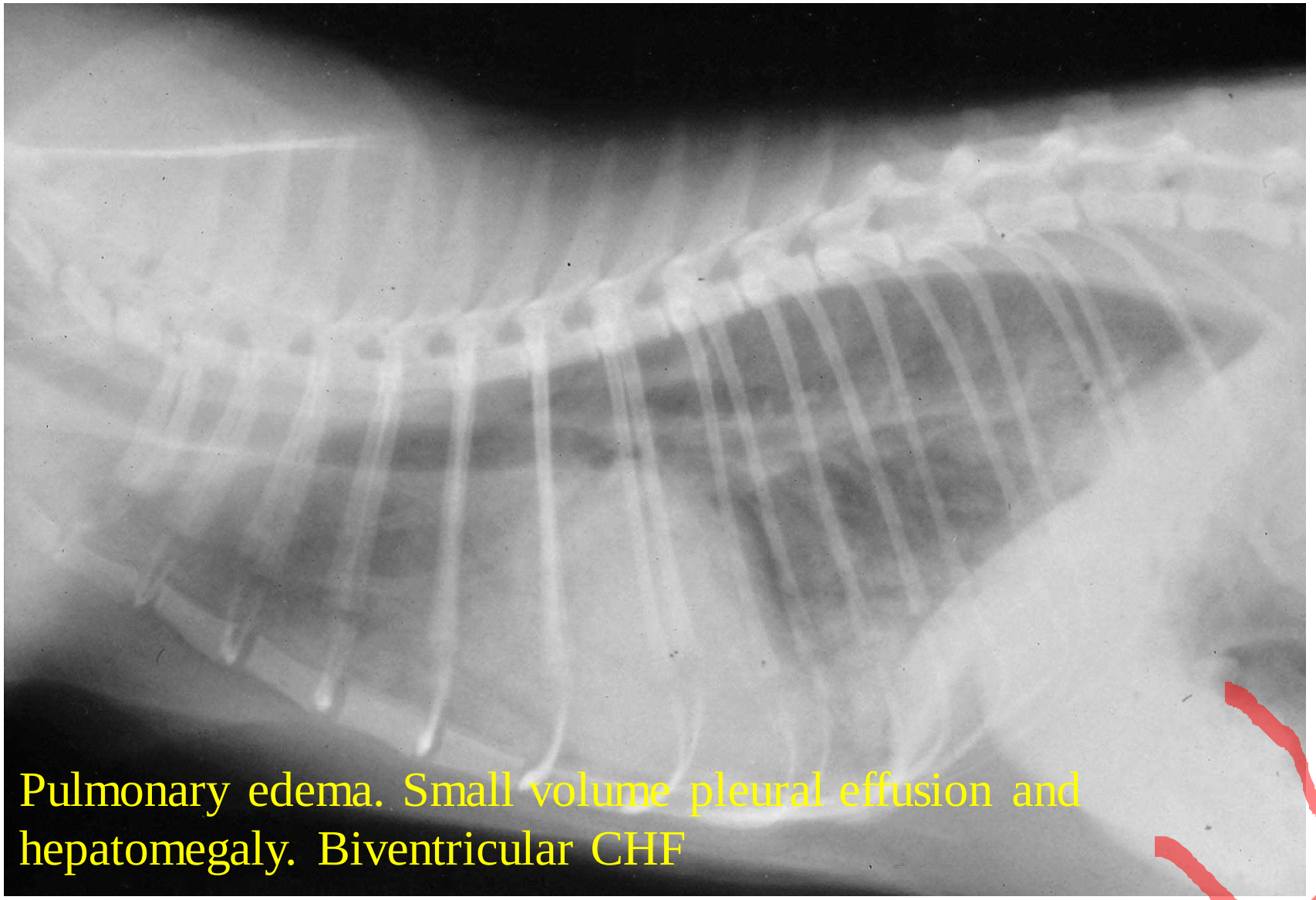


HCM with interstitial and alveolar infiltrate consistent with pulmonary edema

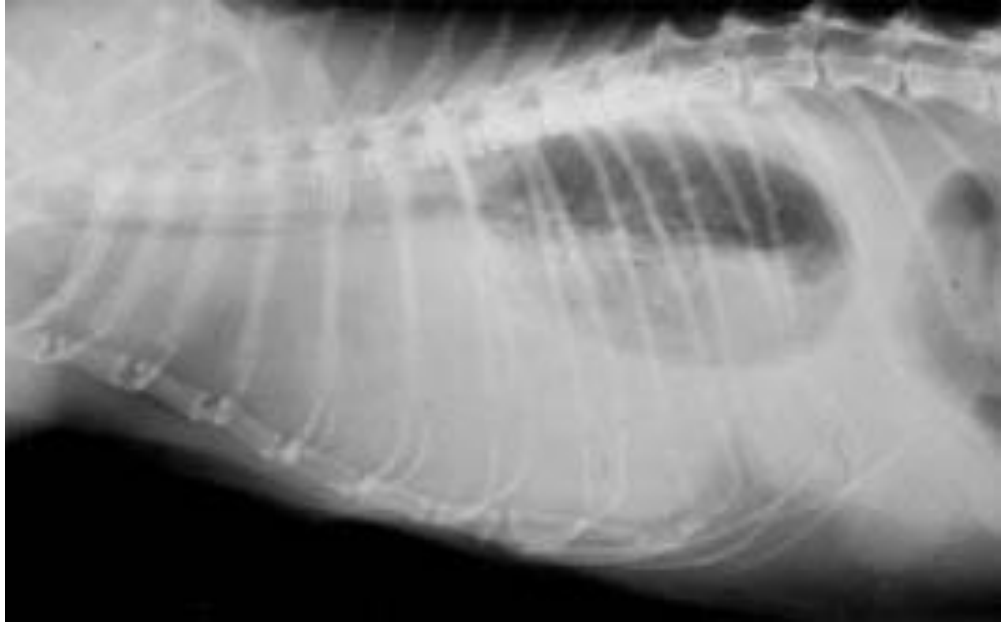


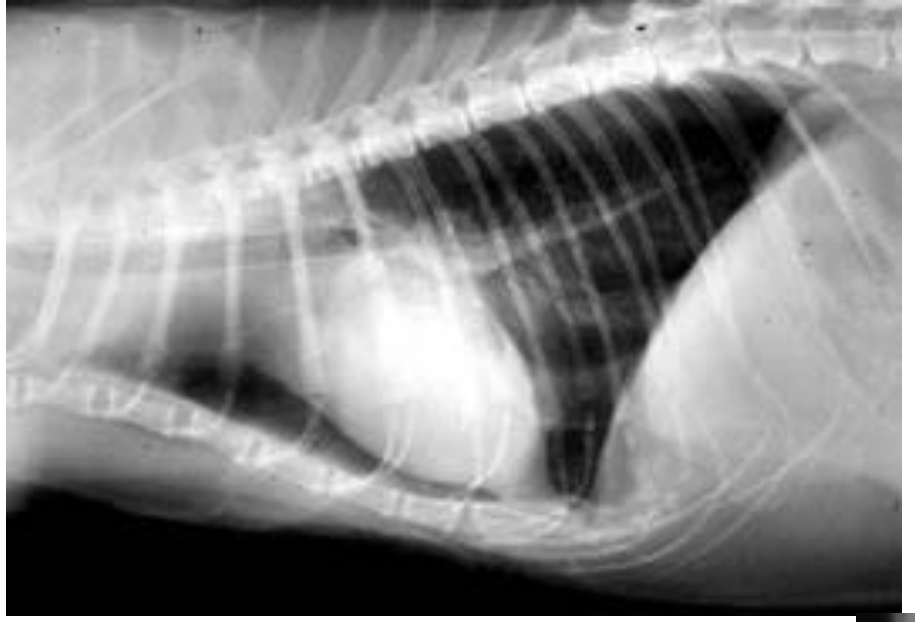


Pulmonary edema in cats can appear as patchy pulmonary infiltrates



Pulmonary edema. Small volume pleural effusion and hepatomegaly. Biventricular CHF



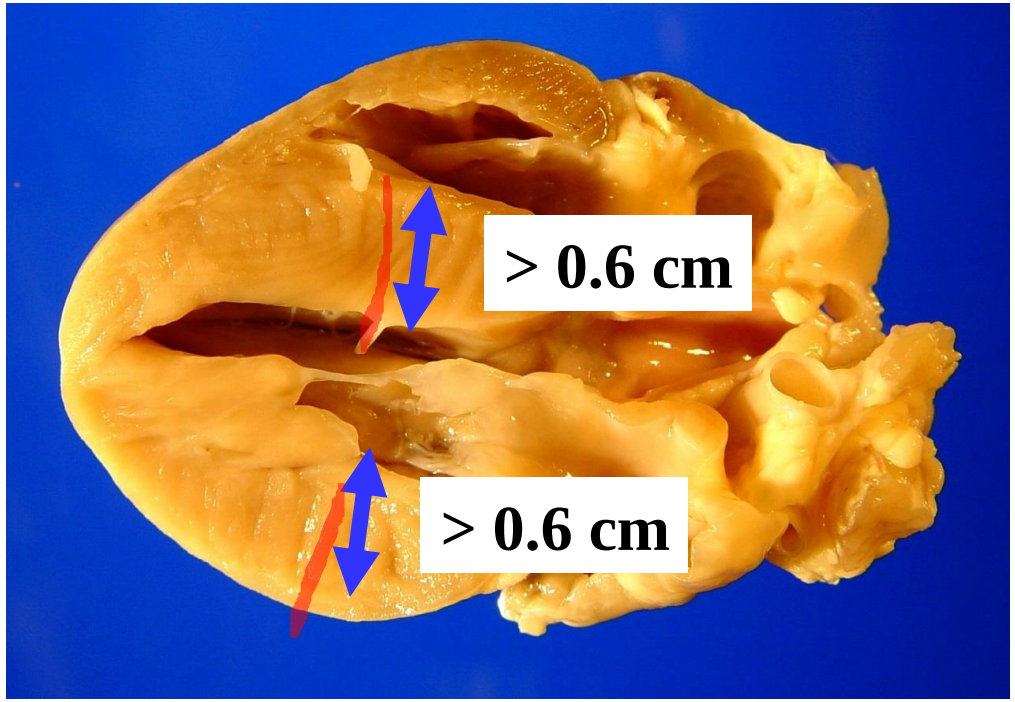


Large volume pleural effusion

Same cat after thoracentesis

# Echocardiography
## Best diagnostic test for feline HCM

- M-mode: LVFW or IVS > 0.55-0.6 cm in diastole
  > 0.9 cm in systole
- Left atrial size
  - ♥ Left sided CHF?
  - ♥ ATE?
- LV anatomy
  - ♥ Hypertrophy?
  - ♥ Papillary muscles?
  - ♥ Aorta?
- Right heart
  - ♥ RV/RA enlargement
  - ♥ Pulmonary artery size

