



*Intro to Critical Care Series Part 3 of 3*

# Telemetry

By Creek't Rebaño (PT)

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# Telemetry

## (Cardiac Monitoring)

- ✿ Tele = "remote"
- ✿ Metron = "measure"
- ✿ Consists of:

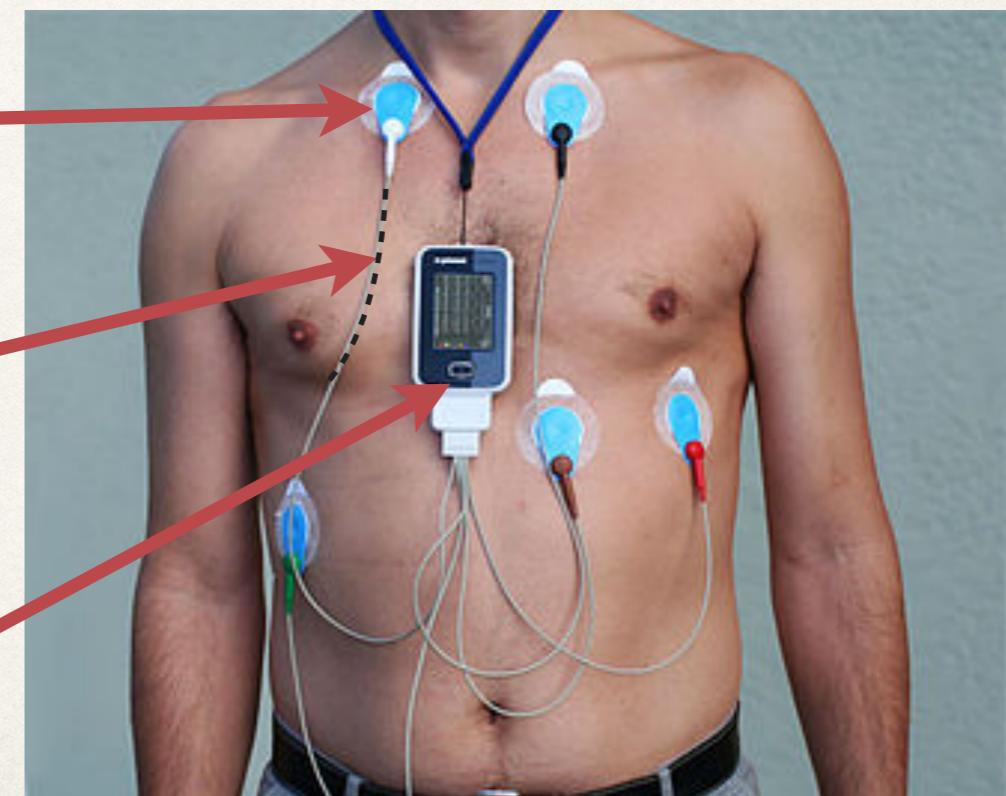
Sensor —————→  
Transmission path —————→  
Display/Recording/Control —————→

The telemetry I ordered on you is expensive, annoying, unnecessary and has all the nurses talking about how stupid I am for ordering it.

**up to \$3,000/day**

Oh, you must work in a hospital too

Original crude med-ecard humor  
from The Happy Hospitalist Blog



# Why this skill?

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Determine when it is appropriate to begin an exercise program, continue with treatment, or terminate the therapy session/exercise.

# What is exercise?

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n. Activity requiring physical effort, carried out especially to sustain or improve health and fitness

v. engaging in physical activity to promote or improve muscular strength, health, and fitness

- ✿ **Repetitive**
- ✿ **Demands increased muscular response**
- ✿ **Demands increased oxygen consumption**
- ✿ **Planned, structured, for the purpose of conditioning**

# Objectives

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1. Correctly place electrodes on a standard telemetry setup.
2. Correctly connect the device base to monitors or tele-box.
3. Identify the basic components of an ECG tracing.
4. Indicate HR based on triplicate or 6-sec strip methods.
5. Identify and correct for presence of motion artifact.
6. Identify rhythms on a monitor output.
7. Identify pacing origin, and rhythms:
  - ✿ sinus rhythms, normal or bradycardia vs tachycardia
  - ✿ abnormal: **atrial** versus **ventricular** rhythms
  - ✿ presence of PACs, PVCs, pacemakers, **heart blocks**
  - ✿ **rhythm switching**, paroxysmal bursts
8. List 3 reasons to terminate a session (based on cardiac or Pt monitoring)

# Who gets monitored? (ACC/AHA)

*Practice standards based on expert consensus (not RCTs)*

## Class I:

- at risk of an **immediate, life-threatening arrhythmia**—typically ICU appropriate
- Pts in first 48 hours of **ACS** or with high grade lesions awaiting tx
- acute heart failure
- **2nd and 3rd degree AV block**
- temporary pacing
- long **QT syndrome**
- WPW w/ rapid anterograde conduction
- **IABP**
- post cardiac **arrest**/code blue
- post **cardiac surgery** (CABG, MVR)
- post-PCI or ablation with complication
- post pacemaker placement with pm dependence
- conscious sedation (MAC)

## Class II:

- chest pain syndromes
- **syncope**
- known & on active **arrhythmia meds** titration
- **heart failure**
- post-PCI, post-ablation or post-pacemaker placement without complications

## Not indicated in Class III:

- includes **rate-controlled afib**
- **chronic PVCs**
- ESRD on HD
- **low risk post-surgical patients**

# Signs of cardiac compromise

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Quiz-mo game!

# Signs of cardiac compromise

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## Signs of heart failure

Shortness of breath, DOE or when lying down  
Fatigue, weakness  
Swelling (edema) in your legs, ankles, feet, abdomen  
Rapid or irregular heartbeat  
Reduced ability to exercise  
Persistent cough, wheezing (white or pink blood-tinged phlegm)  
Increased need to urinate at night  
Sudden weight gain from fluid retention  
Lack of appetite and nausea  
Difficulty concentrating or decreased alertness  
Chest pain if your heart failure is caused by MI  
Heart rate drop with exertion  
Syncope

## Signs of decreased CO

varyations in BP  
tachycardia  
presence of gallop rhythm  
fatigue and weakness  
dyspnea, tachypnea, chest pain  
crackles (rales)  
restlessness, change in mental status  
dizziness, syncope  
diminished or absent peripheral pulses  
cool extremities  
pallor or cyanosis of skin  
capillary refill time greater than 3 seconds  
oliguria  
hemodynamic abnormalities (increased PAP, PCWP, CVP)  
significant decrease in oximetry results  
dysrhythmias

# INPATIENT EXERCISE GUIDELINES

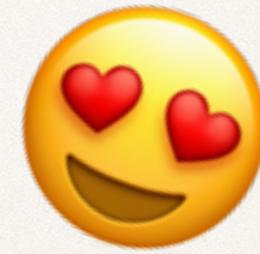
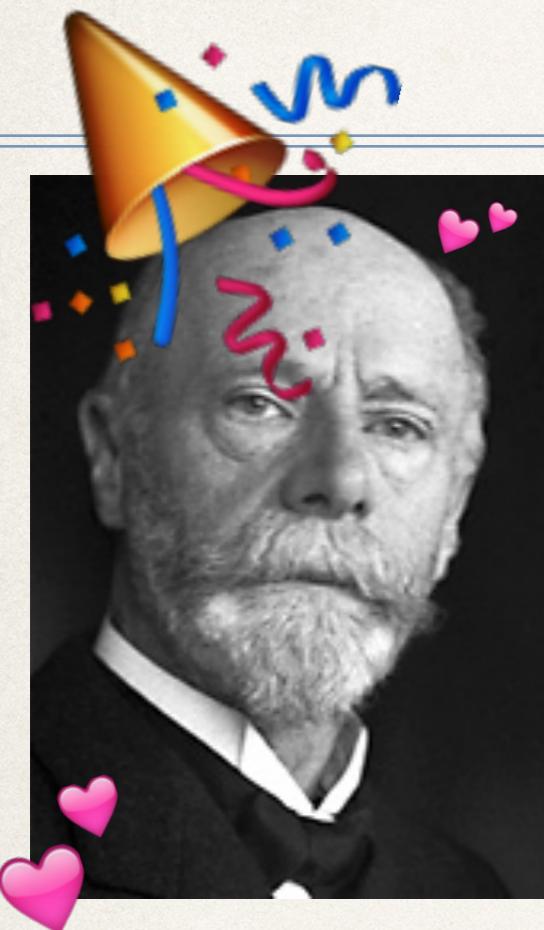
**DON'T START EXERCISE IF:**

**TERMINATE EXERCISE IF:**

VARIABLE	ACSM*	AACVPR**	APTA***	ACSM	AACVPR	APTA
Pulse Rate	> 120 b/min	----	< 40 b/min > 130 b/min	Post MI 20 b/min above rest	Post MI 30 b/min above rest	Med/Surg > 130 b/min
Pulse Rate	----	----	----	Post CABG 30 b/min above rest	Post CABG 30 b/min above rest	Med/Surg > 130 b/min
Respiration	----	----	> 30 b/min	----	----	Inability to converse
SBP	> 200 mm/Hg	----	> 250 mm/Hg	> 220 mm/Hg	10 mm/Hg drop	> 250 mm/Hg 10 mm/Hg drop
DBP	> 110 mm/Hg	> 110 mm/Hg	> 120 mm/Hg	> 110 mm/Hg	> 110 mm/Hg	> 120 mm/Hg
SPO <sub>2</sub>	< 88% (request supplemental oxygen))	----	< 85% (request supplemental oxygen)	Titrate to maintain @ ≥ 90%	----	Change from rest of 3–5% (document)
Fever	----	----	> 100° F	----	----	----
Arrhythmias	30% of complexes in  1 min <sup>-1</sup>	----	> 6 min <sup>-1</sup>	30% of complexes in 1 min <sup>-1</sup>	----	> 6 min <sup>-1</sup>
RPE				13	13	

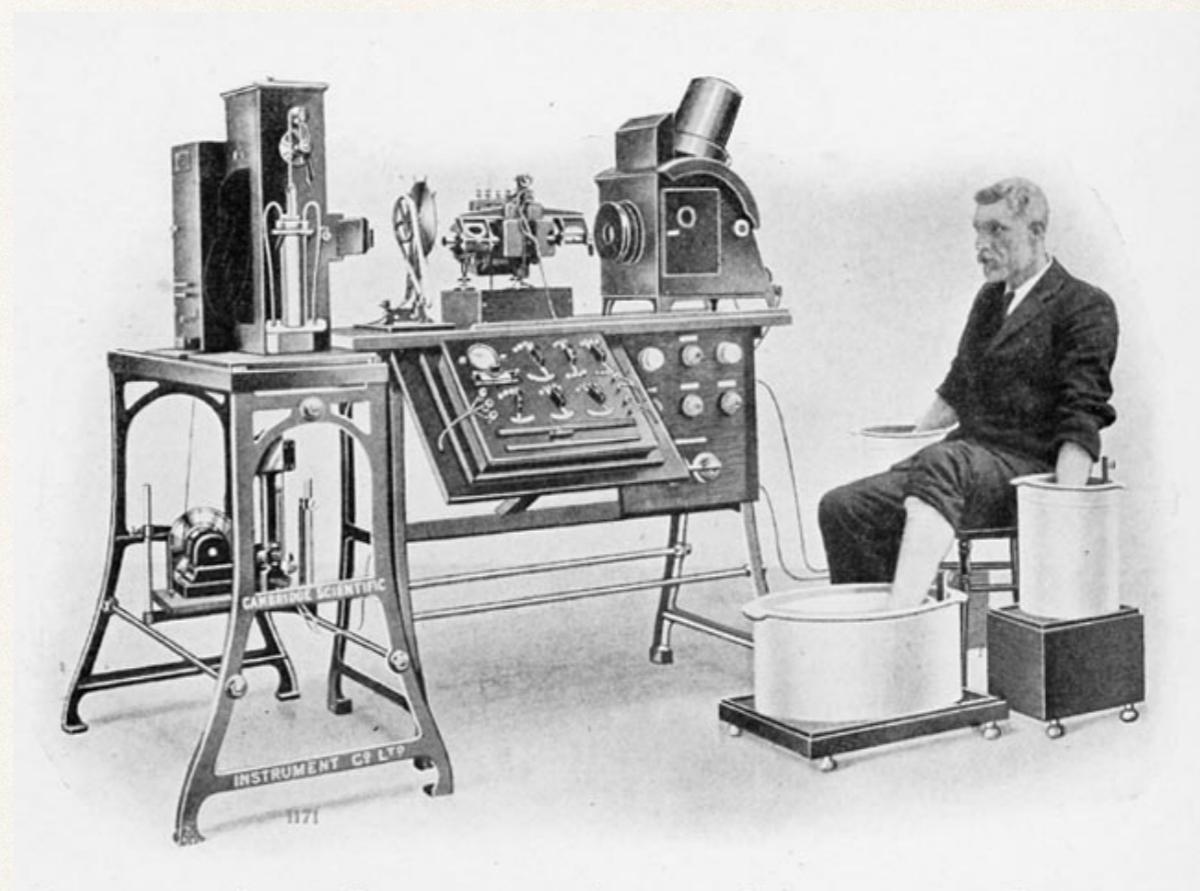
\*American College of Sports Medicine; \*\*American Association of Cardiovascular and Pulmonary Rehabilitation; \*\*\*American Physical Therapy Association – Acute Care Section

# ECG Fun Facts



Willem Einthoven (1860 – 1927)

- Dutch doctor and physiologist
- Inventor of the first practical (ECG or EKG) in 1903
- Received the Nobel Prize in Medicine in 1924 



PHOTOGRAPH OF A COMPLETE ELECTROCARDIOGRAPH, SHOWING THE MANNER IN WHICH THE ELECTRODES ARE ATTACHED TO THE PATIENT, IN THIS CASE THE HANDS AND ONE FOOT BEING IMMERSSED IN JARS OF SALT SOLUTION

- ✿ required water cooling
- ✿ required 5 people to operate
- ✿ weighed 270 kg (595 lbs)

