



Intro to Critical Care Series Part 3 of 3

Telemetry

By Creek't Rebaño (PT)

Telemetry

(Cardiac Monitoring)

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

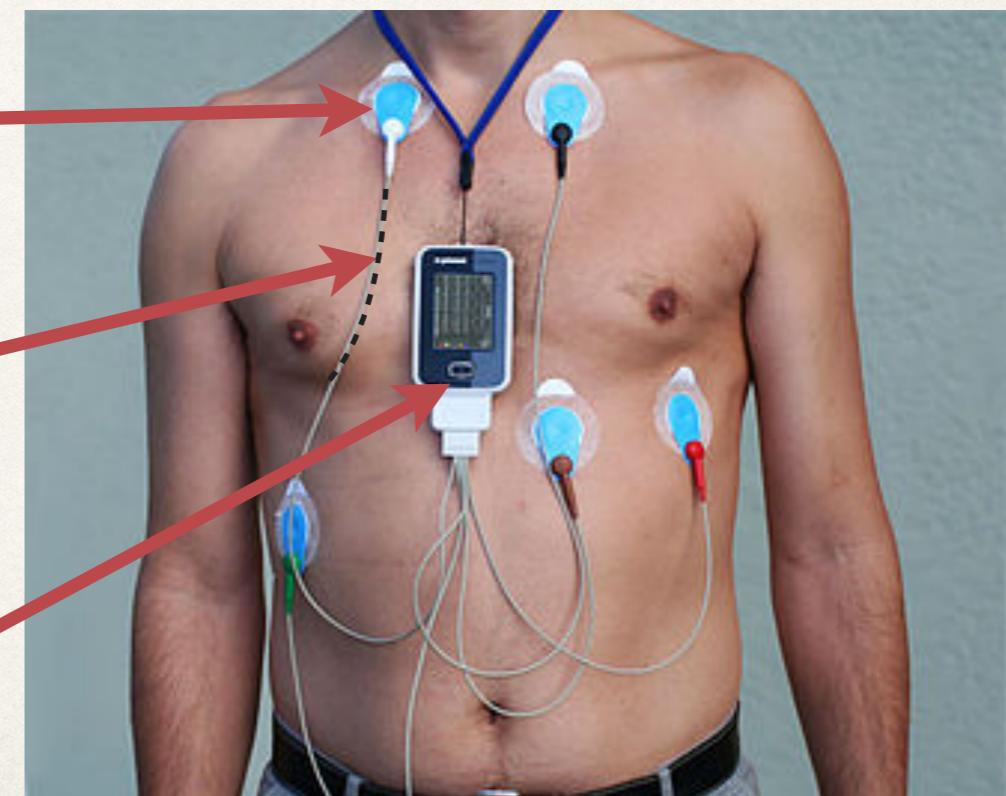
Sensor —————→
Transmission path —————→
Display/Recording/Control —————→

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?

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

What is exercise?

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

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

Quiz-mo game!

Signs of cardiac compromise

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

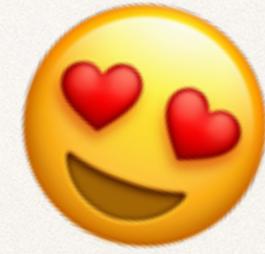
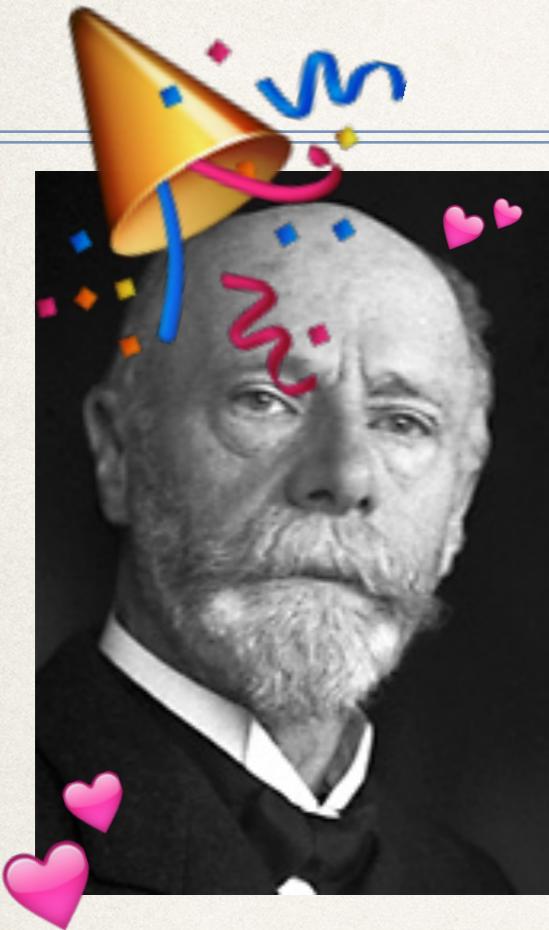
DON'T START EXERCISE IF:

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 ₂	< 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 ⁻¹	----	> 6 min ⁻¹	30% of complexes in 1 min ⁻¹	----	> 6 min ⁻¹
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

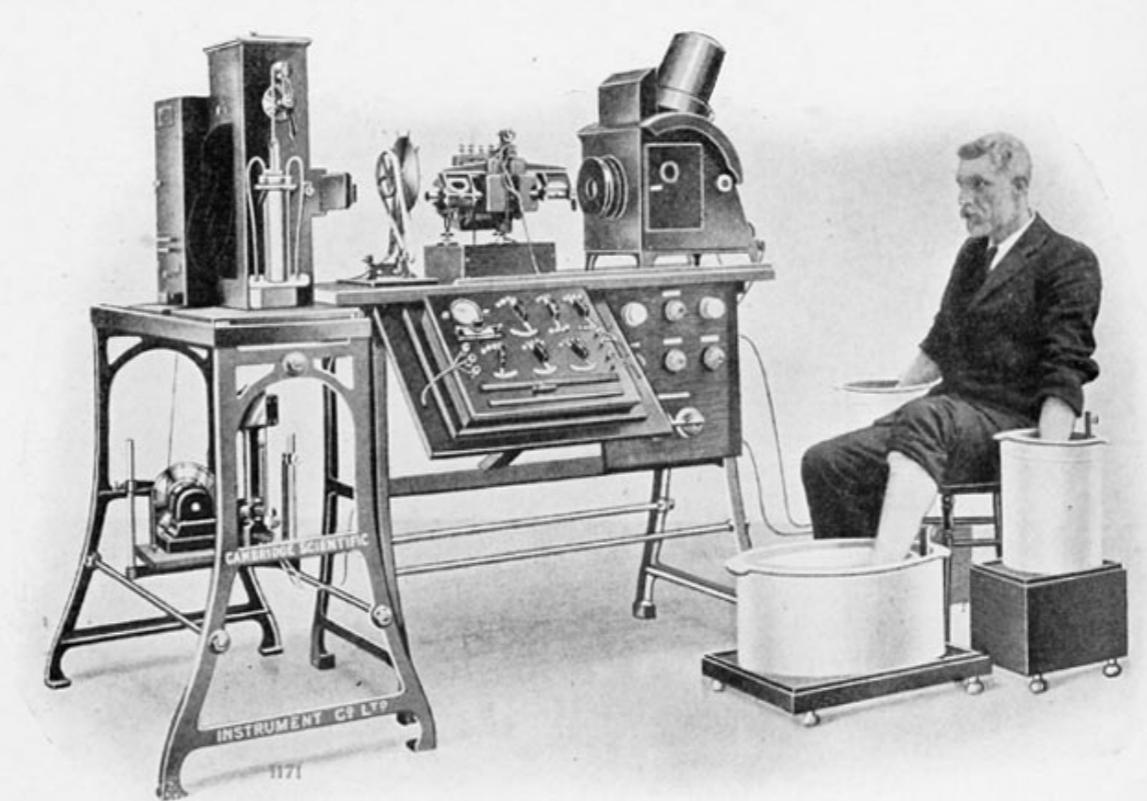


Willem Einthoven (1860 – 1927)

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



series of prototypes of a string galvanometer. This device used a very thin filament of conductive wire passing between very strong magnets. When a current passed through the filament, the magnetic field created by the current would cause the string to move. A light shining on the string would cast a shadow on a moving roll of photographic paper, thus forming a continuous curve showing the movement of the string. The original machine required water cooling for the powerful electromagnets, required 5 people to operate it and weighed some 270 kilograms. This device increased the sensitivity of the standard galvanometer so that the electrical activity of the heart could be measured despite the insulation of flesh and bones.