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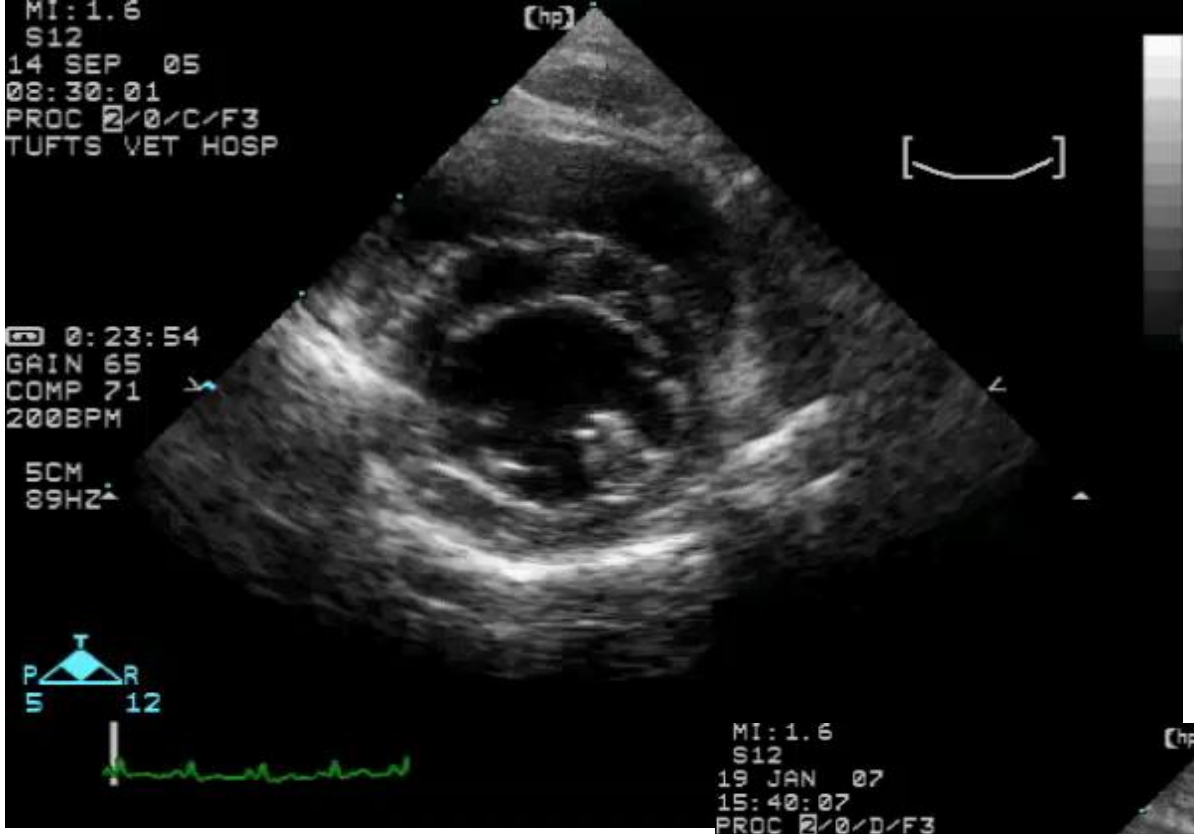
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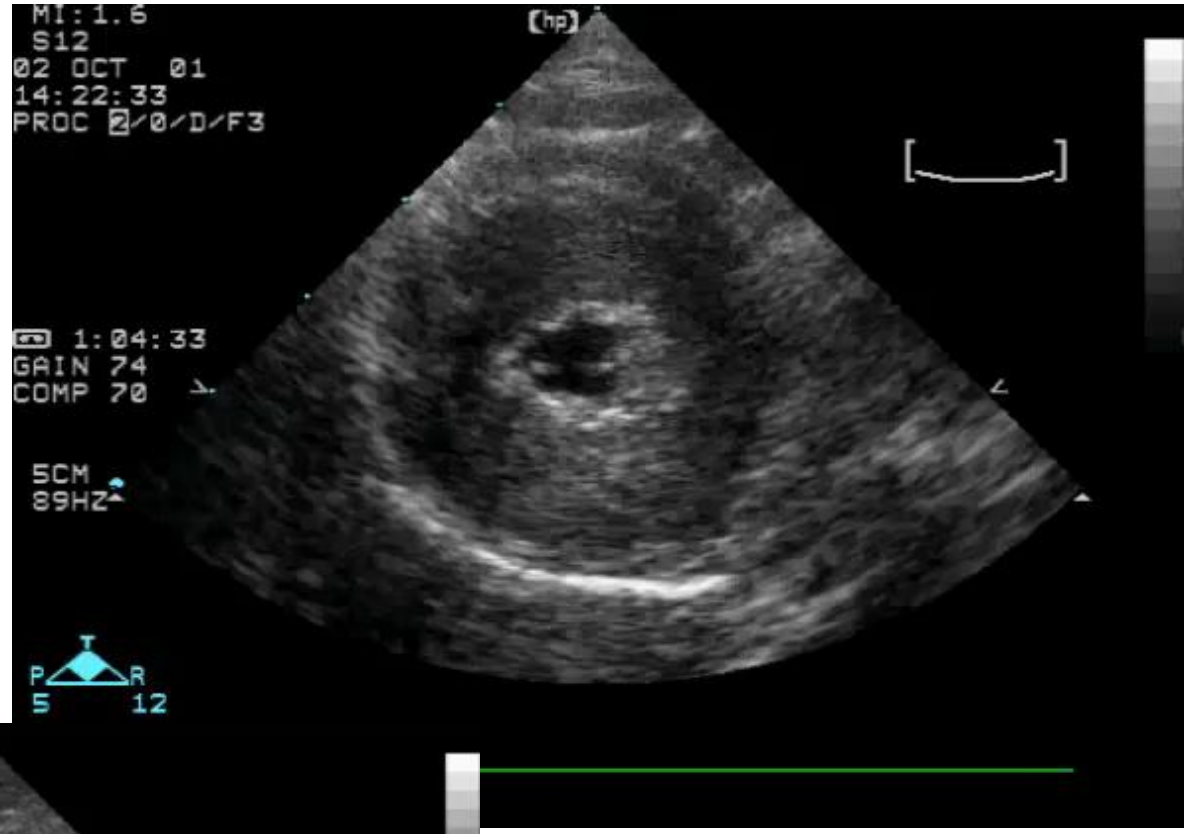
0:23:54
GAIN 65
COMP 71
200BPM
5CM
89HZ
P R
5 12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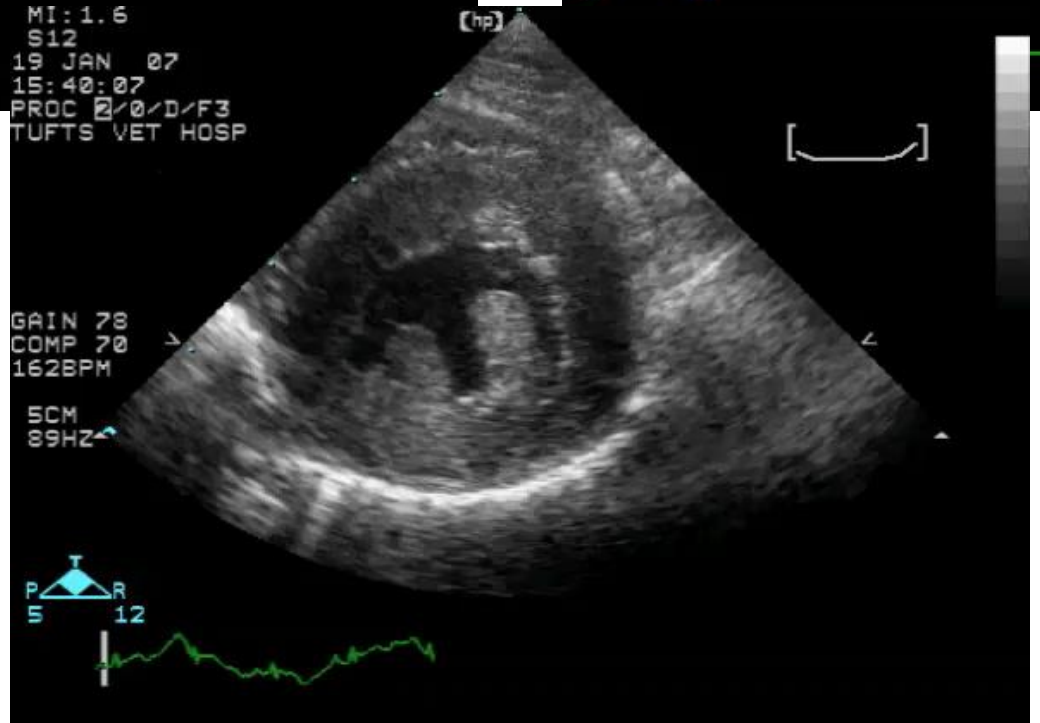
P R
5 12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19 JAN 07
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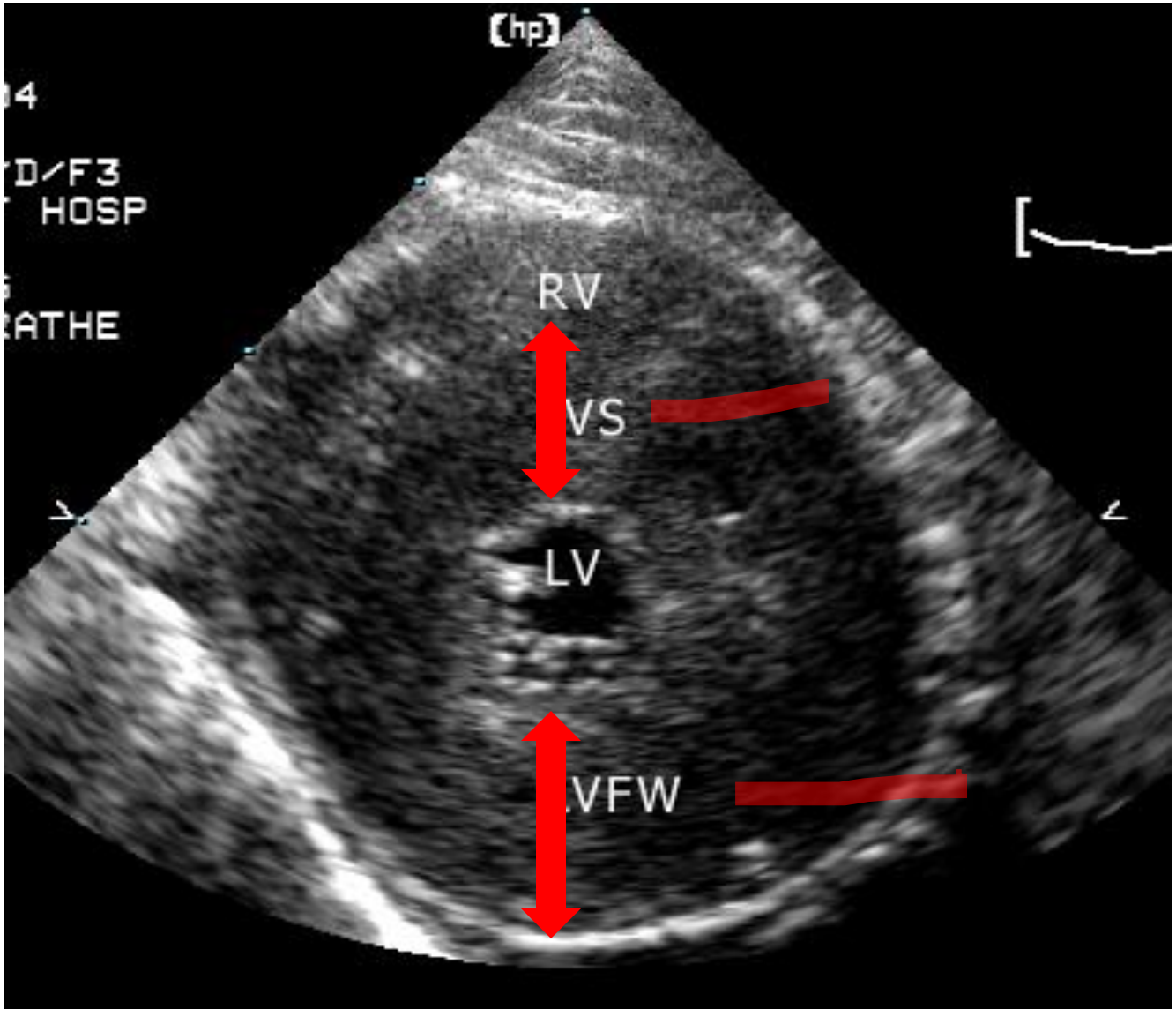
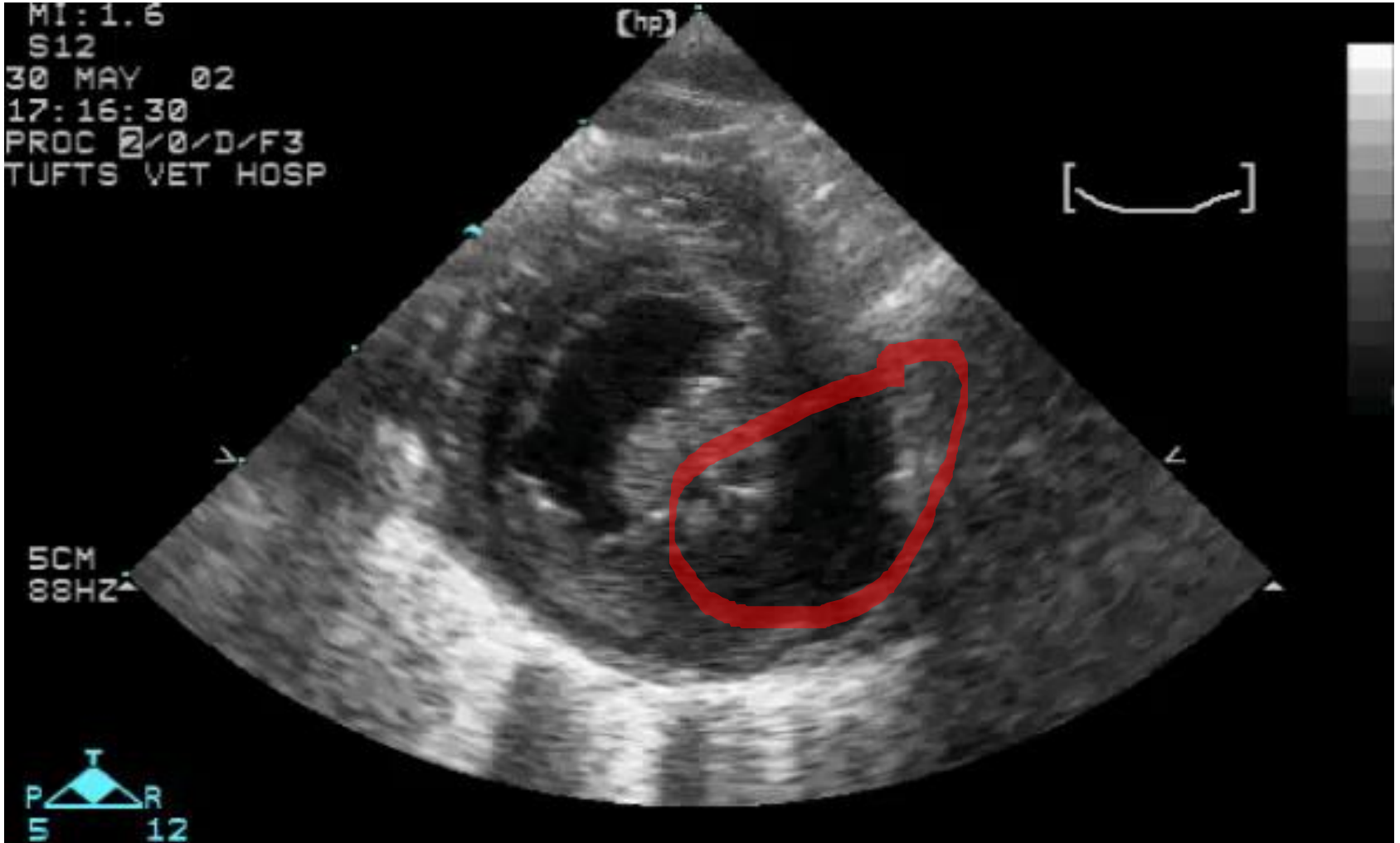
5CM
89HZ
P R
5 12