# Monitors

## Monitor Tech Station



## ICU overhead monitor



# Monitors

## Transport/Portable Monitor



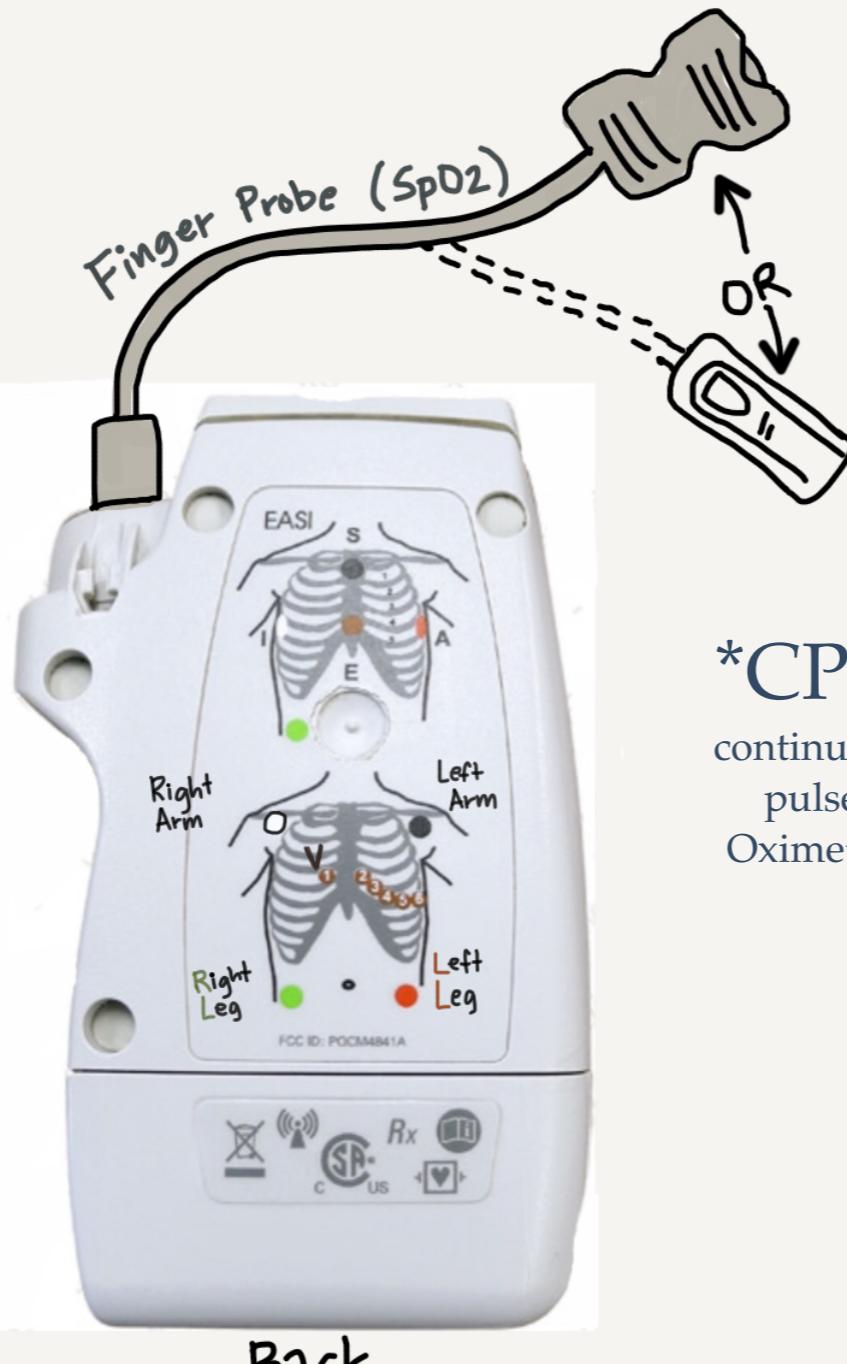
## Portable Tele



# Telemetry Box, Wires, Electrodes



Front



Back

\*CPO  
continuous  
pulse  
Oximetry



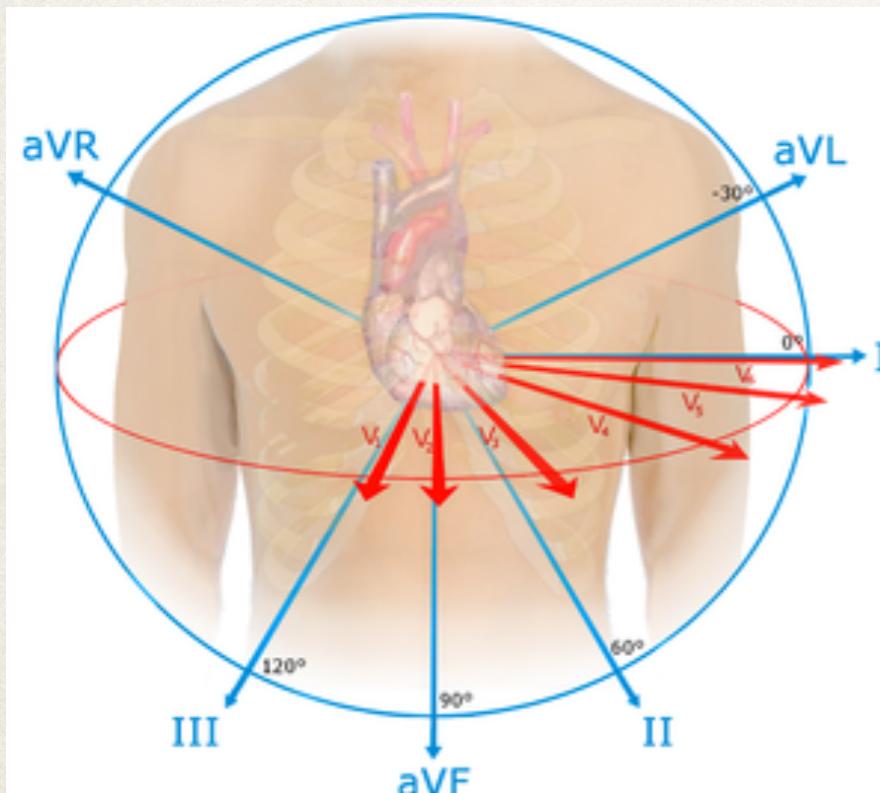
# Camera Exercise

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Views and Views and Views  
(+) vs (-)

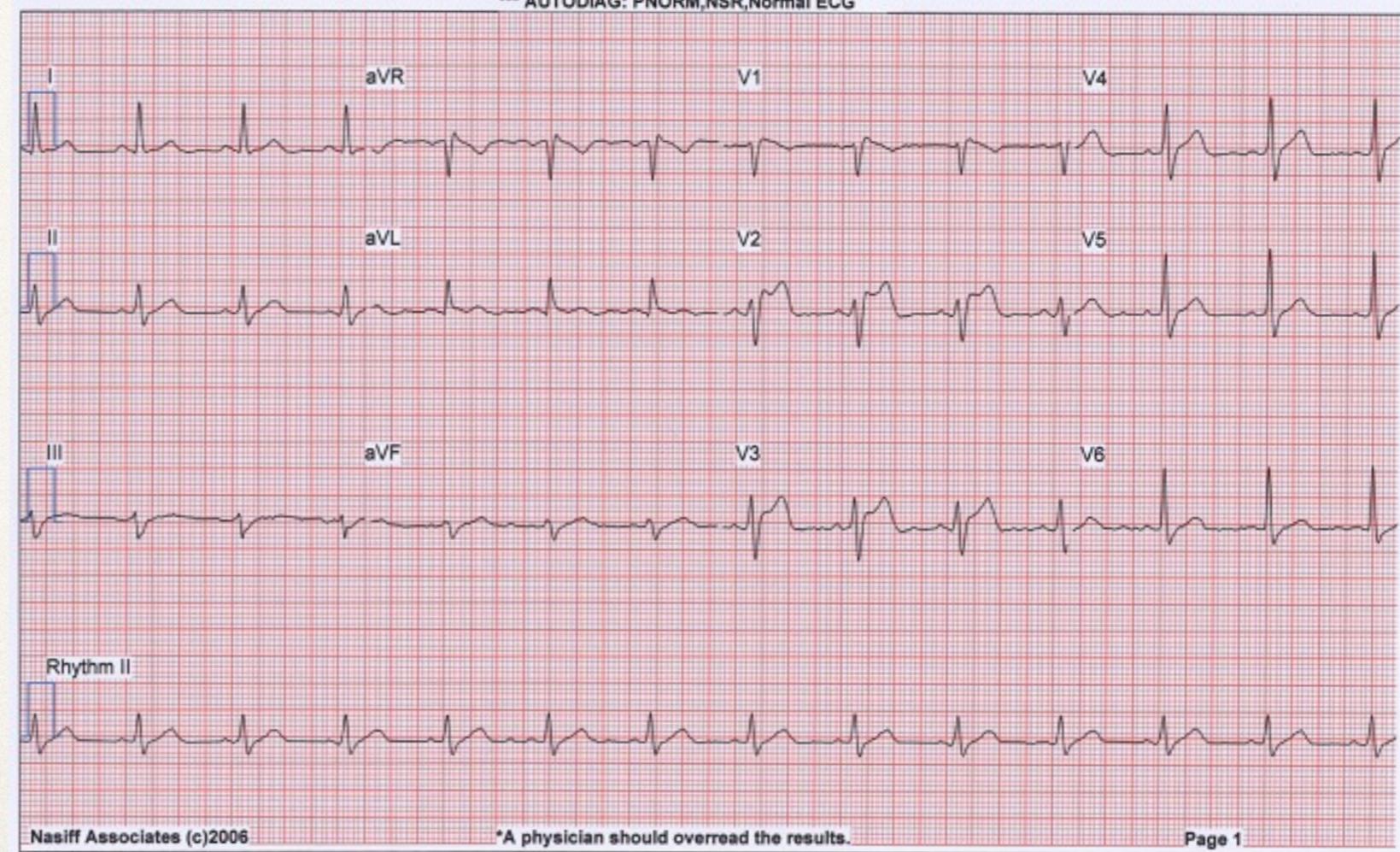


# 12-lead ECG (overview only)



Office:  
Physician:  
PATIENT:  
Pat# (ssn): 100000001  
Age: ,Sex:M,Ht:5'8,Wt:158  
10mm/mV, 0.05-100Hz, 25mm/sec  
Medications:  
Meds (con't):  
Blood Pressure:

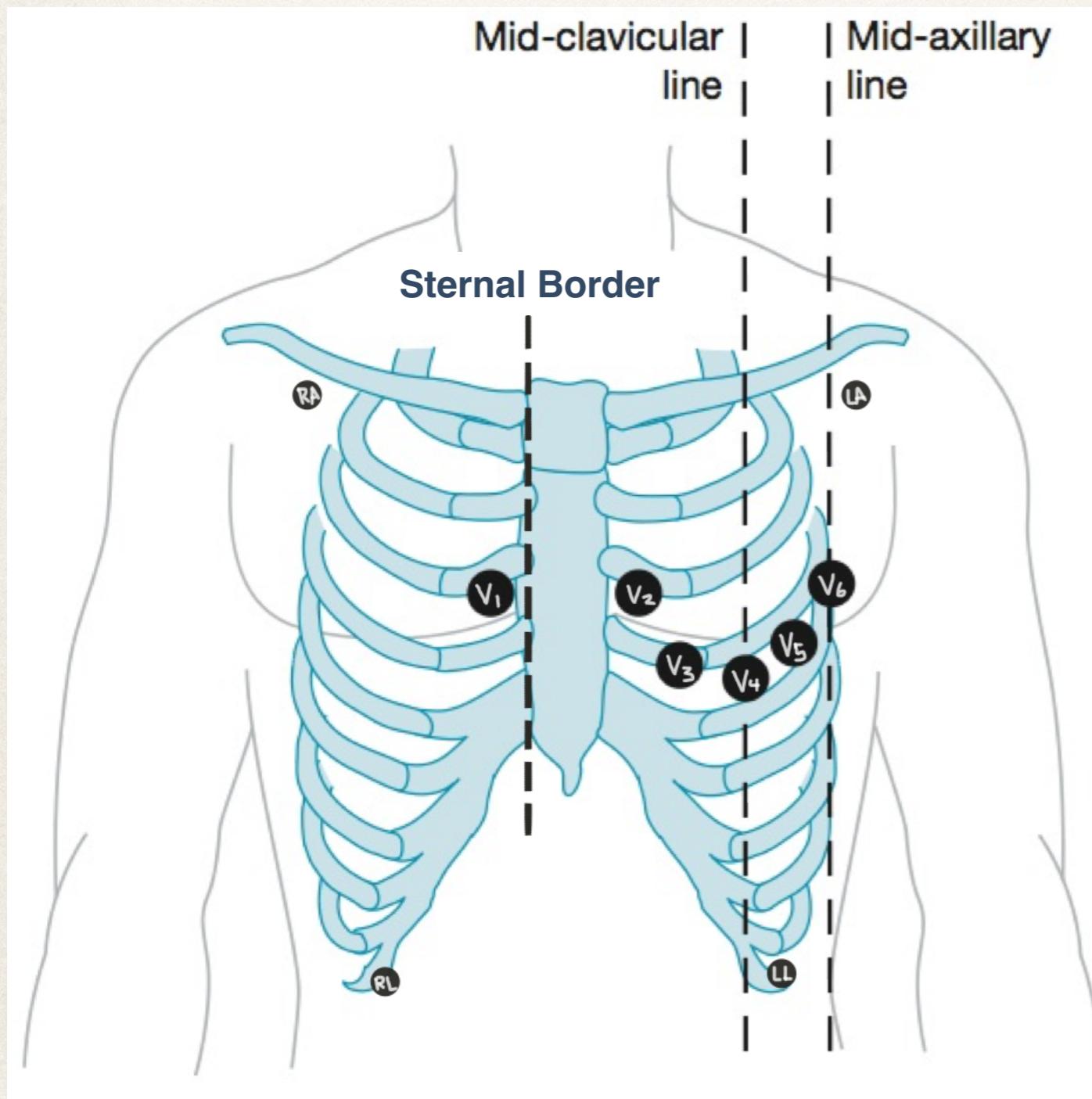
8:09:28 AM,02/24/2008,Run:0  
HR (bpm): 77 (lead II)  
R-R (ms): 779  
P dur (ms): 68  
PR int (ms): 132  
QRS dur (ms): 88  
P/R/T axis: 23/4/36  
QT/Qtc (ms): 376/416  
Referring:  
\*\*\* Confirmed by (required):  
\*\*\* AUTODIAG: PNORM,NSR,Normal ECG



"V" = vector?  
= ventricle?  
= voltage?

\*MUSE Marquette  
Universal System for  
Electrocardiography

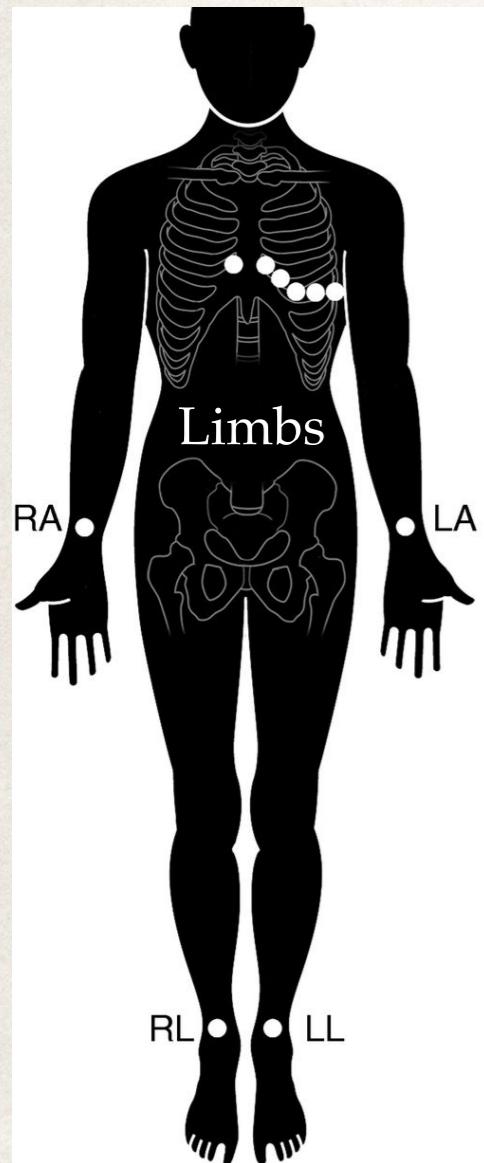
# 12-lead ECG (overview only)



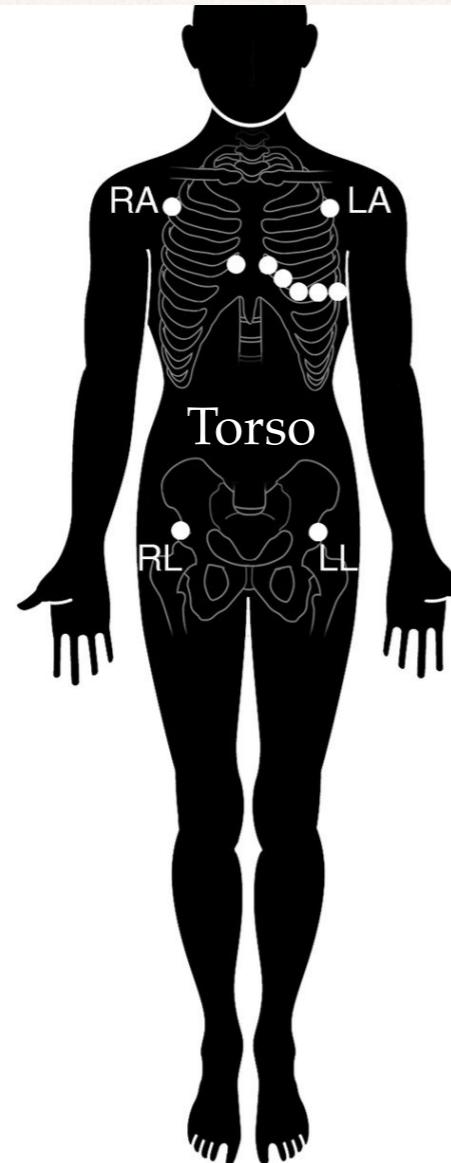
- ✿ **10 electrodes** (4 limb, 6 precordial)
- ✿ **12 views of the heart**
- ✿ **Diagnosis of:**
  - rates and arrhythmias
  - heart blocks
  - bundle branch blocks
  - enlargement/hypertrophy
  - heart failure
  - pericarditis
  - PE / tamponade
  - congenital defects
  - heart valve defects
  - Myocardial Ischemia
  - Myocardial Infarction

