



The ABCs of ECGs Back to Basic Feline Arrhythmia Diagnosis and Case Review

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Lecture outline

- Electrical properties of the heart
- Action potentials
- Normal intracardiac conduction
- ECG interpretation (cases)
- Feline cases



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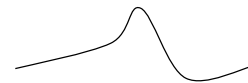
Electrical properties of the heart

- Automaticity
- Excitability
- Refractoriness
- Conductivity

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Automaticity

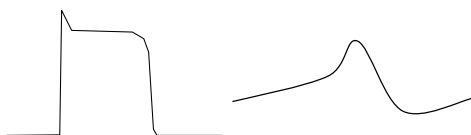
- Only pacemaker cells are *normally* capable of beating spontaneously
- Gradual diastolic reduction in action potential (becoming less negative) toward the cell's threshold potential.



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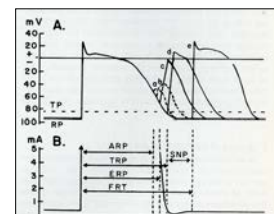
Excitability

- **All** resting myocytes are capable of responding to an effective stimulus by generating an action potential.



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Refractoriness



- Period of recovery following excitation when cells cannot respond to stimuli. Excitability is gradually restored.

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Conductivity



- Intercalated discs in the ends of muscle fibers give the atria and ventricles the property of a syncytium. Therefore, if propagation is blocked along the preferential conducting pathway, depolarization can still spread directly from one cell to the next (a slower process).
- Conduction speed is dependent on cell size (slower in smaller cells), and is normally slowest at the AV node.

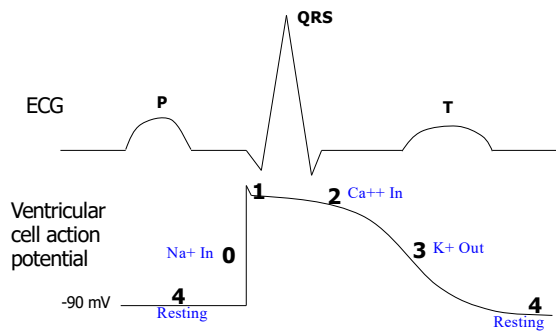
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Contractility

- Peak tension developed by myocardial cells at a specific resting fiber length.
- **ECG gives no information regarding contractility or pump function**

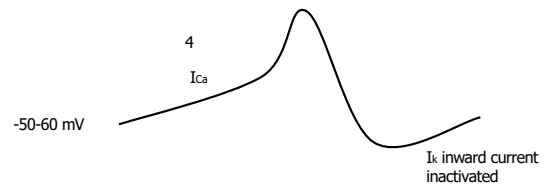
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Cardiac cell action potential



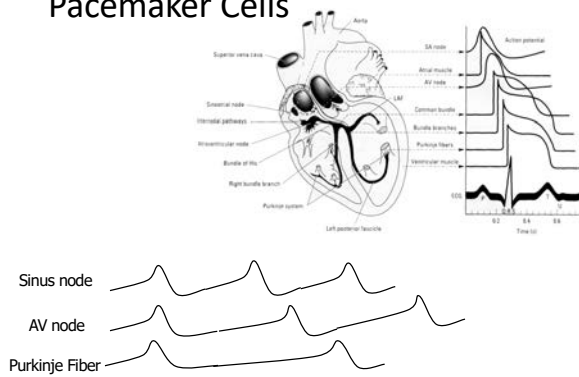
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Pacemaker cell action potential



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Pacemaker Cells



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Analysis of Cardiac Arrhythmias

- Site of impulse origin
 - Supraventricular: **SA node**, atria, AV node
 - Ventricular
- Rate: atrial and ventricular
- Timing
 - **Premature beats**: occur early in the sequence of normal beats
 - **Escape beats**: occur after a pause in the sequence of beats

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Normal wave morphology

In lead II, the RA is negative and the LL is positive.

Therefore, normally in lead II, the P wave is positive and the QRS is predominantly positive (R wave).