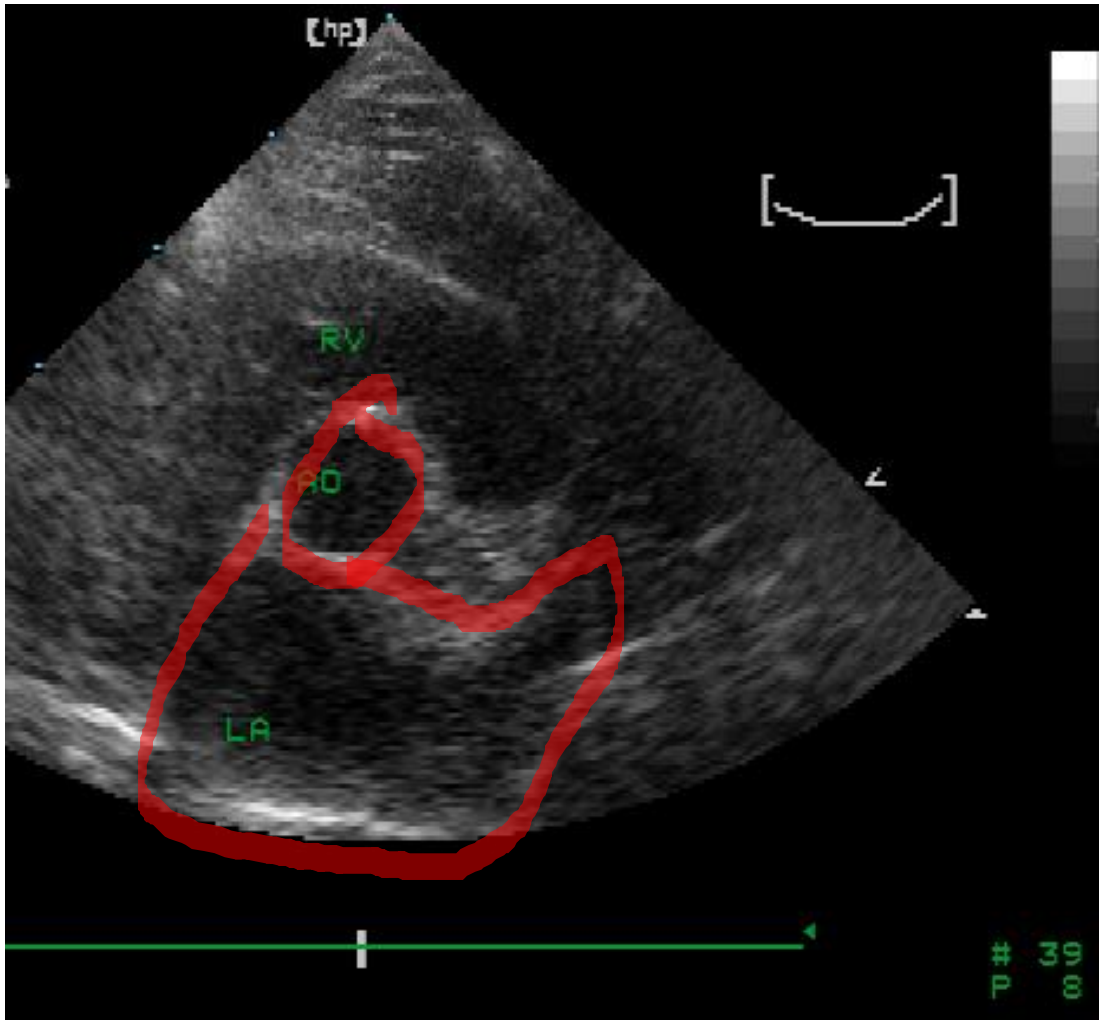
# Echocardiography - HCM

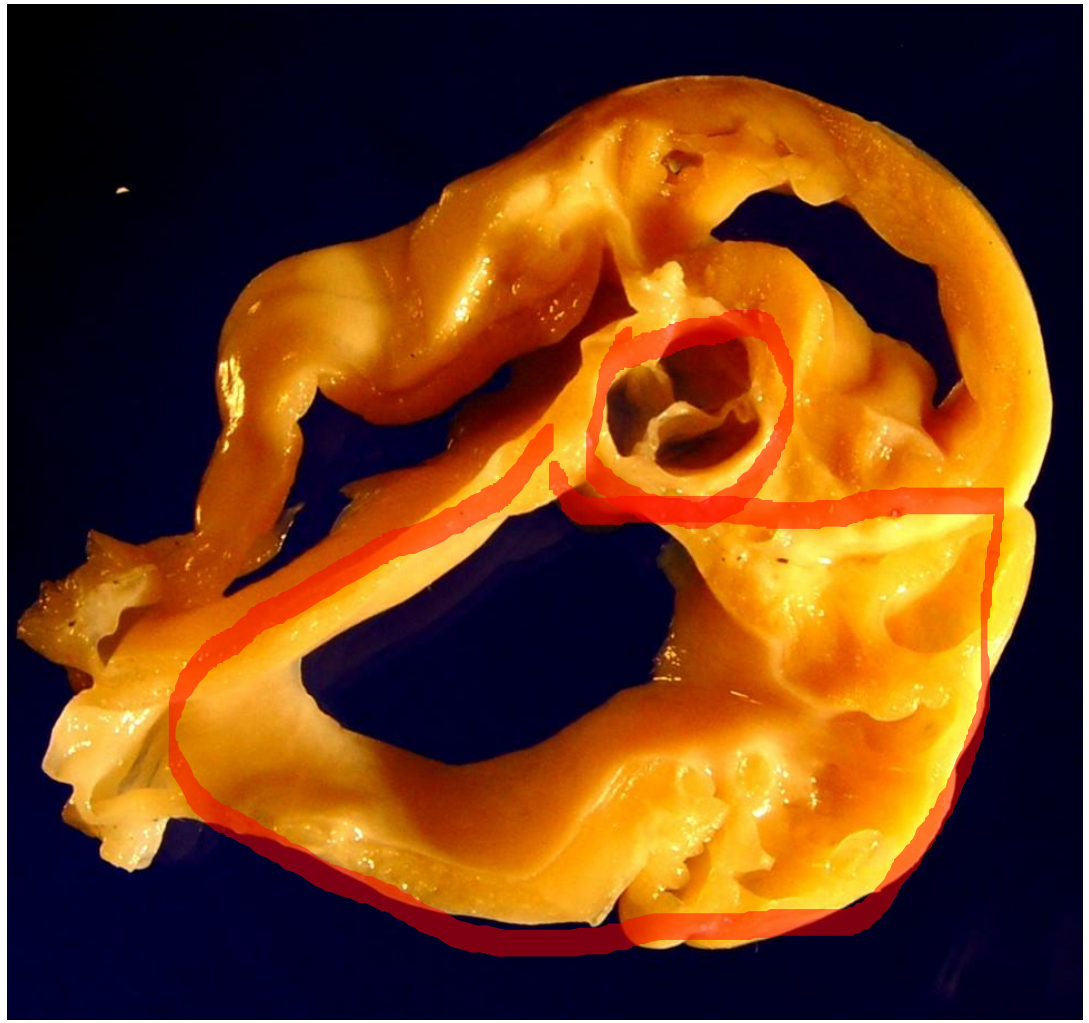


# Asymmetric LV Hypertrophy
# LVFW hypertrophy



# Echocardiography



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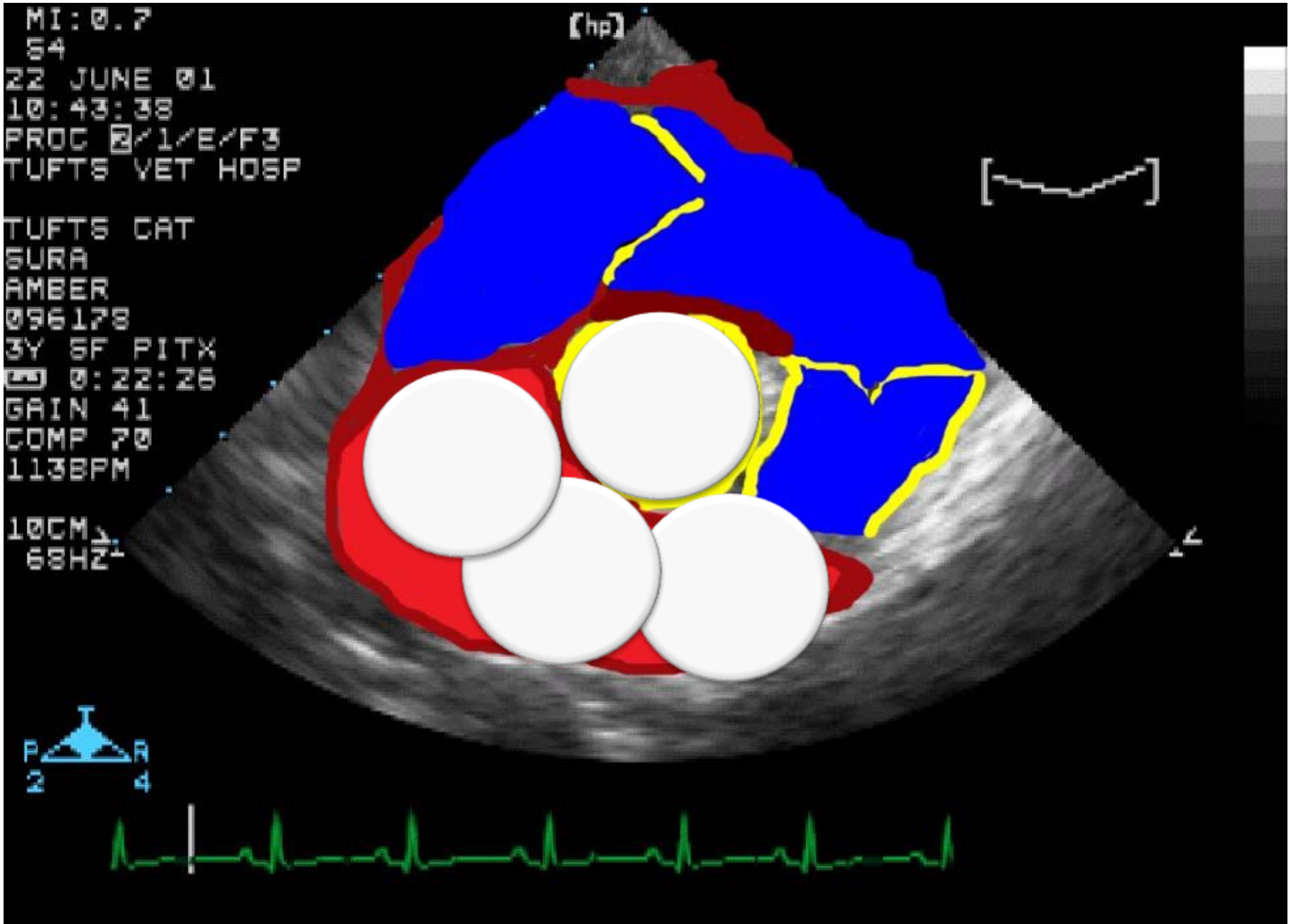
# Normal Left Atrial Size

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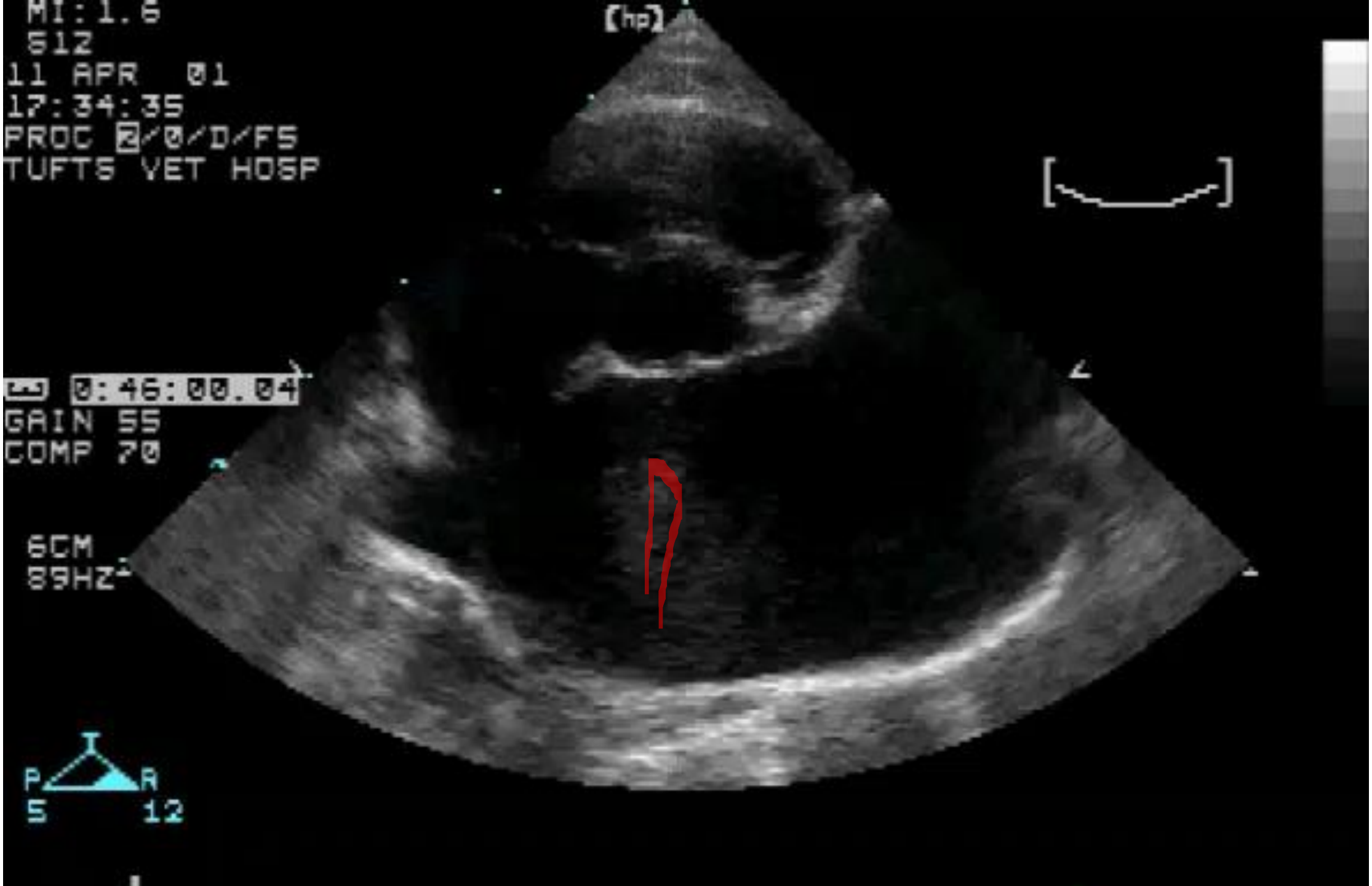
P
R
T
5
12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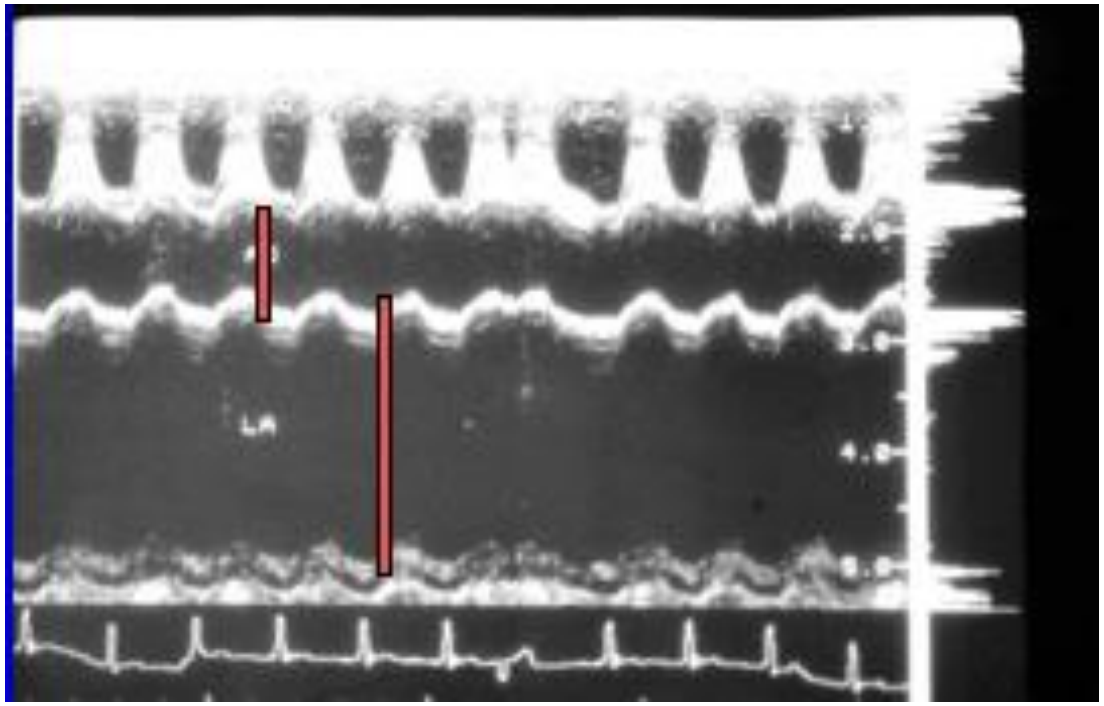
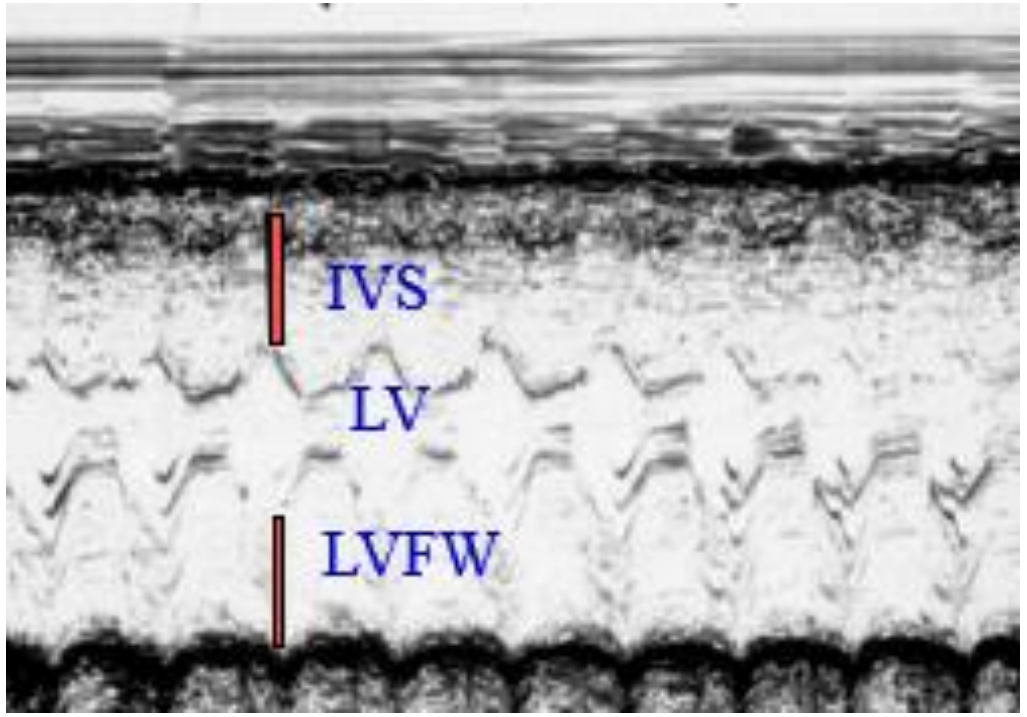
12

