Please sign into pollev.com/mtropf809 on your mobile device.
Arrhythmias give *me* sinus tachycardia: A practical approach to common arrhythmias

Melissa Tropf, DVM, MS, DACVIM (Cardiology)
Which emoji best describes your feelings when you have to interpret an ECG for an arrhythmic patient?

A

B

C

100%
What about ECG interpretation frustrates you?
Agenda

• Tips for success
• Stepwise approach
• Case examples
Tips for success

- Positioning
- Calibration + paper speed
- Systematic approach
Stepwise approach

- Name waveforms
- Heart rate calculation
- Rhythm analysis
- Waveform measures
- ECG diagnosis
Step 1

NAME WAVEFORMS

P wave
(atrial depolarization)
1st (+) deflection

Q wave
1st (-) deflection

R wave
2nd (+) deflection
1st (+) after the 1st (-)
1st large (+) deflection

S wave
(-) deflection after R

T wave
(+ or -) deflection after QRS complex

“QRS complex”
(ventricular depolarization)
Step 1

NAME WAVEFORMS

P & QRS ASSOCIATION V. DISSOCIATION
Step 2

HR CALCULATION

25 mm/sec
# QRS in 15 big boxes (3 sec) x 20
# QRS 1 BIC pen (6 sec) x 10

50 mm/sec
# QRS in 30 big boxes (3 sec) x 20
# QRS 1 BIC pen (3 sec) x 20
Step 3

RHYTHM ANALYSIS

• REGULARITY
Step 3

RHYTHM ANALYSIS

- REGULARITY
- ORIGIN OF THE QRS

**SINUS**
- P-QRS-T
- Associated P and QRS
- Narrow QRS

**SUPRAVENTRICULAR**
- +/- P prime waves-QRS-T
- If present, P prime look different from the sinus P waves
- Narrow QRS

**VENTRICULAR**
- QRS-T
- +/- dissociated P
- Wide, bizarre QRS
Step 4

WAVEFORM MEASURES
### Step 5: ECG Diagnosis

#### Bradyarrhythmias

<table>
<thead>
<tr>
<th>Step 1: Waveforms</th>
<th>Step 2: Rhythm Regularity</th>
<th>Step 3: QRS Complex Origin</th>
<th>Step 4: Complex Measurements</th>
<th>Step 5: ECG Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-QRS-T (associated)</td>
<td>Low</td>
<td>Regularly irregular or regular</td>
<td>Sinus</td>
<td>Variable P wave heights (AWP for height measurements) are common, called a &quot;wandering atrial pacemaker&quot;</td>
</tr>
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<td>QRS-T</td>
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<td>Supraventricular</td>
<td>Absent P waves</td>
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<td>P-QRS-T (associated) and P waves w/o QRS</td>
<td>Low</td>
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<td>Sinus</td>
<td>P waves that are not followed by a QRS complex (&quot;blurred or unaccompanied P waves&quot;)</td>
</tr>
<tr>
<td>Dissociated P and QRS-T</td>
<td>Low</td>
<td>Usually regular</td>
<td>Ventricular</td>
<td>P waves and QRS complexes are unrecorded (&quot;vicious loop&quot;)</td>
</tr>
<tr>
<td>P-QRS-T (associated)</td>
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<td>Irregular</td>
<td>Sinus</td>
<td>Periods of time when there are no P waves or QRS complexes observed called &quot;sinus arrest&quot;</td>
</tr>
</tbody>
</table>

#### Normal Heart Rate

<table>
<thead>
<tr>
<th>Step 1: P-QRS-T (associated)</th>
<th>Step 2: Rhythm Regularly irregular</th>
<th>Sinus</th>
<th>Prolonged PR/PC interval</th>
<th>First degree AV block</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1: P-QRS-T (associated) and Intermittent VPC (associated)</td>
<td>Normal</td>
<td>Irregular</td>
<td>Two populations of beats: 1) Sinus, 2) Ventricular</td>
<td>Sinus rhythm with intermittent VPC</td>
</tr>
<tr>
<td>Two populations of beats: 1) Sinus, 2) VPC (associated)</td>
<td>Normal</td>
<td>Irregular</td>
<td>Two populations of beats: 1) Sinus, 2) Supraventricular</td>
<td>Sinus rhythm with intermittent SVPC</td>
</tr>
</tbody>
</table>