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



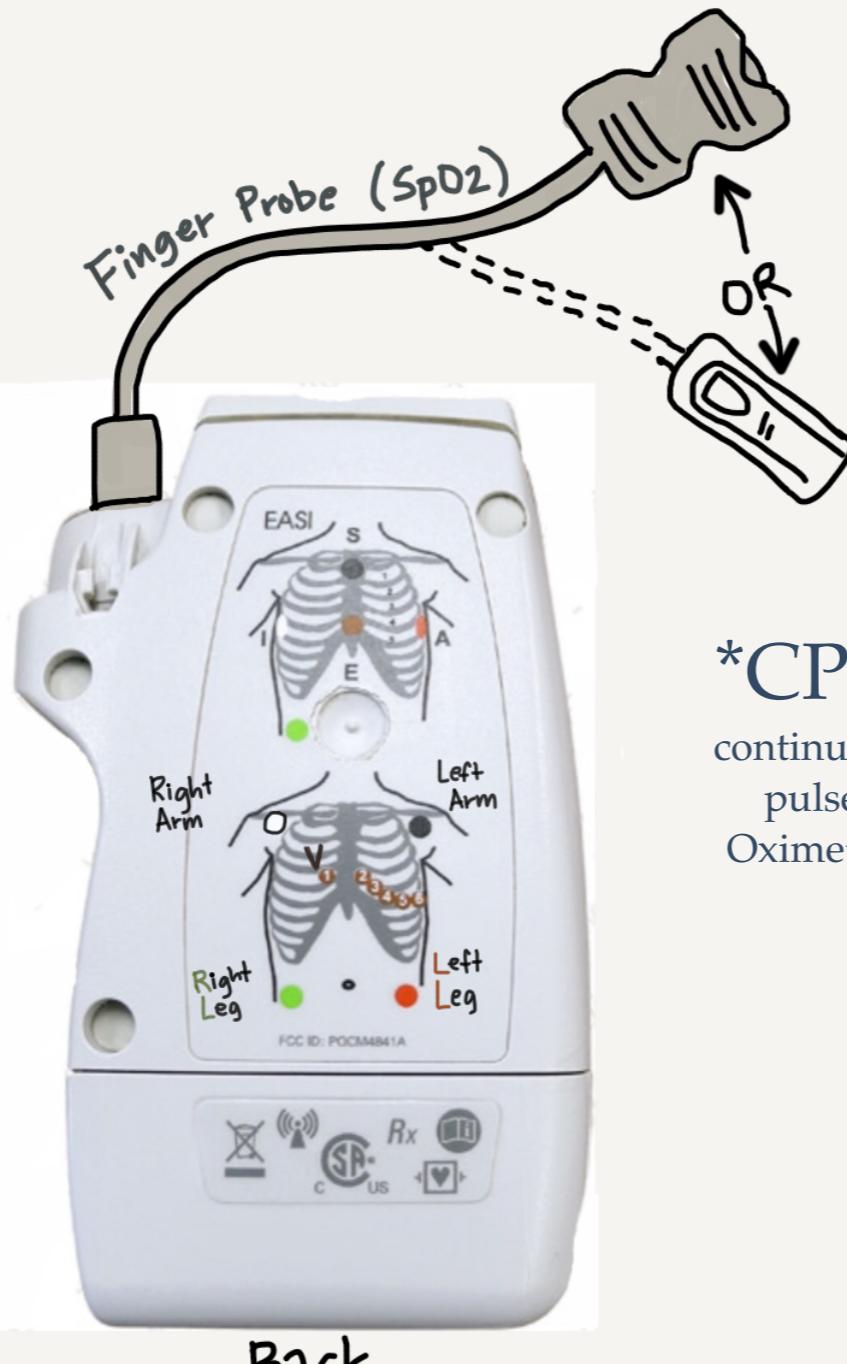
Portable Tele



Telemetry Box, Wires, Electrodes



Front



Back

*CPO
continuous
pulse
Oximetry

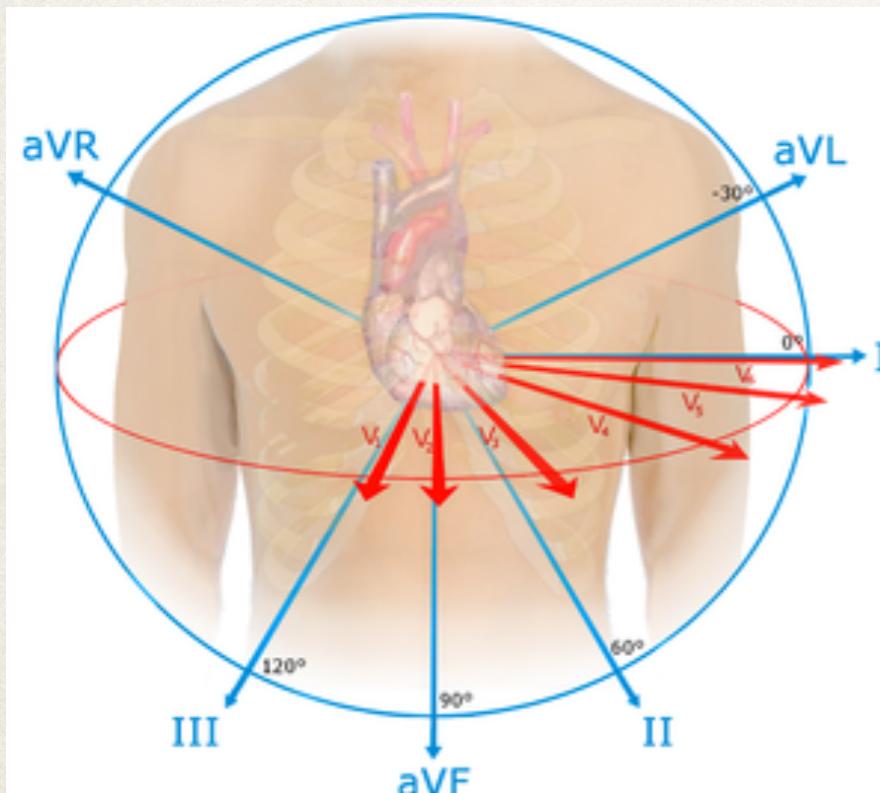


Camera Exercise

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

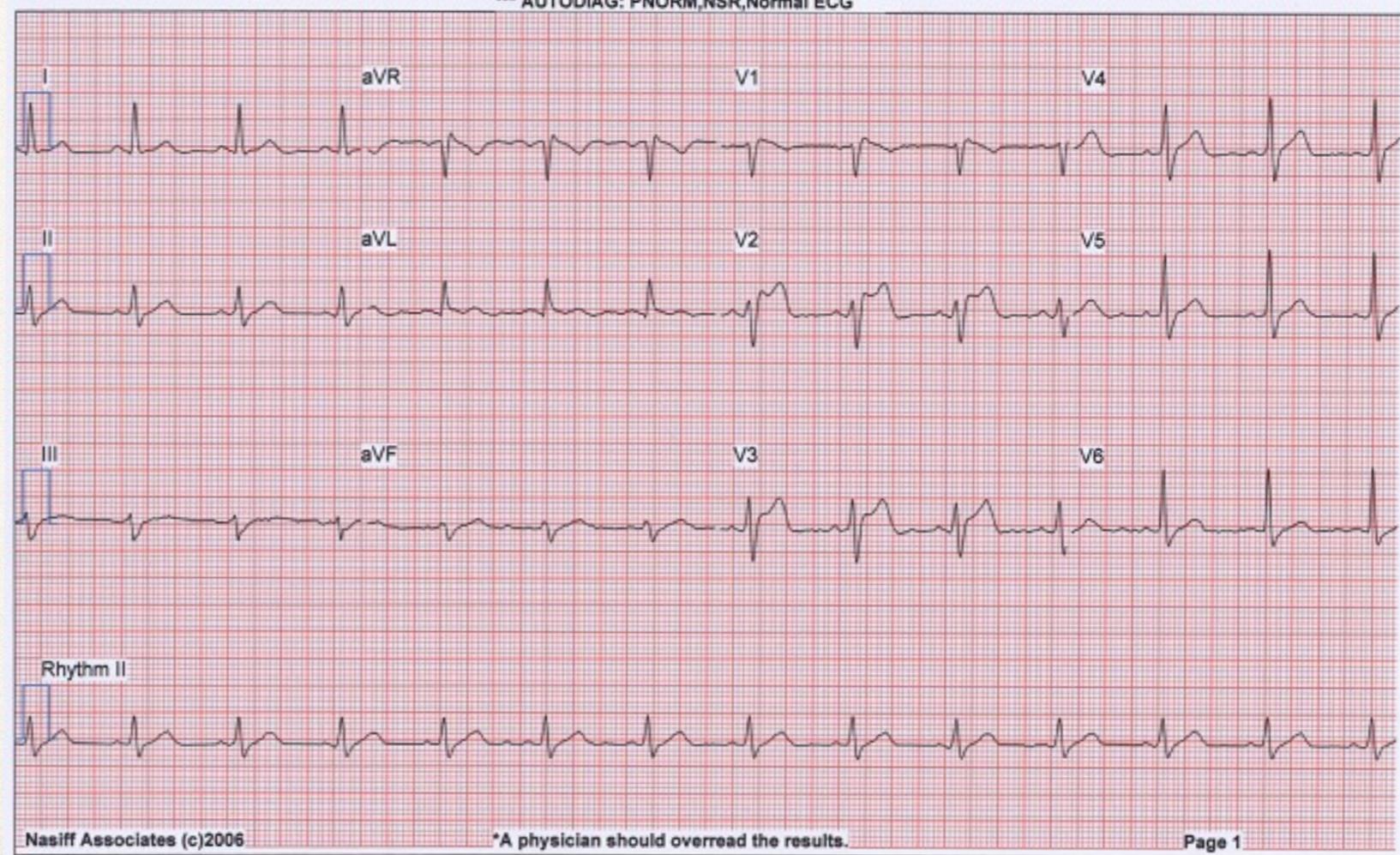


12-lead ECG (overview only)



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:

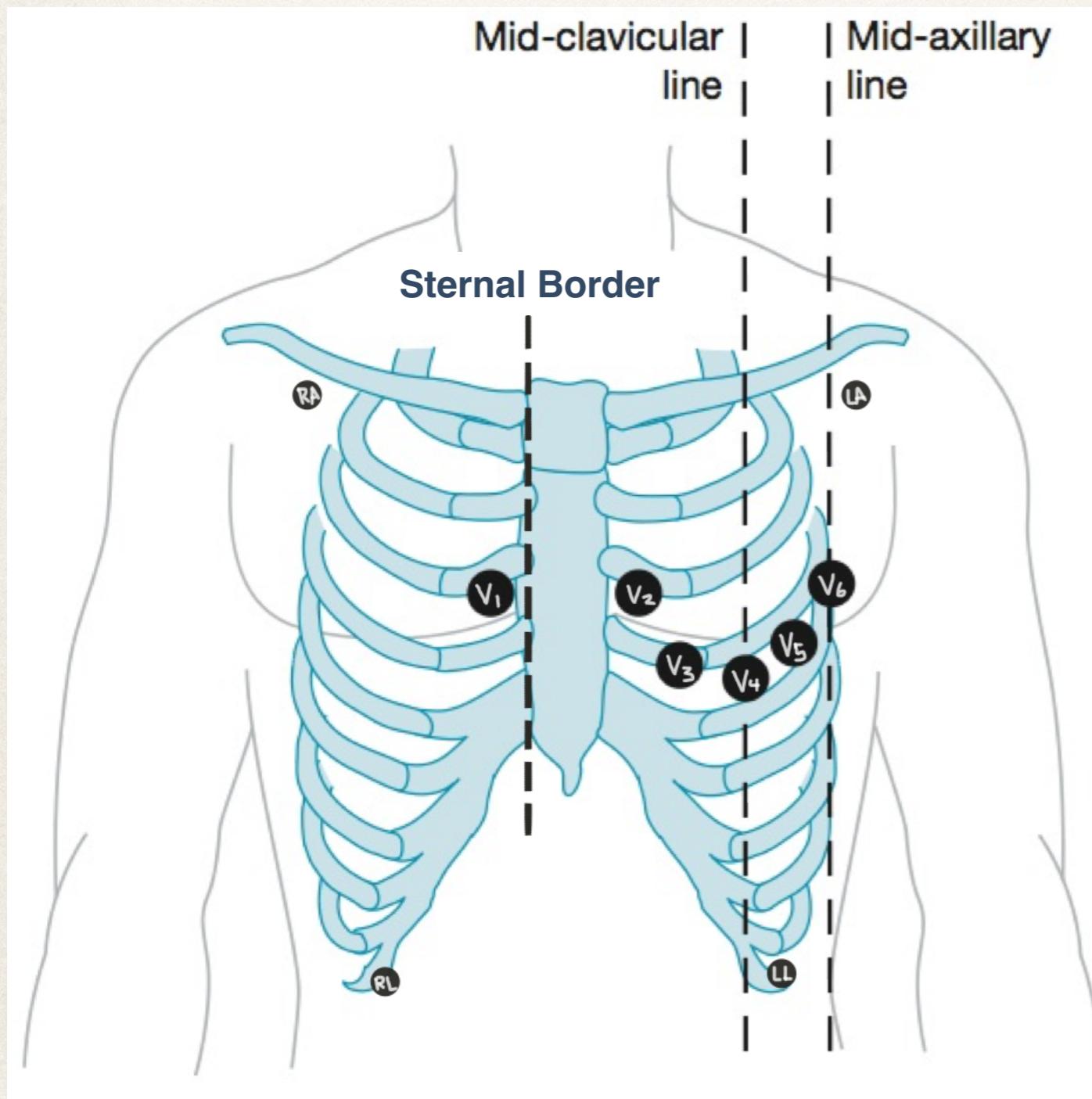
8:09:28 AM,02/24/2008,Run:0
HR (bpm): 77 (lead II)
R-R (ms): 779
P dur (ms): 68
PR int (ms): 132
QRS dur (ms): 88
P/R/T axis: 23/4/36
QT/Qtc (ms): 376/416
Referring:
*** Confirmed by (required):
*** AUTODIAG: PNORM,NSR,Normal ECG