# Echocardiography



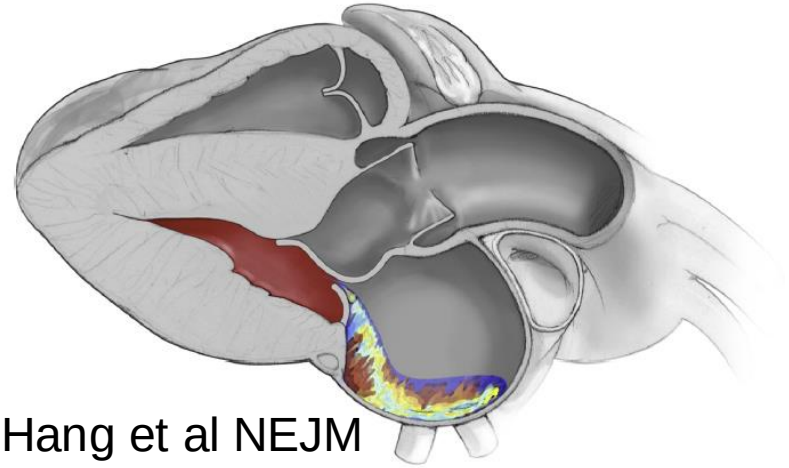



Ao/LA ratio normally < 1:1.25

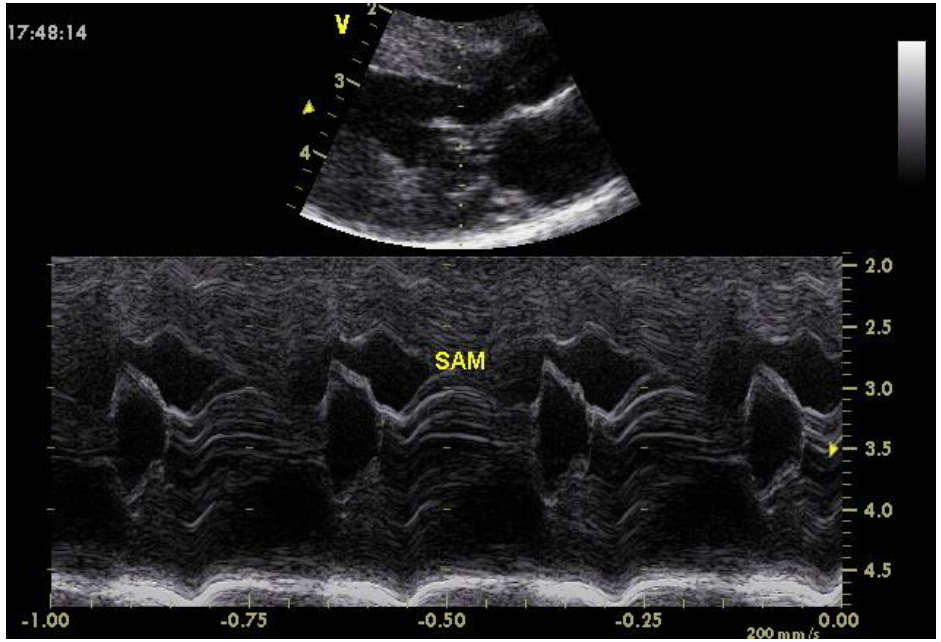
# Echocardiography

## More Echo tests!

- Systolic anterior motion of the mitral valve
- LV outflow track velocity
- Mitral and pulmonary venous inflow patterns
- Tissue Doppler imaging
- Strain imaging



Hang et al NEJM

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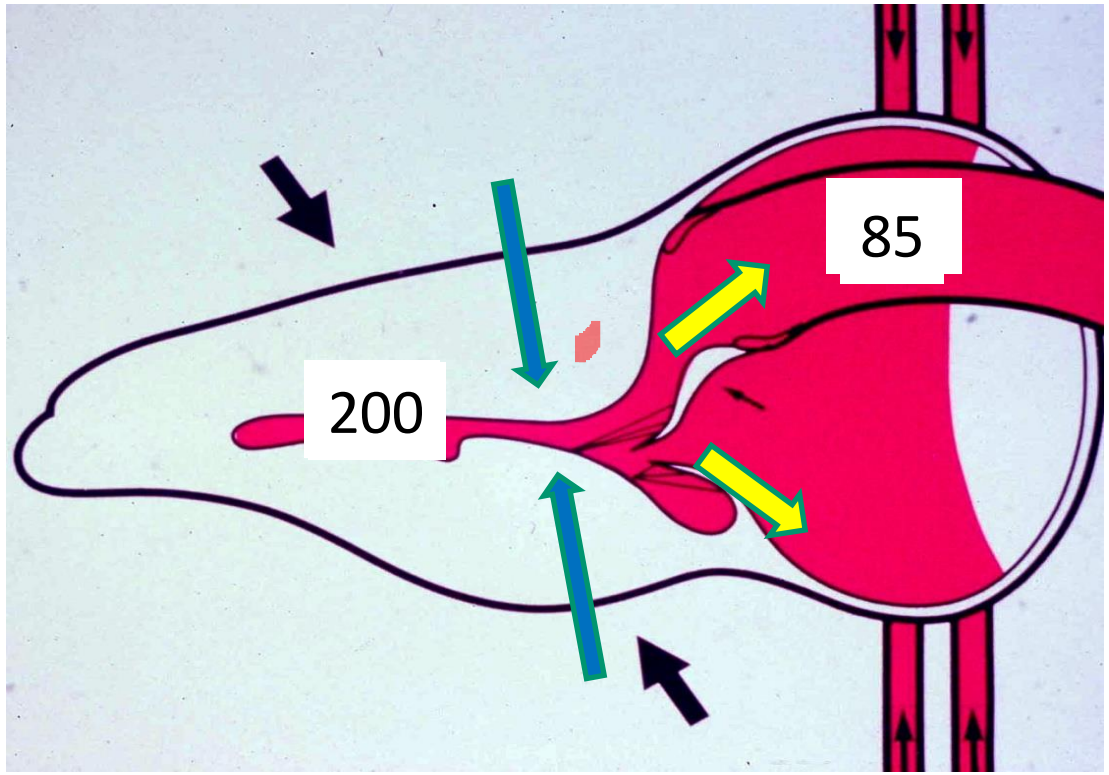
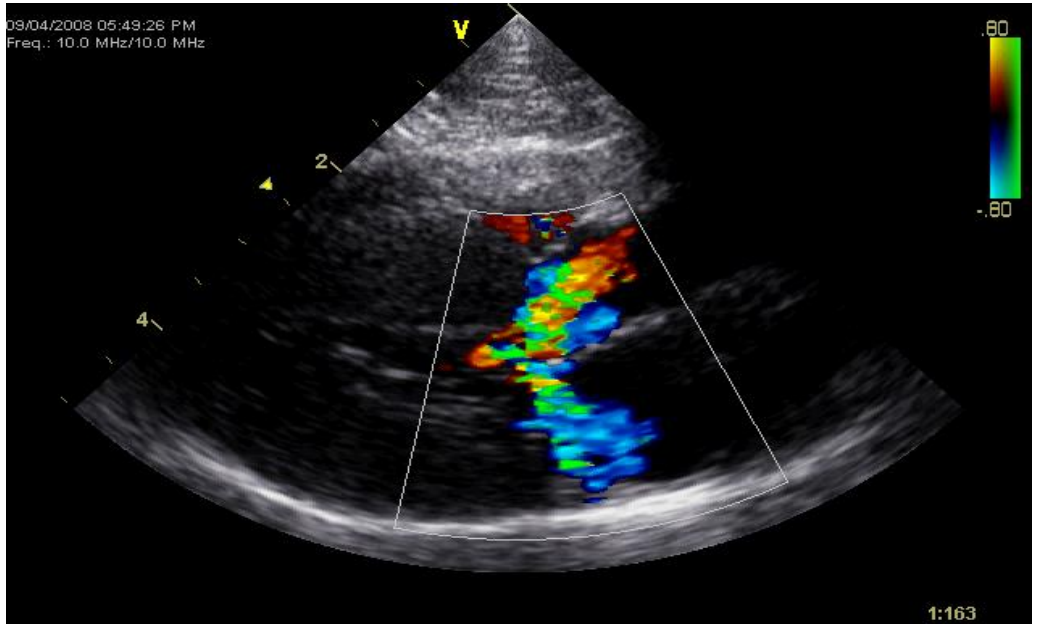
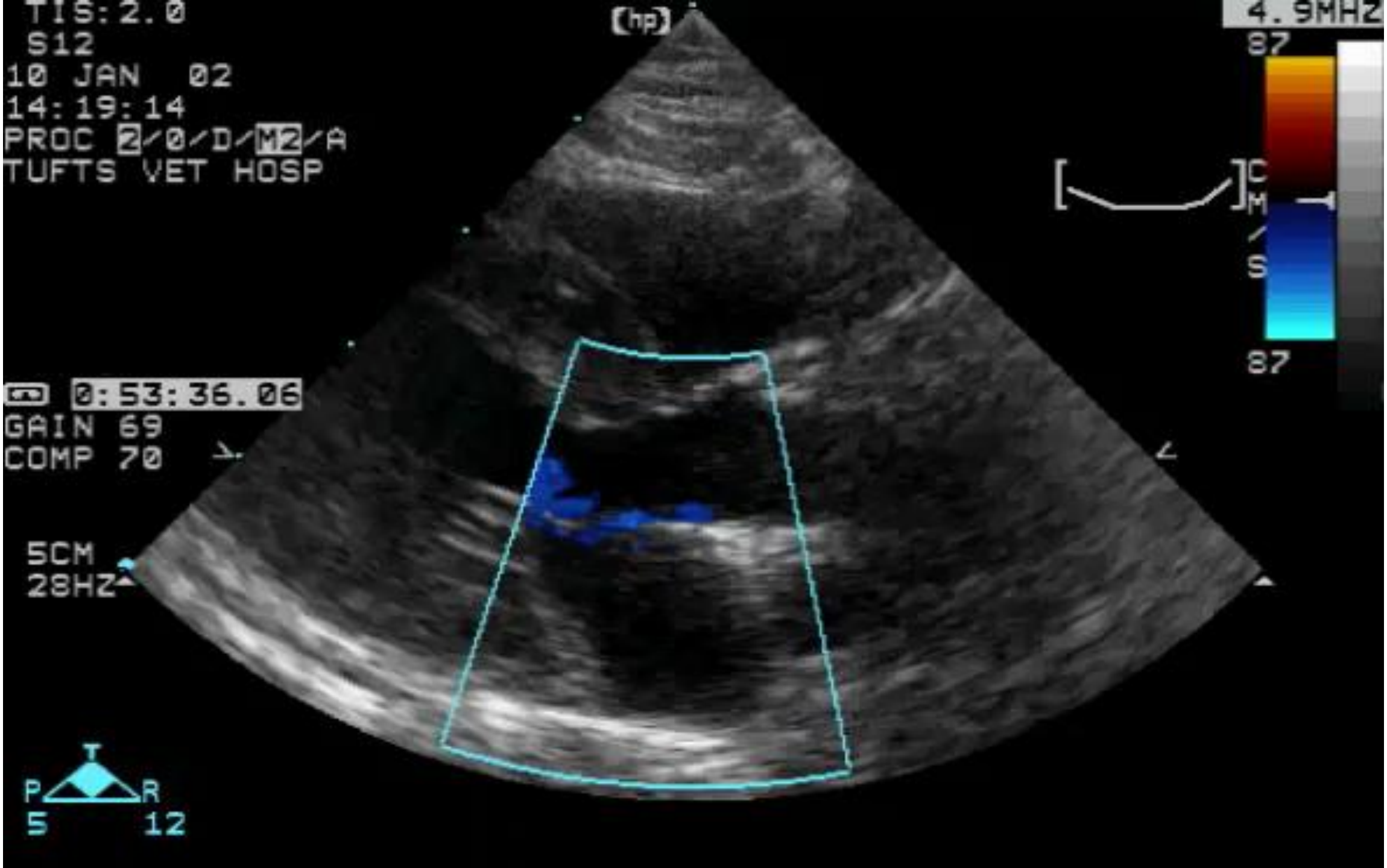
# SAM and Left Ventricular Outflow Track

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S12
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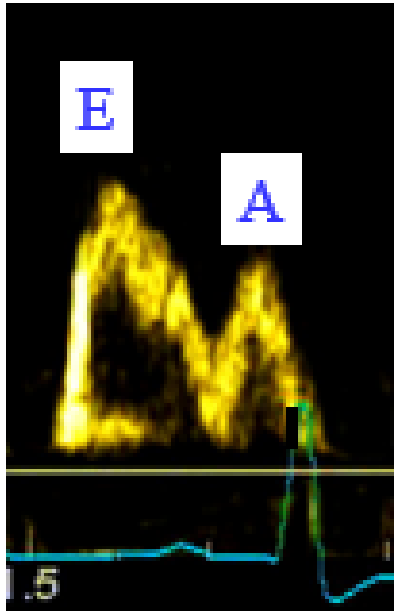
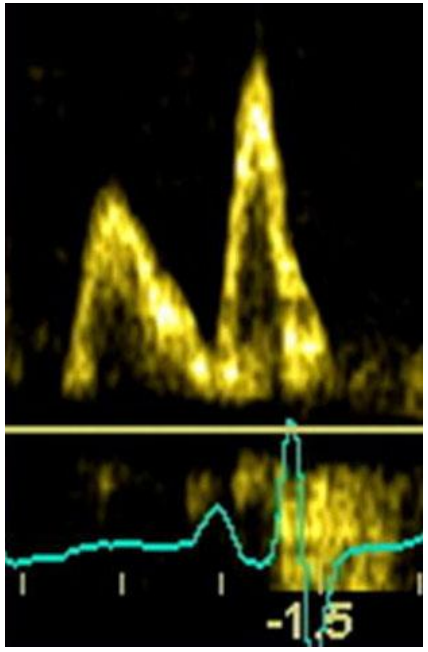
14:19:14
PROC 2/0/D/M2/A
TUFTS VET HOSP
4.9MHZ
87
CM/S
87
0:53:36.06
GAIN 69
COMP 70
5CM
28HZ
P
R
5
12

