ECG Interpretation

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Providing the best quality care and service for the patient, the client, and the referring veterinarian.
GOAL: Reduce Anxiety about ECGs
Back to the Basics!

What is an ECG??
Electrocardiogram = EKG = ECG =
A recording of the electrical activity of the heart from electrodes placed on the surface of skin.

The interiors of heart muscle cells (myocytes*) are negative ("polarized") at rest, but when "depolarized" their interiors become positive and the myocytes contract.

The depolarization wave (cell interiors become positive), and a phase of repolarization (cell interiors return to negative) that follows, are recorded on the EKG as shown.
The 1st Rule of ECG

- A current of depolarization traveling towards the + electrode is recorded as a positive deflection.
- A current of depolarization traveling away from the + electrode is seen as a negative deflection.
- A current of repolarization traveling away from the + electrode is seen as a positive deflection.
The 2nd Rule of ECG

Fibrous = scar tissue

Rapid depolarization/repolarization = narrow tracing
Slow depolarization/repolarization = wide tracing

Horizontal axis represents time. If slower variations of electrical potentials, complexes becomes wider (more tissue to depolarize, fibrosis)
The 3rd rule of ECG

More tissue depolarizing results increases the amplitude (height) of the complexes
What does the P wave represent?

When the wave of atrial depolarization enters the AV Node, depolarization slows, producing a brief pause, thus allowing time for the blood in the atria to enter the ventricles. Slow conduction through the AV Node is carried by calcium (Ca++) ions.
What does the QRS represent?

The terminal filaments of the Purkinje fibers rapidly distribute depolarization to the ventricular myocytes. Depolarization of the entire ventricular myocardium produces a **QRS complex** on EKG.
A cardiac cycle is represented by the P wave, the QRS complex, the T wave, and the baseline that follows until another P wave appears. This cycle is repeated
Why so many leads?

- Why not keep it simple??
- Every extra lead placed is another view or “angle”
To obtain limb leads, electrodes are placed on the R arm, L arm, and L leg. By selecting a different pair, we create lead I, lead II, and lead III.

By pushing the limb leads to the center of the triangle, we produce 3 intersecting lines.

The augmented limb leads intersect at different angles, producing 3 additional leads.

- AVR – R arm positive
- AVL – L arm positive
- AVF – Left Foot positive
Techniques for obtaining an ECG. Remember, the better the ECG, the easier it will be to interpret!

- Place the patient in right lateral recumbency. (A rhythm strip can be obtained from any position)
- Part the hair.
- Attach the electrodes to the skin just proximal (above) to the elbows and stifles.
- Wet the electrodes with alcohol (do not soak).
- If panting or excessive motion, move the front limb leads further distal on the limb.
- Check the speed, amplitude, and other settings.
Methodical Approach to the ECG

- HR -- fast or slow
- Rhythm -- regular or irregular
- Identify P waves
  - normal or abnormal configuration
  - is there a P for every QRS
- Measurements
  - P-R interval, Q-T interval, S-T segment, etc.
Calculating the Average HR

- Average HR = “Bic pen method”:
  - At 25 mm/sec
    - Start at 1 QRS complex
    - Count the number of QRS complexes during 6 sec = 15 cm
      - = 1 pen
    - Multiply by 10
  - At 50 mm/sec
    - Start at 1 QRS complex
    - Count the number of QRS complexes during 3 sec = 15 cm
      - = 1 pen
    - Multiply by 20
Calculating an Instantaneous HR

- If recording at 50 mm/sec:
  \[
  \text{Heart rate} = \frac{3000}{\text{number of 1 mm boxes between 2 beats}}
  \]
  
  ex: \( \frac{3000}{25} = 120 \text{ bpm} \)

  (Why 3000: 3000 one mm boxes = 3000 \( \times 0.02 \text{ sec} = 60 \text{ sec} = 1 \text{ min} \))

- If recording at 25 mm/sec:
  \[
  \text{Heart rate} = \frac{1500}{\text{number of 1 mm boxes between 2 beats}}
  \]
Normal Heart Rates

- **Dog**
  - Normal heart rate: 60 to 150 beats/minute
  - Bradycardia: HR<60 beats/minute
  - Tachycardia: HR>150 beats/minute
  - Usually no clinical signs if rate between 40 and 200 beats/minute

- **Cat**
  - Normal heart rate: 140 to 200 beats/minute
  - Bradycardia: HR<100 beats/minute
  - Tachycardia: HR>200 beats/minute
Approaching the ECG

- Start at the left and go through each complex, identifying known waves.

- Determine:
  - HR ✓
  - Measurements
  - Is the rhythm regular or irregular, then is it regularly, irregular or irregularly, irregular?
  - Is there a “p” wave for every QRS and a QRS for every “p”?
Measurements

P wave
- Atrial depolarization
- Positive in lead II
- Right atrial enlargement
  - Tall p wave
- Left atrial enlargement
  - Wide p wave

PR interval
- Conduction through the AV node
- Onset P wave to onset QRS
- Prolonged P-R interval = slowed down in the AV node = first degree AV block

QRS complex
- Tall R wave in lead II indicates left ventricular hypertrophy (more tissue to depolarize)
- Hypertrophy
  - Concentric: thicker walls
  - Eccentric: dilation of ventricle
- 90% of dogs with tall R wave have hypertrophy of left ventricle
Measurements

P wave:
- Atrial depolarization
- Positive in lead II
- Right atrial enlargement
  - Tall p wave
- Left atrial enlargement
  - Wide p wave