# Electrode Placement (12-lead)

cECG  
Conventional  
ECG



modified  
Mason-Likar  
placement

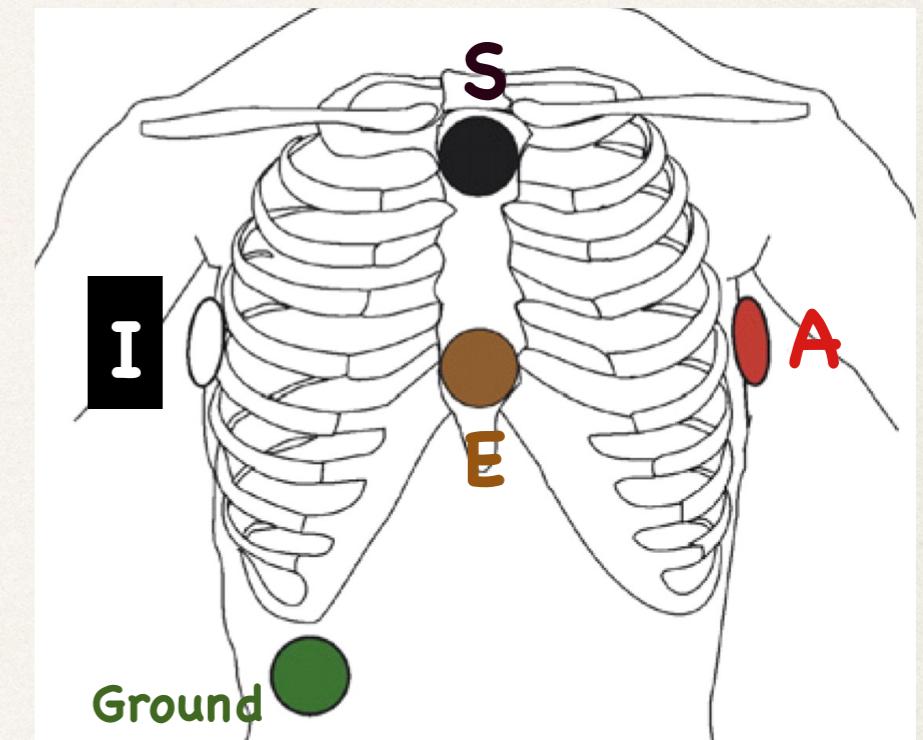


Reduced distortion  
from limb movement

Reduced interference  
from muscle potential

Provide rapid  
acquisition of ECGs

Dower EASI  
placement

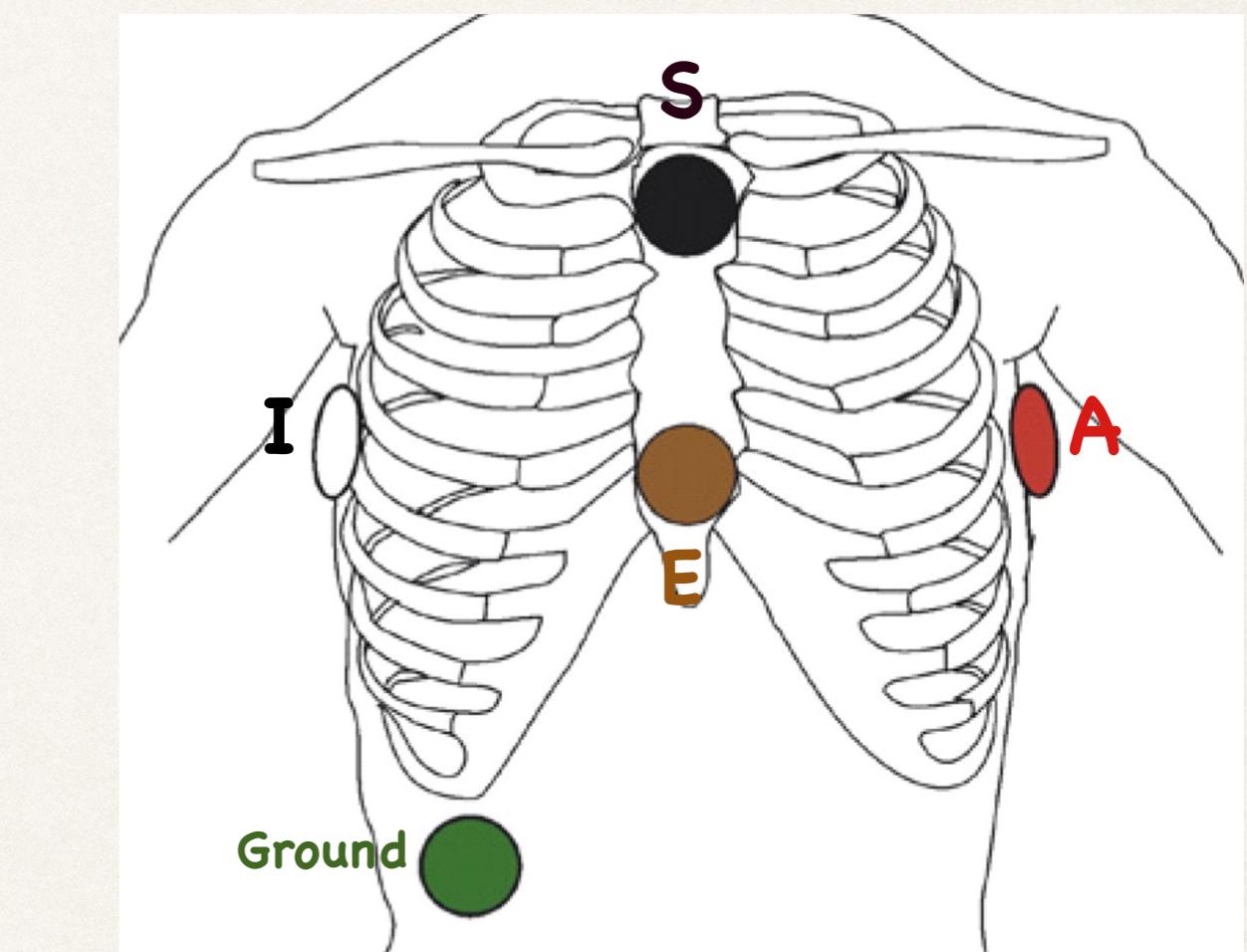
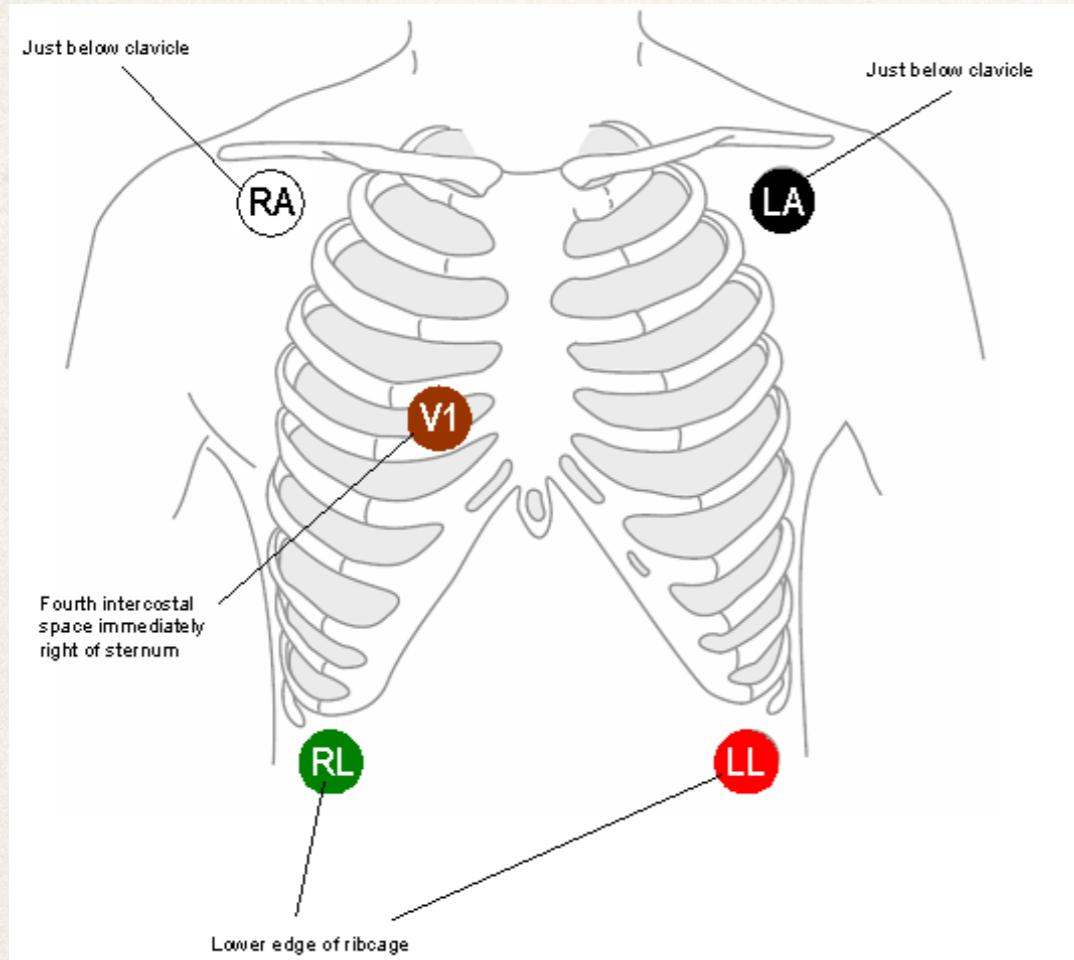


12 lead ECG using only 5 electrodes

Increased Pt mobility

Chest unencumbered - easier  
for imaging

# Electrode Placement (5-lead/tele)



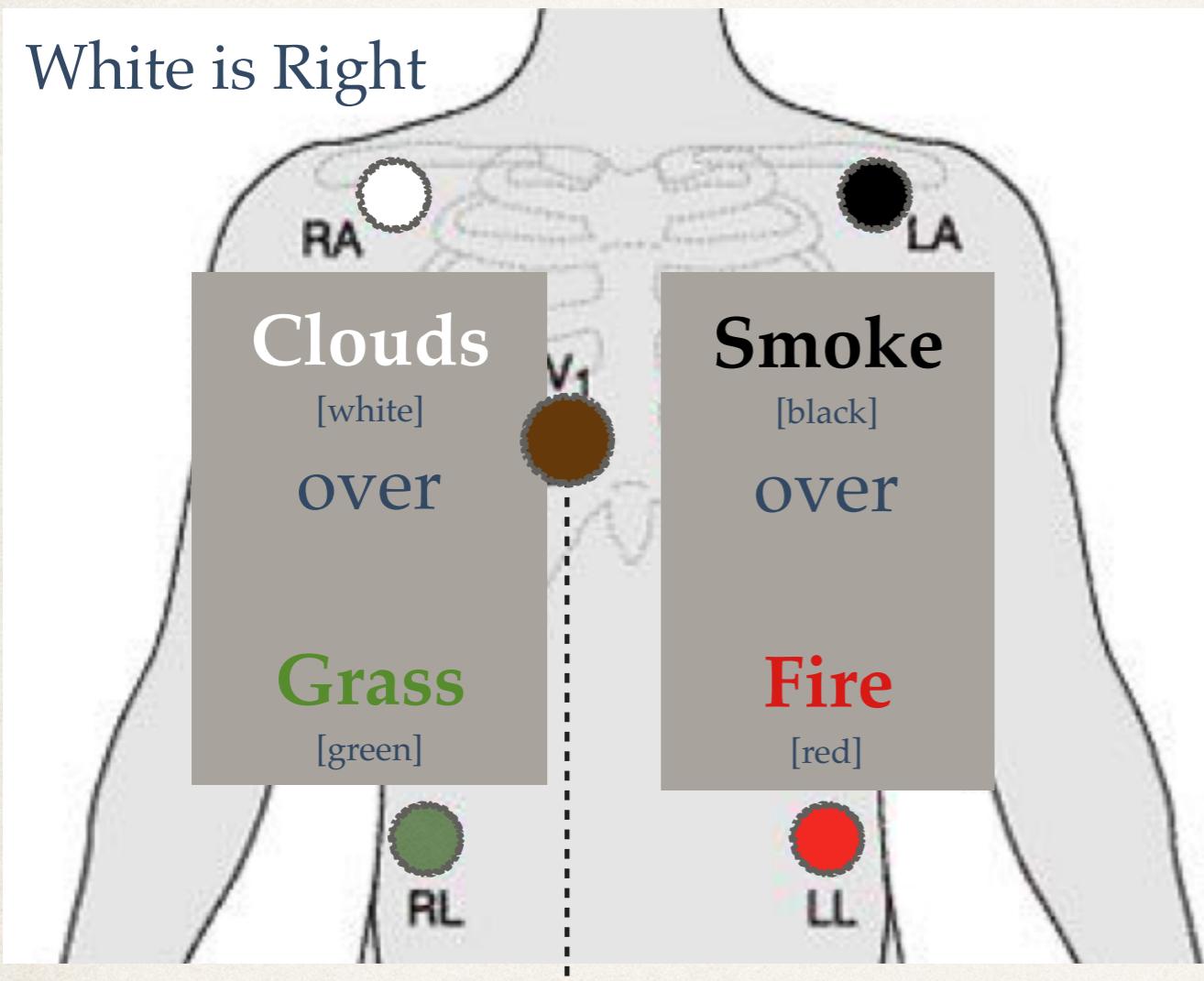
## Standard

- *dysrhythmias*

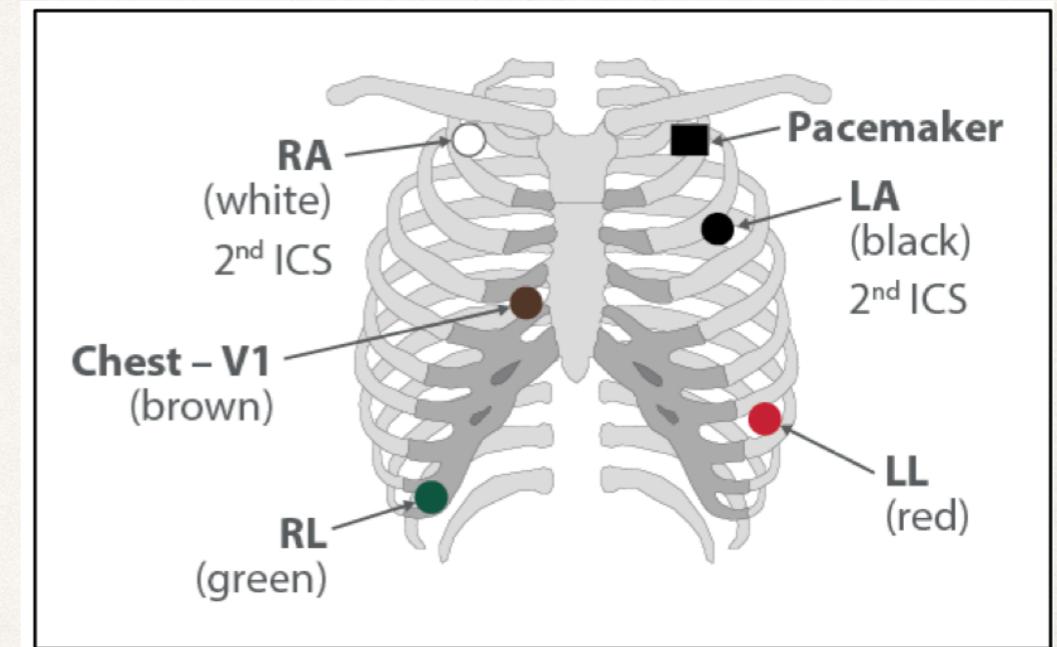
## EASI

- *ischemia monitoring*
- *derive 12-lead ECG*

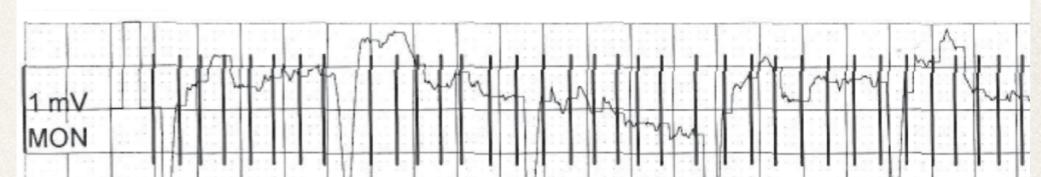
# Placement Mnemonic (+Pacemaker)



Center of the Earth  
[brown]



Example of “Picket Fencing”