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Supraventricular vs. ventricular beats

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VPC and APC Pauses

APC: Non-Compensatory Pause

VPC: Compensatory Pause

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Premature vs. escape ectopics

- Premature beats occur earlier than the next expected beat
- Escape beats occur after a pause

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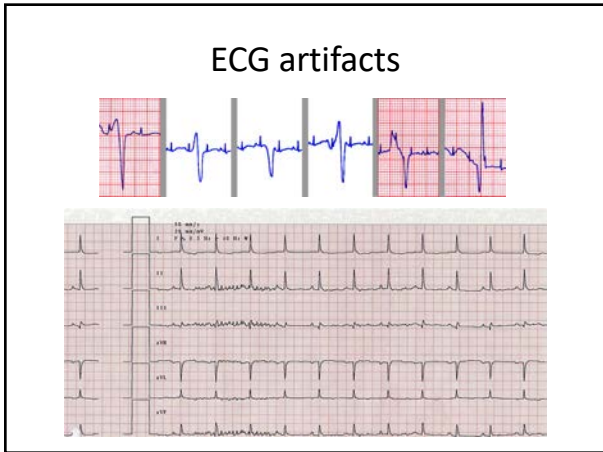
Basic ECG classification

- Arrhythmias
 - Supraventricular origin
 - Normal (sinus)
 - Bradycardias
 - Tachycardias
 - Ventricular origin
- Aberrant conduction
 - AV block (may also be bradycardia)
 - Bundle branch block

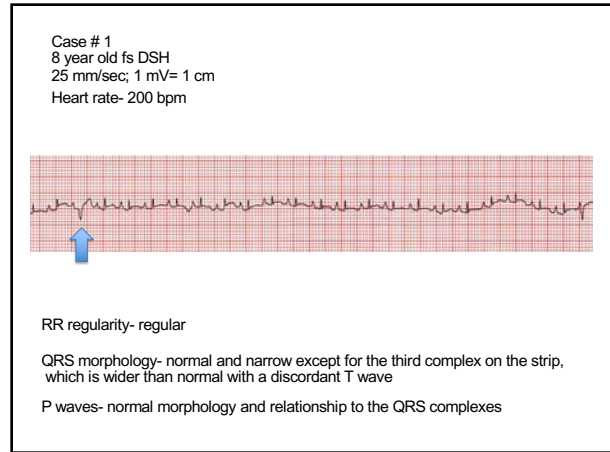
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Sinus rhythm in a cat; HR 220 bpm

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ECG Summary

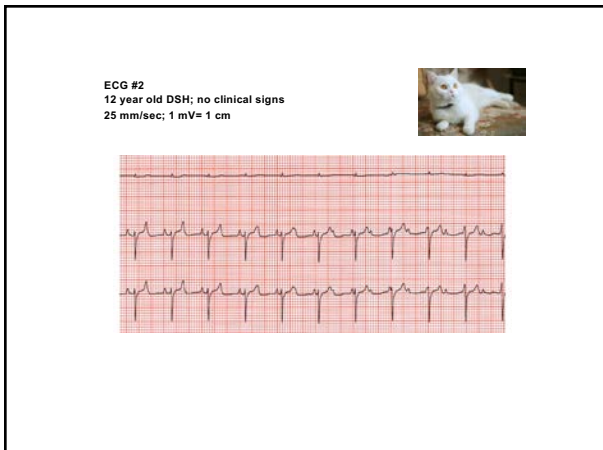
- Normal heart rate
- Single wide QRS with the rest of the complexes normal in appearance
- Differentials for wide QRS?
 - Ventricular ectopic beat
 - Bundle branch block
 - Electrolyte derangement
- Diagnosis:
 - *Sinus rhythm with occasional single ventricular premature complex*

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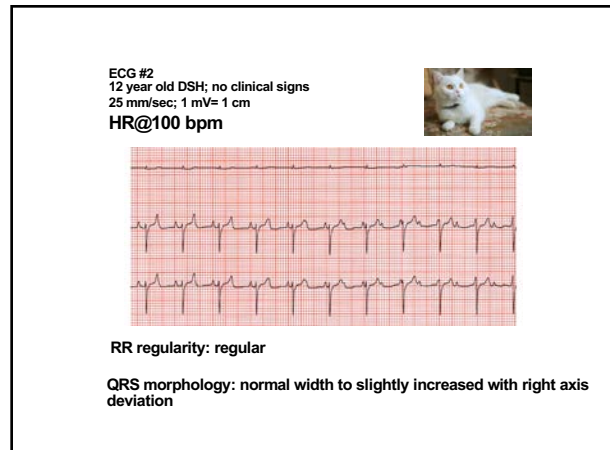
Recommendations

