CANADA WEST VETERINARY SPECIALISTS

The ABC of ECG

30 October 2011

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Outline

- Utility of the surface ECG
- How to interpret an ECG

- ~~Genesis of the Surface ECG~~
- ~~How to record an ECG~~

www.youtube.com/user/canadawestvets

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Why do we record ECGs

- Diagnosis of Arrhythmias
- Detection of ischemia
- Chamber enlargement
- Electrolyte changes
- Monitoring during anesthesia
- Monitoring a critical patient
- Monitoring treatment w/ certain drugs

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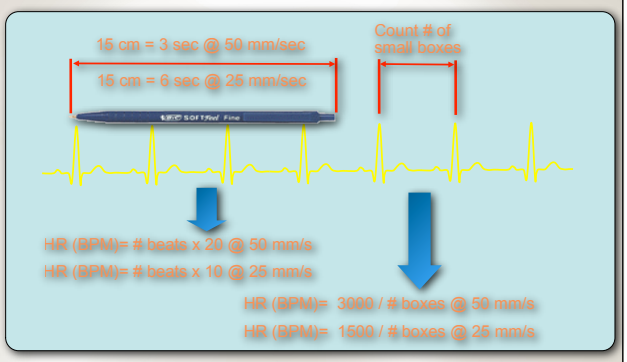
ECG Interpretation

1. Signalment/History
2. Rule out artifacts
3. Determine the heart rate
   - Instantaneous
   - Average
4. Determine the cardiac rhythm
5. Measure amplitudes, widths, intervals
6. Apply criteria for chamber enlargement
7. Calculate mean electrical axis

Determine the HR



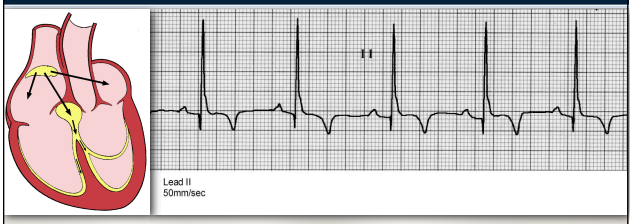
Analysis of Cardiac Arrhythmias

- 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

Analysis of Cardiac Arrhythmias

- Rhythm
  - Regularity
    - Regular
    - Irregular
      - Regularly irregular (pattern)
      - Irregularly irregular (random)
  - P wave for every QRS complex?
  - QRS complex for every P wave?
  - Temporal relationship between P waves and QTS complexes

Sinus Rhythm



- Normal sequence of cardiac activation
- Site of origin: SA node
- Rate: species and size dependent
- Rhythm: regular sequence of P, QRS, T waves; consistent P-P, P-R, R-R intervals

Sinus Arrhythmia

- Normal sequence of P-QRS-T waves
- Rhythm: regularly irregular
  - heart rate increases during late inspiration-early expiration
  - heart rate decreases during late expiration-early inspiration

Wandering Pacemaker

- Origin of impulse shifts slightly within the SA node resulting in changes in the P wave morphology
- Usually associated with changes in vagal tone due to respiration
  - Inspiration: P wave taller
  - Expiration: P wave smaller

Sinus Tachycardia

- Similar criteria for sinus rhythm except for the heart rate which is elevated
  - Regular sequence of P-QRS-T waves
  - Dogs: >160-180 bpm; cats >240 bpm
- Usually due to elevated sympathetic tone

Sinus Bradycardia

- Rate: dogs <70 bpm; cats <120bpm
- Sinus arrhythmia and wandering pacemaker may also be present
- Treatment: not usually required, usually due to elevated vagal tone

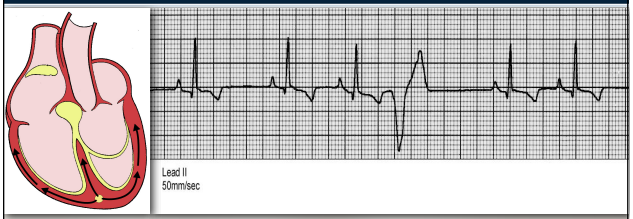
Premature Beats

- Ectopic pacemaker depolarizes more rapidly than the SA node: occur earlier than expected
  - Supraventricular (atrial, junctional)
  - Ventricular
- Occur in a wide variety of cardiac and extra-cardiac diseases