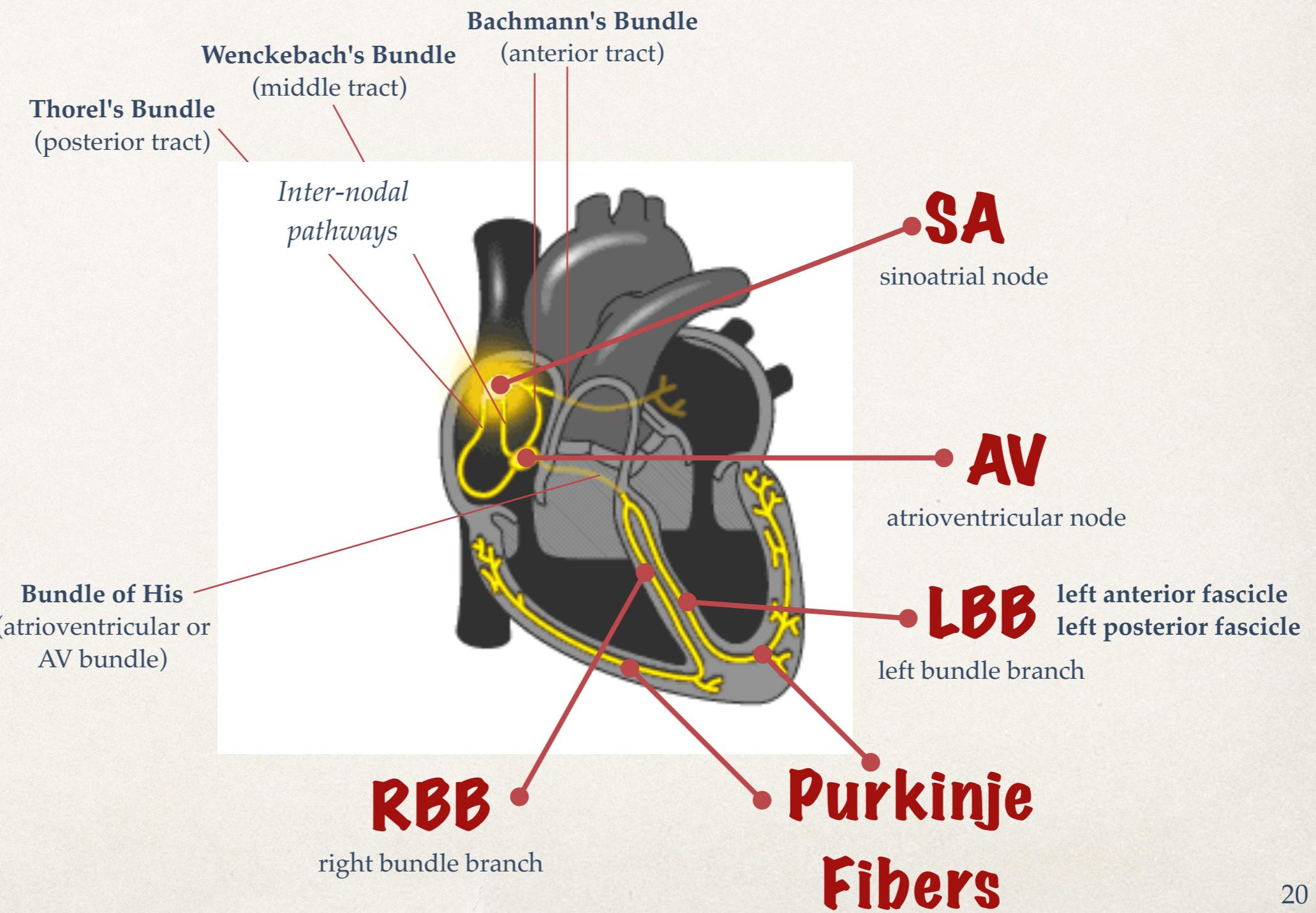


Corrected Lead Placement

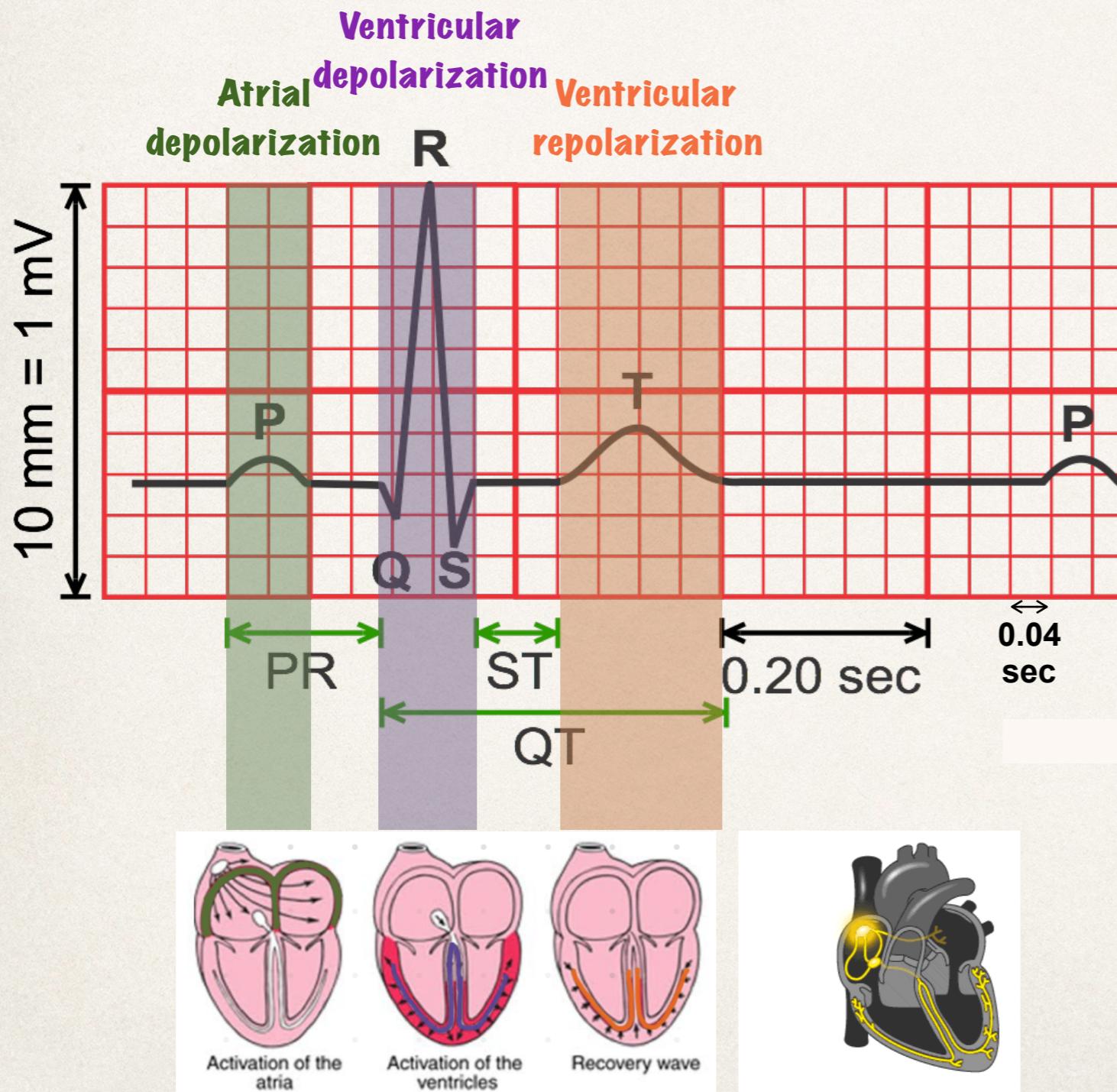


# Conduction System

For active image, visit <https://epsavealife.org/resources/heart-concepts/>



# ECG Waveforms

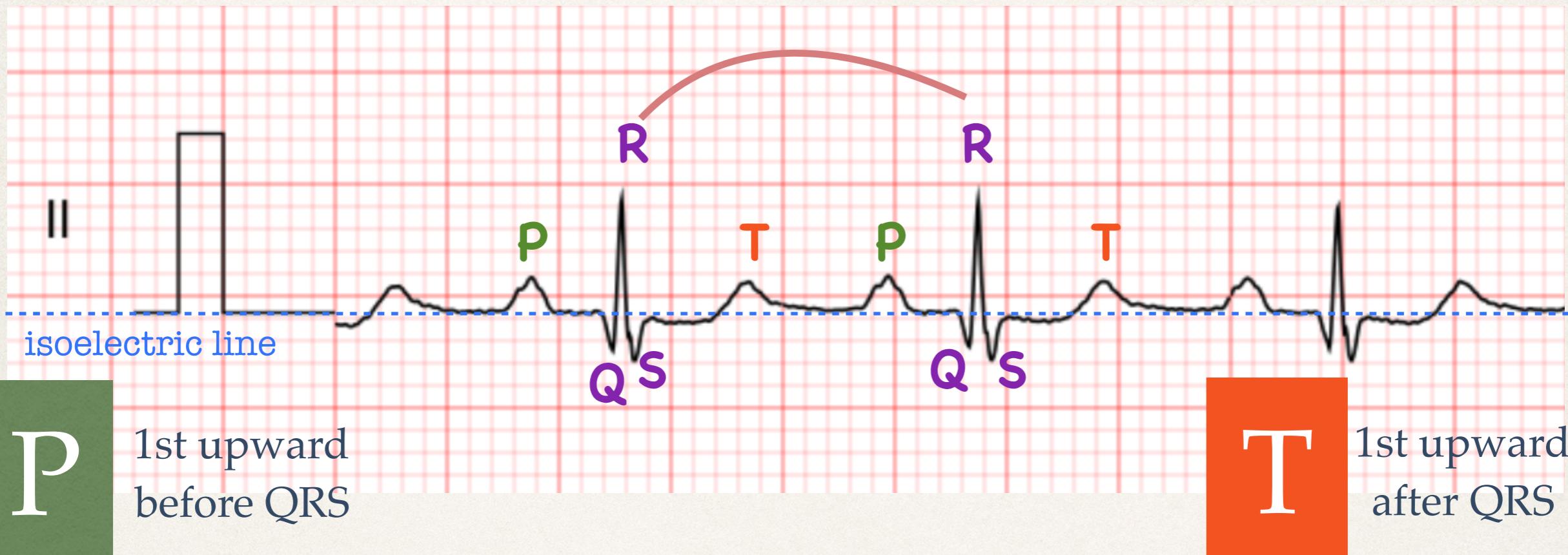


- P wave**
- precedes the QRS
  - "small bump"
  - amp: 1.5-2.5 mm
  - PR duration: 0.12-0.20 sec

- QRS complex**
- most prominent
  - duration: <0.12 sec
  - amp: criteria specific
  - ddx: narrow vs wide, variable forms
  - ST segment: elev / dep

- T wave**
- comes after the QRS
  - "long, higher bump"
  - amp: <5 mm
  - QT duration: <440(m)  
<460(f) ms
- \* < half before next RR, QTc
- ddx: inversion, peak

# Deflections (QRS complex)



**Q**

1st downward

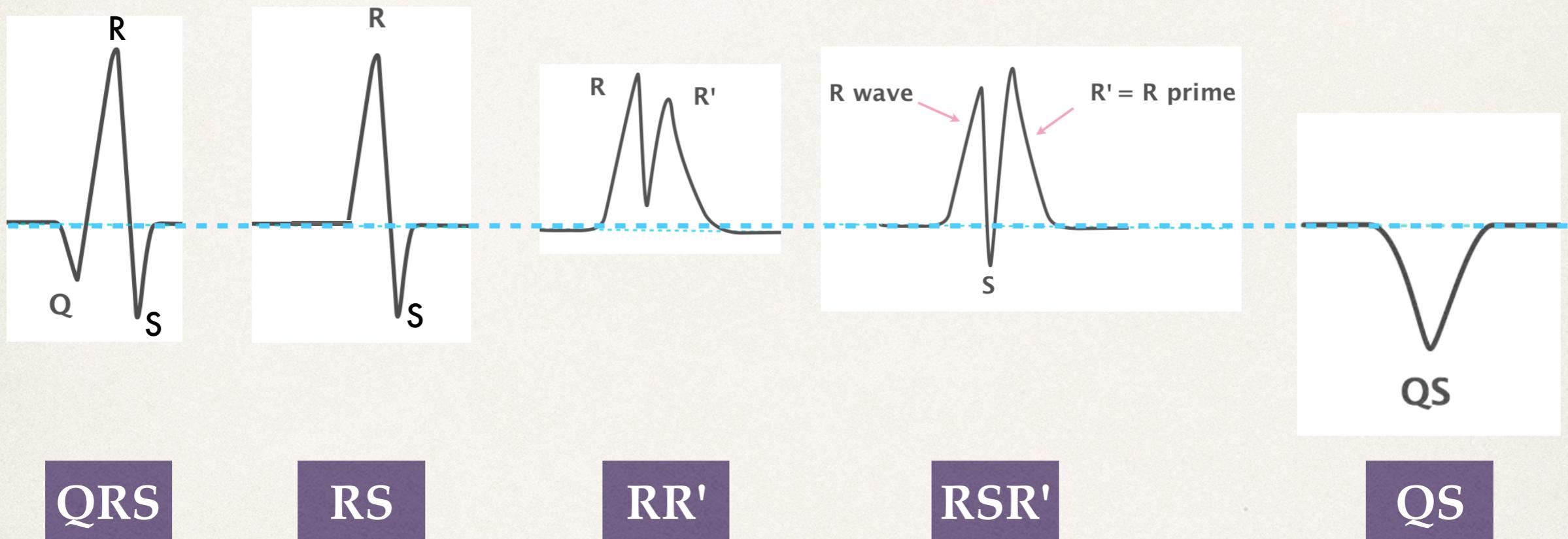
**R**

1st upward  
2nd upward:  
R' (R prime)

**S**

any downward after R that crosses isoelectric line

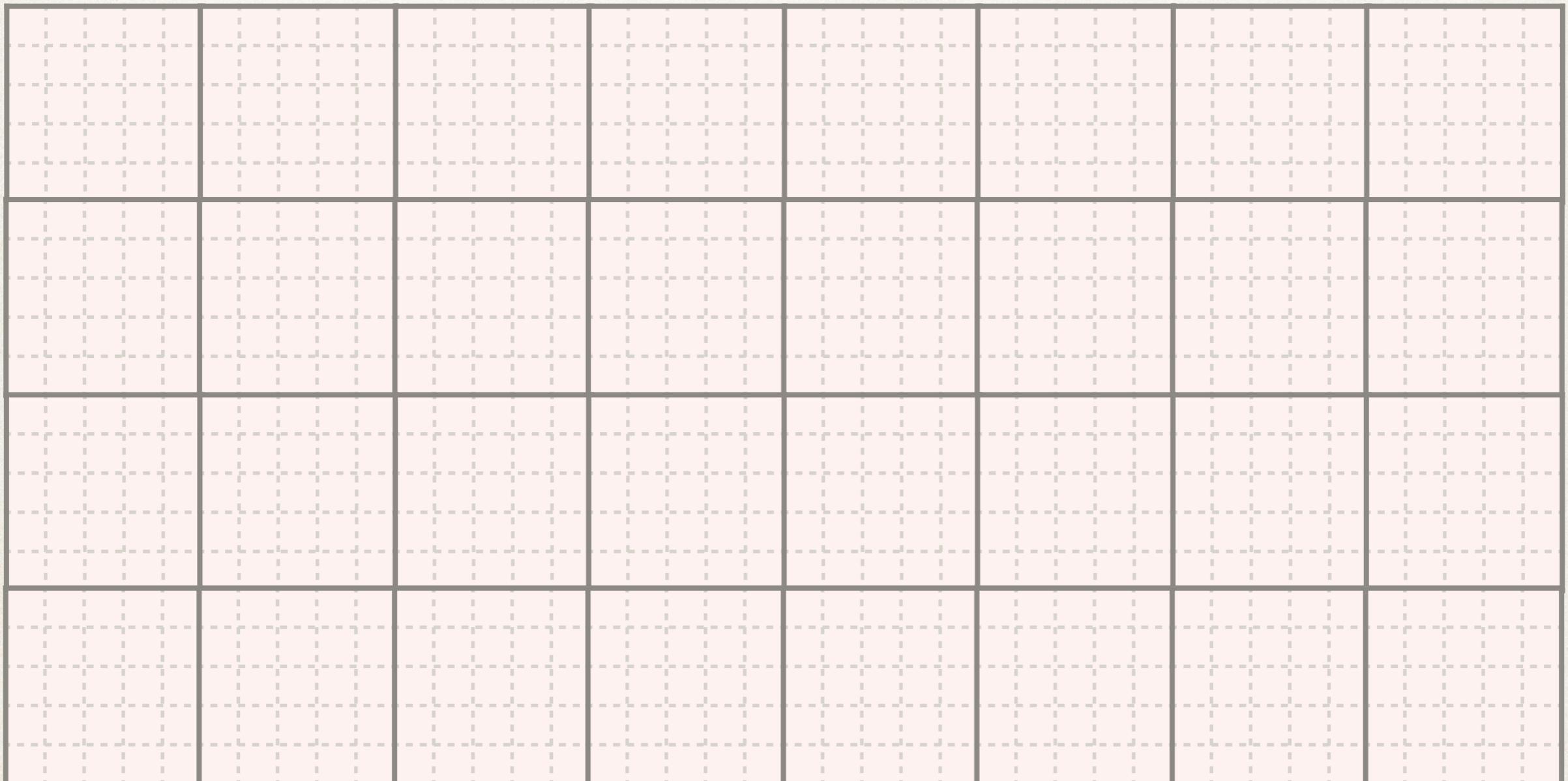
# Examples:



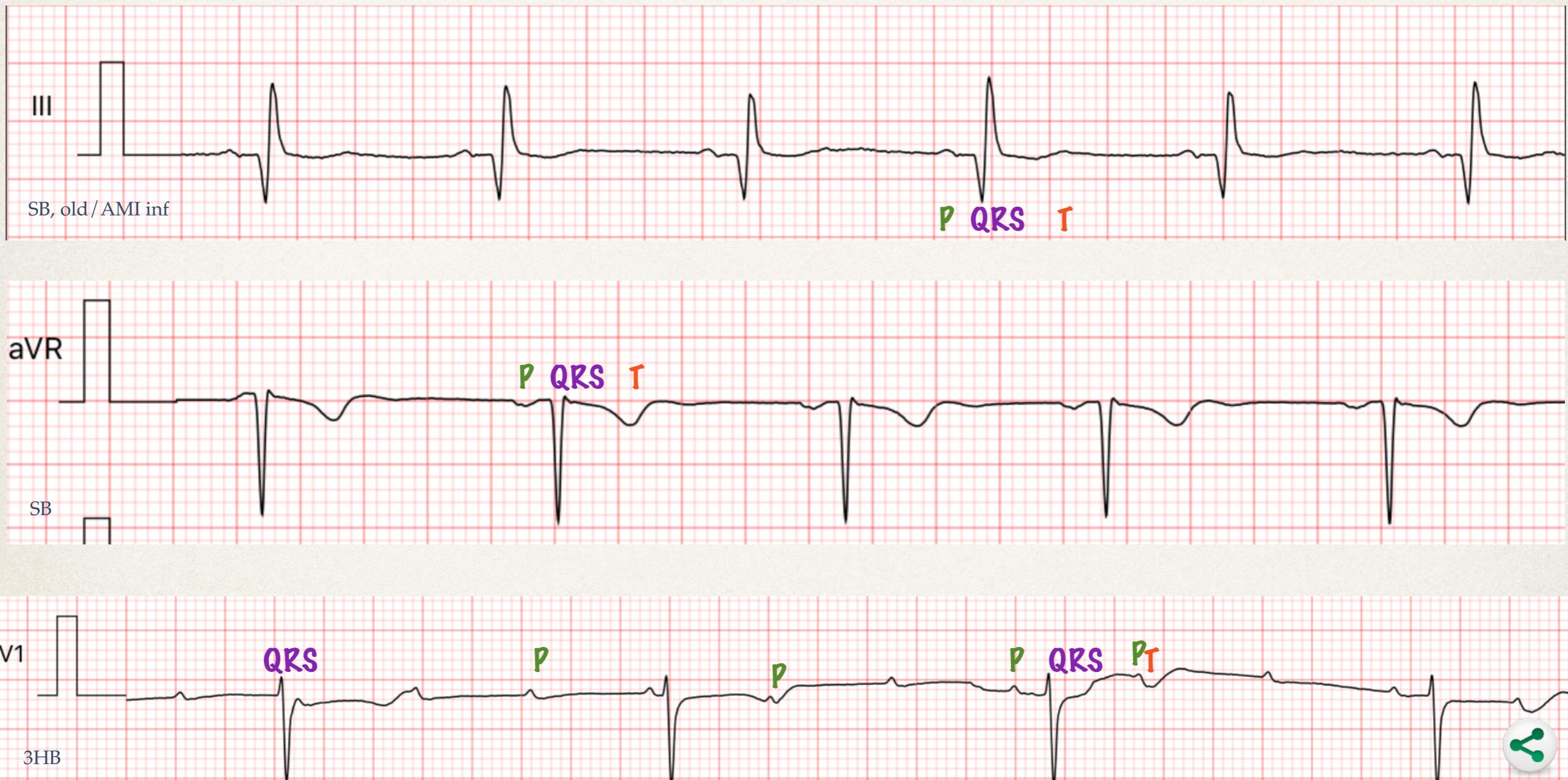
The presentation of the QRS complex is valuable in identifying disease and conduction deficits.