- Diagnostics to search for underlying cause of arrhythmia
 - Blood work
 - Echocardiogram
- Treatment
 - None vs. a beta blocker (atenolol- 1-1.5 mg/kg orally every 12-24 hours)

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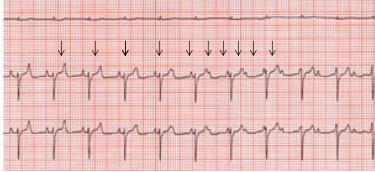


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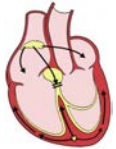
ECG #2
12 year old DSH; no clinical signs
25 mm/sec; 1 mV= 1 cm
HR@100 bpm



P waves: regular and asynchronous with QRSs

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Summary



- Bradycardia
- Regular RR and PP, but asynchronous
- PR intervals variable
- Abnormal morphology QRS
- Diagnosis:
 - **Complete heart block or third degree AV block**

Diagnostics for underlying heart disease warranted


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Treatment complete heart block

- Depends on symptoms and heart rate
- If asymptomatic:
 - nothing but monitoring for secondary heart disease
- If symptomatic:
 - Pacemaker vs medical management
 - Terbutaline
 - 0.1 mg/kg q 8 hours (oral)
 - Theophylline
 - 10-15 mg/kg q 12-24 hours (extended release; oral)

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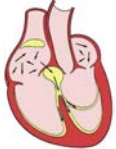
ECG #3
8 year old DSH; no clinical signs
1 mV= 2 cm
HR@ 300 bpm



RR regularity: irregularly irregular
QRS morphology: normal
P waves: not visible

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Summary




- Irregularly, irregular rhythm
- Lack of P waves
- Normal QRS morphology
- Rhythm diagnosis:
 - **Atrial fibrillation**

Treatment: Control heart rate by slowing AV nodal conduction:
Beta adrenergic blocker (atenolol)
Calcium channel blocker (diltiazem)
Digoxin

Diagnostics for underlying heart disease warranted

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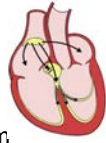
ECG #4
8 year old Persian; no clinical signs
1 mV= 1 cm
HR@ 140 bpm



RR regularity: irregular
QRS morphology: two different morphologies
P waves: irregular
some without QRS

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Summary



- Slow heart rate with irregular rhythm
- Occasional blocked P waves
- QRS morphology normal
- Rhythm diagnosis:
 - **Second degree AV block type 2**
 - **Sick Sinus Syndrome**

Atropine response test- 0.04 mg/kg IV or IM

Diagnostics for underlying heart disease warranted

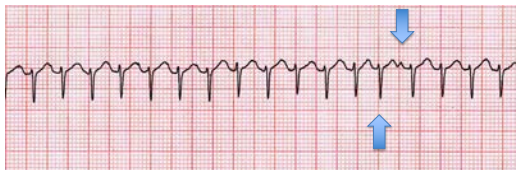
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Treatment options

- If atropine response test is normal, look for underlying disease that is causing elevated vagal tone (respiratory, GI, ocular or neurologic)
- If abnormal atropine response test, gold standard therapy would be pacemaker. If not possible consider medical management with:
 - Propranolol: 0.25-5 mg/kg q 8-12 hour (oral)
 - Terbutaline: 0.1 mg/kg PO q 8 hour (oral)
 - Theophylline: 10-15 mg/kg q 12-24 hour (extended release; oral)

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ECG #4
8 year old Persian; no clinical signs
1 mV= 1 cm
HR@ 140 bpm



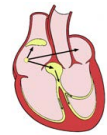
RR regularity- irregular

QRS morphology- abnormal (predominantly negative)

P waves- only one visible

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ECG Summary



- Normal heart rate
- Single early QRS with same morphology as rest of beats
- Differentials for abnormal QRS morphology?
 - Ventricular ectopic beat
 - Bundle branch block
 - Electrolyte derangement
- Diagnosis:
 - **Sinus rhythm with right bundle branch block and single atrial premature complex**
- Treatment
 - None vs. a beta blocker (atenolol- 1-1.5 mg/kg orally every 12-24 hours)

Diagnostics for underlying heart disease warranted

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Case studies in feline heart disease

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Case 1

- 8 year old DSH with a grade III/VI left and right parasternal systolic murmur which has not previously been detected
- PE: HR- 200 bpm and regular; murmur intensity varies with HR; good pulse strength; MM- pink and moist with prompt crt; Normal breath sounds and RR effort
- Differential diagnoses: physiologic flow murmur vs. cardiomyopathy
- Diagnostics:
 - thoracic radiographs vs. echocardiography
 - blood pressure and T₄