#### Tachyarrhythmias

<table>
<thead>
<tr>
<th>Step 1: P-QRS-T (associated)</th>
<th>Step 2: Rhythm Regular</th>
<th>Sinus</th>
<th>P waves are the upper limits for height, shortened PR intervals are common</th>
<th>Sinus tachycardia</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-QRS-T +/− dissoc P waves</td>
<td>High</td>
<td>Regular</td>
<td>Ventricular</td>
<td>Ventricular tachycardia</td>
</tr>
<tr>
<td>1/P prime QRS-T</td>
<td>High</td>
<td>Regular</td>
<td>Supraventricular</td>
<td>Supraventricular tachycardia</td>
</tr>
<tr>
<td>QRS-T</td>
<td>High</td>
<td>Irregularly irregular</td>
<td>Supraventricular</td>
<td>Atrial fibrillation</td>
</tr>
</tbody>
</table>
Case Examples
Emma

7-YEAR-OLD FS BOXER

Presented for evaluation of a murmur noted during her yearly wellness exam.
STEP 1
Name waveforms

STEP 2
Calculate HR

STEP 3
Evaluate rhythm

STEP 5
ECG diagnosis

- P
- QRS
- T
- P and QRS associated
- P and QRS dissociated

___________ bpm

- Regular
- Irregular
- Irregularly irregular
- Regularly irregular
- Sinus
- Supraventricular
- Ventricular

(skipping STEP 4 today)
Lead II  50mm/sec  10mm/mV

STEP 1
Name waveforms

STEP 2
Calculate HR

STEP 3
Evaluate rhythm

STEP 5
ECG diagnosis

- P
- QRS
- T
- P and QRS associated
- P and QRS dissociated

140 bpm

- Regular
- Irregular
- Irregularly irregular
- Regularly irregular
- Normal
- Bradycardia
- Tachycardia
- Sinus
- Supraventricular
- Ventricular

(skipping STEP 4 today)
### Normal Heart Rate

<table>
<thead>
<tr>
<th>Step 1: Waveforms</th>
<th>Step 2: HR</th>
<th>Step 3: Rhythm Regularity</th>
<th>Step 4: QRS Complex Origin</th>
<th>Step 5: Complex Measurements</th>
<th>Step 5: ECG Diagnosis</th>
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<td>Sinus rhythm</td>
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<td>Two populations of beats: 1) P-QRS-T (associated) 2) Intermittent VPC (dissociated)</td>
<td>Normal</td>
<td>Regular or regularly irregular</td>
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<td>First degree AV block</td>
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<td>SVPCs are similar width to the sinus origin QRS complexes and may have a P prime wave associated with them</td>
<td>Sinus rhythm with intermittent SVPC</td>
</tr>
</tbody>
</table>
Emma
NEXT STEPS

• Etiology?
• Treatment?
• Efficacy?

• Frequency
  - > 1000 per day

• Complexity
  - Couplets, triplets, runs
  - Short coupling intervals; R-on-T
  - Bigeminy, trigeminy
  - Polymorphic

• Other factors
  - Concurrent cardiomyopathy
  - Systemic disease
  - Symptomatic (syncope, exercise intolerance, hypotension)
Emma