# ECG tracings

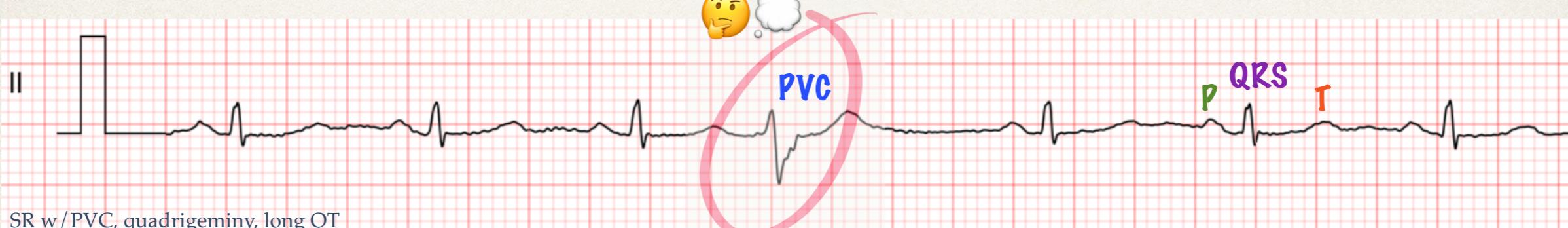
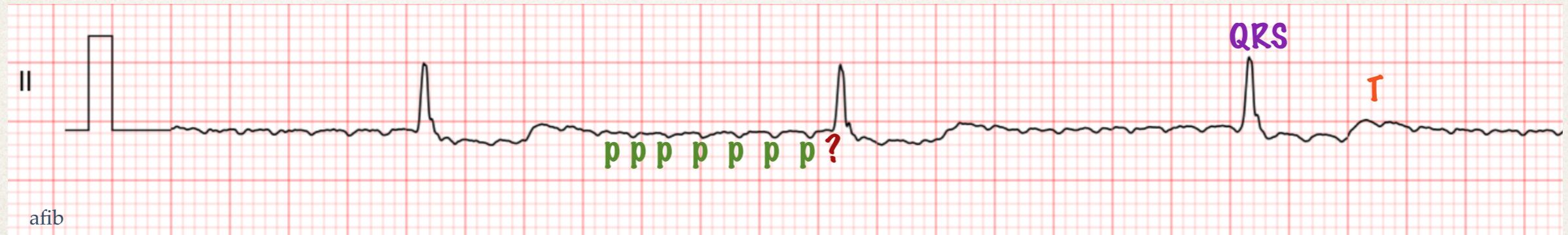
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# Identify the waves/complexes

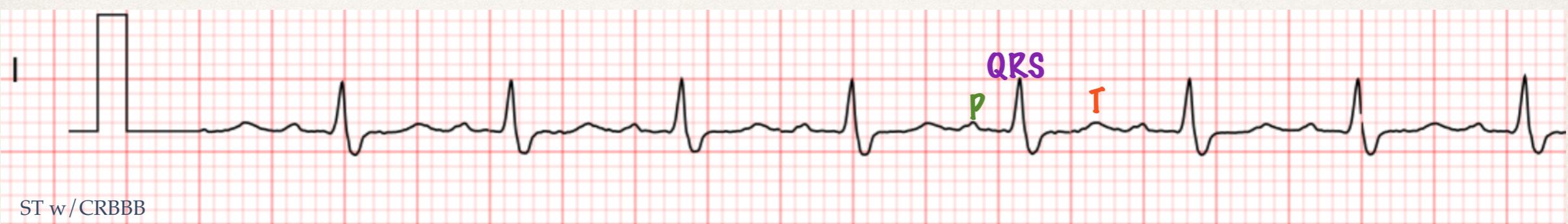


# Identify the waves/complexes



3+ consecutive PVCs = VT

# Identify the waves/complexes



# Identify the waves/complexes



# Rates (tachycardia vs bradycardia)

300 - 150 - 100 - 75 - 60 - 50 - 43 - 37 - 33 - 30 - 27 - 25 ...

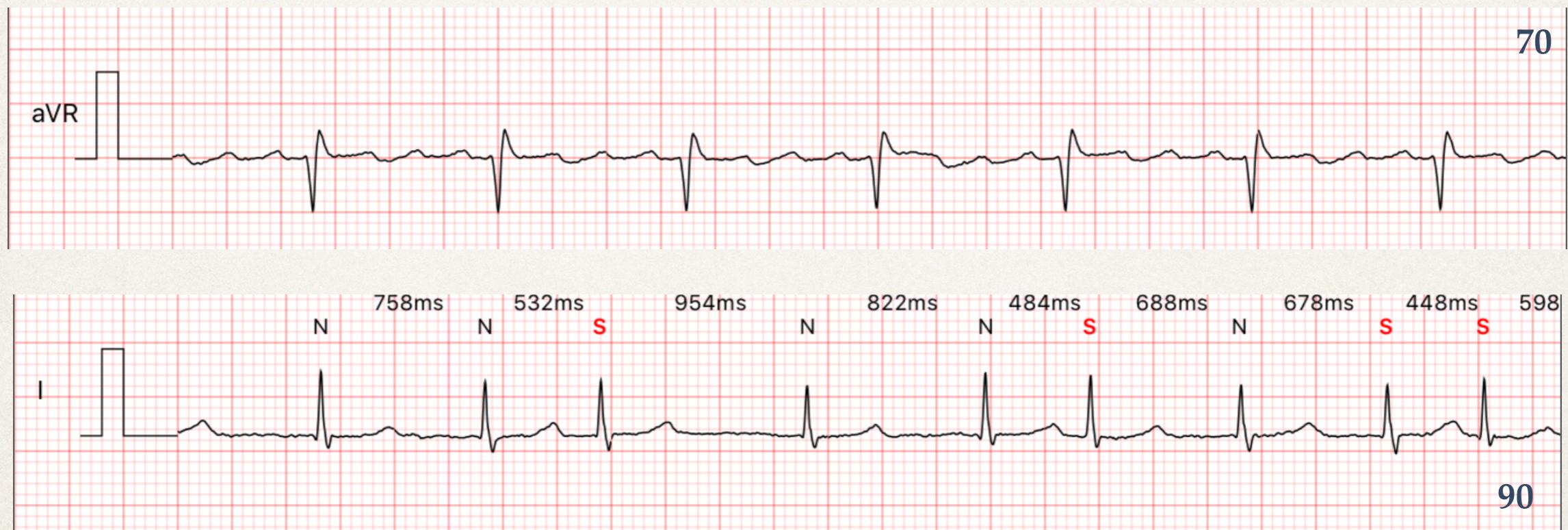


# Rates



**6 sec. strip x10**

count the QRS complexes or  
number of RR intervals



# Rhythms (regular vs irregular)

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# Technical Problems

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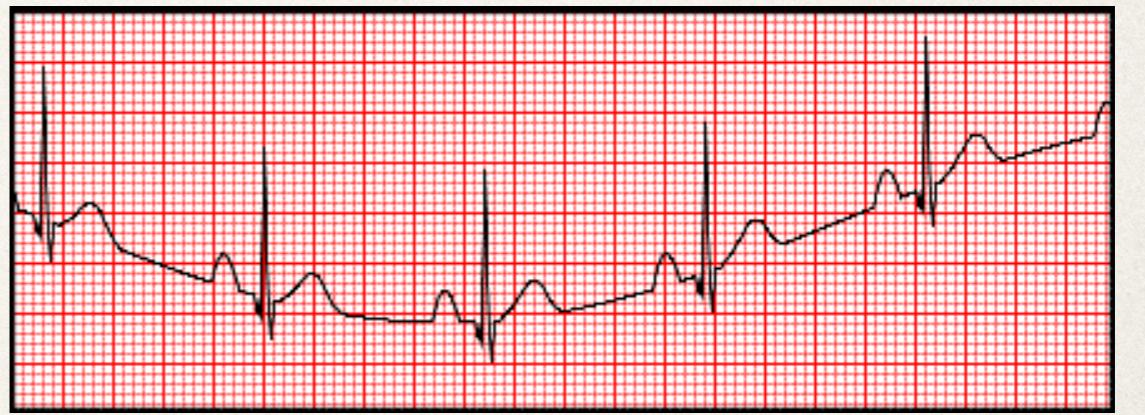
## Muscle Artifact

- high frequency, low amplitude
- poorly supported / tense muscles in the arms and legs
- loose, dry or outdated electrodes or lead wire
- poor patient cable connection
- poor skin prep



## Wandering Baseline

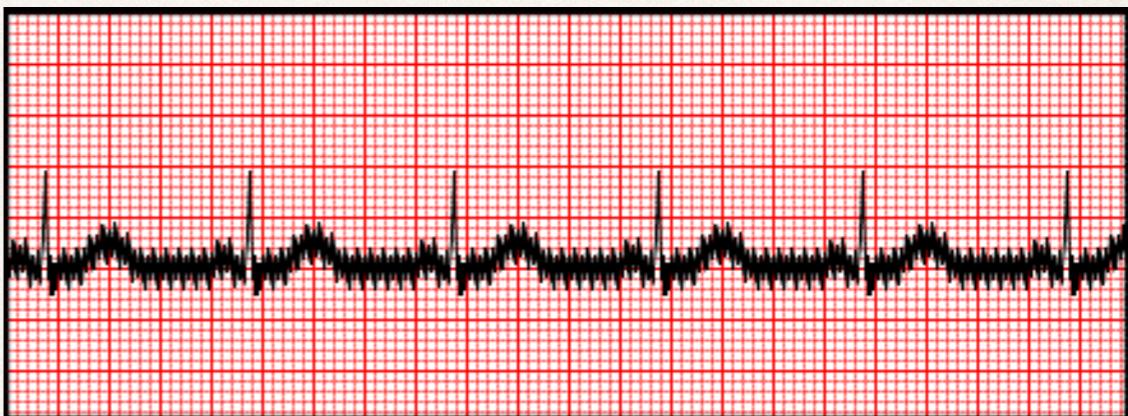
- low frequency, high amplitude artifact
- observed during deep inhalations and exhalations



# Technical Problems

## Electromagnetic Interference (EMI)

- interference from electronic sources such as power cords
- near-by use of a hand held radio, mobile devices
- AC powered equipment (switch to battery supply)
- noisy environment



## Artificial Pacemaker / Pacer Spikes

- seen when implanted pacemaker is firing
- thin upright spikes (one is marked with "x")
- QRS complex following represents ventricles depolarizing
- "(artificial) pacemaker captures" when it is able to successfully depolarize its intended target.
- If a pacing spike is not followed by its intended response, we say that it has "failed to capture" ("z")



**V-paced**

# Sinus Rhythms

P waves

P "married" to R

P morphology constant

P-P constant, R-R constant

## Normal Sinus Rhythm (NSR)



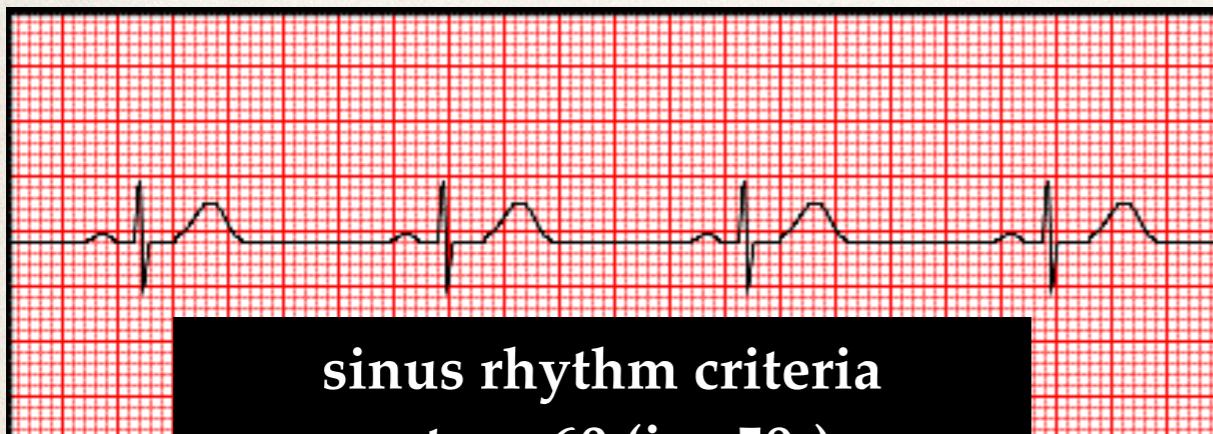
"normal" only if 60-100  
normal PR-QRS intervals

## Sinus Tachycardia (ST) >100 bpm



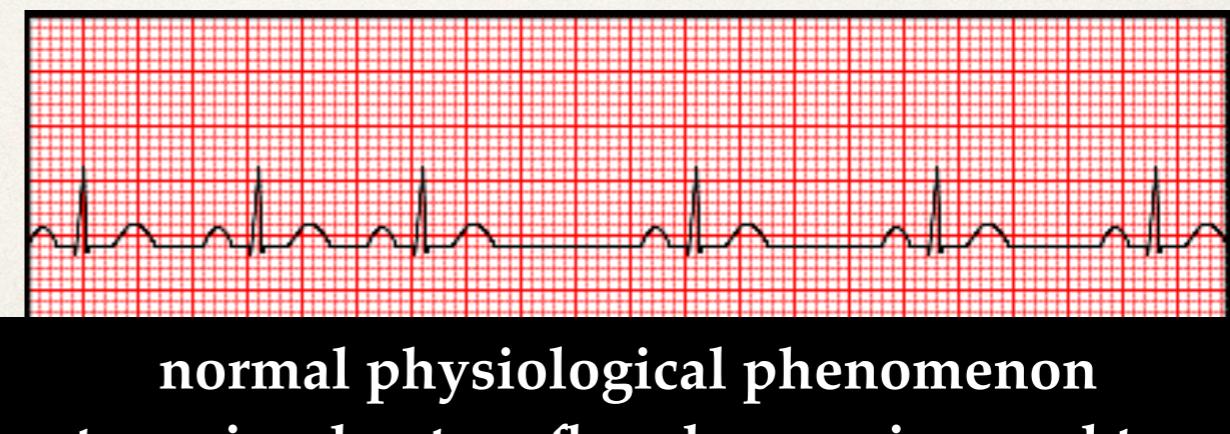
sinus rhythm criteria  
rates >100 (i.e. 101+)

## Sinus Bradycardia (SB) <60 bpm



sinus rhythm criteria  
rates <60 (i.e. 59-)

## Sinus Arrhythmia



normal physiological phenomenon  
rate varies due to reflex changes in vagal tone  
inspiration: HR, expiration: <HR

## Normal Sinus Rhythm



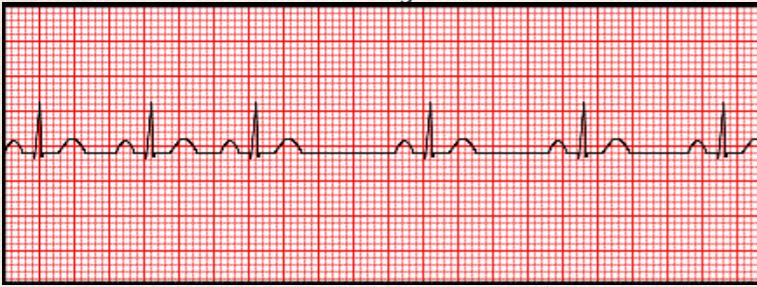
## Sinus Tachycardia (ST)



## Sinus Bradycardia (SB)



## Sinus Arrhythmia



Only referred to as "Normal" if the rate is between 60-100. If there are other abnormalities, just "sinus rhythm"

**NO SPECIFIC TX REQUIRED**

> 140 difficult to identify P from T. If Pt is symptomatic, try vagal maneuver to distinguish from an SVT

**Normal Response to sympathetic tone, fevers, dehydration, hypovolemia, PNA**

- ischemia compensation
- cardiogenic shock(+MI)
- hypotension, hypoxia
- POTS (exag. response)

May be seen in: athletes, sleep, hypothermia, increased ICP, seizures, medications, HF