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Case 1

- Thoracic radiographs

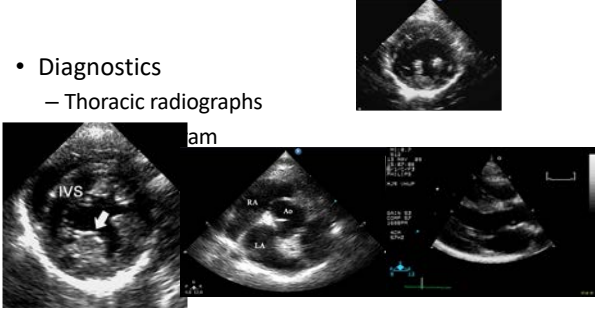


Interpretation: VHS=7.8V; Normal heart size and clear lung fields

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Case 1

- Diagnostics
 - Thoracic radiographs



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Case 1

- Diagnostics
- Thoracic radiographs
- Echocardiogram
- Systolic blood pressure: 128 mmHg
- T₄: 3.1µg/dl
- Diagnosis: Physiologic flow murmur; possible early cardiomyopathy (stage B1)
- Recommendations
 - No cardiac drugs recommended
 - Recheck in 12 months
 - Client education

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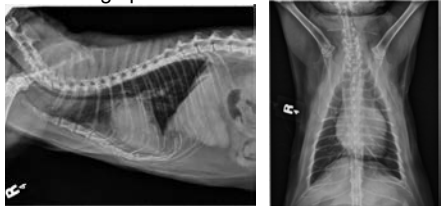
Case 2

- 9 year old DSH with a grade III/VI left and right parasternal systolic murmur, which has not previously been detected
- PE: HR- 190 bpm and regular; moderate pulse strength; MM- pink and moist with prompt crt; Normal breath sounds and RR effort
- Diagnosis: physiologic flow murmur vs. cardiomyopathy
- Diagnostics:
 - thoracic radiographs vs. echocardiography
 - blood pressure and T₄

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Case 2 Diagnostics

- Thoracic radiographs

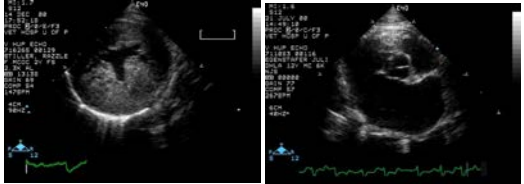


Interpretation: VHS= 9.6V; Generalized heart enlargement, particularly left atrium; Clear lung fields

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Case 2 Diagnostics

- Benefit of echocardiogram
 - Diagnosis of definitive type of cardiomyopathy



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Case 2

- Diagnostics
 - Systolic blood pressure: 142 mmHg
 - T₄: 2.8µg/dl
- Diagnosis: Hypertrophic cardiomyopathy; no evidence of congestive heart failure (stage B2)
- Recommendations
 - Anticoagulant because of significant left atrial enlargement
 - Clopidogrel
 - Fish oil supplementation
 - General client education
 - Resting respiratory log

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Case 3

- 10 year old DSH
- History
 - Normal prior to today. When owners returned home from work they found him having difficulty breathing
- Physical examination
 - No cardiac murmur
 - HR- 200 bpm and regular
 - RR- 68 bpm with increased effort
 - Moderate femoral pulses

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Case 3- Thoracic radiographs



Diagnosis: Moderate cardiomegaly; generalized, patchy interstitial to alveolar pulmonary pattern
>>>CHF (stage C)

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Recommendations

- Emergent CHF therapy
 - Oxygen supplementation
 - 1-2 mg/kg furosemide IV every 1-2 hours until RR decreases by 20-30% or is under 40 bpm, then reduce frequency to every 8 hours
 - +/- butorphanol if anxious
 - +/- pimobendan
 - NEVER START BETA BLOCKERS IN ANIMALS WITH UNCONTROLLED CHF

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Recommendations

- Chronic therapy
 - Echocardiography allows definitive diagnosis of type of underlying heart disease
 - Furosemide- 0.5-2 mg/kg twice daily (lowest dose that controls clinical signs)
 - ACE inhibitor (enalapril or benazepril)- 0.5 mg/kg once to twice daily
 - Heart rate control if necessary (atenolol or diltiazem)
 - +/- Anticoagulant therapy (depending on LA size)
 - +/- Pimobendan (if systolic dysfunction or poor response to standard therapy)