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

*MUSE Marquette
Universal System for
Electrocardiography

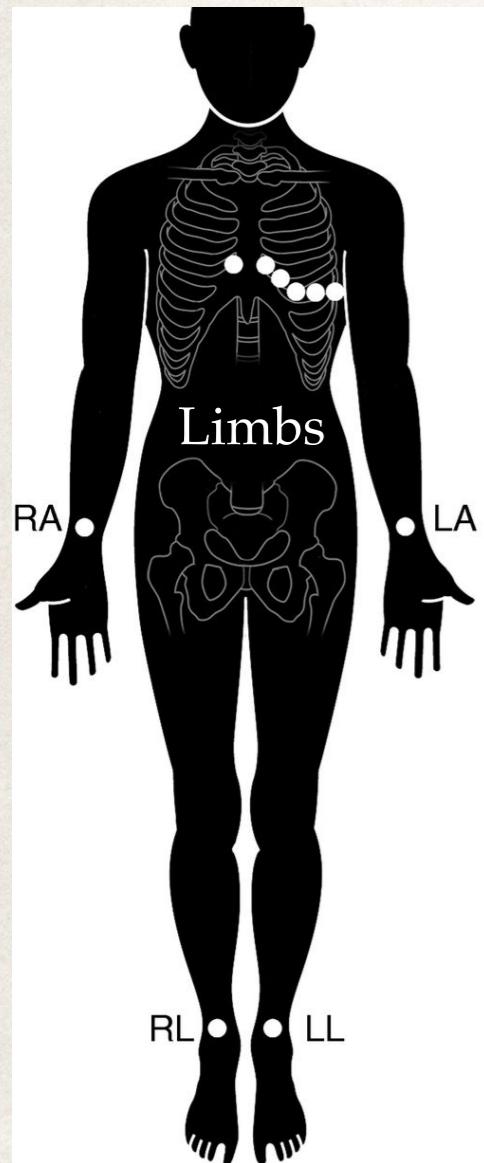
12-lead ECG (overview only)



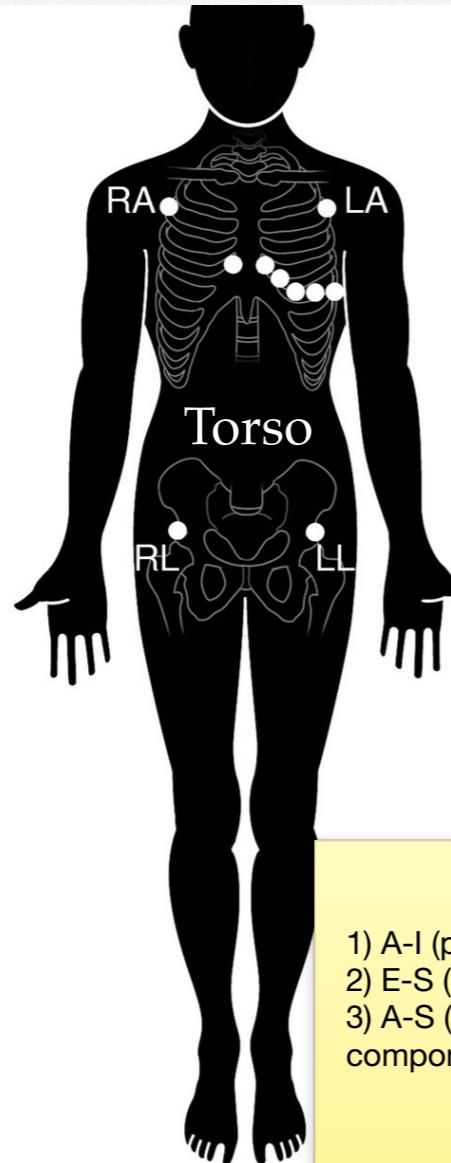
- ✿ **10 electrodes** (4 limb, 6 precordial)
- ✿ **12 views of the heart**
- ✿ **Diagnosis of:**
 - rates and arrhythmias
 - heart blocks
 - bundle branch blocks
 - enlargement/hypertrophy
 - heart failure
 - pericarditis
 - PE / tamponade
 - congenital defects
 - heart valve defects
 - Myocardial Ischemia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

Electrode Placement (12-lead)

cECG
Conventional
ECG



modified
Mason-Likar
placement



Valuable in exercise testing & ambulatory monitors

Elderly pt comfort

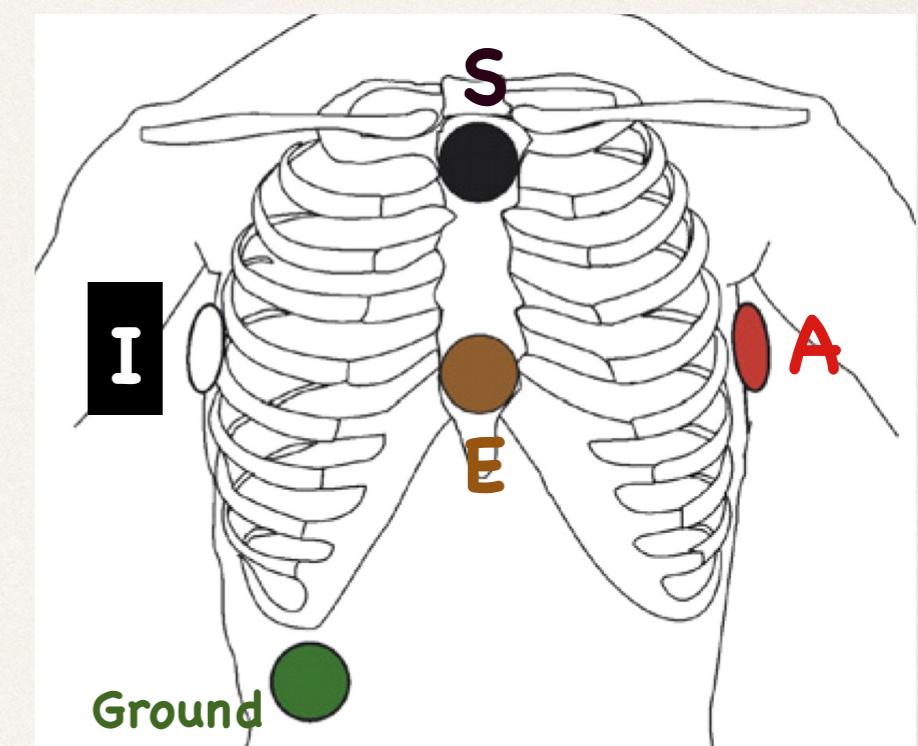
Reduced distortion from limb movement

Reduced interference from muscle potential

Provide rapid acquisition of ECGs

- 1) A-I (primarily X, or horizontal vector component)
- 2) E-S (primarily Y, or vertical vector component)
- 3) A-S (containing X, Y, plus Z, the anteroposterior component)