**Can cause decreased cardiac output, and may lead to atrial, junctional, or ventricular ectopic rhythms**

**Monitor Pt for lightheadedness, hypotension, vertigo, syncope, or BRADYCARDIA with exercise**

It can be naturally occurring or in the elderly due to heart damage or digoxin

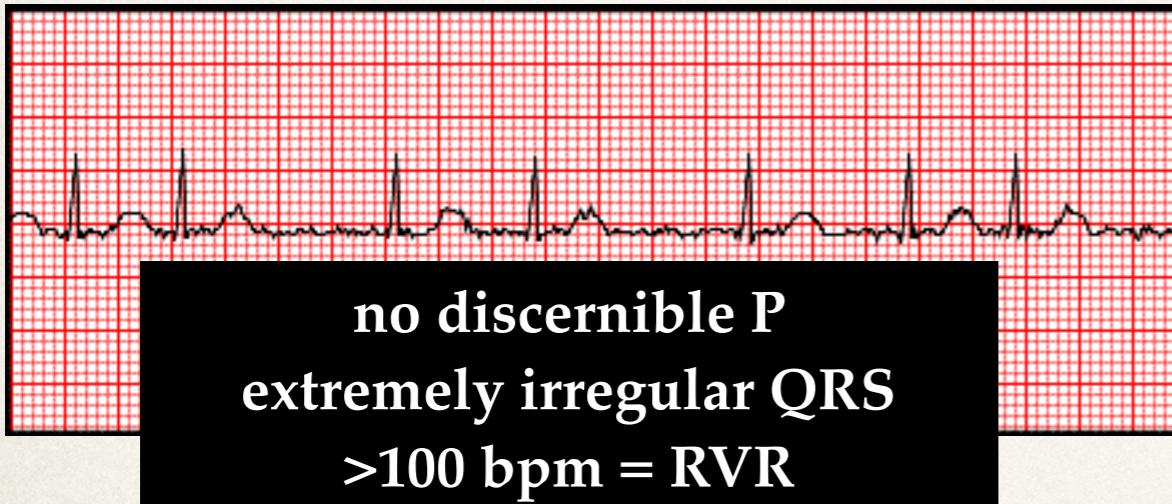
**P-P variation, but PR is constant.**

# Atrial Rhythms

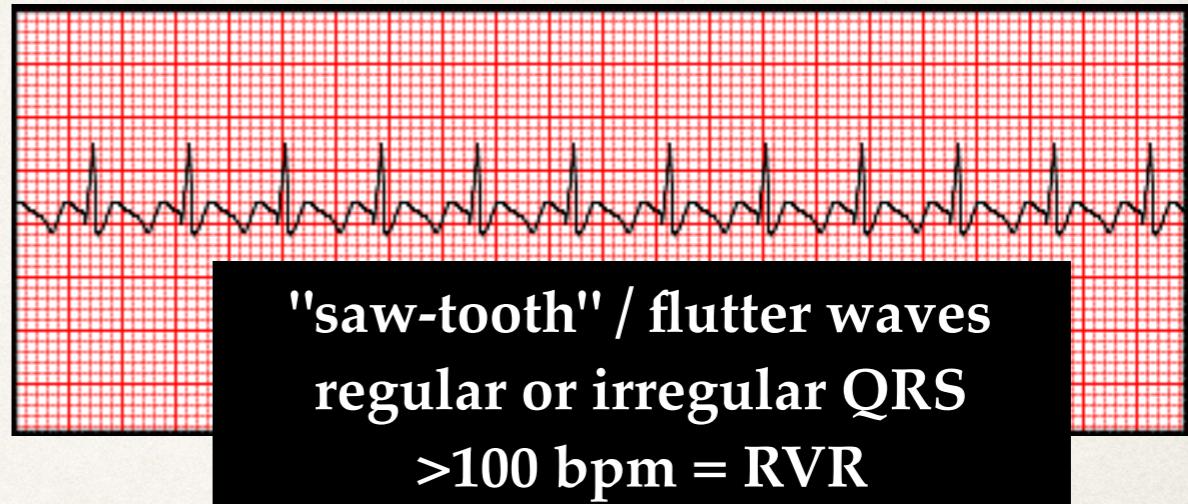
Odd "p"  
usually narrow QRS  
(QRS duration <0.12)  
may have WCTs

SVTs include several different types of arrhythmias, such as atrial fibrillation (RVR), atrial flutter (RVR), atrial tachycardia, AVNRT, and AVRT (WPW).

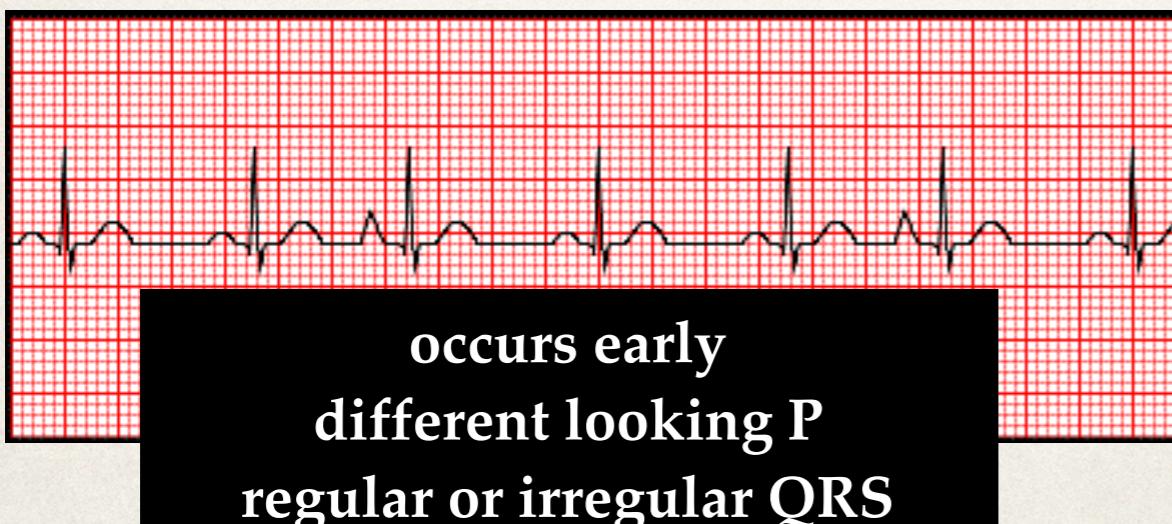
## Atrial Fibrillation (afib / AF)



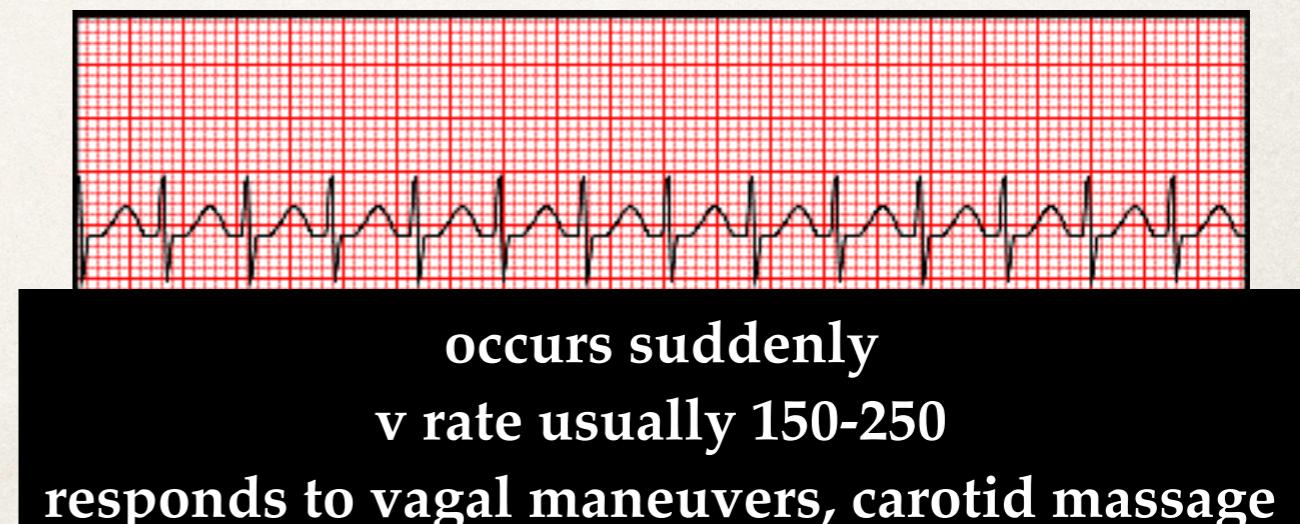
## Atrial Flutter (a-flutter / AFL)



## Premature Atrial Complex (PAC)



## Paroxysmal SVT



## Atrial Fibrillation (afib / AF)



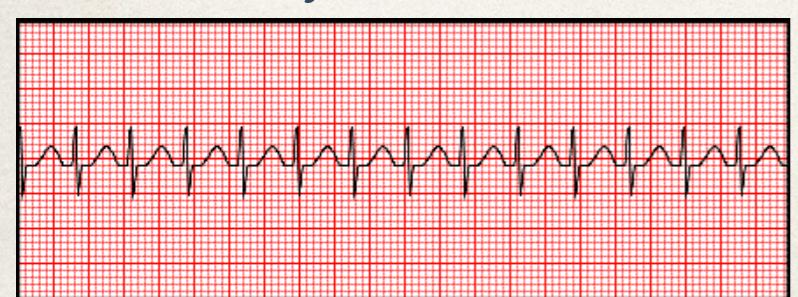
## Atrial Flutter (a-flutter)



## Premature Atrial Complex (PAC)



## Paroxysmal SVT



	<p>may cause no symptoms often associated with palpitations, fainting, chest pain, or CHF, irr-irregular pulse rate</p>	<p>paroxysmal AF of &gt; 48 hr duration is unlikely to spontaneously revert to sinus rhythm and anticoagulation must be considered</p>	<p>"RVR" can cause decreased CO, Tx may include cardioversion</p>
	<p>often in individuals with CVD (HTN, CAD, cardiomyopathy), DM. can occur spontaneously in healthy hearts</p>	<p>Typically not a stable rhythm, frequently degenerates into atrial fibrillation (AF)</p>	<p>Tx by cardioversion, ablation. Can cause clots, SUDDEN DEATH if with pre-existing conduction deficits</p>
	<p>another region of the atria depolarizes before SA node, triggers a premature heartbeat</p>	<p>often completely asymptomatic, some get "palpitations". no treatment usually, but beta blockers can reduce the freq PACs</p>	<p>PACs can indicate heart disease or an increased risk for other cardiac arrhythmias, underlying cause must be treated</p>
	<p>one of two mechanisms:</p> <ol style="list-style-type: none"><li>1. re-entry (SNRT, AVNRT, JRT, WPW)</li><li>2. automaticity (EAT, MAT, AF, AFL)</li></ol>	<p>SVT is generally not life threatening, though it may cause worsening heart function if prolonged</p>	<p>Pounding heart, SOB, CP, Tachypnea, Dizz, LOC (in only the most serious cases)</p>

# Practice!

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On your worksheets,  
identify sinus and atrial  
rhythms and indicate  
their rates (any method)

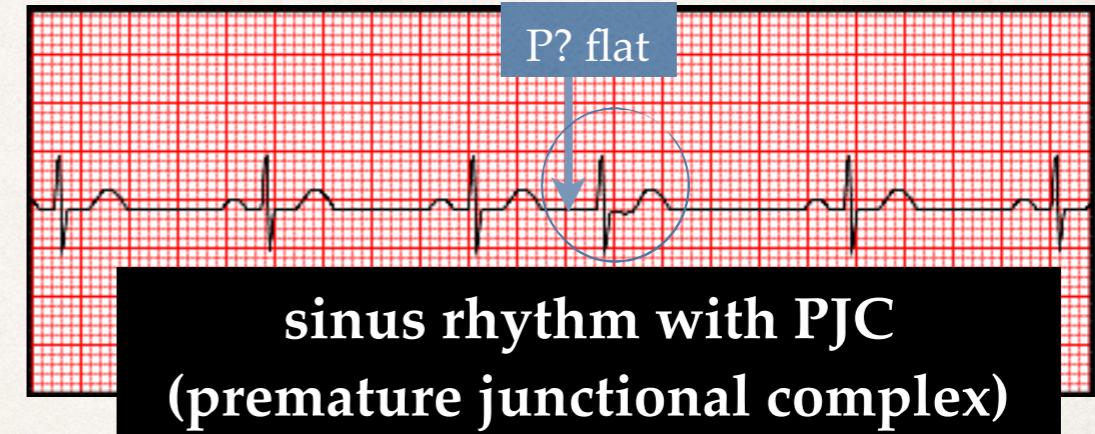
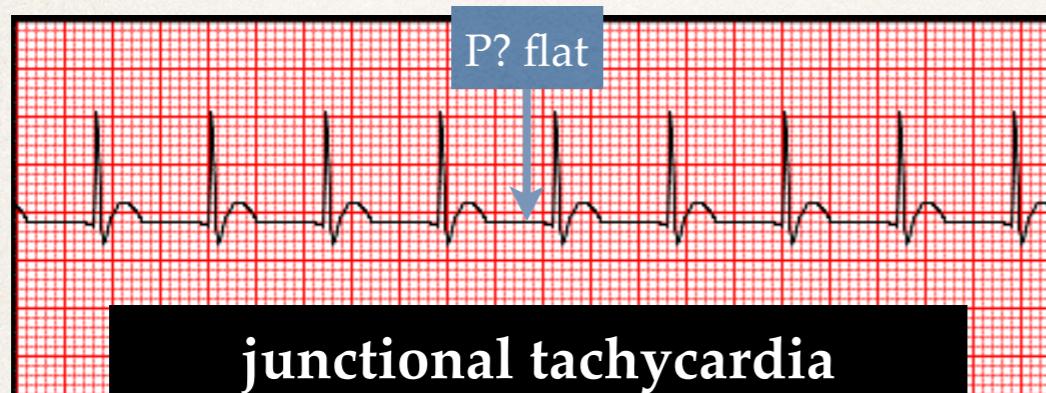
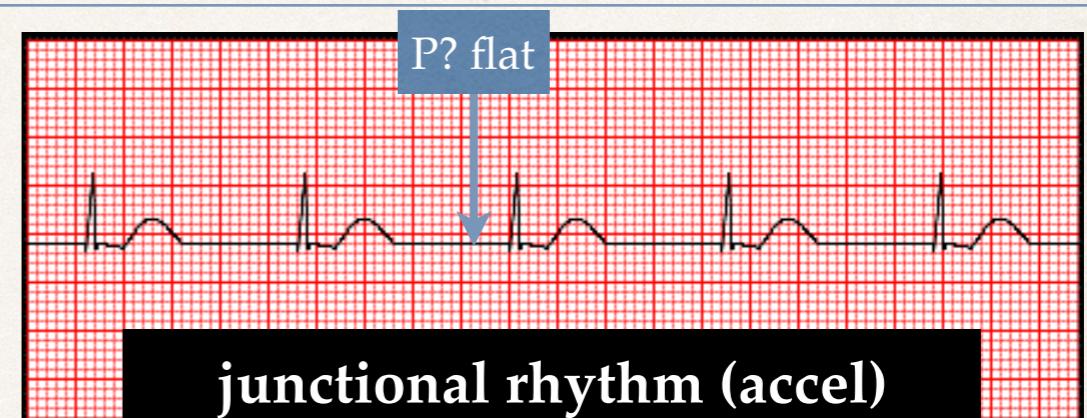
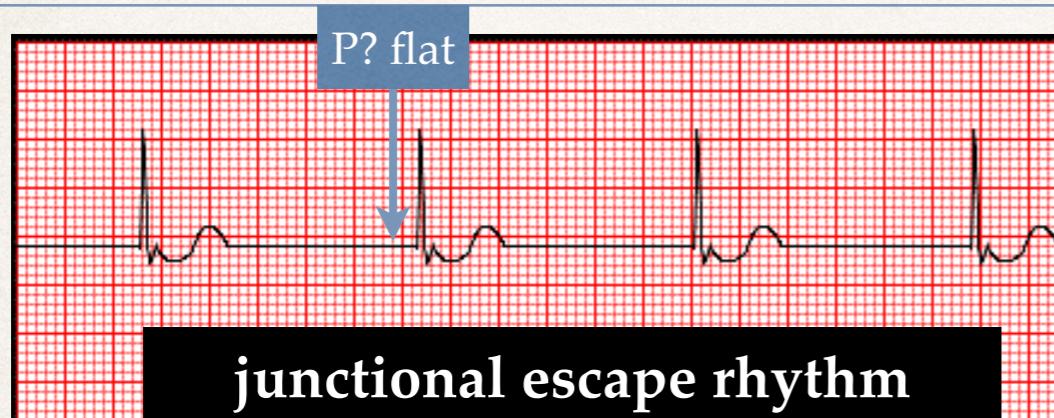
# Junctional Rhythms

inverted or no p waves

rate is 40-60

usually narrow QRS

(because normal conduction pathway  
through ventricles)

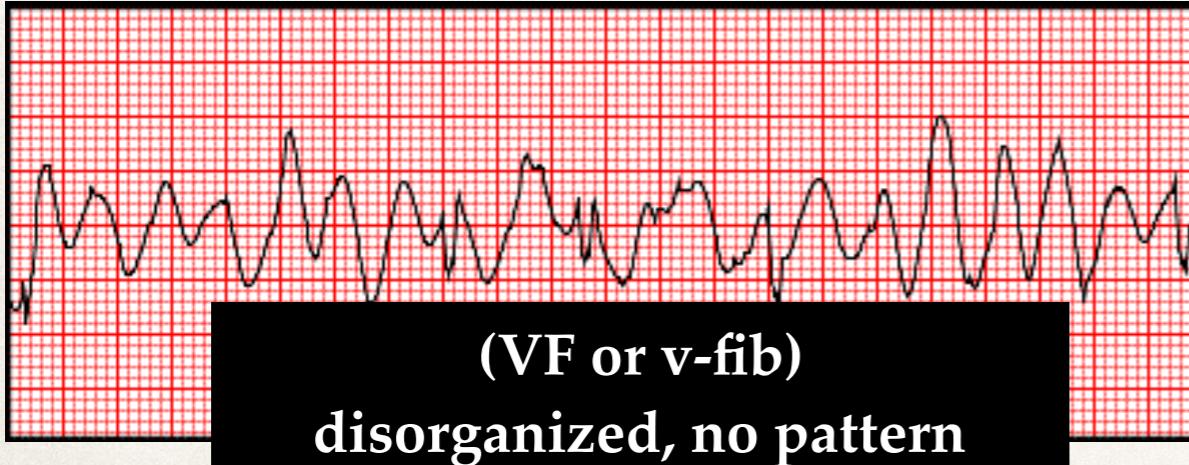


- ✿ "back up intrinsic pacemaker"
- ✿ usually no P wave (SA not active)
- ✿ may or may not have retrograde P