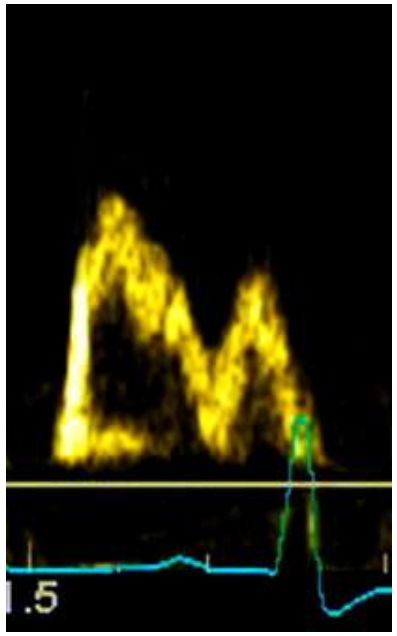
# Mitral Inflow Patterns



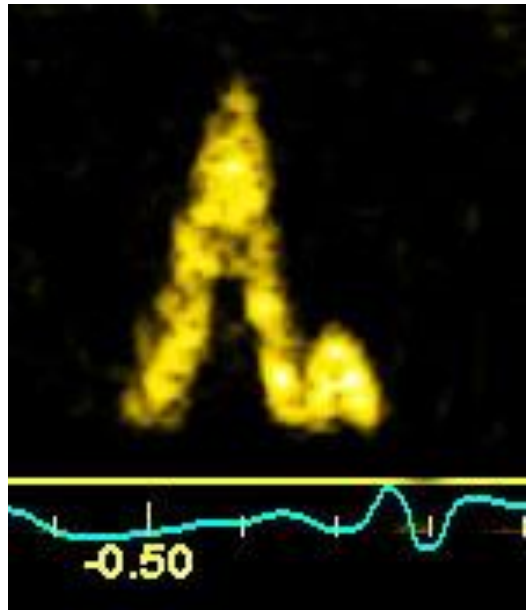

Normal




Delayed Relaxation




Pseudonormal




Restrictive


TDI

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# FOCUS Echo for Cats
# 2 minute echo for veterinarians in primary care

https://www.youtube.com/watch?v=I4U8AoxYmok&feature=youtu.be

# Blood Pressure

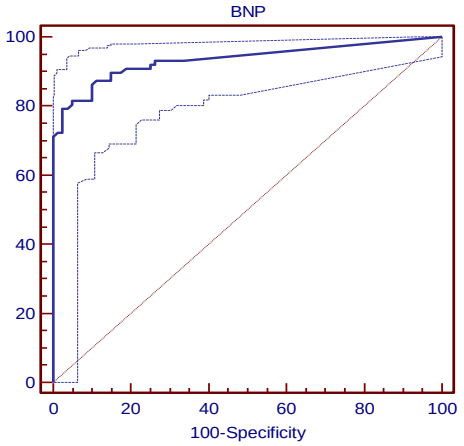
- Doppler technique preferred
- Normal range
  - Establish normal values for your setting
- Hypotension:
  - Less than 90 mmHg systolic
  - Most cats > 120 mmHg systolic
- Hypertension:
  - Get 3 measurements, 3 sessions
  - Consistently above 160-180 mmHg

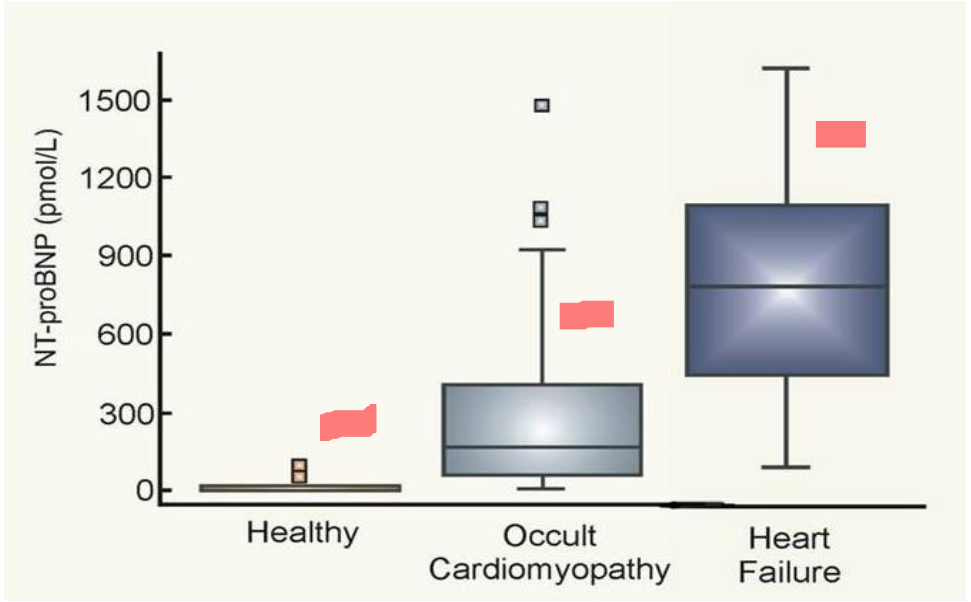
# Laboratory Testing

- CBC – normal or neutrophilic leukocytosis
- Chemistry profile
  - Azotemia - diuretic, prerenal, renal disease
  - Increased liver enzymes - AST, ALT if CHF
  - Electrolytes - Diuretics: $\Downarrow Cl^-$, $\Downarrow K^+$, $\Downarrow Na^+$, $\Uparrow tCO_2$
- T4 - cats over 6 years of age
- Urinalysis?
- NT-proBNP concentration
  - > 50-100 pmol/L consistent with heart disease
  - > 265 pmol/L CHF likely

# Diagnostic Tests for Hypertrophic Cardiomyopathy NT-proBNP

- NT-proBNP concentrations increased in HCM
- NT-proBNP elevated in most asymptomatic cats
- Progressive NT-proBNP elevations with worsening disease
- Very high concentrations associated with CHF

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Pictures from Fox

# Where/When could I use NT-proBNP?

## Asymptomatic cat

- Murmur
- Gallop
- Arrhythmia
- Should I do an echo?
- Should I be worried about anesthesia?
- NT-proBNP < 50-100 pmol/L then low chance of major heart disease

## Cat with respiratory signs

- Dyspnea
- Cough
- Open mouth breathing
- Is this heart or lung disease?
- NT-proBNP > 256 pmol/L indicates high chance clinical signs are due to heart disease

# Hypertrophic Cardiomyopathy

- Drugs to slow heart rate and improve diastolic function:
- Beta-blockers
  - ♥ Atenolol 6.25 mg/cat q 12-24 hr
  - ♥ Carvedilol 0.2-0.8 mg/kg q 12 hr
- Calcium channel blockers
  - ♥ Diltiazem - 7.5 mg q 8 hr
  - ♥ Cardizem CD - 10 mg/kg SID
  - ♥ Dilacor - Give 30 mg/cat q 24 hr


# Beta-Blocker?

- Do they have tachycardia?
  - Worthwhile to slow heart rate?
- Do they have ventricular arrhythmias?
  - B-blocker might reduce arrhythmia
- Hypertrophy of IVS, SAM or outflow obstruction?
  - B-blocker might reduce obstruction
- Are they also hyperthyroid?
  - B-blocker may blunt hyperthyroid effects
- Do they have CHF?
  - One study indicated worse outcome if *B*-blocker initiated after development of CHF
- Will it alter disease progression?
  - 5 year study failed to document benefit of atenolol

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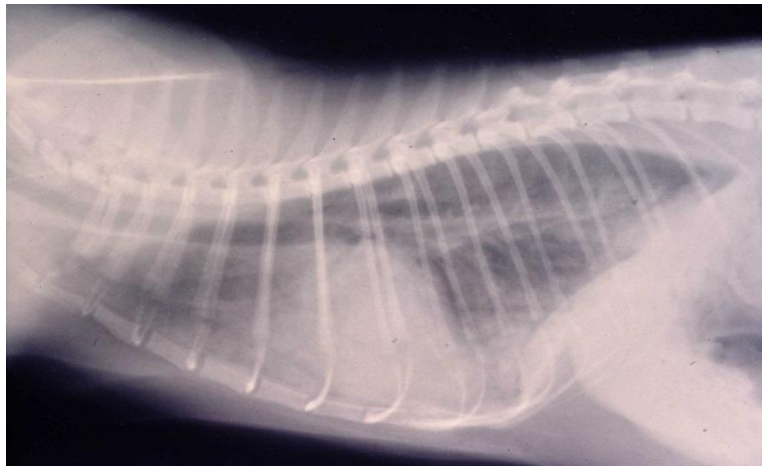
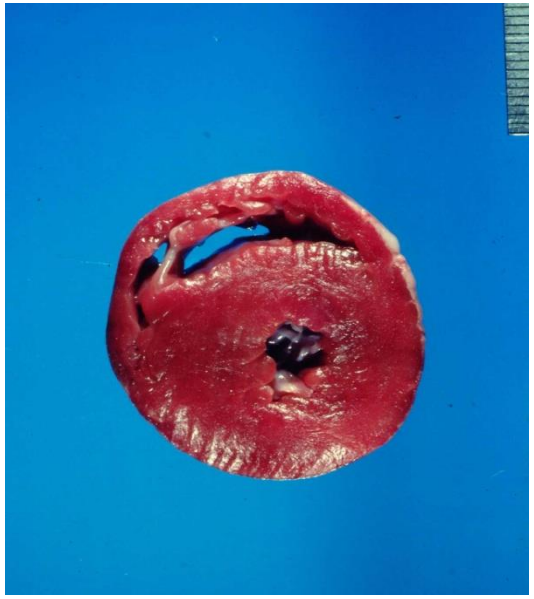
# Feline Hypertrophic Cardiomyopathy

- Clinical Scenarios
  - ♥ Congestive Heart Failure (CHF)
  - ♥ Arterial Thromboembolism (ATE)
  - ♥ Syncope
  - ♥ Asymptomatic cat





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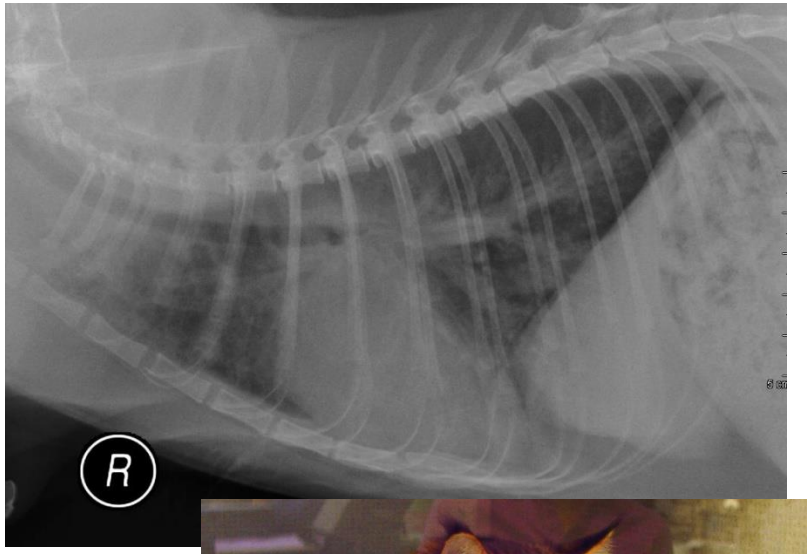
# Management of CHF in Cats

- Furosemide
- ACE inhibitor
- Drugs to slow HR (?)
  - ♥ Beta-blocker
- Pimobendan?
  - ♥ Probably yes if no LVOTO?
  - ♥ No if LVOTO (probably concerning)
- Antithrombotic
- Dietary modification

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# Arterial Thromboembolism

- Occurs in 10-40% of all cats with cardiomyopathy
- Originate in LA or LV; rarely right heart (PTE)
- ⇑ LA size associated with ATE

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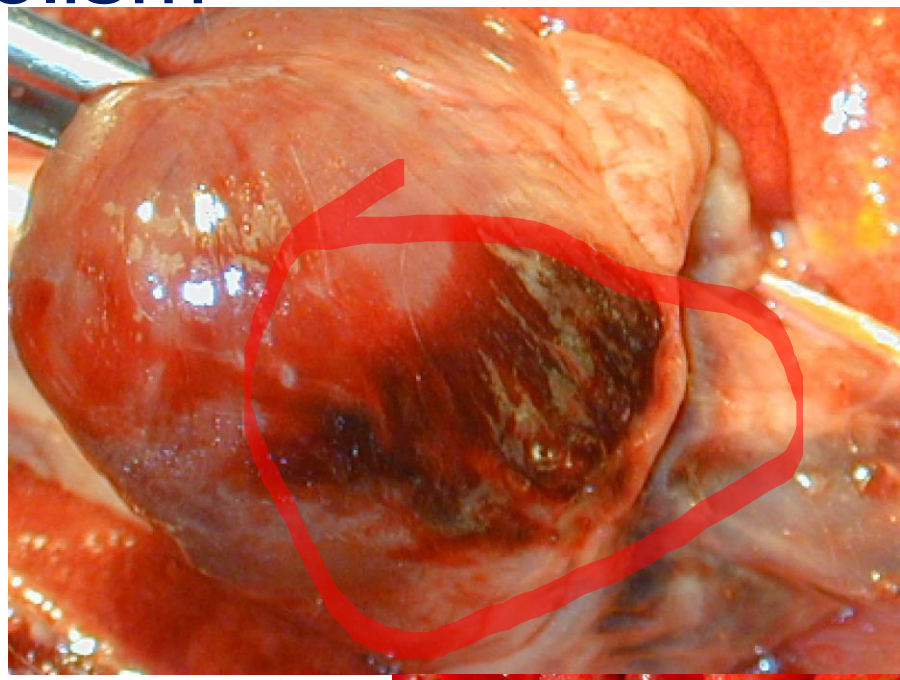
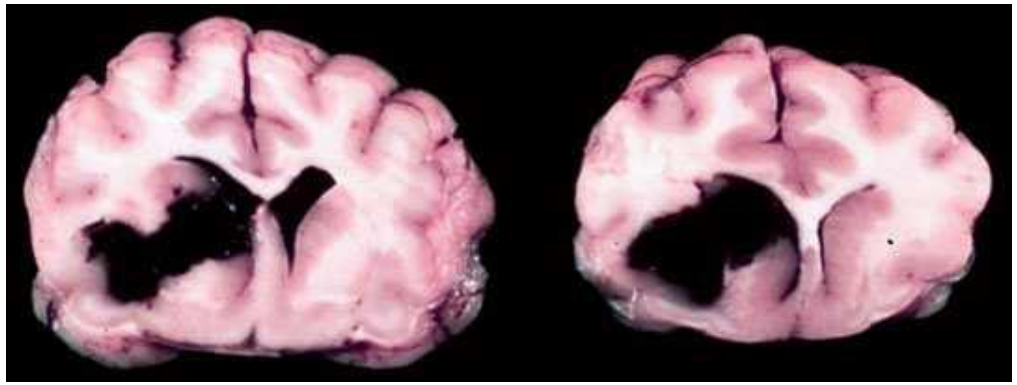
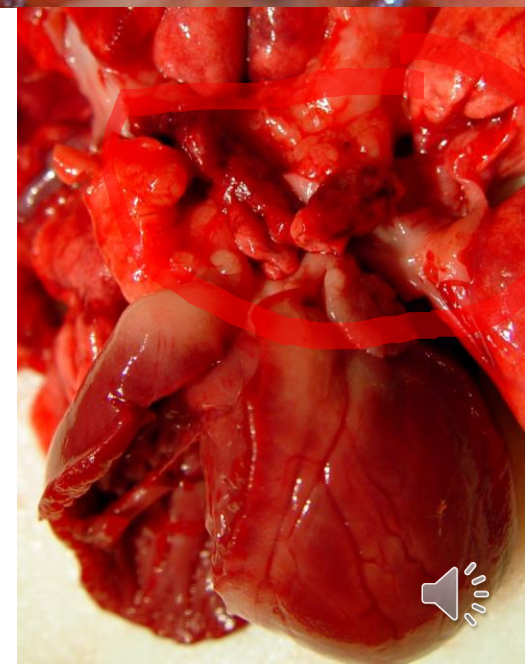
# Arterial Thromboembolism
## Sites of Emboli