Supraventricular Premature Beats

- Short R-R interval; P wave morphology altered
- Impulse uses the normal ventricular conduction pathway (His-Purkinje system)
  - Normal QRS configuration
- Followed by non-compensatory pause (= 1 R-R interval)

Ventricular Premature Beats

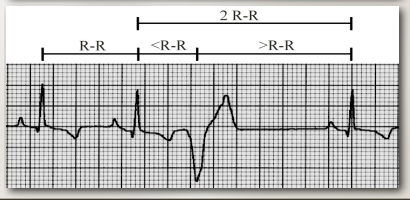


- Short R-R interval
- Abnormal QRS morphology (wide and bizarre)
  - Uniform or multiform
  - Not associated with a P wave
- Followed by compensatory pause (>1 R-R interval)

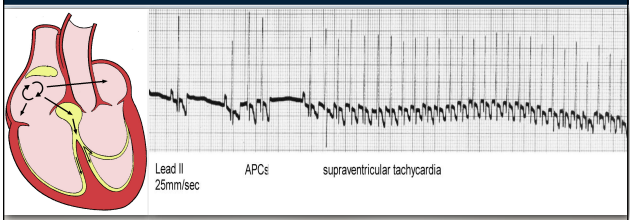
VPC and APC Pauses

APC:
Non-Compensatory
Pause

VPC:
Compensatory
Pause

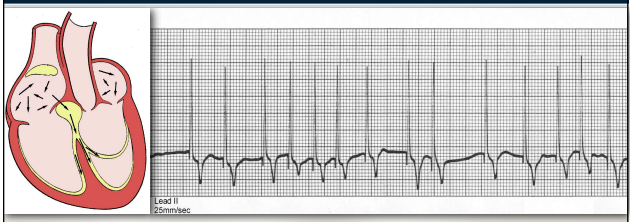


Supraventricular Tachycardia



- Rate: commonly 150-300 bpm in dogs
- Rhythm: regular and rapid series of P-QRS-T waves
- QRS morphology normal
- P waves may be buried in preceding T wave
- Presence of atrial premature beats is common

Atrial Fibrillation

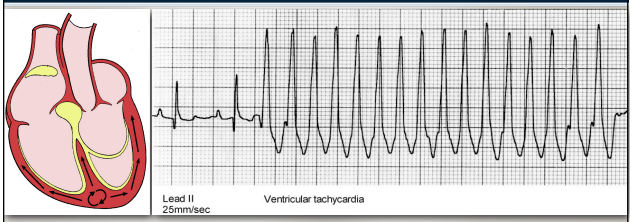


- Three hallmarks
  - Irregularly irregular rhythm
  - Absence of P waves
  - Supraventricular QRS-T morphology
- Additional feature: undulating baseline

Atrial Flutter

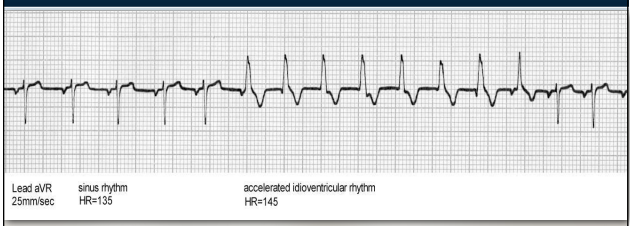
- Variant of atrial fibrillation
- Prominent and regular baseline undulations
  - F waves (“sawtooth” baseline)
- Rate
  - F wave rate: 300-500 bpm
  - Ventricular rate: variable and dependent on AV nodal conduction

Ventricular Tachycardia



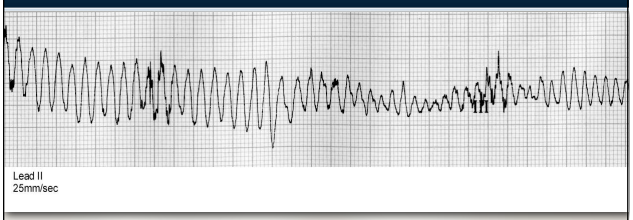
- Rhythm: regular
- **HR > 180 bpm**
- Morphology: QRS wide and bizarre
- P waves have no relationship to the QRS wave and are usually buried within the QRS complex
- unifocal or multifocal; sustained vs. non-sustained