Dower EASI placement



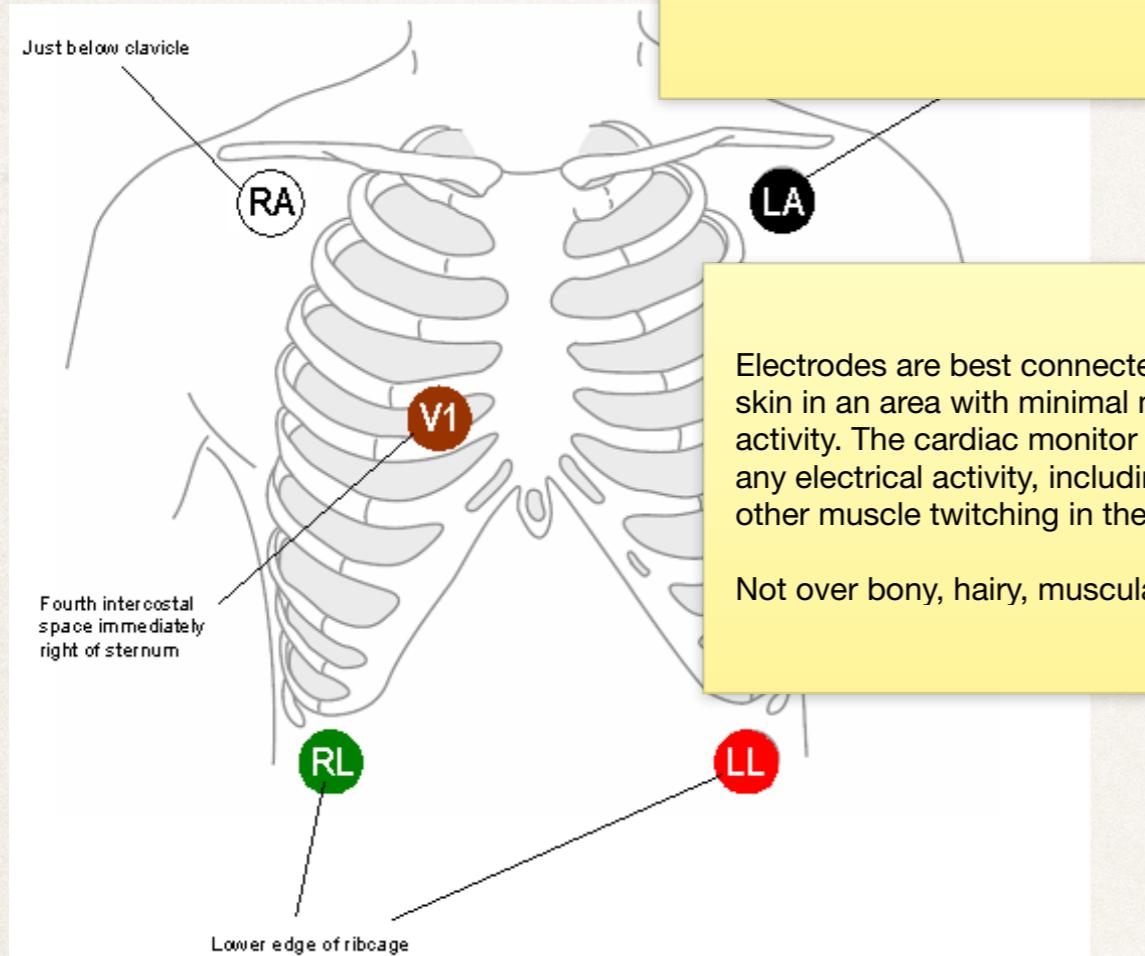
12 lead ECG using only 5 electrodes

Increased Pt mobility

Chest unencumbered - easier for imaging

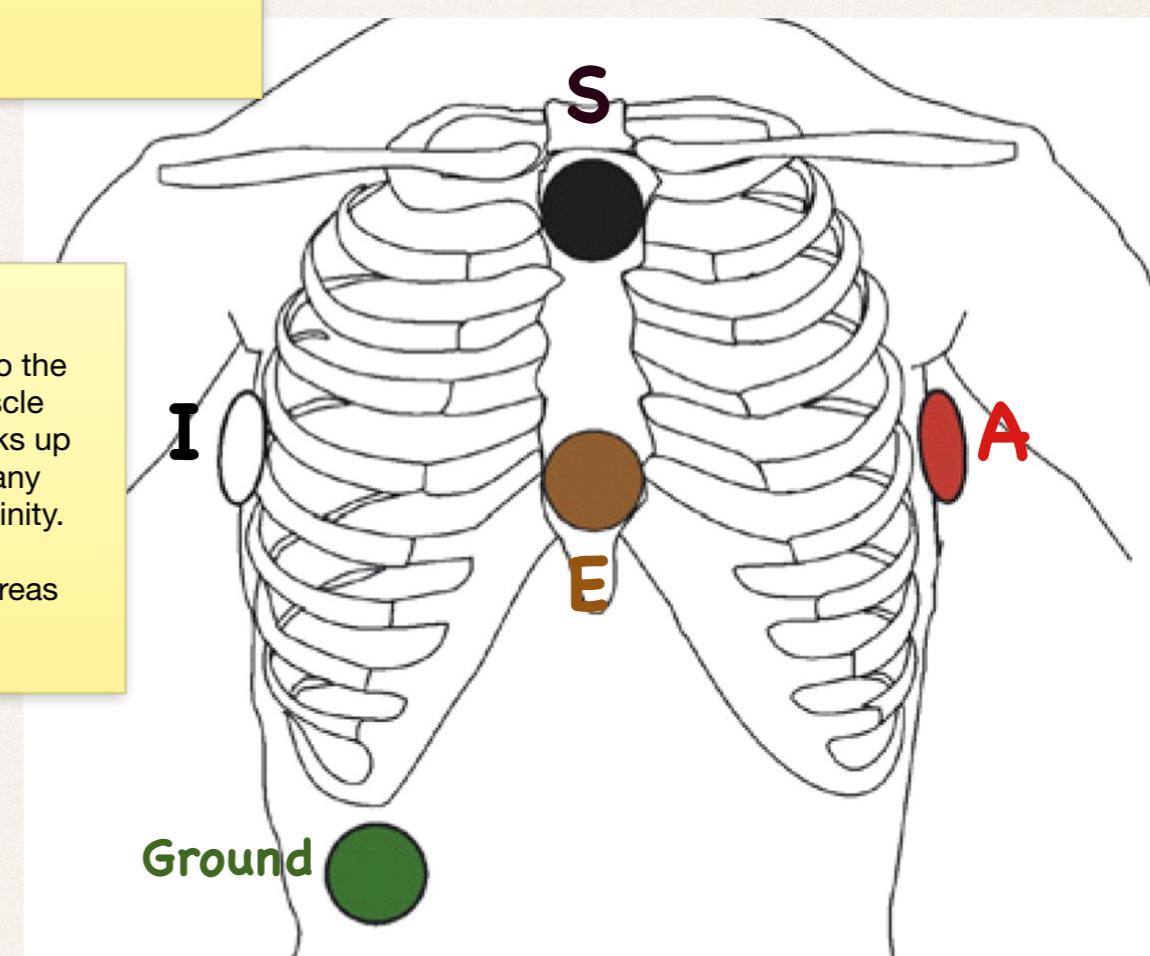
Electrode

(5-lead/tele)



Electrodes are best connected to the skin in an area with minimal muscle activity. The cardiac monitor picks up any electrical activity, including any other muscle twitching in the vicinity.

Not over bony, hairy, muscular areas



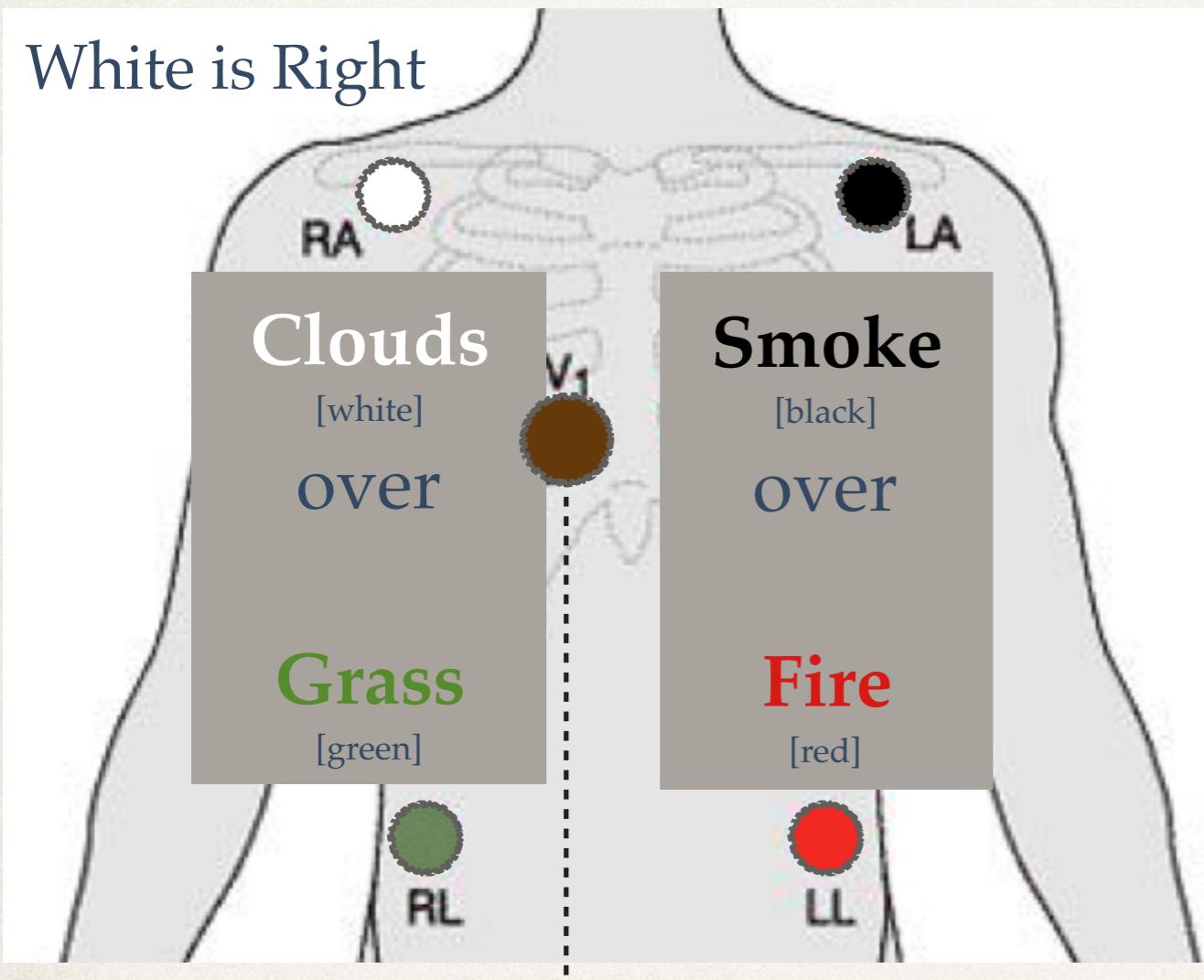
Standard

- *dysrhythmias*

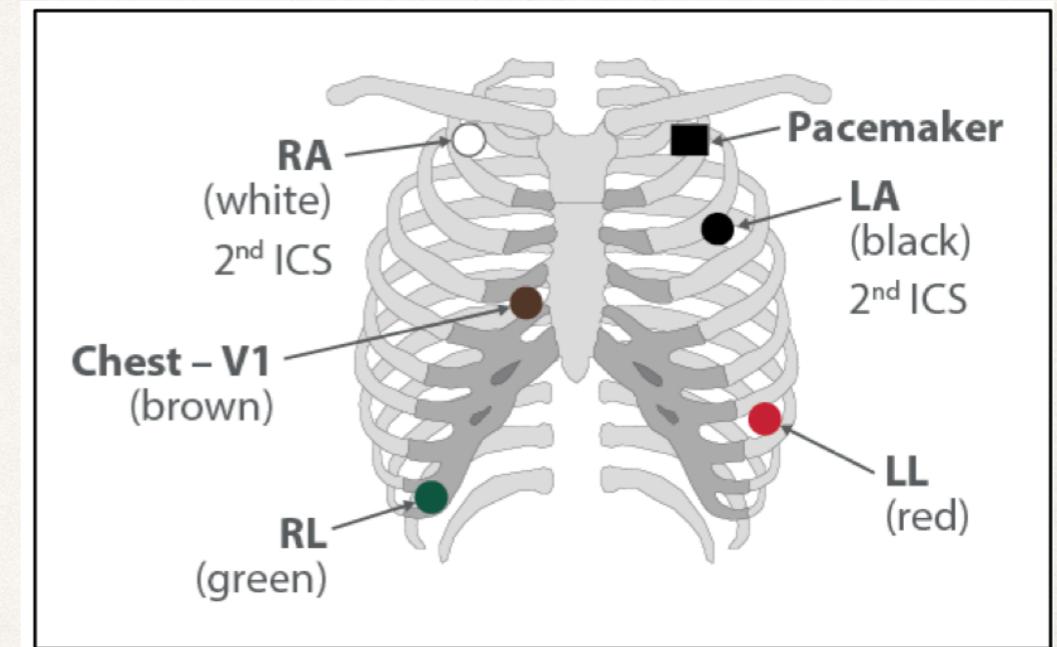
EASI

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

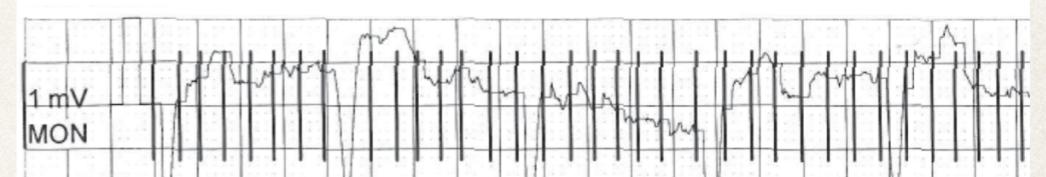
Placement Mnemonic (+Pacemaker)



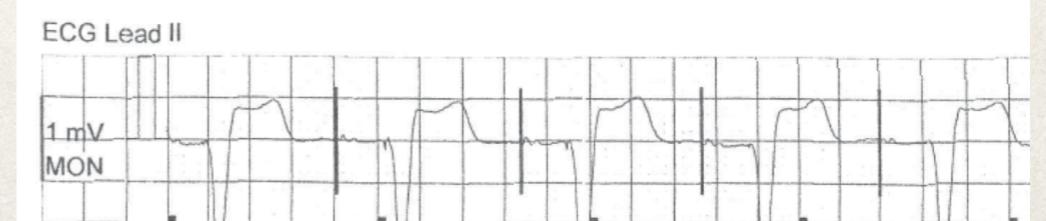
Center of the Earth
[brown]



Example of “Picket Fencing”