- Rear limbs – 85 to 90%
- Front limb – 5 to 10%
- Other sites:
  - Kidneys
  - GI tract
  - Brain
  - Heart
  - Lungs (PTE)







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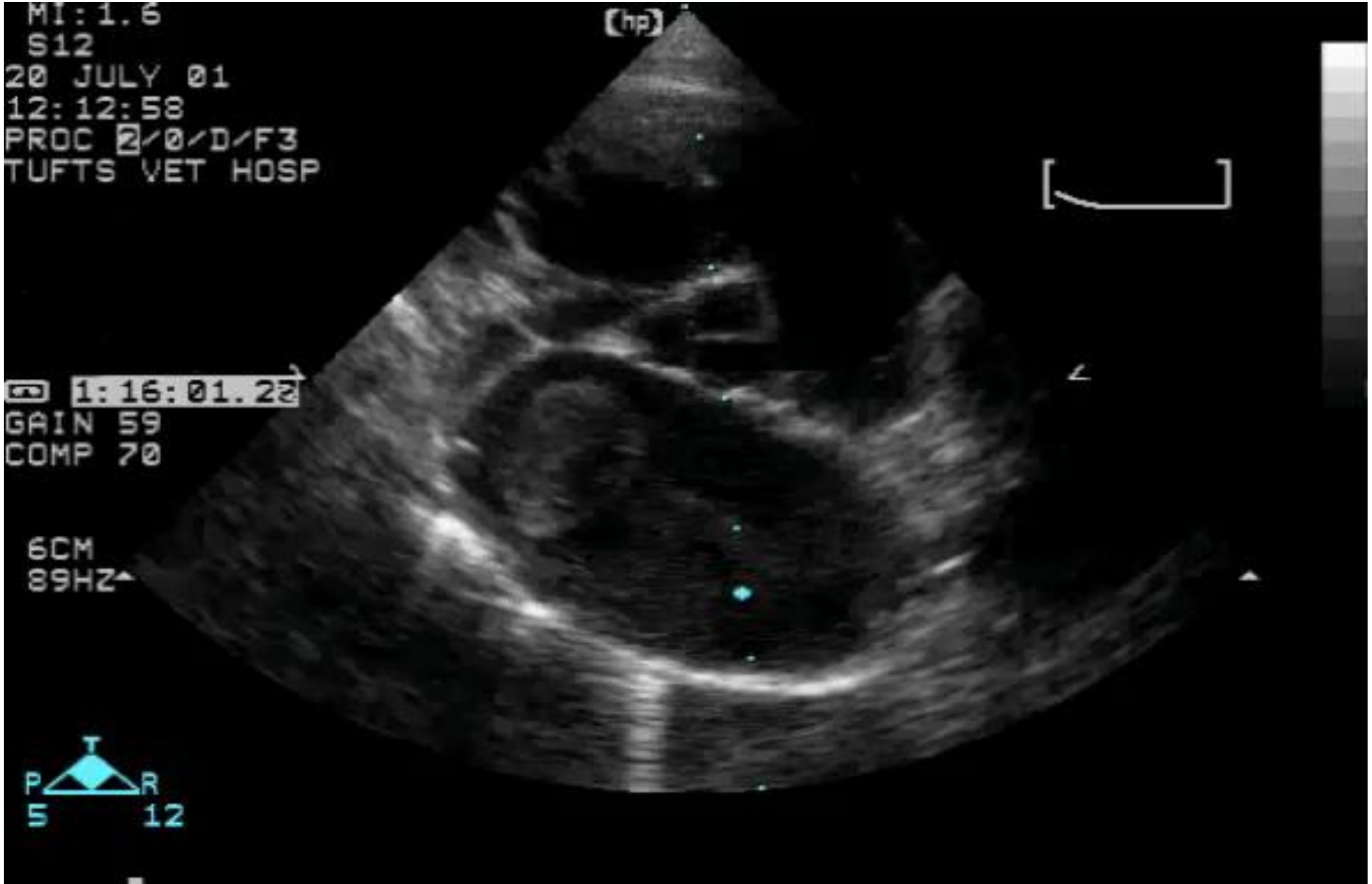
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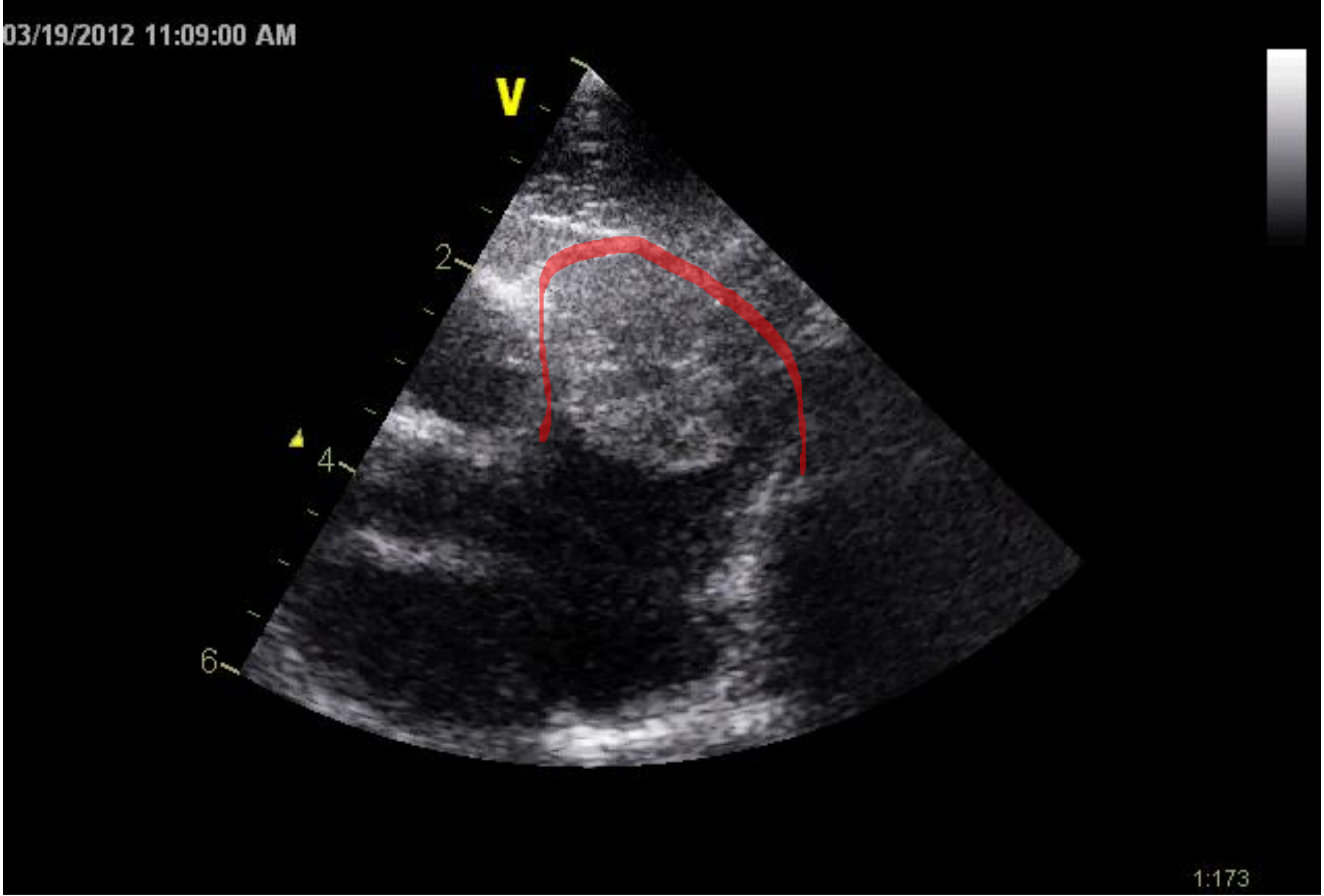
03/19/2012 11:09:00 AM
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2
4
6
1:173

# Arterial Thromboembolism

## Treatment and Prevention

- Treatment of active ATE
  - Supportive care
  - Antithrombotics (high dose heparin, clopidogrel)
  - Thrombolytics (Streptokinase, tPA)
  - Surgical or catheter thrombolectomy

- Prevention
  - Aspirin
  - Low molecular weight heparin (dalteparin, enoxaparin)
  - Clopidogrel
  - Rivaroxaban or Apixaban
  - Coumadin (warfarin)

# Should I Treat the Asymptomatic Cat?

- What is the goal of Rx?
  - ♥ Slow HR
  - ♥ Alleviate obstruction / Make SAM go away
  - ♥ Alter diastolic Doppler indices
  - ♥ Alter progression of disease
    - •Troponin I pre- and post- Rx?
    - •Longitudinal studies lacking!
- Is the left atrium enlarged?
  - Should I start an antithrombotic?
- Does the cat need anesthesia or surgery?

# How long will they live?

- Prognosis linked to presenting signs (HCM)
  - ♥ Asymptomatic (1,129 or 1,830 days or longer)
  - ♥ CHF (563 or 92 days or shorter)
  - ♥ Syncope (654 days)
  - ♥ ATE (184 or 61 days or shorter)
- Left atrial size
- Age
- SAM, LVH, fractional shortening

(Rush 2002, Atkins 1992, Fox 1995, Peterson 1993, Fox 2019)

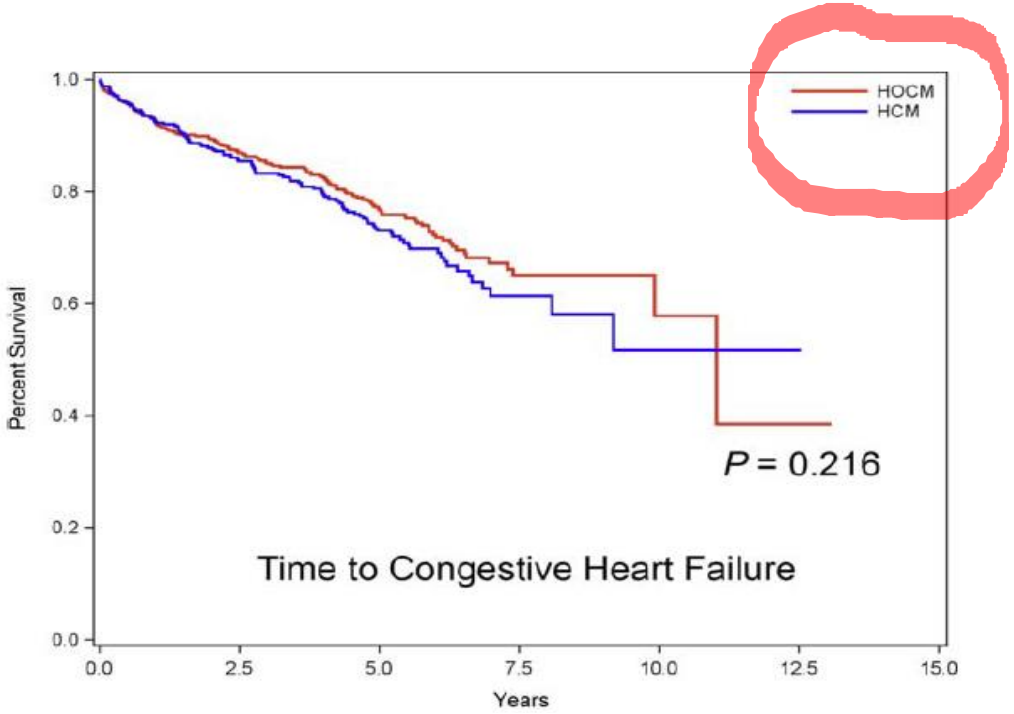
# Retrospective Study of Asymptomatic Cats

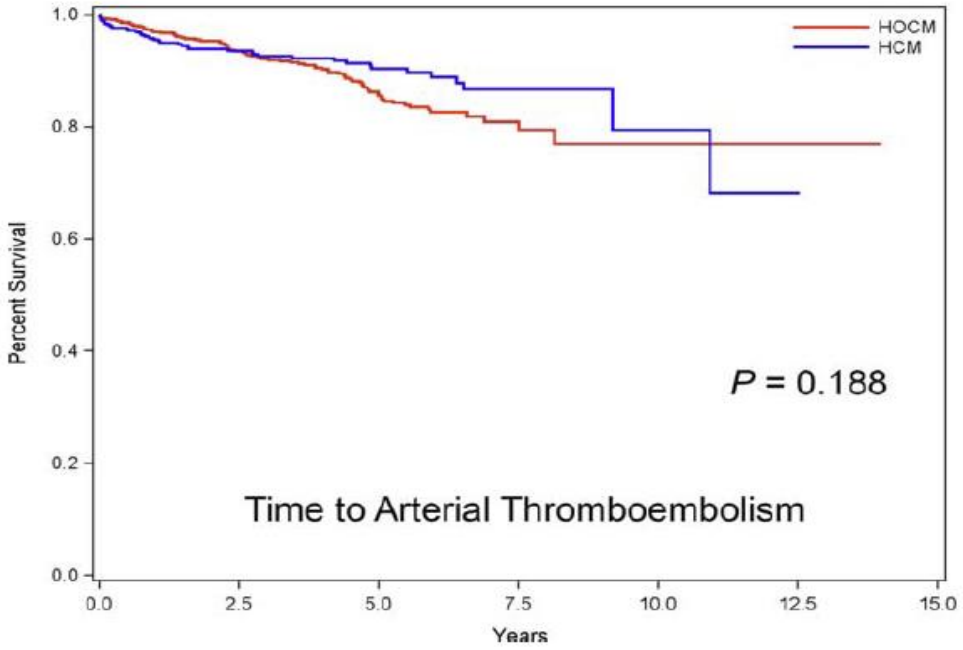
TABLE 3 Cardiovascular morbidity and mortality in feline study populations

| Study Population Groups | AH n = 722 | | HCM n = 430 | | HOCM n = 578 | | HCM/HOCM n = 1008 | |
|---|---|---|---|---|---|---|---|---|
| Cardiovascular morbidity | Number events | % Normal | Number events | % HCM | Number events | % HOCM | Number events | % HCM/ HOCM |
| CHF | 6 | 0.83 | 106 | 24.7 | 138 | 23.9 | 244 | 24.2 |
| ATE | 5 | 0.69 | 41 | 9.5 | 76 | 13.2 | 117 | 11.6 |
| Sudden death | 0 | 0 | 9 | 2.1 | 13 | 2.3 | 22 | 2.2 |
| All cardiovascular death | 7 | 0.97 | 115 | 26.7 | 166 | 28.7 | 281 | 27.9 |