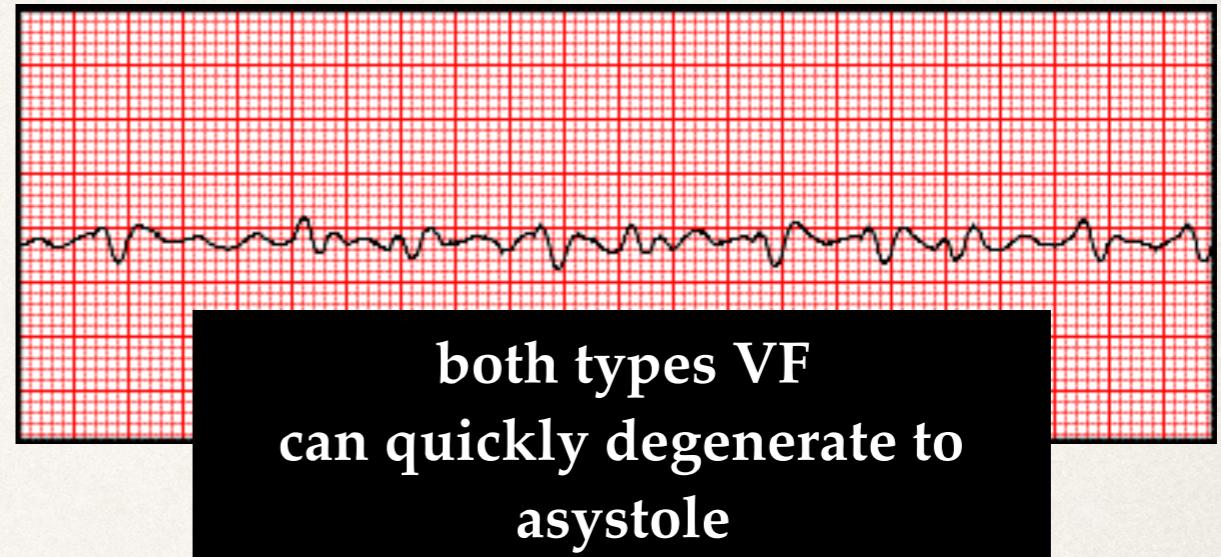
# Ventricular Rhythms

wide QRS  
(QRS duration >0.12)  
needs immediate care

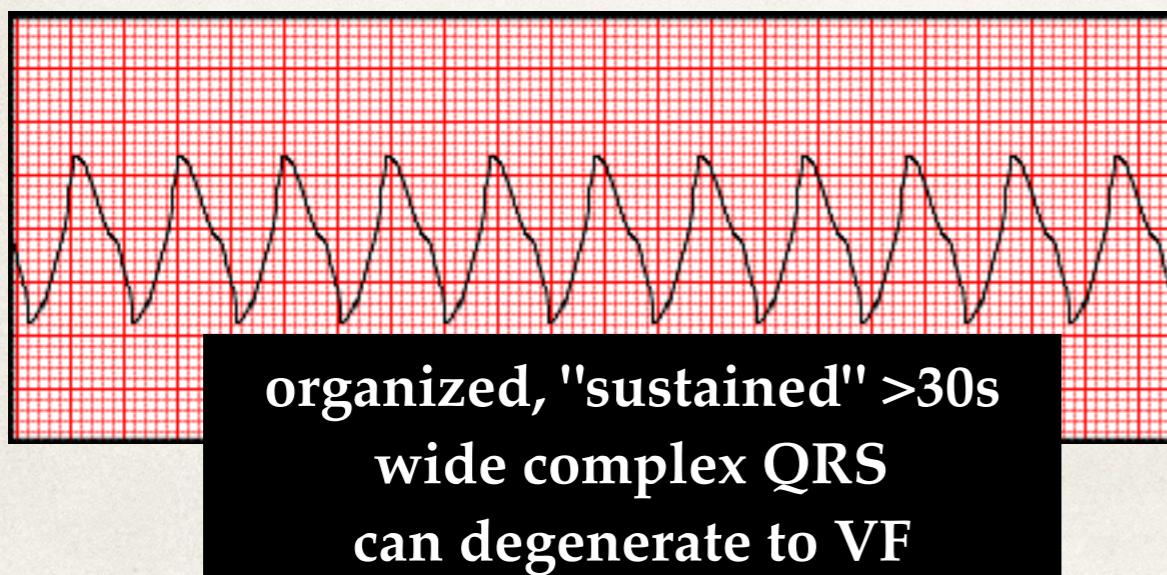
## Ventricular Fibrillation (coarse)



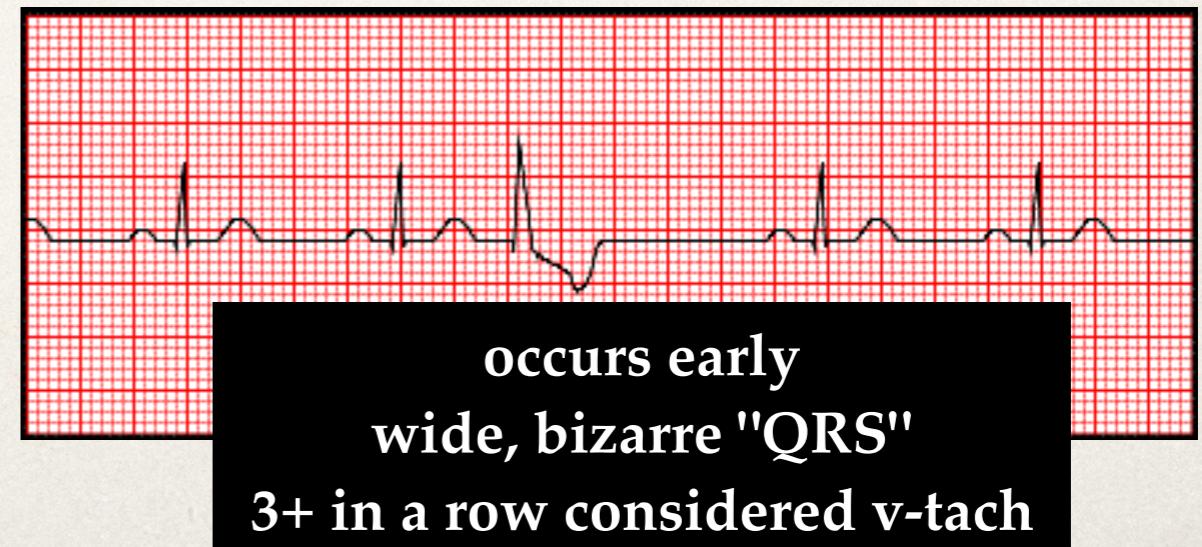
## Ventricular Fibrillation (fine)



## Ventricular Tachycardia



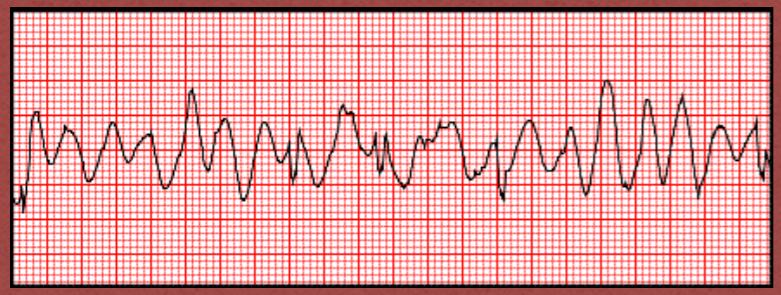
## Premature Ventricular Complex (PVC)



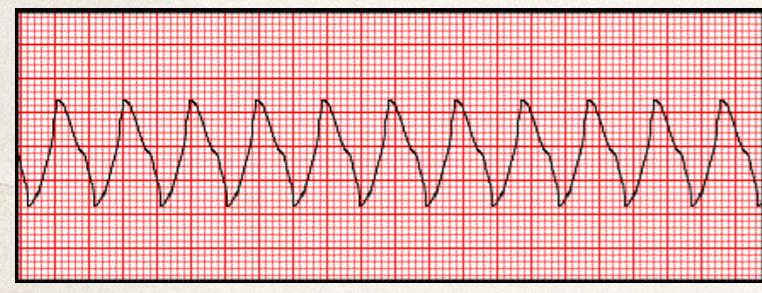
### Ventricular Fibrillation (fine)



### Ventricular Fibrillation (coarse)



### Ventricular Tachycardia



### Premature Ventricular Complex (PVC)



## TX: DEFIBRILLATE IMMEDIATELY (unsynchronized cardioversion)

**VF may lead to asystole, and sudden death**

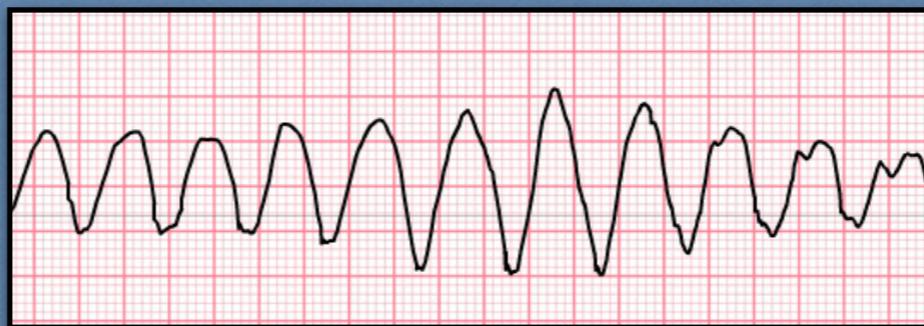
\***Implantable Cardiac Defibrillators (ICDs) can either deliver "pacing impulses" or a shock.**

**Pt: "baseball hitting the back or chest"**  
**Handler/CG: "tingle" or "static shock"**

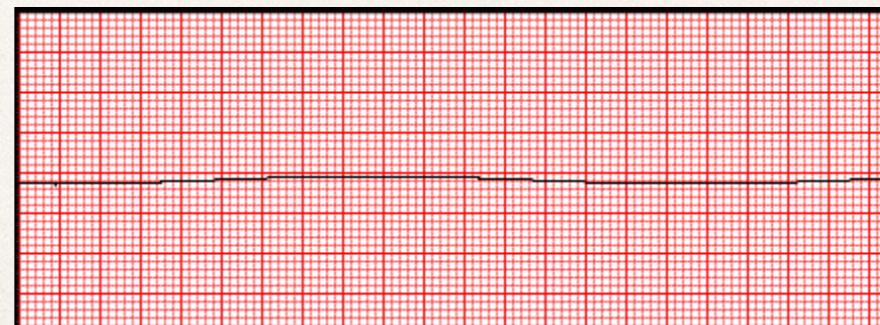
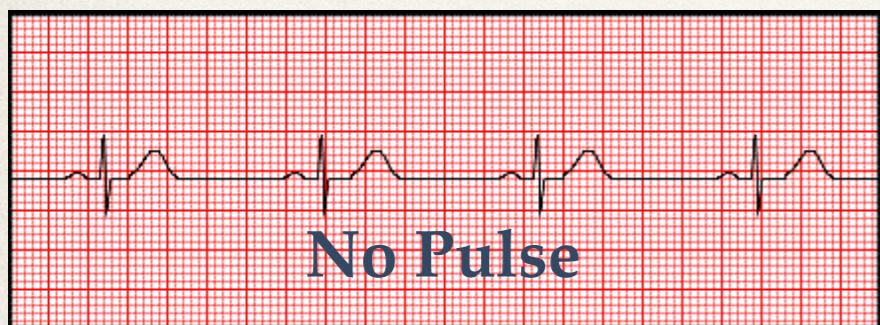
according to morphology, duration (sustained >30 secs), symptomatic/pulseless	Pt may be asymptomatic. Regardless, need immediate cardioversion	<b>TX: Synchronized CARDIOVERSION (with pulse) if no pulse, defib as VT may lead to ventricular fibrillation, asystole, and sudden death</b>
Be concerned if 30% of complexes occur in 1 min. Example: in a HR of 100, cut off is 33 PVCs	Pt may be asymptomatic. Possibly reduced CO in Bigeminy, couplets, etc. 3 or more PVCs in a row considered VT	<b>"R on T" phenomenon can trigger VTach</b>  <b>May have CO compromise (I.e, ventricular Bigeminy where rate is 70 but actual PR / beats could be 35</b>

- ❖ Unresponsive
- ❖ Pulseless

BEGIN CPR 30:2



SHOCKABLE  
defibrillate



High Quality  
CPR 30:2

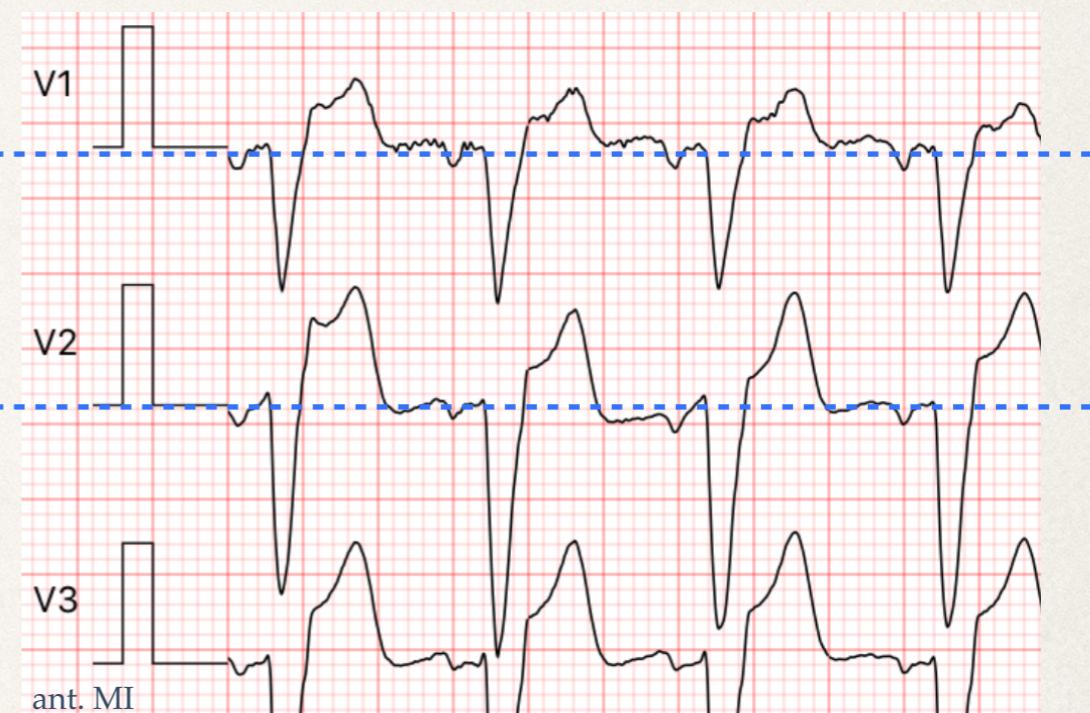
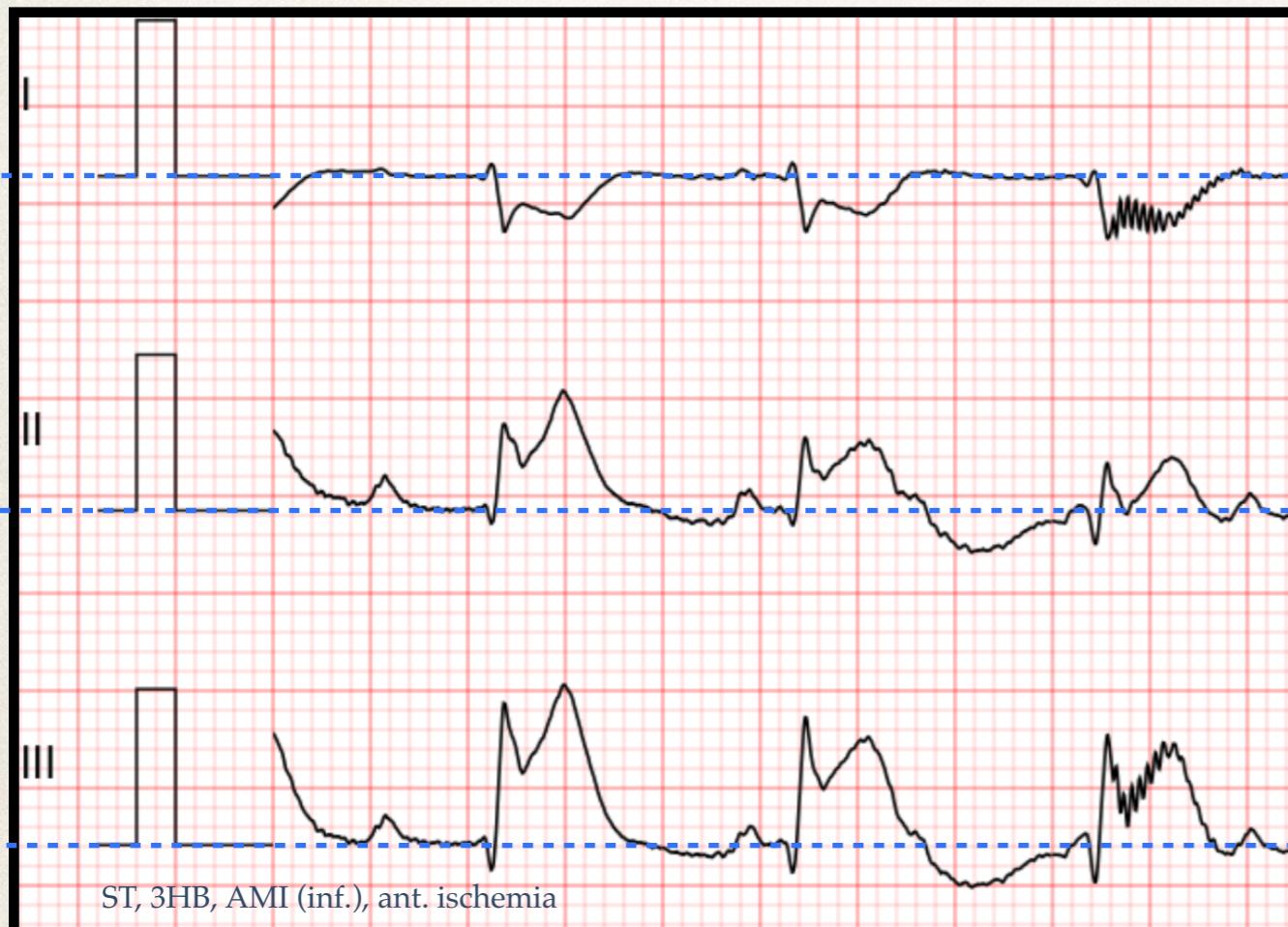
# Practice!