Corrected Lead Placement

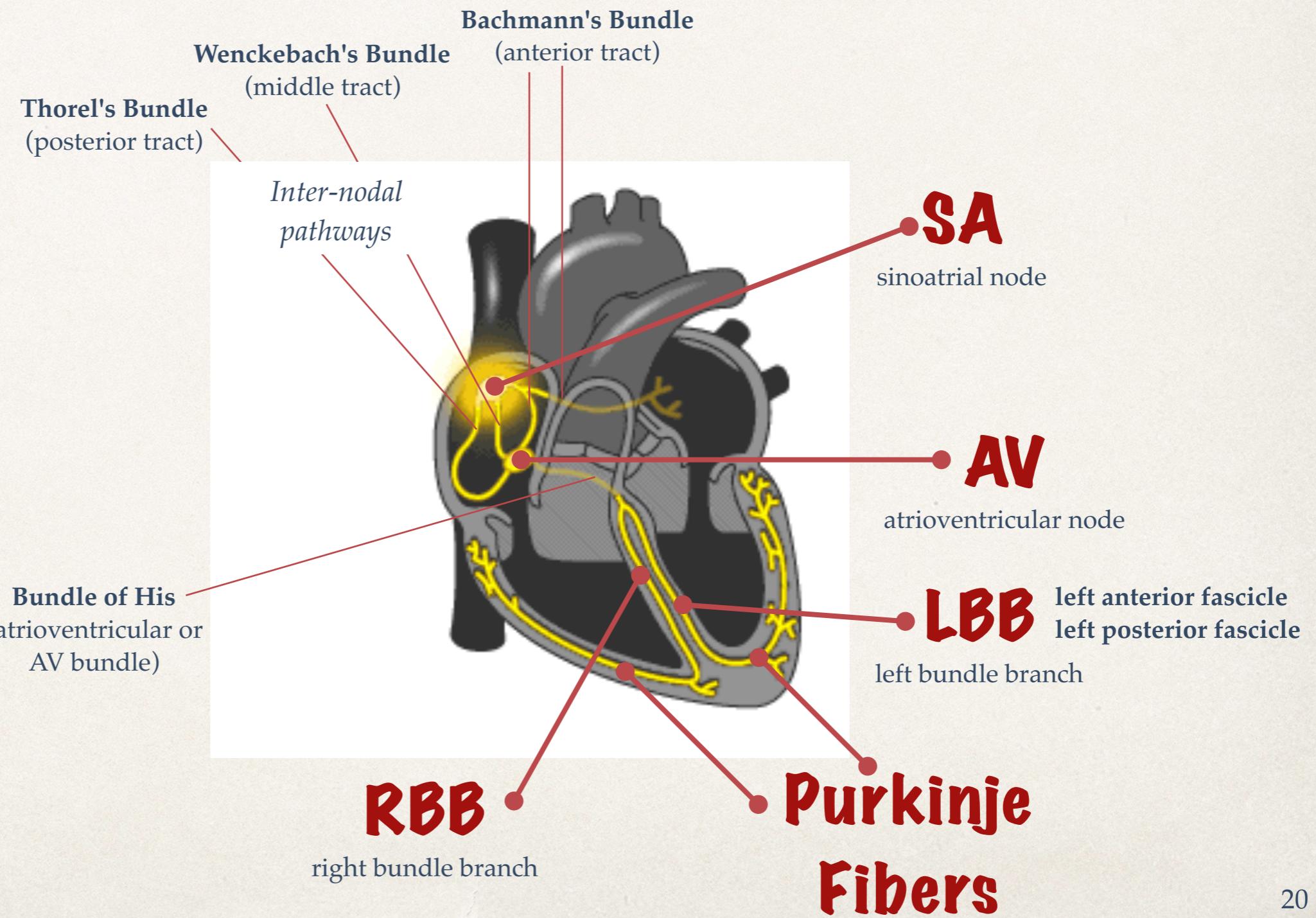


Conduction System

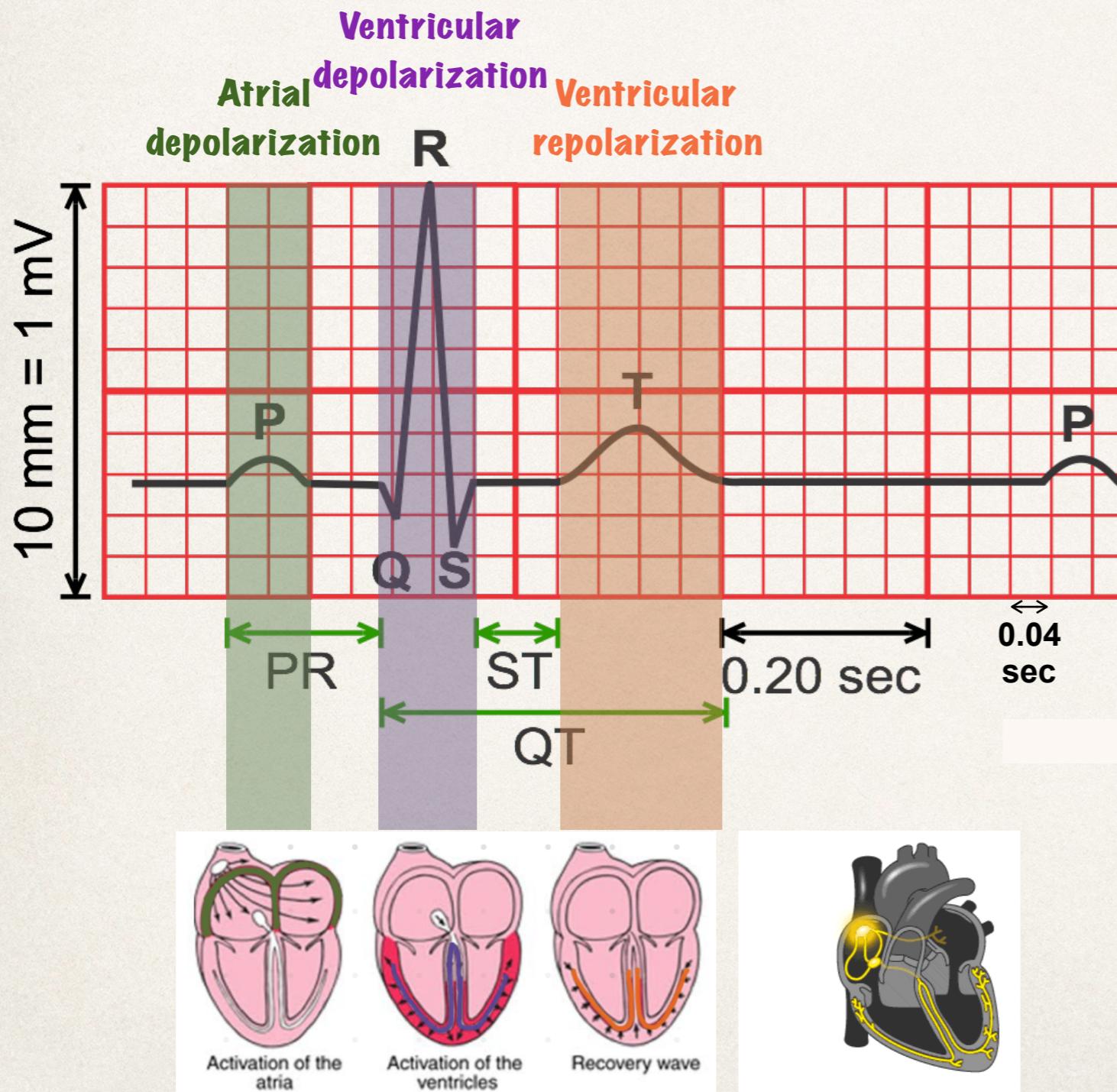
For active image, visit <https://epsavealife.org/resources/heart-concepts/>

Conduction speed through intermodal pathways 1000 mm/s

Through purkinje fibers /network is 5000 mm/s



ECG Waveforms

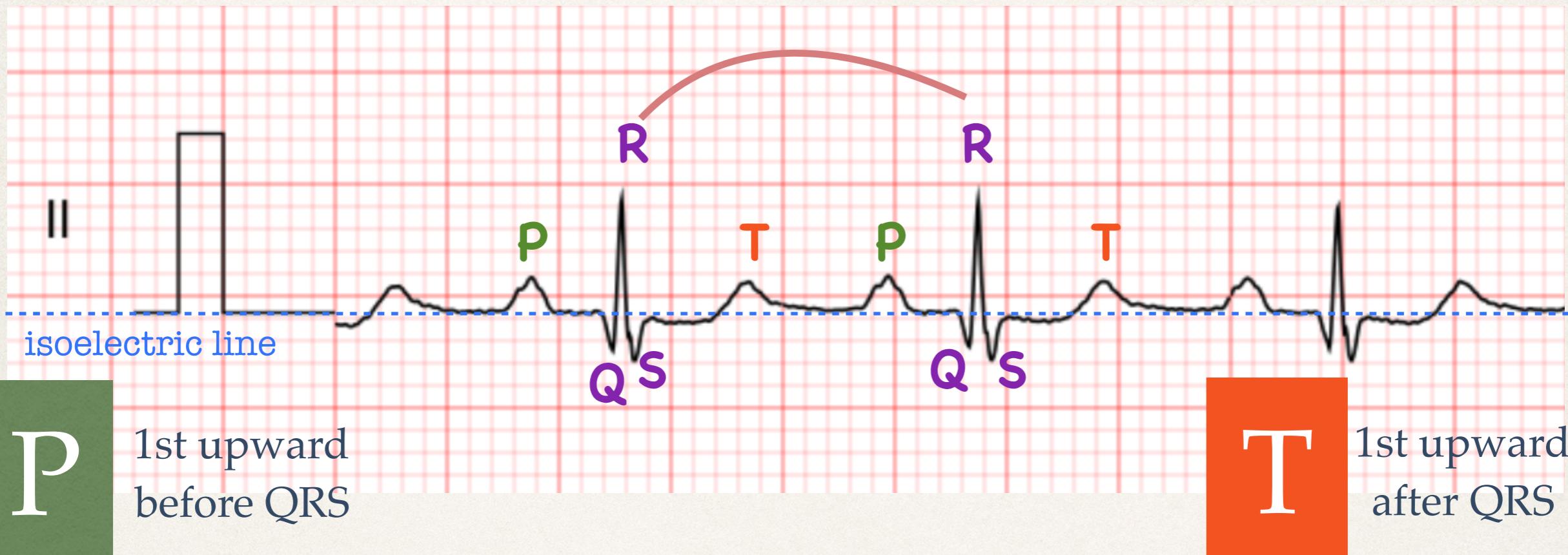


- P wave**
- precedes the QRS
 - "small bump"
 - amp: 1.5-2.5 mm
 - PR duration: 0.12-0.20 sec

- 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)