PR interval:
- Reflects conduction through the AV node
- Onset P wave to onset QRS
- Prolonged P-R interval = slowed AV conduction = first degree AV block

QRS complex:
- Tall R wave in lead II indicates left ventricular hypertrophy (more tissue to depolarize)
- Hypertrophy
  - Concentric: thicker walls
  - Eccentric: dilation of ventricle
- 90% of dogs with tall R wave have hypertrophy of left ventricle
QRS Complex LBBB

- QRS duration > 60 ms = 3 mm = 3 small boxes at 50 mm/sec
- Indicates more time to depolarize
- Associated with a disruption of the LBB
- Associated to severe left myocardial disease
QRS complex: Right ventricular enlargement

- Deep S wave in lead II
  = negative QRS in lead II
- Mean axis shifts to the right
- Indicates eccentric or concentric hypertrophy of the right ventricle
QRS complex: RBBB

- Deep S wave in lead I, II, III, and aVF
- Positive R wave in aVR
- Wide QRS complex
  - Indicates more time to depolarize
- The QRS reflects the slowest portion of depolarization
- It can be incidental or reflect right sided disease
QRS Complex: Left Anterior Fascicular Block Pattern

- **LAFB:**
  - Typically pathologic
  - Tall R wave in I and aVL
  - Deep S in II, III, aVF

- **RBBB:**
  - Deep S wave in lead I, II, III, and aVF
  - Positive R wave in aVR
S-T Segment and T Wave Abn

S-T Segment Changes:
- **Depressed S-T:**
  - myocardial ischemia
  - acute MI
  - electrolyte abnormalities
  - digitalis toxicity
  - cardiac trauma
- **Elevated S-T:**
  - myocardial infarction
  - pericarditis
  - myocardial hypoxia

T Wave Abnormalities:
- Myocardial hypoxia
- Anesthetic complications
- Hyperventilation
- Heart failure
- Bradycardia
- Hyperkalemia (large, spiked)
- Hypokalemia (small, biphasic)
- Anemia
- Shock
- Uremia
- Hypothyroidism
- Fever
Approaching the ECG

- Start at the left and go through each complex, identifying known waves.
- Determine:
  - HR ✓
  - Measurements ✓
  - Is the rhythm regular or irregular, then is it regularly, irregular or irregularly, irregular?
  - Is there a “p” wave for every QRS and a QRS for every “p”?
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<th>RHYTHM</th>
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Classifications of arrhythmias

- **Origin**: Defines acute and chronic treatment
  - Supraventricular
  - Ventricular

- **Rates**: Defines necessity for treatment
  - Bradyarrhythmias
  - Tachyarrhythmias

- **Regularity**: Helps classify arrhythmia
  - Regularly, Irregular
  - Irregularly, Irregular
Sinus Bradycardia

- Positive P wave in lead II -> impulse initiated in sinus node
- Each QRS is initiated by a P wave
- Normal P-R interval
- HR
  - <60 bpm - dog
  - <100-110 bpm - cat
- Usually caused by increased vagal tone
Sinus Tachycardia

- Positive P wave in lead II -> impulse initiated in sinus node
- Each QRS is initiated by a P wave
- Normal P-R interval
- HR
  - >150 bpm – dog
  - >200-220 bpm - cat
- Usually caused by increased adrenergic tone (exercise, stress)
- Sinus rhythm
- R-R interval varies
- Heart rate:
  - Increases during inspiration
  - Decreases during expiration
- Effect of vagal tone on sinus node
- NORMAL in dogs
Atrial Premature Complexes (APCs)

- “Premature” ectopic impulse that originates from atrial myocyte
- Impulse propagates to ventricle through AV node and normal conduction pathways
- Occurs commonly with LAE
Atrial Fibrillation

- Discernible P waves are absent
- “f waves” -- large oscillations of varying amplitude may be present
- Ventricular HR is rapid and irregularly irregular (rarely – slow with lone AF or on medications)
- QRS configuration is normal unless BBB (commonly) or aberrant conduction
1st Degree AV Block

- Prolonged P-R interval
- QRS usually normal
2nd Degree AV Block

Mobitz Type I - Wenchebach

- P-R interval progressively prolongs before “dropping”

Mobitz Type II

- P-R constant with a regular rhythm then dropped “P”

[Images of ECG tracings showing different types of AV block]
3rd Degree AV Block

- Complete AV Dissociation
- Impulse originates in the sinus node - > P wave
- Impulse always blocked in AV node
- Secondary pacemaker takes over:
  - AV node (junction): 40 - 60 beats/min
  - Purkinje fibers: 20-40 beats/min
Ventricular Premature Complexes

- Impulses arising from an ectopic focus in the ventricular myocardium

- Characteristics:
  - "Premature" ectopic QRS complexes
  - Wide and bizarre appearance w/ large amplitude
  - Irregular rhythm with normal HR
  - Normal p waves that are not associated with the ectopic QRS.
  - Compensatory pause
  - Large T wave with direction opposite to QRS complex
VPCs
Ventricular Tachycardia

- Tachycardia with wide and bizarre QRS complexes (no sinus conduction)
- Three or more consecutive VPCs
- Intermittent, paroxysmal, or sustained
- May cause serious, life-threatening hemodynamic impairment
- Differential diagnoses:
  - Supraventricular tachycardia with aberration
  - Bundle branch blocks (Look for “p” waves!)
Ventricular Tachycardia
LBBB with acute onset of Ventricular Tachycardia
Ventricular Fibrillation

- Rapid disorganized depolarization of all ventricular cells
- No QRS complex
- No effective mechanical contraction
- No cardiac output
- Death unless electrical defibrillation