NEXT STEPS

- Presumptive ARVC
- RX: sotalol 2 mg/kg BID

<table>
<thead>
<tr>
<th>24 HOUR HOLTER MONITOR</th>
<th>PRE-TREATMENT</th>
<th>TREATMENT sotalol</th>
<th>TREATMENT mexiletine</th>
</tr>
</thead>
<tbody>
<tr>
<td>VPC SINGLE</td>
<td>4982</td>
<td>9010</td>
<td>377</td>
</tr>
<tr>
<td>COUPLET</td>
<td>60</td>
<td>129</td>
<td>2</td>
</tr>
<tr>
<td>TRIPLET</td>
<td>2</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>RUN</td>
<td>2</td>
<td>15</td>
<td>0</td>
</tr>
</tbody>
</table>
Gidget
17-YEAR-OLD FS DSH

Presented for acute onset dyspnea and coughing that failed to improve after albuterol administration.
Step 1: Name waveforms

- P
- QRS
- T
- P and QRS associated
- P and QRS dissociated

Step 2: Calculate HR

200 bpm

Step 3: Evaluate rhythm

- Normal
- Bradycardia
- Tachycardia
- Regular
- Irregular
- Irregularly irregular
- Regularly irregular
- Sinus
- Supraventricular
- Ventricular

Step 5: ECG diagnosis

Ventricular

(Skipping Step 4 today)
### Normal Heart Rate

**Step 1**  
Waveforms

**Step 2**  
HR

**Step 3**  
Rhythm regularity

**Step 4**  
QRS complex origin

**Step 5**  
Complex measurements

**STEP 5 ECG Diagnosis**

<table>
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<tr>
<th>Two populations of beats:</th>
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<td>Sinus rhythm with intermittent VPC</td>
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<tr>
<td>2) Intermittent VPC (dissociated)</td>
<td>Normal</td>
<td>Irregular</td>
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<td>Normal</td>
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<td>2) Intermittent SVPC (associated)</td>
<td>Normal</td>
<td>Irregular</td>
<td>Sinus</td>
<td>SVPCs are similar width to the sinus origin QRS complexes and may have a P prime wave associated with them</td>
<td>Sinus rhythm with intermittent SVPC</td>
</tr>
</tbody>
</table>
NEXT STEPS

• HCM + LCHF
• RX: Sotalol 3mg/kg BID, furosemide, ACEI, clopidogrel
• NSR on recheck AliveCor
Eddie
10-YEAR-OLD MN TERRIER X

Presented for multiple episodes of collapse over the past 3 days.
**STEP 1**  
Name waveforms  
- P
- QRS
- T
- P and QRS associated
- P and QRS dissociated

**STEP 2**  
Calculate HR  
20-100 bpm

**STEP 3**  
Evaluate rhythm  
- Regular
- Irregular
- Irregularly irregular
- Regularly irregular
- Sinus
- Supraventricular
- Ventricular  
(skipping **STEP 4** today)

**STEP 5**  
ECG diagnosis  
- Normal
- Bradycardia
- Tachycardia
**BRADYARRHYTHMIAS**

<table>
<thead>
<tr>
<th>STEP 1 Waveforms</th>
<th>STEP 2 HR</th>
<th>STEP 3 Rhythm regularity</th>
<th>QRS complex origin</th>
<th>STEP 4 Complex measurements</th>
<th>STEP 5 ECG Diagnosis</th>
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<td>P-QRS-T (associated)</td>
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<tr>
<td>QRS-T No P waves</td>
<td>Low</td>
<td>Regular</td>
<td>Supraventricular</td>
<td>Absent P waves</td>
<td>Atrial standstill</td>
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<td>P-QRS-T (associated) and P waves w/o QRS</td>
<td>Low</td>
<td>Regular or irregular</td>
<td>Sinus</td>
<td>P waves that are not followed by a QRS complex (&quot;blocked or unconducted P waves&quot;)</td>
<td>Atrioventricular block First degree</td>
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<tr>
<td>Dissociated P and QRS-T</td>
<td>Low</td>
<td>Usually regular</td>
<td>Ventricular</td>
<td>P waves and QRS complexes are unrelated (&quot;dissociated&quot;)</td>
<td>Second degree</td>
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<td>Sinus</td>
<td>Periods of time when there are no P waves or QRS complexes observed called “sinus arrest”</td>
<td>Sinus arrest</td>
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**Notes:**
- **Lead II  25mm/sec  10mm/mV**
- Waveforms:
  - P-QRS-T (associated)
  - QRS-T No P waves
  - P-QRS-T (associated) and P waves w/o QRS
  - Dissociated P and QRS-T
- Rhythm regularity:
  - Regularly irregular or regular
  - Regular
  - Usually regular
  - Irregular
- Complex measurements:
  - Absent P waves
  - P waves that are not followed by a QRS complex ("blocked or unconducted P waves")
  - P waves and QRS complexes are unrelated ("dissociated")
  - Periods of time when there are no P waves or QRS complexes observed called “sinus arrest”
Eddie
NEXT STEPS