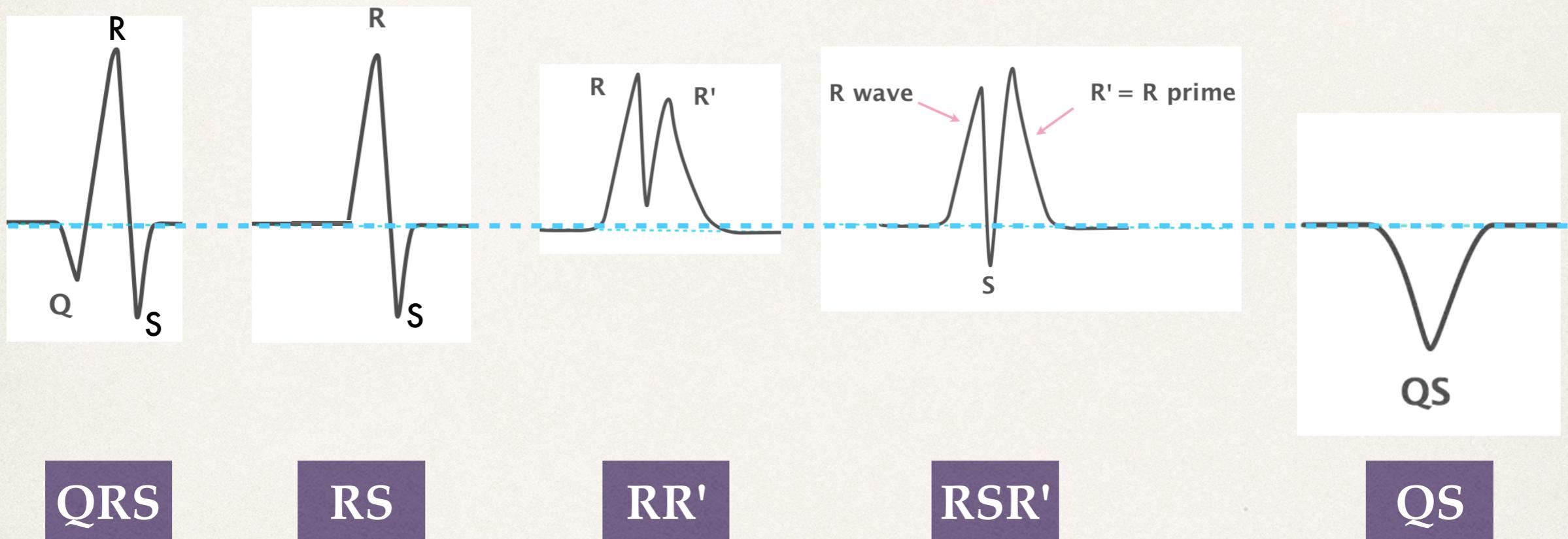


Q
1st downward

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

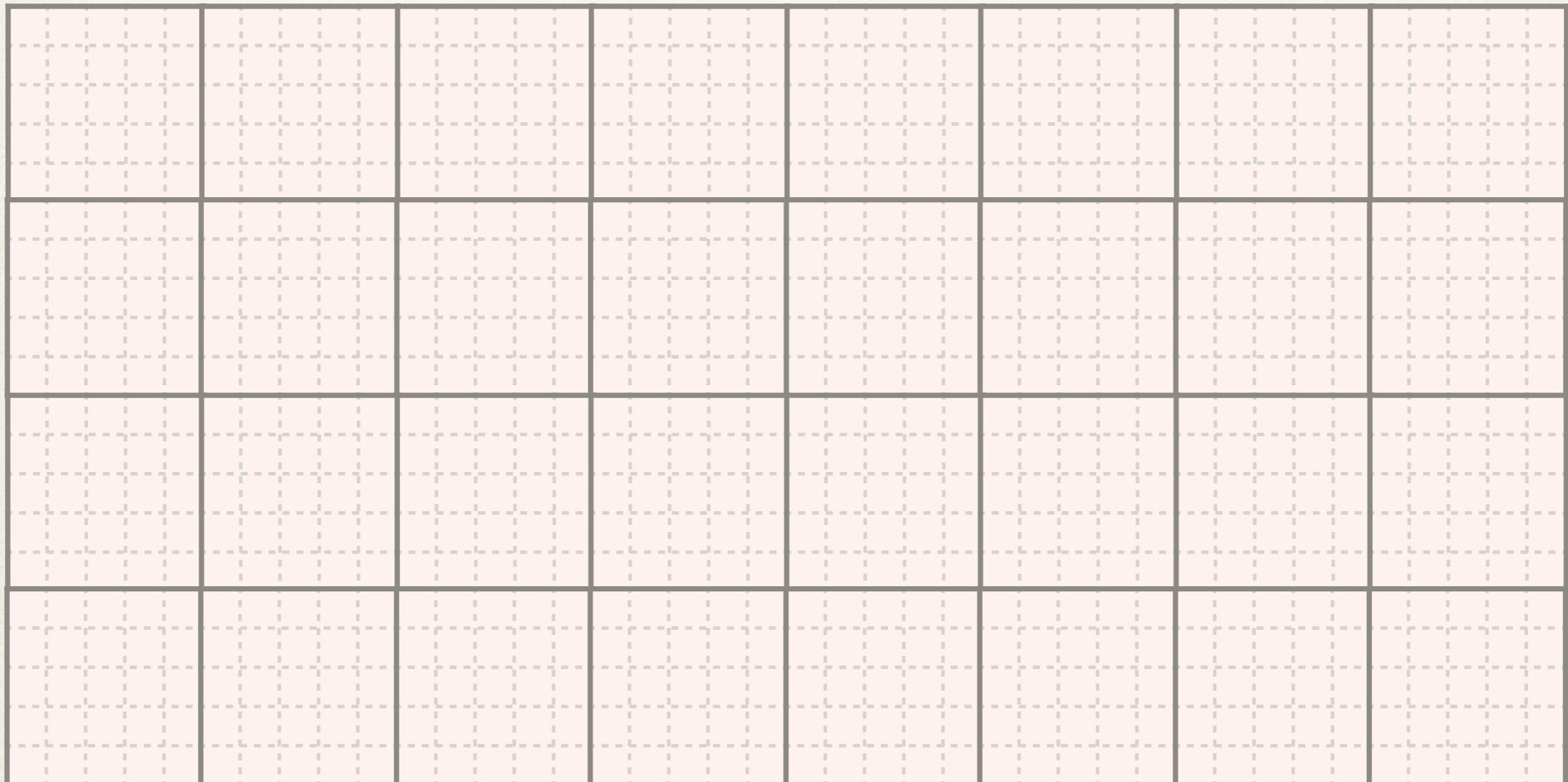
S
any downward
after R that crosses
isoelectric line

Examples:



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

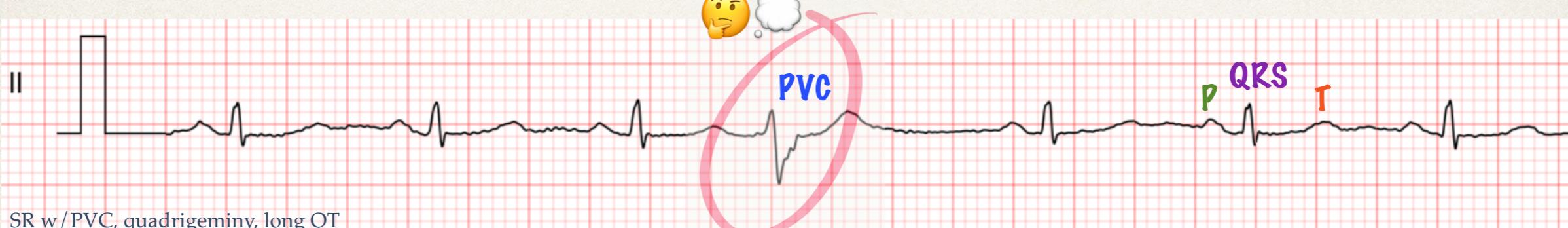
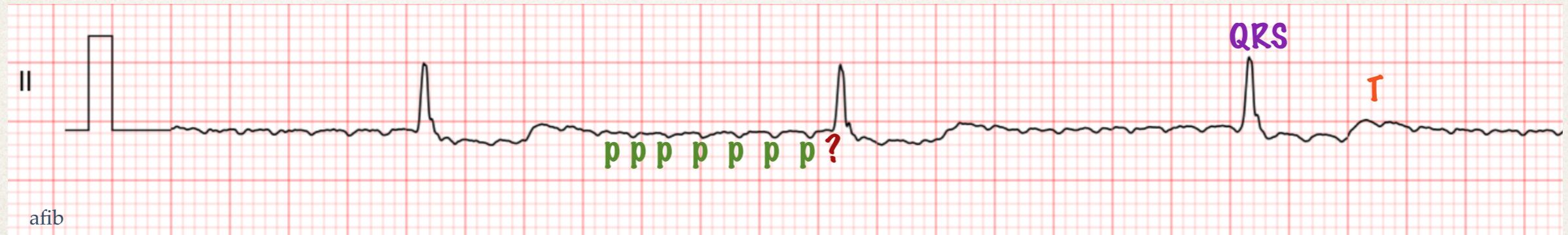
ECG tracings



Identify the waves/complexes

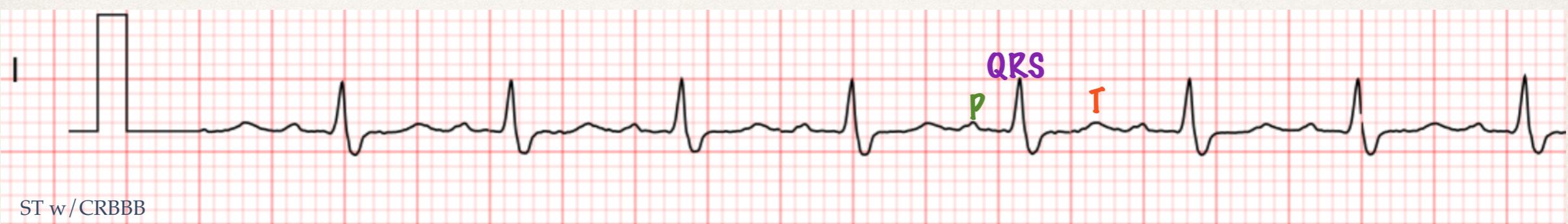


Identify the waves/complexes



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 ...

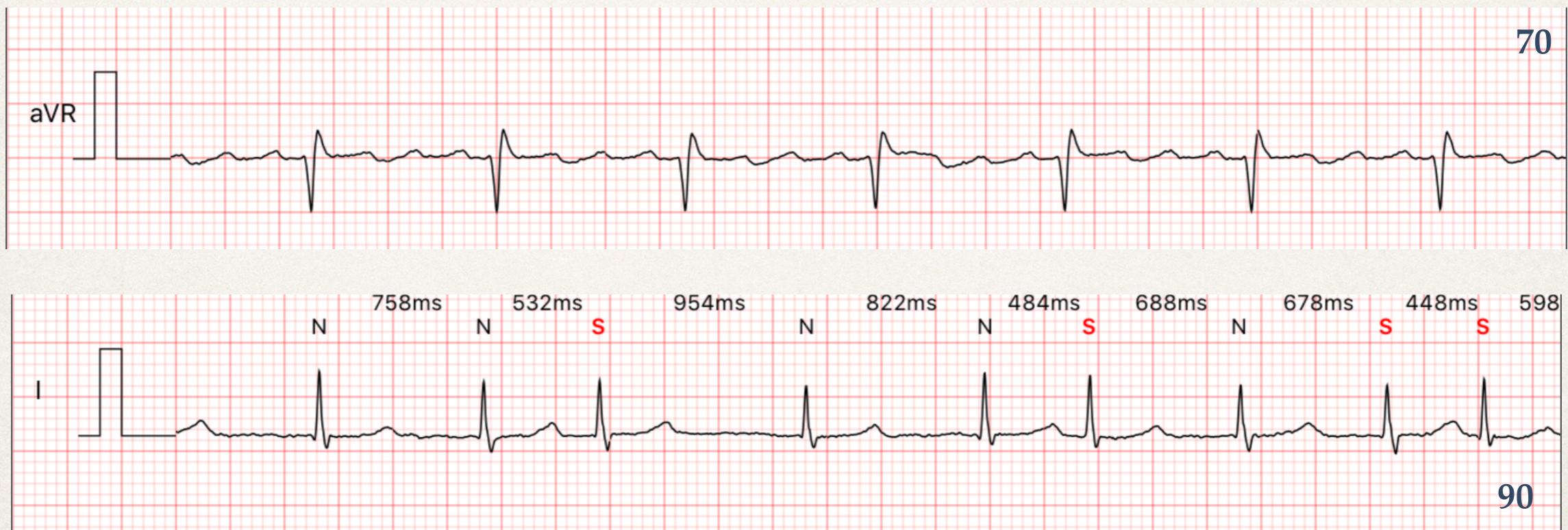


Rates



6 sec. strip x10

count the QRS complexes or
number of RR intervals



Rhythms (regular vs irregular)



Technical Problems

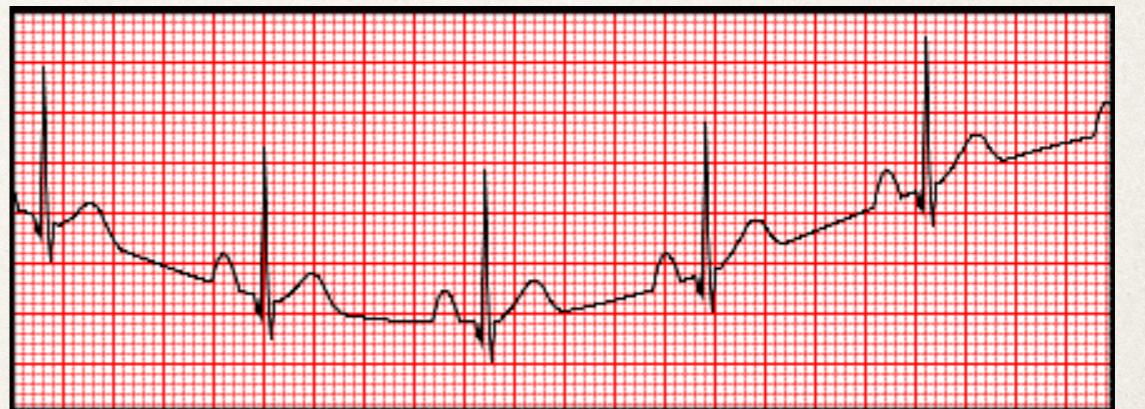
Muscle Artifact

- 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

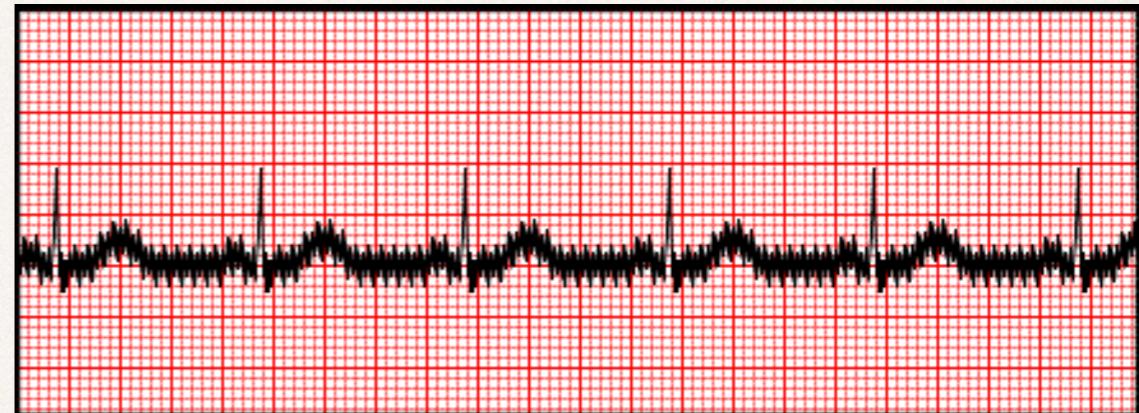
- low frequency, high amplitude artifact
- observed during deep inhalations and exhalations