Accelerated Idioventricular Rhythm



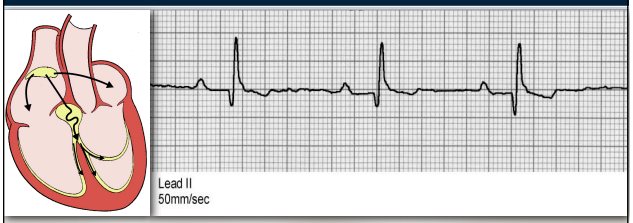
- Accelerated ventricular escape rhythm
  - Onset usually follows a pause in the rhythm rather than occurring prematurely
- Rate usually 70-150 bpm (**<180 bpm**) and similar to the prevailing sinus rate

Ventricular Fibrillation



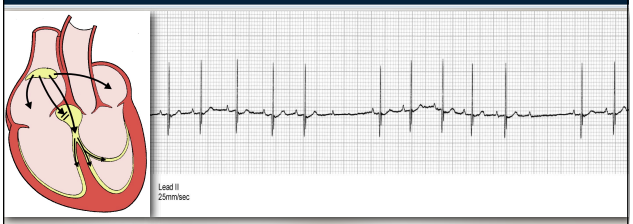
- Rate: no organized ventricular contractions
- ECG: baseline undulations of various amplitude and shape; no discernible P, QRS, T waves
- Course vs. Fine VF

First degree AV block



- Prolonged P-R interval
  - Dogs >0.13 sec
  - Cats >0.09 sec
- Each P wave produces a QRS complex

Second Degree AV Block



- Rate: ventricular rate slower than the atrial rate
- P waves present without a corresponding QRS complex

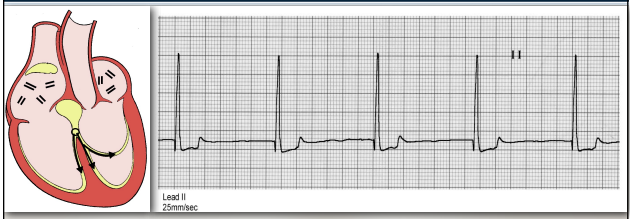
Second Degree AV Block

- High Grade: cannot determine changes in the P-R interval prior to the dropped beat due to the lack of two consecutively conducted beats
- May cause clinical signs (weakness, fainting)

Third Degree AV Block

- No consistent relationship between the P waves and QRS complexes (variable P-R interval)
- QRS morphology abnormal
- P wave (atrial) rate faster than the QRS (ventricular) rate

Atrial Standstill



- Absence of P waves in all leads
- Slow regular escape rhythm (junctional or ventricular)

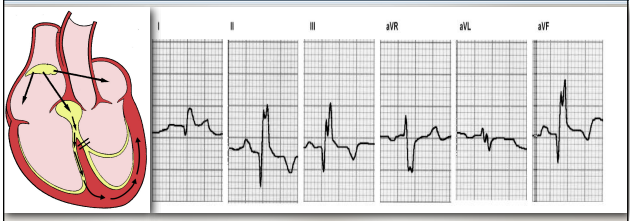
Bundle Branch Block

- Right bundle branch block (RBBB)
  - Seen commonly in otherwise normal dogs
  - No hemodynamic abnormalities are associated with RBBB
  - No treatment needed
- Left bundle branch block (LBBB)
  - Usually associated with significant underlying heart disease
  - Presence of LBBB should prompt a cardiac work-up to identify the underlying cause