Fox et al 2018 JVIM

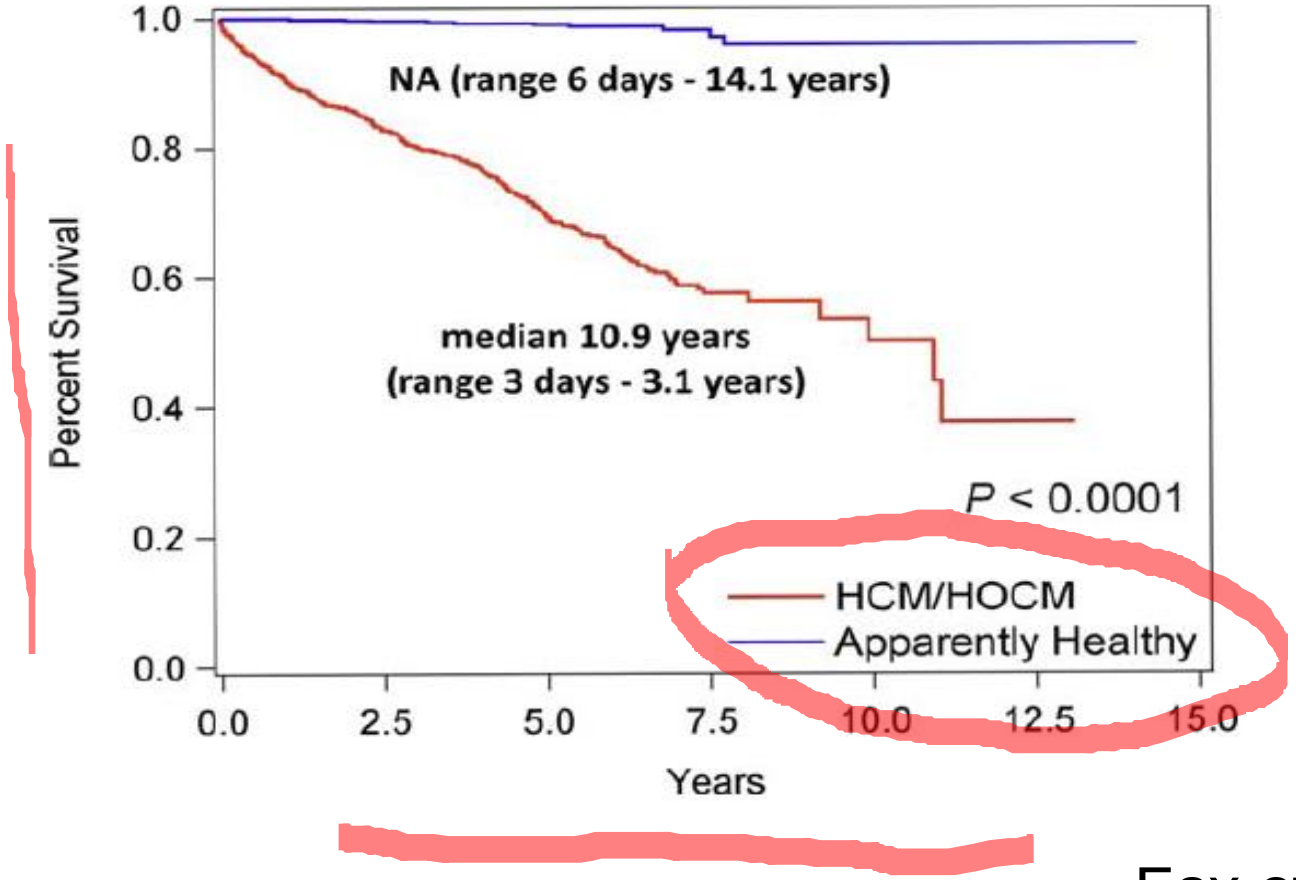
# Retrospective Study of Asymptomatic Cats



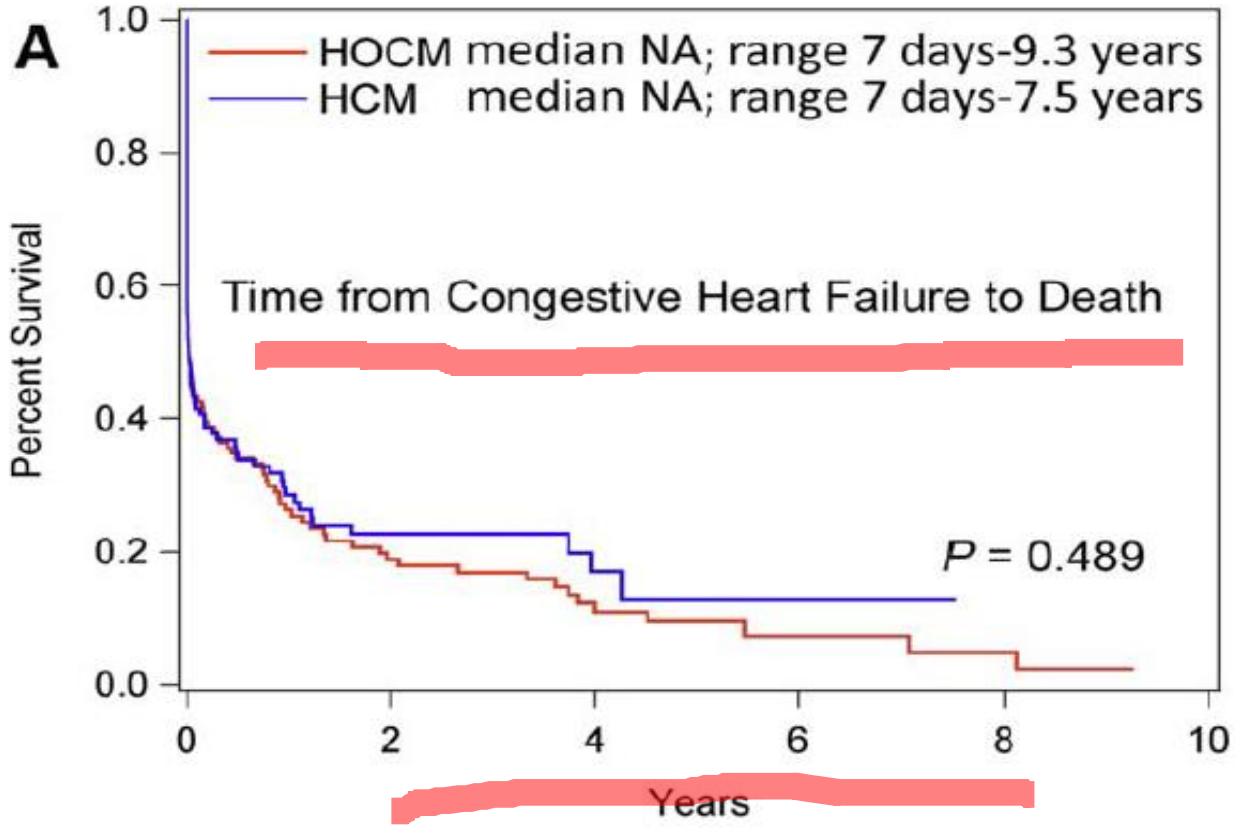

Fox et al 2018 JVIM

# Retrospective Study of Asymptomatic Cats



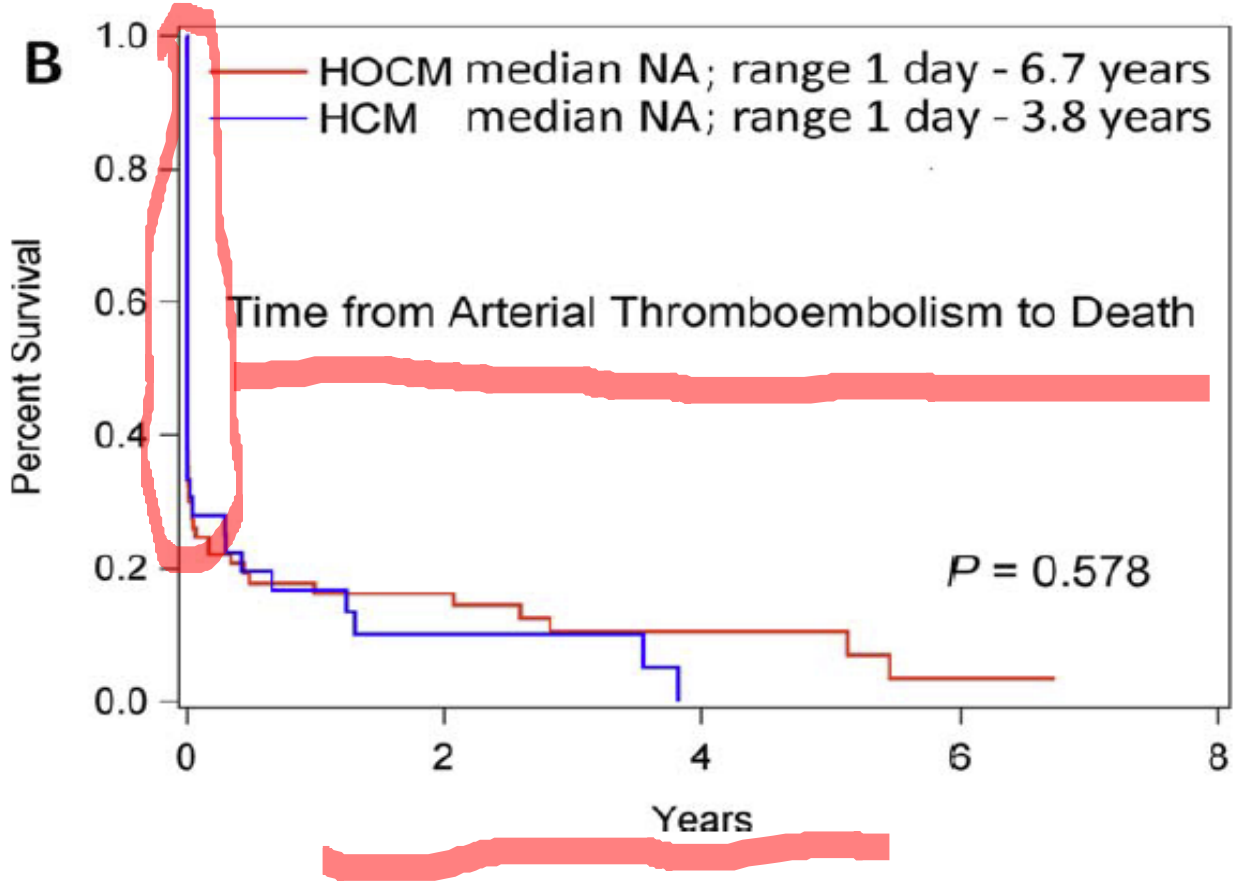

Fox et al 2018 JVIM

# Retrospective Study of Asymptomatic Cats




Fox et al 2018 JVIM

# Retrospective Study of Asymptomatic Cats




Fox et al 2018 JVIM

# Which cats should be screened for HCM?

- Cat with cardiac murmur or gallop
- Cat with arrhythmia
- Open mouth breathing/unexplained respiratory distress
- Related cat has cardiac disease
- Breed predisposed to cardiomyopathy

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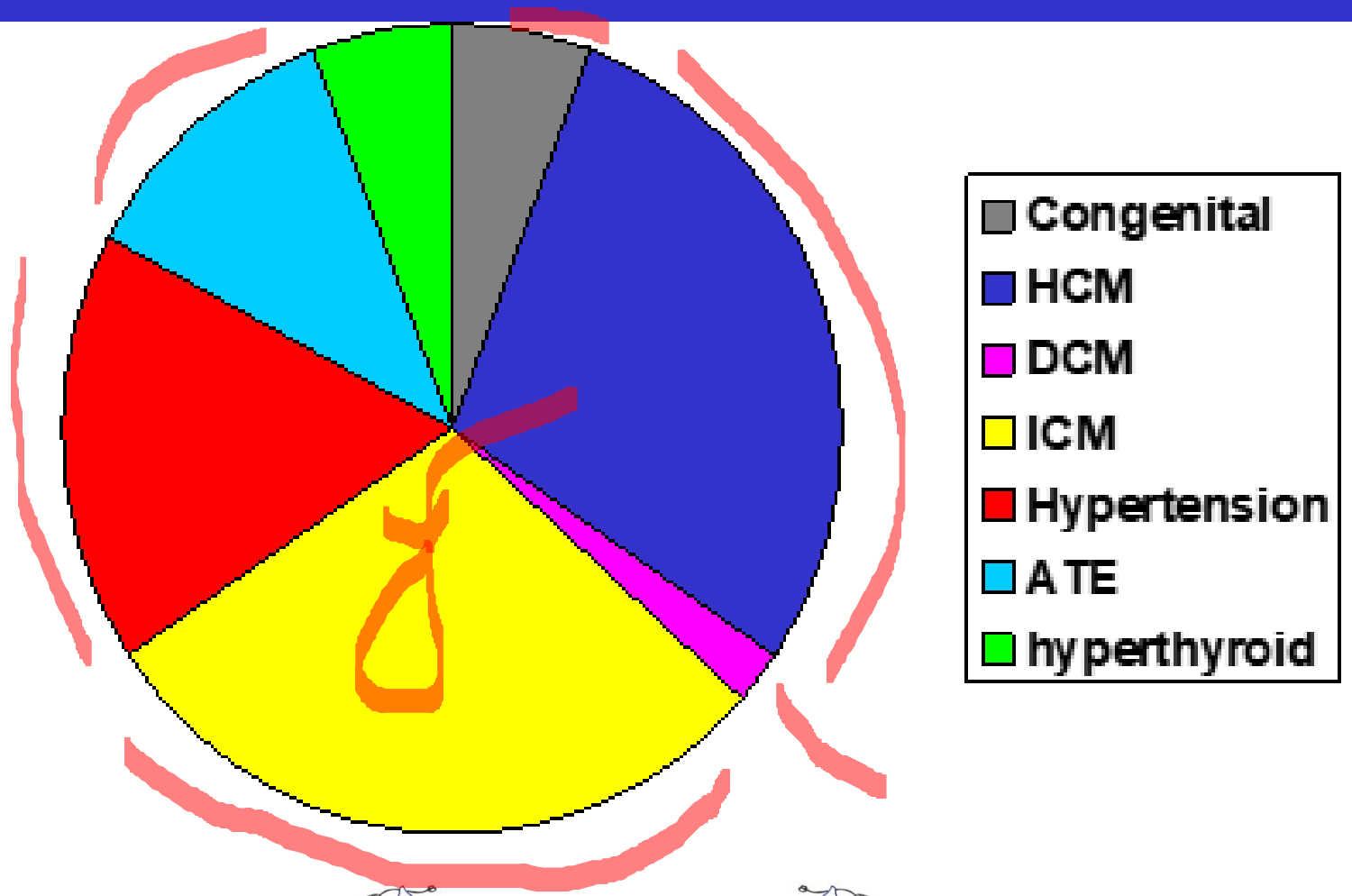
# Feline Cardiac Disease