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

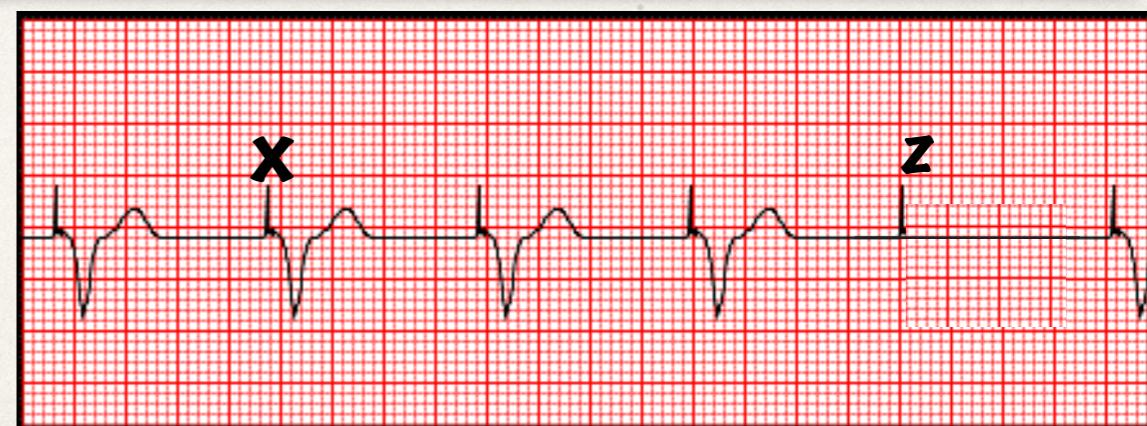


primary purpose of pacemaker is to maintain an adequate heart rate, either because the heart's natural pacemaker is not fast enough, or there is a block in the heart's electrical conduction.

ICD treat Ventricular Tachycardia and Ventricular Fibrillation. ICDs are a separate category and usually not considered pacemakers although they do have a pacing function.

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)



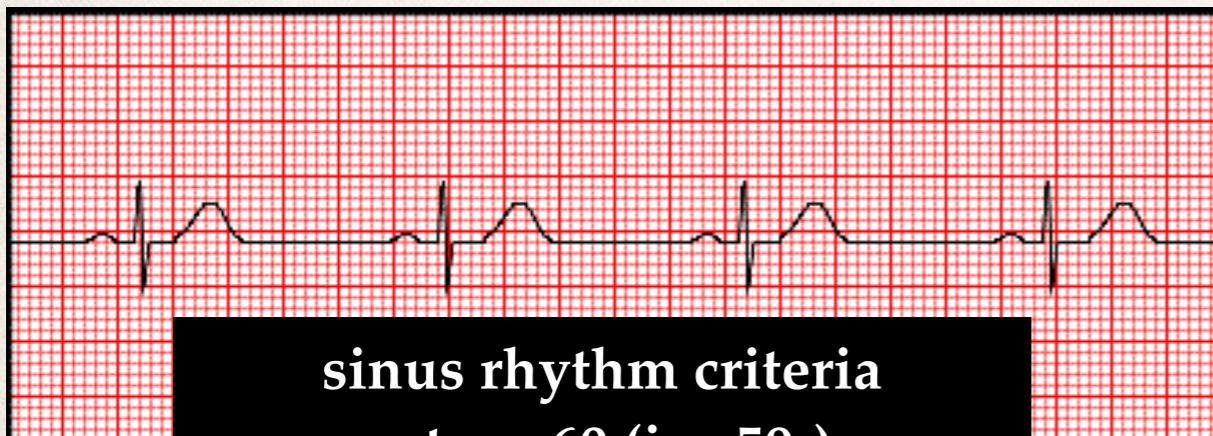
"normal" only if 60-100
normal PR-QRS intervals

Sinus Tachycardia (ST) >100 bpm



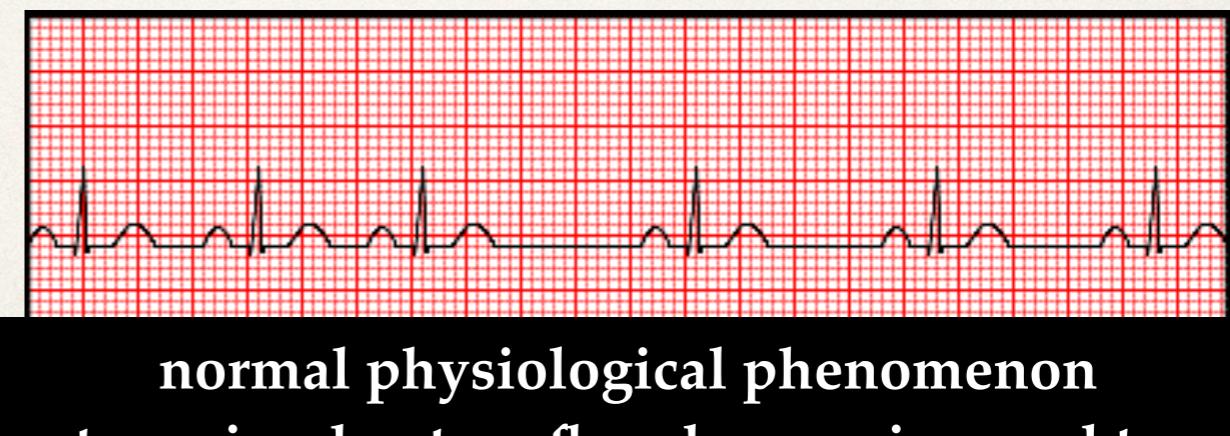
sinus rhythm criteria
rates >100 (i.e. 101+)

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



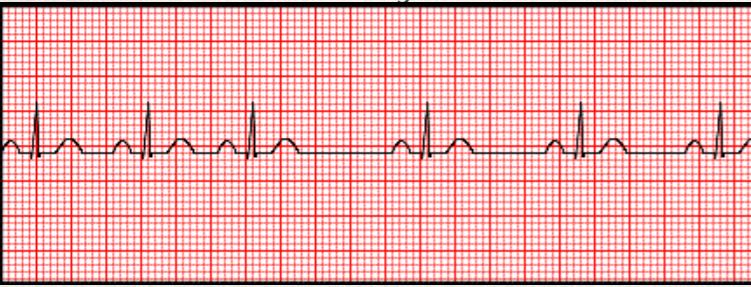
Sinus Tachycardia (ST)



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.

heart rate increase of 30 beats per minute (bpm) or more, or over 120 bpm, within the first 10 minutes of standing, in the absence of orthostatic hypotension, Dx via TT or VS in supine,

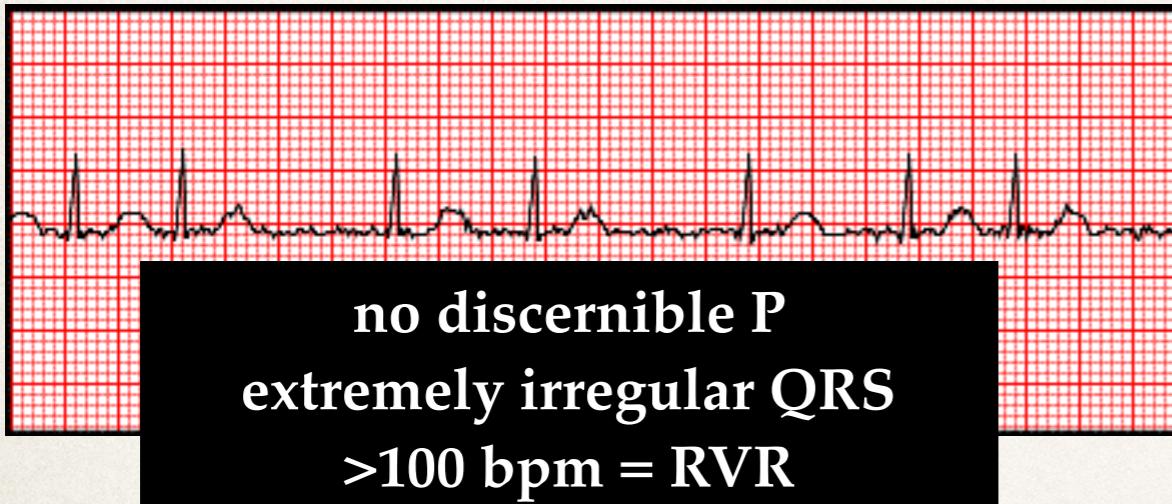
Atrial Rhythms

Without rapid ventricular response, fibrillation and flutter are usually not classified as SVT

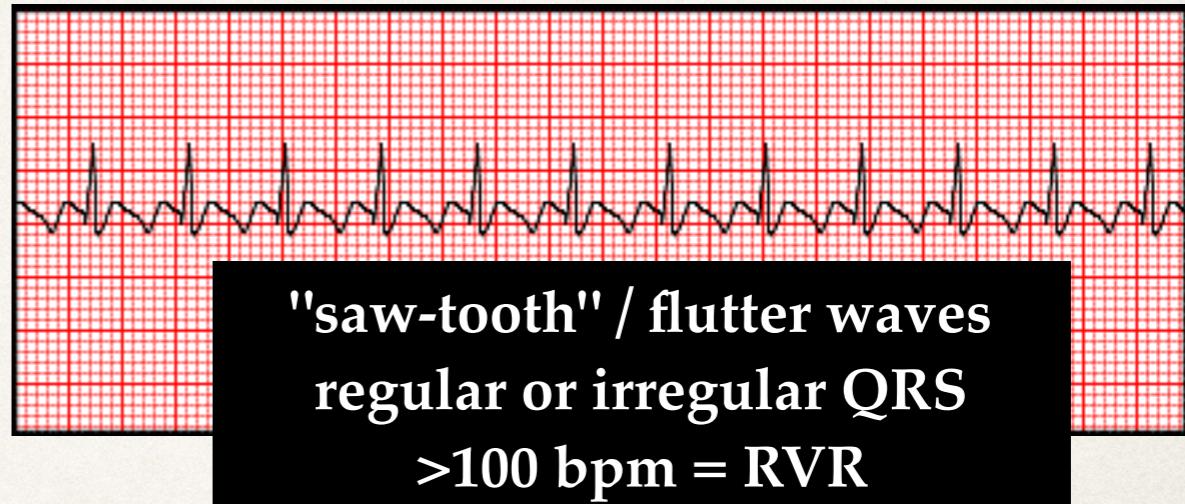
Odd "p"
usually narrow QRS
(QRS duration <0.12)
may have WCTs