• Sick sinus syndrome
• ART partial response (HR 150 bpm)
• RX: Theophylline 15mg/kg BID
• Recurrent symptoms 6m later → pacemaker
Finn
5-YEAR-OLD MC GOLDEN

Presented for evaluation of a bradyarrhythmia.
STEP 1
Name waveforms

STEP 2
Calculate HR

STEP 3
Evaluate rhythm

STEP 5
ECG diagnosis

- \( P \)
- \( QRS \)
- \( T \)
- \( P \) and QRS associated
- \( P \) and QRS dissociated
- 58-60 bpm
- Regular
- Irregular
- Irregularly irregular
- Regularly irregular
- Normal
- Bradycardia
- Tachycardia
- Sinus
- Supraventricular
- Ventricular

(Skipping STEP 4 today)
### BRADYARRHYTHMIAS

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<tr>
<th>STEP 1</th>
<th>STEP 2</th>
<th>STEP 3</th>
<th>QRS complex origin</th>
<th>STEP 4</th>
<th>STEP 5</th>
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<td>Rhythm regularity</td>
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<td>Periods of time when there are no P waves or QRS complexes observed called &quot;sinus arrest&quot;</td>
<td>Sinus arrest</td>
</tr>
</tbody>
</table>
Finn
NEXT STEPS

• Negative atropine response test
• Permanent transvenous pacemaker implant
Duke
7-YEAR-OLD MC DANE

Presented for dyspnea.
Lead II  50mm/sec  10mm/mV

STEP 1
Name waveforms

STEP 2
Calculate HR

STEP 3
Evaluate rhythm

STEP 5
ECG diagnosis

❑ P
❑ QRS
❑ T
❑ P and QRS associated
❑ P and QRS dissociated

220 bpm

❑ Regular
❑ Irregular
❑ Irregularly irregular
❑ Regularly irregular
❑ Normal
❑ Bradycardia
❑ Tachycardia
❑ Sinus
❑ Supraventricular
❑ Ventricular

(skipping STEP 4 today)
### TACHYARRHYTHMIAS

<table>
<thead>
<tr>
<th>Condition</th>
<th>Morphology</th>
<th>Heart Rate</th>
<th>Location</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-QRS-T (associated)</td>
<td>High</td>
<td>Regular</td>
<td>Sinus</td>
<td>P waves at the upper limits for height. Shortened PR intervals are common</td>
</tr>
<tr>
<td>QRST-T</td>
<td>High</td>
<td>Regular</td>
<td>Ventricular</td>
<td>VPCs have wide and bizarre looking QRS complexes</td>
</tr>
<tr>
<td>(+/-) P prime-QRS-T</td>
<td>High</td>
<td>Regular</td>
<td>Supraventricular</td>
<td>P waves may not be visible particularly at very high heart rates; if visible, the morphology is different than sinus (&quot;P prime waves&quot;)</td>
</tr>
<tr>
<td>QRST-T No P waves +/- flutter waves</td>
<td>High</td>
<td>Irregularly irregular</td>
<td>Supraventricular</td>
<td>Fibrillation (&quot;T waves&quot;) are low amplitude waves that are commonly filtered out by today’s ECG machines.</td>
</tr>
</tbody>
</table>