Right Bundle Branch Block

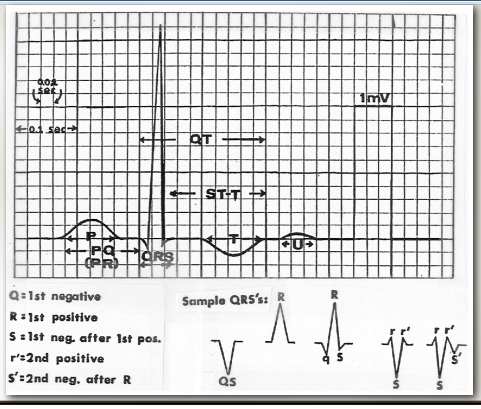
- Normal P wave and P-R interval
- QRS >0.08 sec
- Right axis shift: MEA>150 degrees
- Notched S waves in I, II, III, aVF common

Left Bundle Branch Block

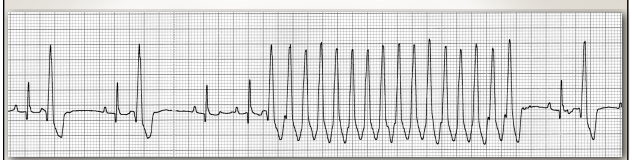


- P wave and P-R interval normal
- QRS duration >0.08 seconds
- Normal mean electrical axis
  - Partial LBBB may cause a left axis shift
- Notched R wave in I, II, III, aVF common

Measure amplitudes and intervals



Measure amplitudes and intervals



Lead II rhythm strip

Paper Speed = 50 mm/sec

Sensitivity: 10mm=1mV

Only on Sinus-initiated beats

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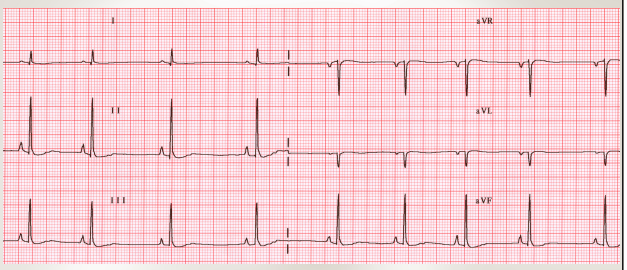
Normal Canine ECG



Paper Speed: 50 mm/sec

Sensitivity: 1.0 mv = 10 mm

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Canine ECG: Normal Values

Heart Rate
60-160 bpm in adult dogs
Up to 200 in puppies

Normal Rhythms:
Sinus arrhtyhmia,
Wandering pacemaker,
Sinus rhythm (uncommon)

Mean Electrical Axis:
+40º to 103º

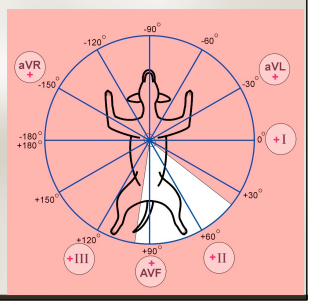
P wave:
0.4 mv tall (4 boxes)
0.045 seconds wides (2 boxes)

P-R interval:
0.06 to 0.13 seconds (3 to 6.5 boxes)

QRS complexes:
Up to 3.0 mv tall (30 boxes)
Up to 0.05 sec. wide (2.5 boxes)

S-T segment:
Inspect for elevation/depression

Q-T interval:
0.15 to 0.25 seconds (7.5 to 15 boxes)



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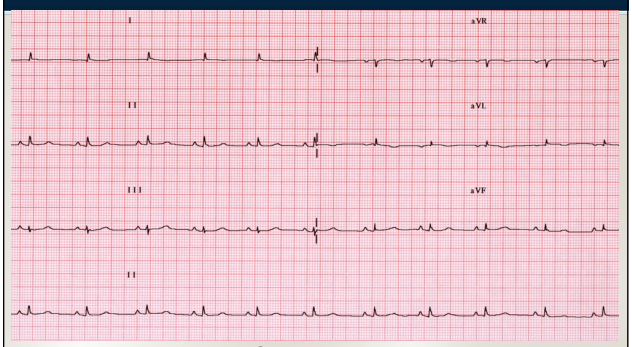
Normal Feline ECG



Paper Speed: 50 mm/sec

Sensitivity: 1.0 mv = 10 mm

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Normal Canine ECG

Heart Rate
140 to 240 beats/minute

Normal Rhythms:
Sinus rhythm
Sinus tachycardia
Sinus arrhythmia (rare)