- Myocardial disease
  - ♥ HCM
  - ♥ DCM
  - ♥ ICM or unclassified myocardial disease
  - ♥ Restrictive, Moderator bands, Myocarditis
- Systemic hypertension
- Hyperthyroid heart disease
- Congenital heart disease
- Anemia and heart disease
- Heartworm disease
- Bacterial endocarditis

# Cardiac Disease Frequency

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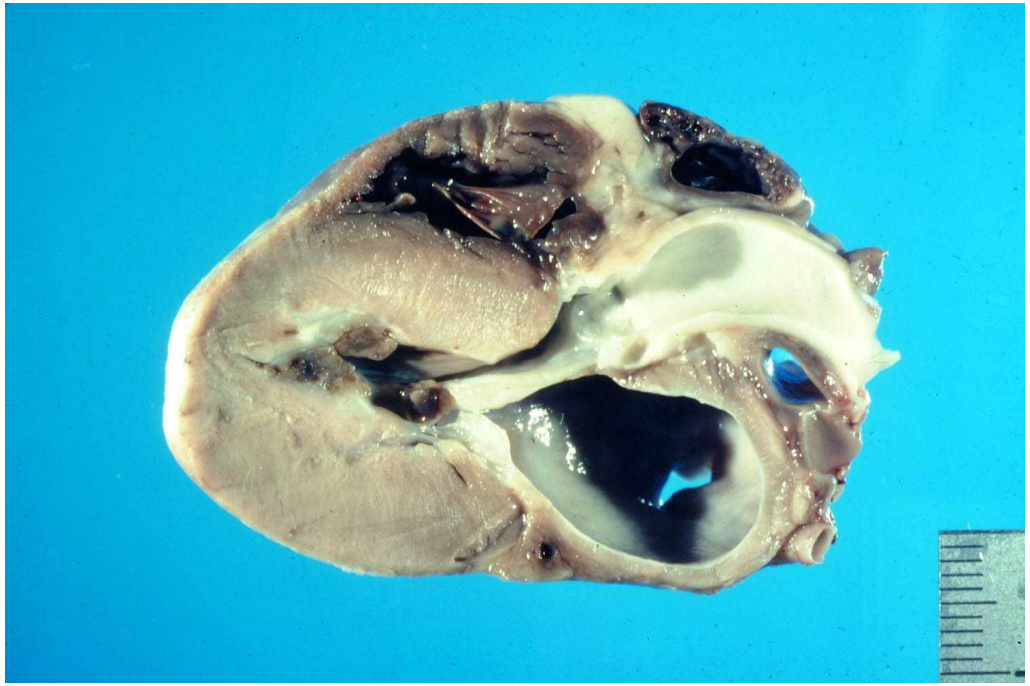
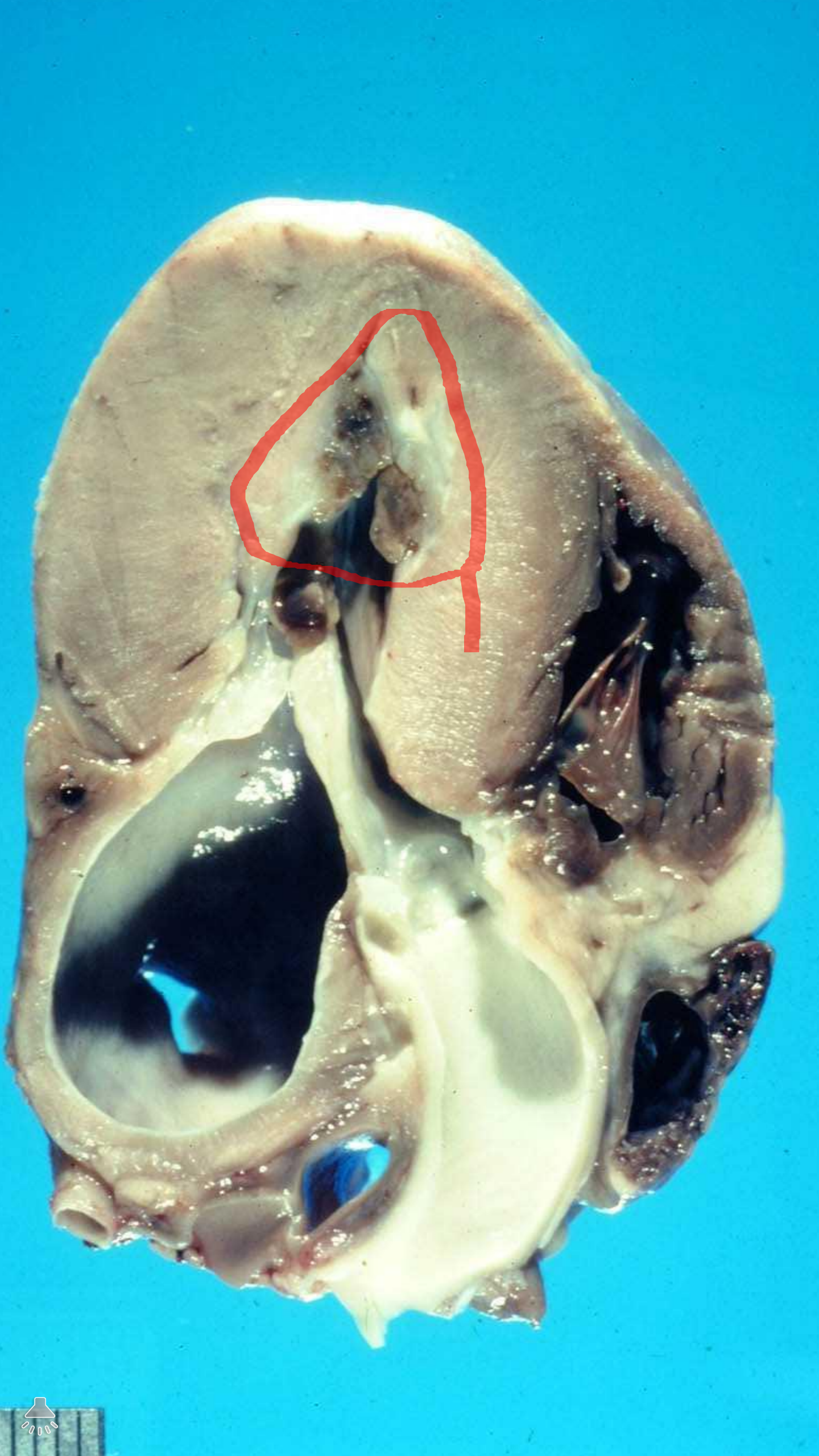
# Restrictive cardiomyopathy

- Dramatic fibrosis in the LV endocardium
- Often myocardial inflammation below fibrosis
- Fibrosis restricts LV diastolic filling
- Left atrial enlargement
- Prone to ATE





# Restrictive Cardiomyopathy
## Myocardial Form

- Non-dilated left ventricle; sometimes small LV
- Non-hypertrophied LV, sometimes mild LVH
- Systolic function typically OK
- Dilated LA
- +/- Mottled LV myocardium; may have endocardial changes or scar formation of intraventricular obstruction
- +/- Restrictive filling pattern on spectral Doppler

# Right Ventricular Cardiomyopathy

- AKA: Arrhythmogenic right ventricular cardiomyopathy
- Thinning of the RV free wall with RV dilation
- RV wall replaced with fat or fibrous tissue
- Thinning of the RV apex
- Can be confused with tricuspid dysplasia
- Right heart failure
- Arrhythmias or conduction disturbances
- May eventually affect LV as well

# Unspecified Cardiomyopathy

- Do not fulfill diagnostic criteria for DCM and HCM
- No apparent pericardial, coronary, valvular disease or systemic hypertension
- Myocardial disease that defies classification
  - Walls of variable thickness
  - Cavity may be dilated
  - May have reduced systolic function
  - Mild valvular regurgitation may be evident
- "Burned out" HCM?

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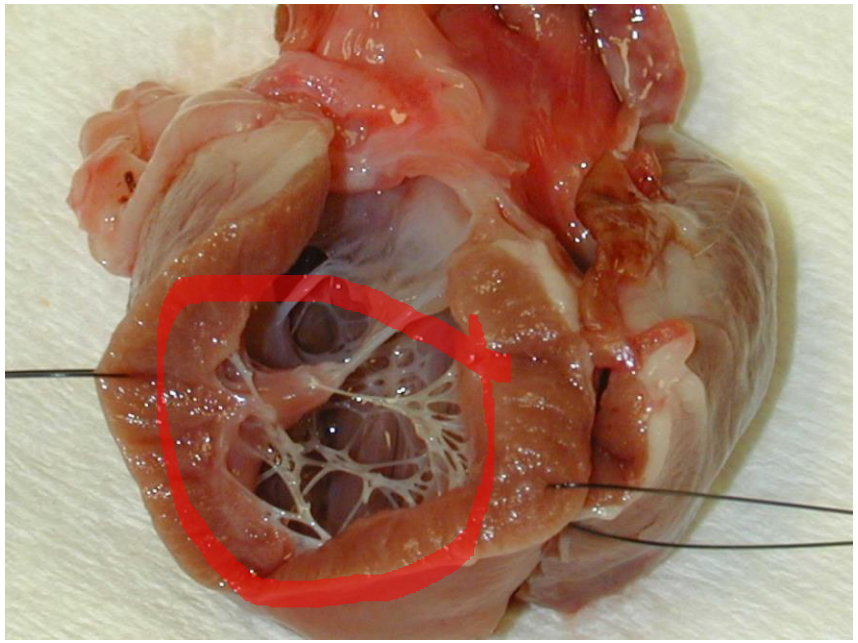
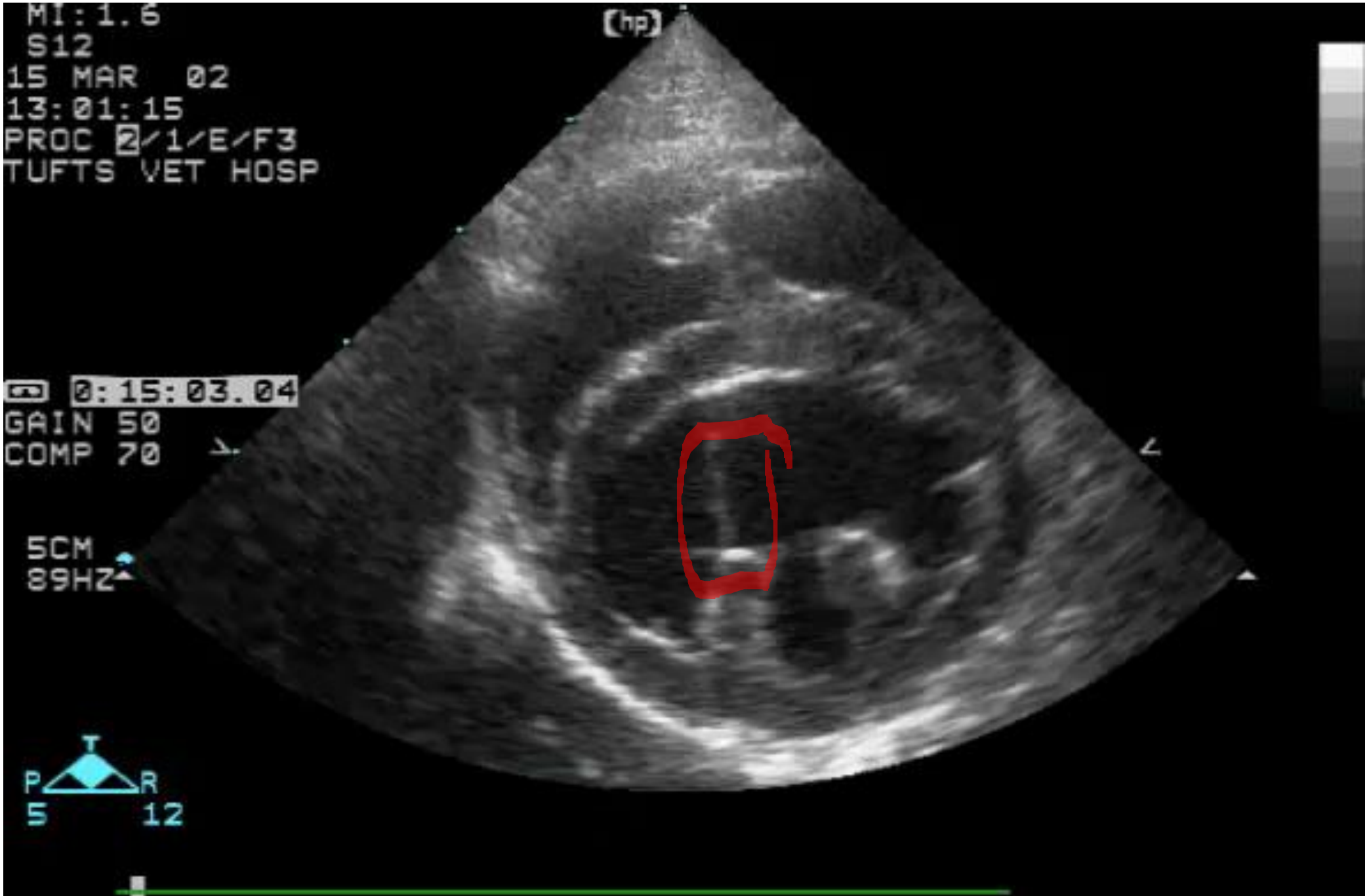
# Moderator bands

## Abnormal Chordae Tendinae

- Can be seen with various forms of cardiomyopathy
- Proposed to restrict cardiac filling
- Pathophysiologic limitation theoretical?
- Chicken or egg?
- Innocent bystander?

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PROC 2/1/E/F3
TUFTS VET HOSP
0:15:03.04
GAIN 50
COMP 70
5CM
89HZ
P
R
5
12

# Laboratory Testing

- CBC – often normal or mild leukocytosis
- Chemistry profile - required, ideally pre-Rx
  - Azotemia - diuretic, prerenal, renal disease
  - Increased LE's - AST, ALT - passive congestion
  - Electrolytes - Diuretics: $\Downarrow Cl^-$, $\Downarrow K^+$, $\Downarrow Na^+$, $\Uparrow tCO_2$
- T4 - cats over 6 years of age
- Taurine (plasma and whole blood) cats with DCM or LV systolic dysfunction
- Feline heartworm test? If significant right heart enlargement (Ab vs. Ag test)
- NT-proBNP – elevated in most cats; higher if CHF

# Management of CHF in Cats

- Furosemide – up to 12.5 mg q 12-48 hr
- Pimobendan – yes in most cases?
  - Avoid if LVOTO
- ACE inhibitor – Likely yes unless side effects
- Antithrombotics? Probably yes in most cats
- Spironolactone - 6.25 mg/cat q 12-24 hr
- Beta-blocker or calcium channel blocker?
- Diet - Sodium restriction, Taurine if reduced contractile function?