- **Sinus Tachycardia**: P waves at the upper limits for height. Shortened PR intervals are common.
- **Ventricular Tachycardia**: VPCs have wide and bizarre looking QRS complexes.
- **Supraventricular Tachycardia**: P waves may not be visible particularly at very high heart rates; if visible, the morphology is different than sinus ("P prime waves")
- **Atrial Fibrillation**: Fibrillation ("T waves") are low amplitude waves that are commonly filtered out by today’s ECG machines.
Duke

NEXT STEPS

• DCM + L-CHF + Afib
• RX: digoxin, diltiazem, furosemide, ACEI, pimo
• Recheck: Chemistry WNL, serum digoxin 1.1 ng/mL, HR 165 bpm
• Holter average HR 78
Arley
6-YEAR-OLD FS EBD

Presented for collapse.
Lead II  50mm/sec  10mm/mV

**STEP 1**
Name complexes

**STEP 2**
Calculate HR

**STEP 3**
Evaluate rhythm

**STEP 5**
ECG diagnosis

- ☑ P
- ☑ QRS
- ☑ T
- ☑ P and QRS associated
- ☑ P and QRS dissociated
- ☑ Regular
- ☑ Normal
- ☑ Bradycardia
- ☑ Sinus
- ☑ Supraventricular
- ☑ Irregular
- ☑ Irregularly irregular
- ☑ Tachycardia
- ☑ Regularly irregular
- ☑ Ventricular
- (skipping STEP 4 today)

___ 320 bpm ___
### TACHYARRHYTHMIAS

<table>
<thead>
<tr>
<th>Type</th>
<th>P-QRS-T (associated)</th>
<th>QRS-T</th>
<th>QRS-T</th>
<th>QRS-T</th>
</tr>
</thead>
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<tr>
<td></td>
<td>P waves at the upper limits for height. Shortened PR intervals are common</td>
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<td>High</td>
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<tr>
<td></td>
<td>Sinus tachycardia</td>
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<td>Sinus tachycardia</td>
</tr>
<tr>
<td></td>
<td>VPCs have wide and bizarre looking QRS complexes</td>
<td>Ventricular tachycardia</td>
<td>Ventricular tachycardia</td>
<td>Ventricular tachycardia</td>
</tr>
<tr>
<td></td>
<td>(+/-) P prime-QRS-T</td>
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<td>(+/-) P prime-QRS-T</td>
</tr>
<tr>
<td></td>
<td>Narrow QRS complexes</td>
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<tr>
<td></td>
<td>P waves may not be visible particularly at very high heart rates; if visible, the morphology is different than sinus (“P prime waves”)</td>
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<td>Supraventricular tachycardia</td>
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</tr>
<tr>
<td></td>
<td>No P waves +/- flutter waves</td>
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<td></td>
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<td>Atrial fibrillation</td>
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</tr>
</tbody>
</table>
Arley

NEXT STEPS

- Hemoabdomen, splenic mass
- Lidocaine 2mg/kg IV
  Lidocaine CRI 50 mcg/kg/min
- Sotalol 3mg/kg BID

Lead II  50mm/sec  10mm/mV

HR 130 bpm
Accelerated idioventricular rhythm (AIVR)
No treatment required
Cowboy
7-YEAR-OLD MN CATTLE DOG

Arrhythmia ausculted on pre-dental exam.
STEP 1
Name complexes

STEP 2
Calculate HR

STEP 3
Evaluate rhythm

STEP 5
ECG diagnosis

• P
• QRS
• T
• P and QRS associated
• P and QRS dissociated

100 bpm

• Regular
• Irregular
• Irregularly irregular
• Regularly irregular
• Normal
• Bradycardia
• Tachycardia