Mean Electrical Axis:
+0º to 160º

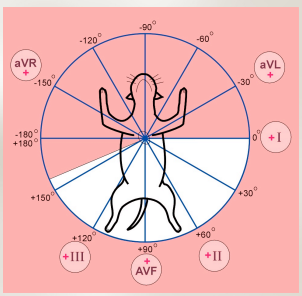
P wave:
0.2 mv tall (2 boxes)
0.04 seconds wides (2 boxes)

P-R interval:
0.05 to 0.09 seconds (2.5 to 4.5 boxes)

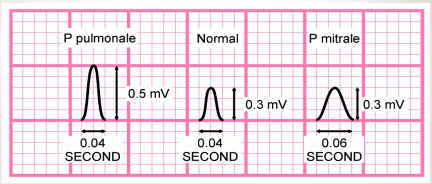
QRS:
Up to 1.0 mv tall (10 boxes)
Up to 0.04 sec. wide (2 boxes)

S-T segment:
Inspect for elevation/depression

Q-T interval:
0.12 to 0.18 seconds (6 to 9 boxes)



Atrial enlargement patterns



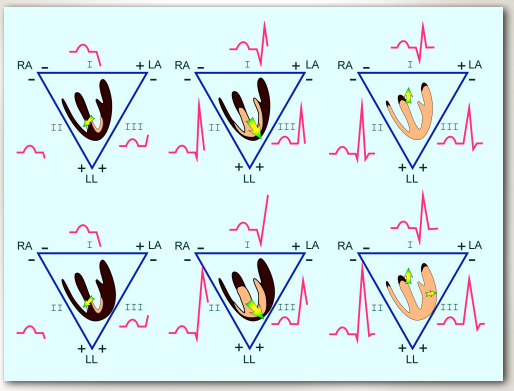
LAE = P-mitrale

RAE = P-pulmonale

Dog:
LAE P > 0.04 sec
RAE P > 0.4 mV

Cat:
LAE P > 0.04 sec
RAE P > 0.2 mV

LV enlargement pattern



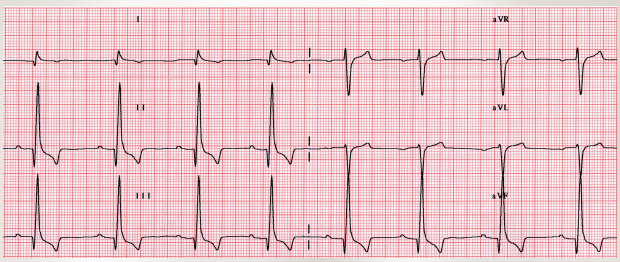
LV enlargement criteria

Increased R wave amplitude
Increased QRS complex width
Associated with P-mitrale

Dogs:
QRS > 0.06 seconds
R > 1.0 mV in lead I
R > 3.0 mV in II or aVF
$R_{(I+aVF)}$ > 4.0 mV
R > 3.0 mV in CV_6LU
R > 3.0 mV in CV_6LL

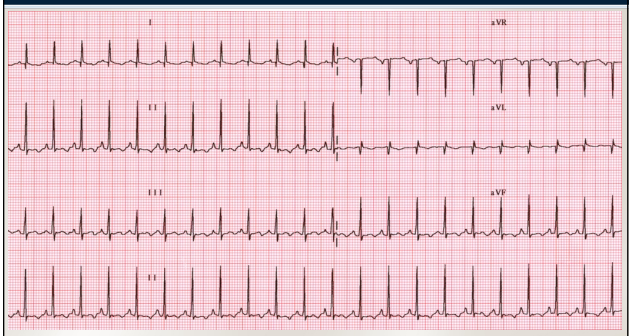
Cats:
QRS > 0.06 seconds
R ≥ 0.9 mV in any lead