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On your worksheets,  
identify heart blocks  
and ventricular rhythms  
and indicate their rates

# Ischemia monitoring (ST-T changes)

**Ischemia/Infarctions Diagnosed only with 12-lead ECG**



>2 mm depression = ischemic

T wave inversions

i2chemmic

L

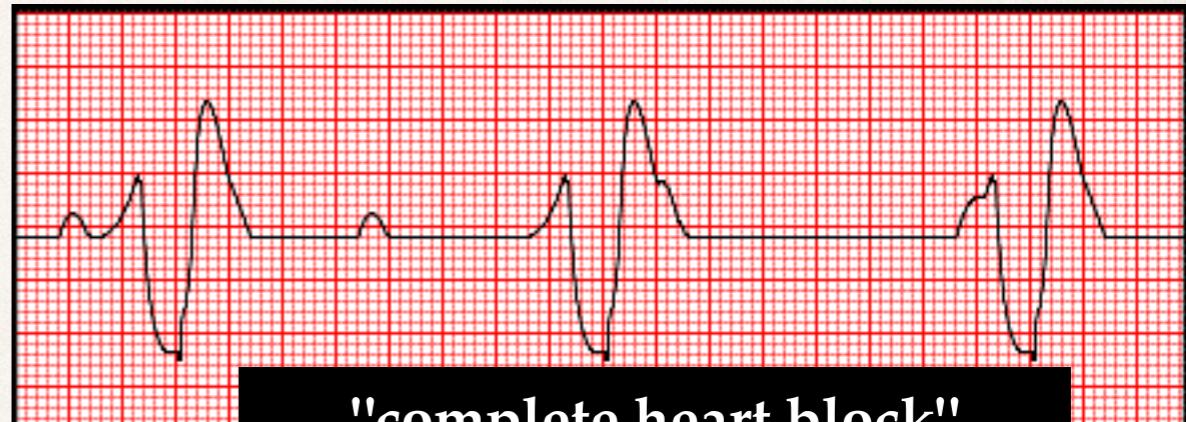
# Heart Blocks (Conduction blocks)

1st degree AV block



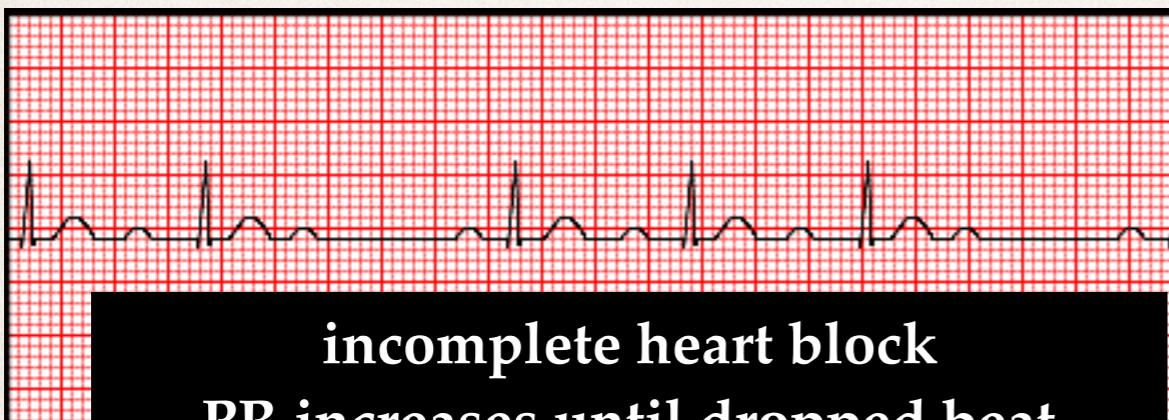
PR >0.2  
no hemodynamic disturbance

3rd degree (complete) AV block



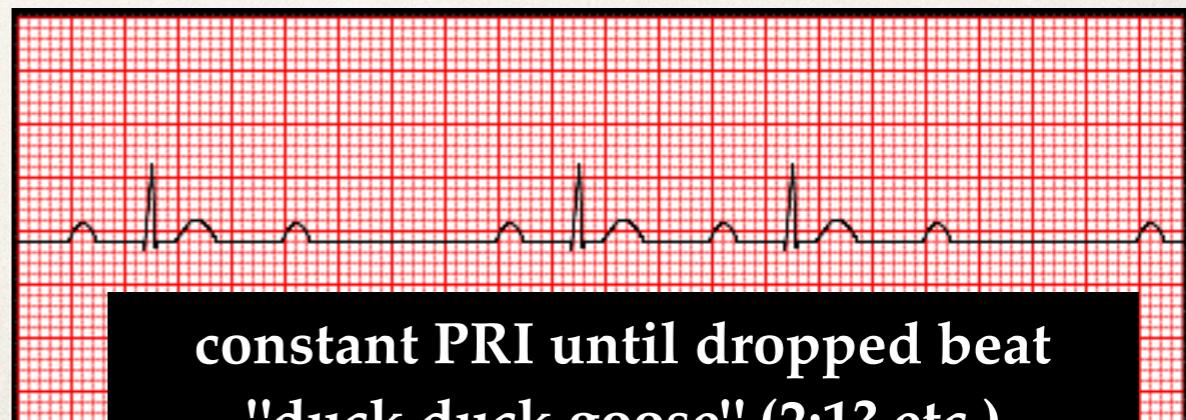
"complete heart block"  
atria & ventricles divorced

2nd degree AVB (I - Wenckebach)



incomplete heart block  
PR increases until dropped beat  
pattern resets itself

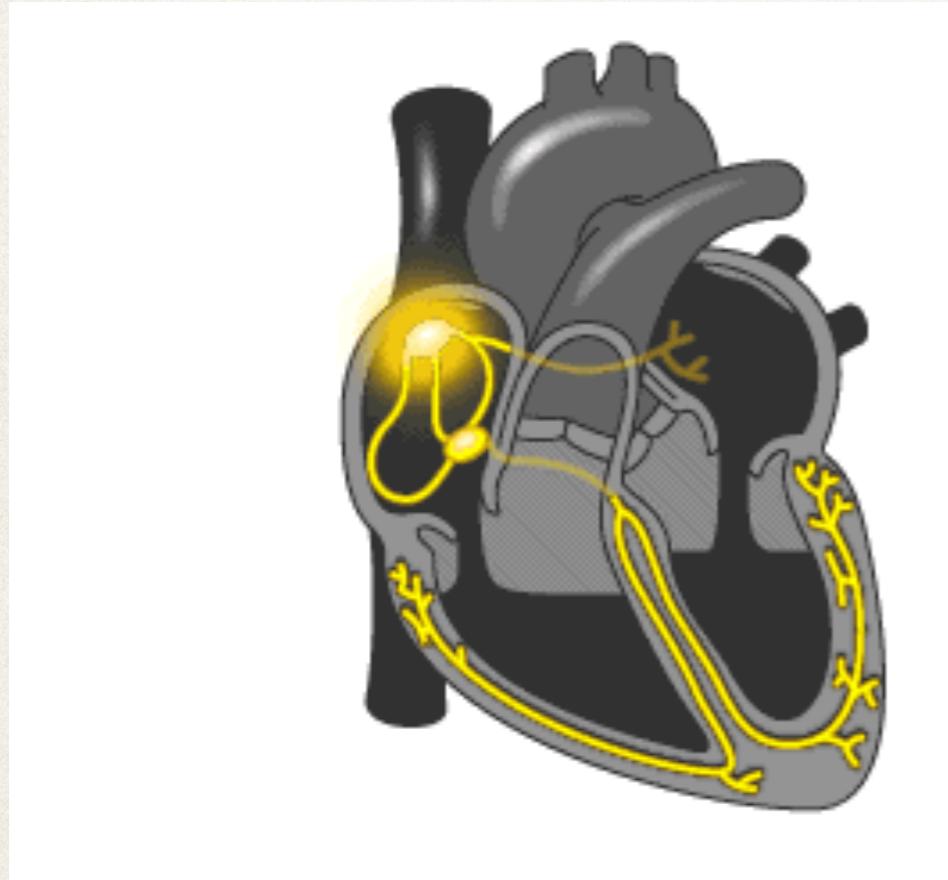
2nd degree AVB (Mobitz II)



constant PRI until dropped beat  
"duck duck goose" (2:1? etc.)  
worse outcome: His-Purkinje failure

# Sketchpad

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## 1st degree AVB



May be seen in: Athletic training, Mitral valve surgery, Electrolyte disturbances, AV nodal blocking drugs

**NO SPECIFIC TX REQUIRED, except ax of electrolyte levels & drug screens**

**may be at an increased risk of progression to complete heart block if accompanied by BBB or fascicular blocks**

## 2nd degree AVB (Type I)



incomplete heart block  
PR increases until  
dropped beat  
pattern resets itself

**Usually due to reversible conduction block at AVN  
Usually benign**

**No Tx unless with Sx (Atropine)  
Caused by malfunctioning AVN cells fatiguing**

## 2nd degree AVB (Type II)



May be seen in:  
infarction, necrosis,  
fibrosis at His-Purkinje level below AVN, MI, autoimmune

**TX: Urgent Pacing, Pacemaker Placement**

**\*High risk progressing to complete block  
\*Hemodynamic instability sudden, unexpected**

## 3rd degree AV block



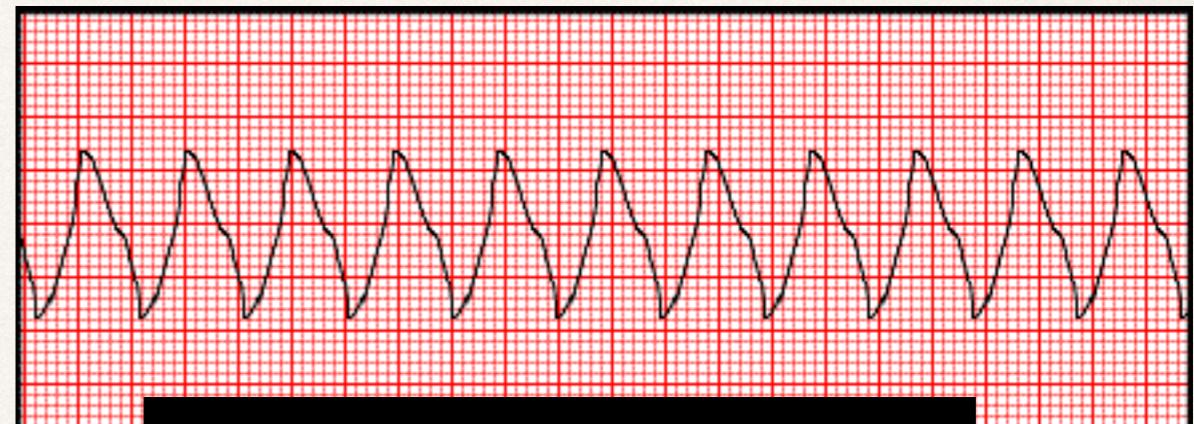
May be seen in: Inferior MI, AV nodal blocking drugs, progression of Type II blocks

**TX: Urgent Pacing, Pacemaker Placement**

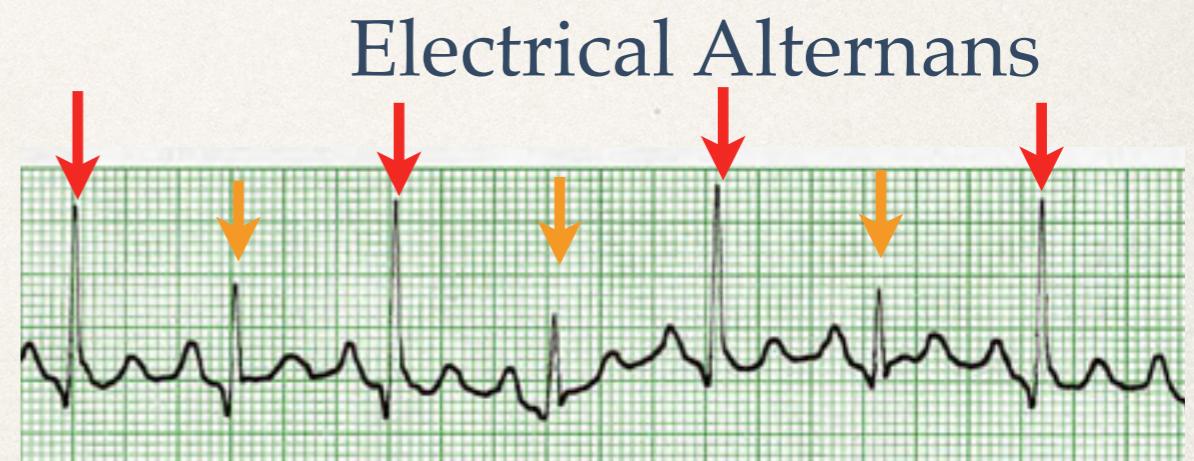
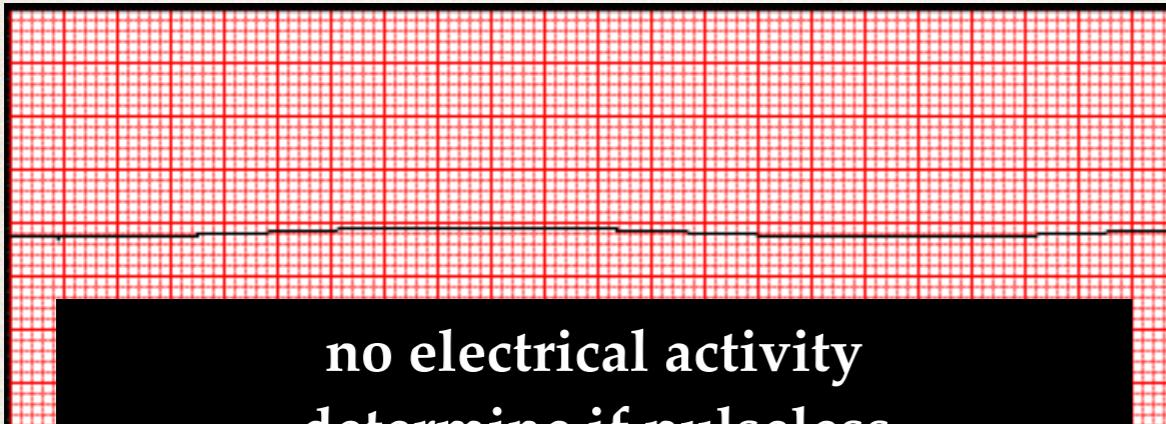
**•SYNCOPE (self-terminating)  
•SUDDEN CARDIAC DEATH (prolonged)**

# Other ECG findings

## PEA (Pulseless Electrical Activity)



## Asystole / Flatline



no electrical activity  
determine if pulseless  
check all connections/other lead views

low volt + tachycardia + Alt. QRS amp.  
triad of massive pericardial effusion  
❤️ swinging inside fluid-filled pericardium

# Drips & Drugs

## Pressors

- \*Dopamine (3-10, or 10-20 mcg/kg/min)
- \*Norepinephrine (0.01-1 mcg/kg/min) \*potent
- \*Epinephrine (0.04-1 mcg/kg/min)
- Phenylephrine (0.05-8 mcg/kg/min)
- \*Dobutamine (0.04-1 mcg/kg/min)
- \*Vasopressin
- \*Milrinone

*\*Inotropes (hard/soft), Chronotropes (slow/fast)*

## Sedation

- propofol
- benzodiazepines
- opioids, e.g. morphine, fentanyl
- ketamine
- tranquillisers, e.g. haloperidol (haldol)

## /NM blockade (paralysis)

- Vecuronium, Rocuronium, Pancuronium

## Antiarrhythmics

- Adenosine, Digoxin, Magnesium Sulfate
- Amiodarone
- Atenolol, Metoprolol, Esmolol (BB)
- Lidocaine, Phenytoin
- Verapamil, Diltiazem

## Antihypertensive

- Esmolol, Nicardipine, Sodium Nitroprusside

# Take-Away!

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Rely on ECG knowledge to assess or anticipate changes in cardiac output but the Patient - not the monitor - is the gold standard.

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