• Sinus
• Supraventricular
• Ventricular

(skipping STEP 4 today)
### NORMAL HEART RATE

<table>
<thead>
<tr>
<th>STEP 1</th>
<th>STEP 2</th>
<th>STEP 3</th>
<th>STEP 4</th>
<th>STEP 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waveforms</td>
<td>HR</td>
<td>Rhythm regularity</td>
<td>QRS complex origin</td>
<td>Complex measurements</td>
</tr>
<tr>
<td>P-QRS-T (associated)</td>
<td>Normal</td>
<td>Regular</td>
<td>Sinus</td>
<td></td>
</tr>
<tr>
<td>Two populations of beats:</td>
<td>1) P-QRS-T (associated)</td>
<td>2) Intermittent VPC (dissociated)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>Regular or regularly irregular</td>
<td>Sinus</td>
<td>Prolonged PR/PQ interval</td>
</tr>
<tr>
<td>Two populations of beats:</td>
<td>1) P-QRS-T (associated)</td>
<td>2) Intermittent SVPC (associated)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>Irregular</td>
<td>Sinus</td>
<td>VPCs are wider than the sinus origin QRS complexes</td>
</tr>
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<td>Two populations of beats:</td>
<td>1) P-QRS-T (associated)</td>
<td>2) Intermittent VPC (dissociated)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>Irregular</td>
<td>Sinus</td>
<td>VPCs are similar width to the sinus origin QRS complexes and may have a P prime wave associated with them</td>
</tr>
</tbody>
</table>

**Lead II 50mm/sec 10mm/mV**
Cowboy

NEXT STEPS

- DCM
- RX: Sotalol 2.5mg/kg BID, ACEI, Pimo
- L-CHF 6m later → furosemide
- SCD 1.5y after initial diagnosis
Davi
15-YEAR-OLD MN COCKER SPANIEL

History of valvular heart disease. Arrhythmia ausculted on pre-dental exam.
STEP 1
Name complexes

STEP 2
Calculate HR

STEP 3
Evaluate rhythm

STEP 5
ECG diagnosis

- P
- QRS
- T
- P and QRS associated
- P and QRS dissociated

300 bpm

- Regular
- Irregular
- Irregularly irregular
- Regularly irregular
- Sinus
- Supraventricular
- Ventricular

( skipping STEP 4 today)
### TACHYARRHYTHMIAS

<table>
<thead>
<tr>
<th>Description</th>
<th>P</th>
<th>QRS-T</th>
<th>T</th>
<th>Pattern</th>
<th>Rate</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-QRS-T (associated)</td>
<td>High</td>
<td>Regular</td>
<td>Sinus</td>
<td>P waves at the upper limits for height. Shortened PR intervals are common</td>
<td></td>
<td>Sinus tachycardia</td>
</tr>
<tr>
<td>QRS-T +/- dissociated P waves</td>
<td>High</td>
<td>Regular</td>
<td>Ventricular</td>
<td>VPCs have wide and bizarre looking QRS complexes</td>
<td></td>
<td>Ventricular tachycardia</td>
</tr>
<tr>
<td>(+/-) P prime-QRS-T</td>
<td>High</td>
<td>Regular</td>
<td>Supraventricular</td>
<td>P waves may not be visible particularly at very high heart rates; if visible, the morphology is different than sinus (“P prime waves”)</td>
<td></td>
<td>Supraventricular tachycardia</td>
</tr>
<tr>
<td>QRS-T No P waves +/- flutter waves</td>
<td>High</td>
<td>Irregularly irregular</td>
<td>Supraventricular</td>
<td>Fibrillation (“f waves”) are low amplitude waves that are commonly filtered out by today’s ECG machines.</td>
<td></td>
<td>Atrial fibrillation</td>
</tr>
</tbody>
</table>
Davi

NEXT STEPS

• Stage B2 DMVD, severe LA enlargement
• Diltiazem XR 3mg/kg BID
• Recheck: 5min ECG NSR
• 4m later: CHF with Afib, added digoxin 0.003mg/kg BID