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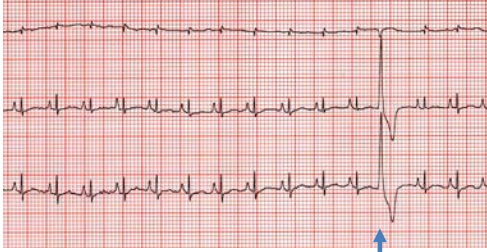
Case 4

- 6 year old DLH – asymptomatic; an irregular rhythm was detected on routine physical examination
- Physical examination
 - Irregular cardiac rhythm- occasional premature beats
 - Otherwise NSF
- Diagnostics:
 - electrocardiography
 - thoracic radiographs vs. echocardiography
 - Complete blood work +/- T₄
 - blood pressure

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Case 4- diagnostics

- Electrocardiogram

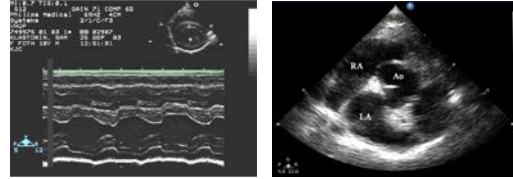


ECG- sinus rhythm with one ventricular premature complex

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Case 4- diagnostics

- Echocardiography



Results: normal LV wall thickness, normal heart size and function >>>> normal heart

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Case 4- recommendations

- Diagnosis- Ventricular ectopy without a cardiac or underlying cause identified (normal clinical laboratory results, blood pressure and echocardiogram)
- Recommendations-
 - Address ventricular arrhythmia if patient is symptomatic or there is evidence of R on T (couplets or bursts of ventricular tachycardia)
 - Atenolol- first line antiarrhythmic in cats (6.25-12.5 mg per cat S-BID)
 - Sotalol- (2 mg/kg BID)
 - Fish oil supplementation?
 - Yearly rechecks

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Case #5-Sylvester



- 7 year old mn DLH cat
- No clinical signs until 2 months ago when he began intermittent coughing

Physical examination

- HR- 200 bpm in a regular rhythm; RR- 36 bpm with normal effort; Good femoral pulse strength; MM- pink and moist with normal CRT; No obvious abnormalities on PE

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Case 5- diagnostics

- Thoracic radiographs



Normal heart size; prominent right caudal pulmonary artery

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Case #5-diagnostics

- Heartworm antigen (-) and antibody(+)
- CBC and chemistry
 - Mild eosinophilia; otherwise normal
- Fecal (-)
- Echocardiogram- normal
- DX- highly suspicious for heartworm disease

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Heartworm Associated Respiratory Disease

- Arrival of immature worms into the small arteries in the lungs initiates a severe inflammatory response
- Many cats launch an immune response which kills the parasite but lower airway disease persists
- Feline asthma

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Case#5- treatment

- Heartworm preventative
 - Ivermectin
- Course of doxycycline
 - 10 mg/kg PO BID X 4wks
- Treat as for feline asthma
 - Anti-inflammatory prednisolone (0.5-2.0 mg/kg) or fluticasone (1 actuation q12h)
 - Bronchodilators
 - Theophylline, terbutaline, albuterol
 - General supportive care

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Case #6-

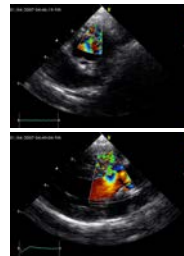
- 1 year old mn Sphynx cat
- History: Recently adopted. Cardiac murmur. No other clinical signs referable to the cardiovascular system.

Physical examination

- HR- 200 bpm in a regular rhythm; Grade V/VI right parasternal systolic murmur. RR- 28 bpm with normal effort; No other obvious abnormalities on PE

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Case #6 Diagnostics



- Echocardiography findings
 - Normal LV wall thickness
 - Normal systolic function
 - Normal heart size
 - High velocity flow noted in right ventricular outflow tract with CF and spectral Doppler
 - Diagnosis- ventricular septal defect (VSD)

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Case #6 Recommendations

- Prognosis is excellent because the VSD is small and restrictive
 - No cardiac remodeling
 - Doppler flow velocities
- No cardiac medications recommended
- Recheck every 1-3 years to make sure cardiac status remains stable

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Questions?

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