LV enlargement dog



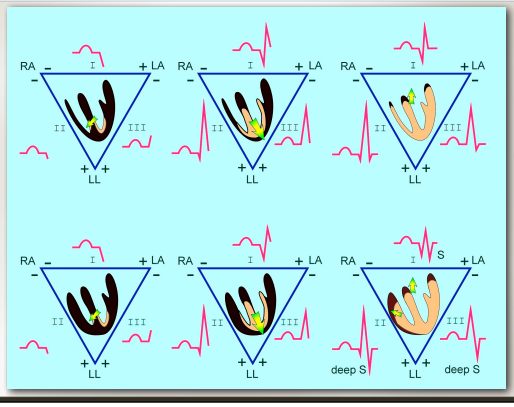
Paper Speed: 50 mm/sec
Sensitivity: 1.0 mv = 5 mm

LV enlargement - Cat



Paper Speed: 50 mm/sec
Sensitivity: 1.0 mv = 10 mm

RV enlargement pattern

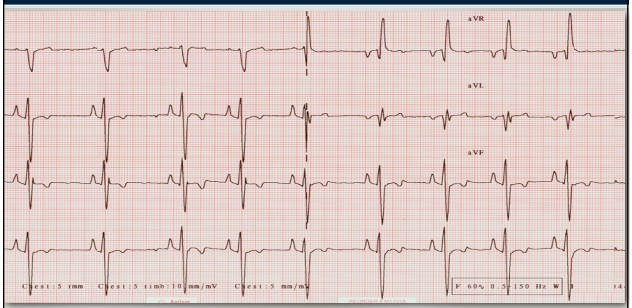


RV enlargement criteria

S wave lead I
Deep S waves on II, V2 and V4
MEA shift to the right
Associated with P-pulmonale

Dogs:
MEA > 103^0
S > 0.05 mV in
S > 0.35 mV in II
S > 0.8 mV in CV_6LL
S > 0.7 mV in CV_6LU
R/S > 0.87 in CV_6LU
Q > 0.3 mV aVR
+T > 0.25 mV in I
R' in lead II

RV enlargement dog



Paper Speed: 50 mm/sec
Sensitivity: 1.0 mv = 10 mm

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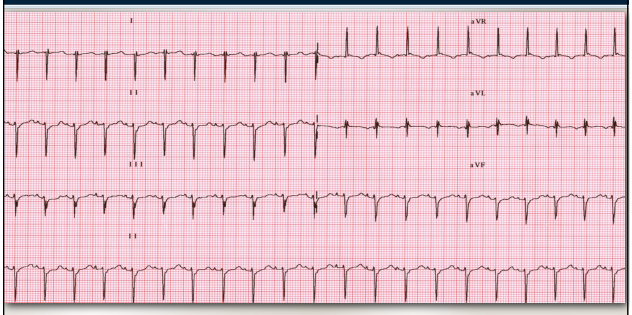
RV enlargement cat



Paper Speed: 50 mm/sec
Sensitivity: 1.0 mv = 10 mm

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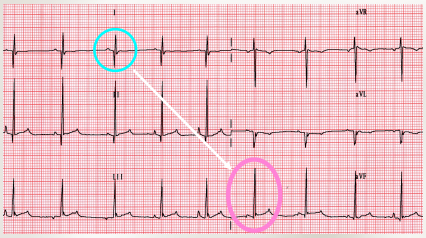
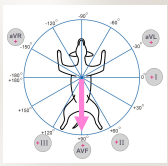
Determine the MEA

Method of the isoelectric lead





MEA = +90°

Which lead is isoelectric ?
Which lead is perpendicular ?
What is the polarity of the “perpendicular”?

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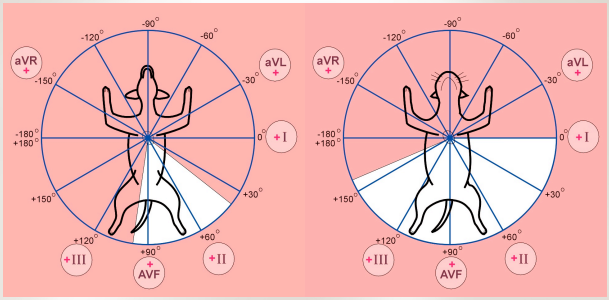
Normal MEA



Dogs: 40°-103°

Cats: 0°-160°

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Thank You!!