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

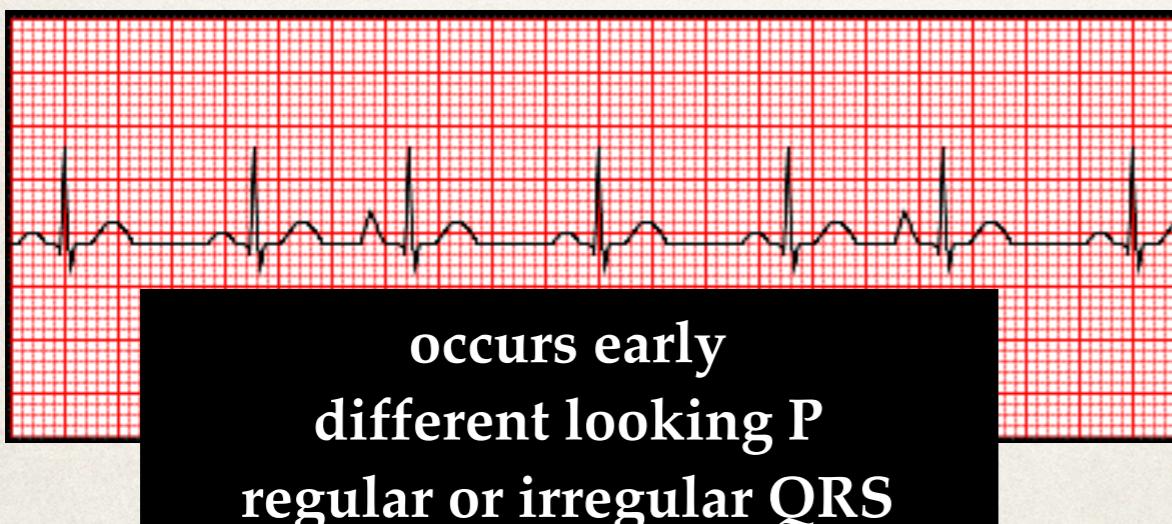
Atrial Fibrillation (afib / AF)



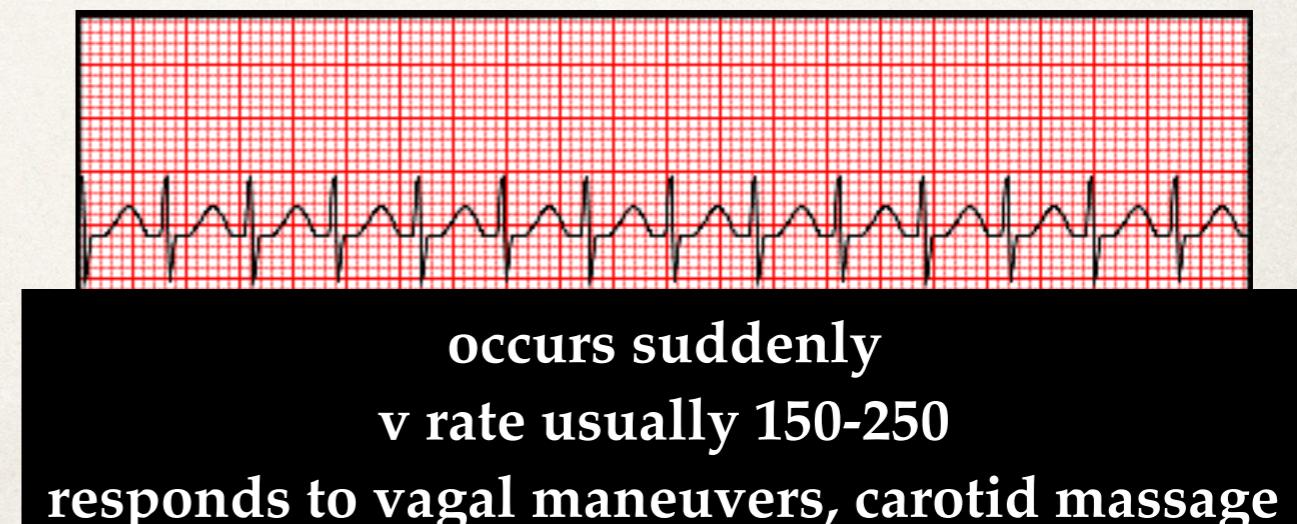
Atrial Flutter (a-flutter / AFL)



Premature Atrial Complex (PAC)



Paroxysmal SVT



Atrial Fibrillation (afib / AF)



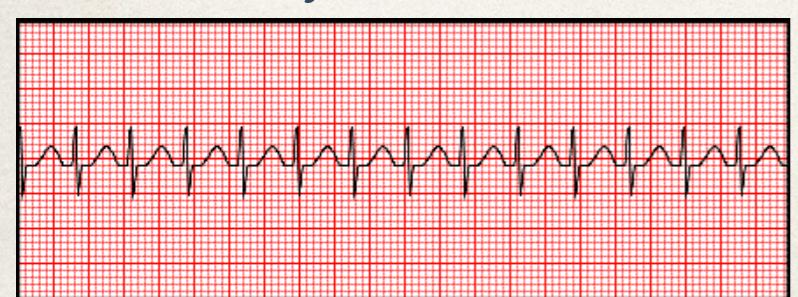
Atrial Flutter (a-flutter)



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 > 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">1. re-entry (SNRT, AVNRT, JRT, WPW)2. automaticity (EAT, MAT, AF, AFL)	<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!

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

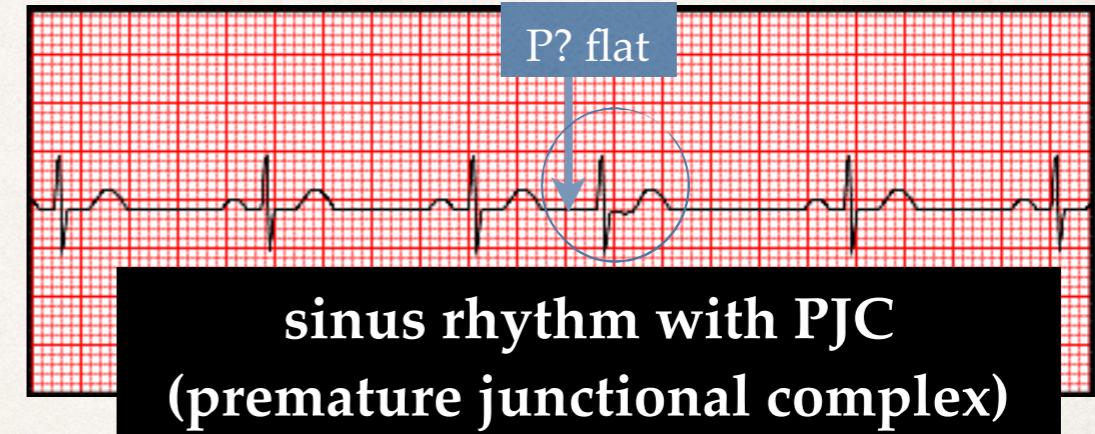
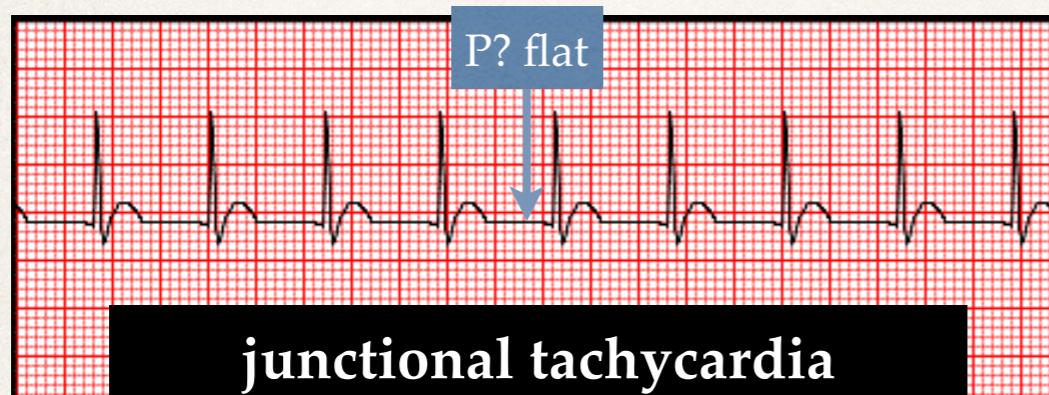
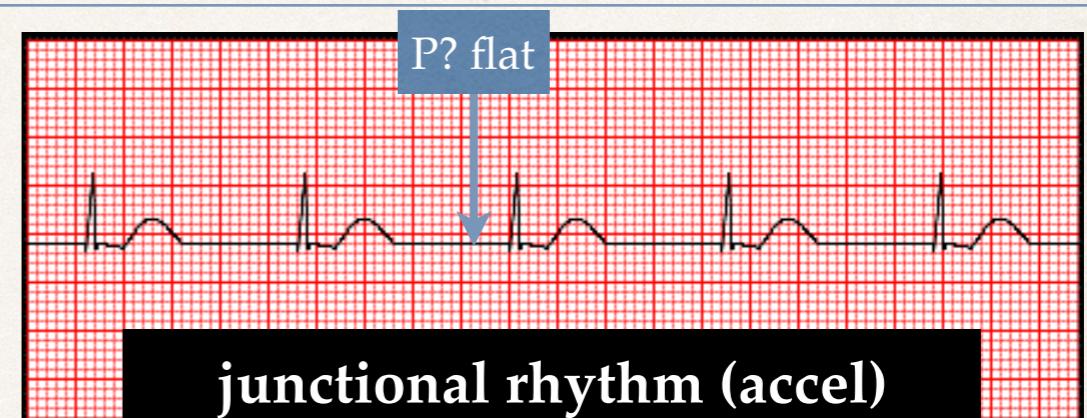
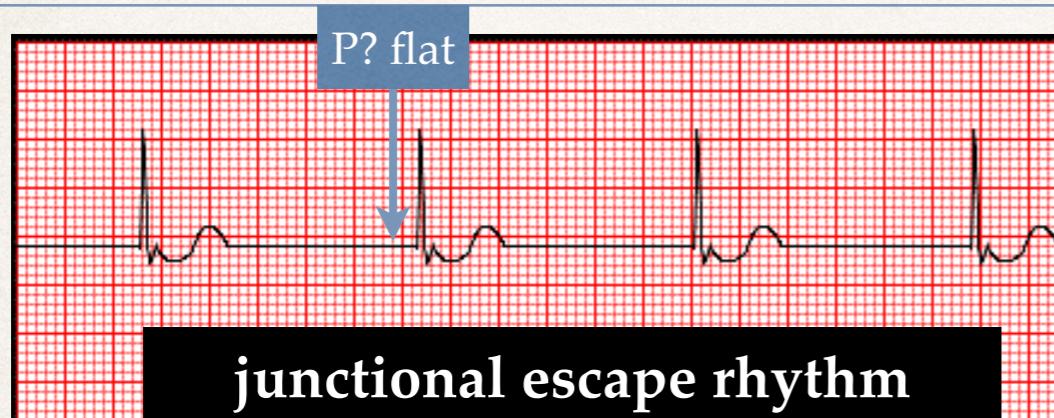
Junctional Rhythms

inverted or no p waves

rate is 40-60

usually narrow QRS

(because normal conduction pathway
through ventricles)

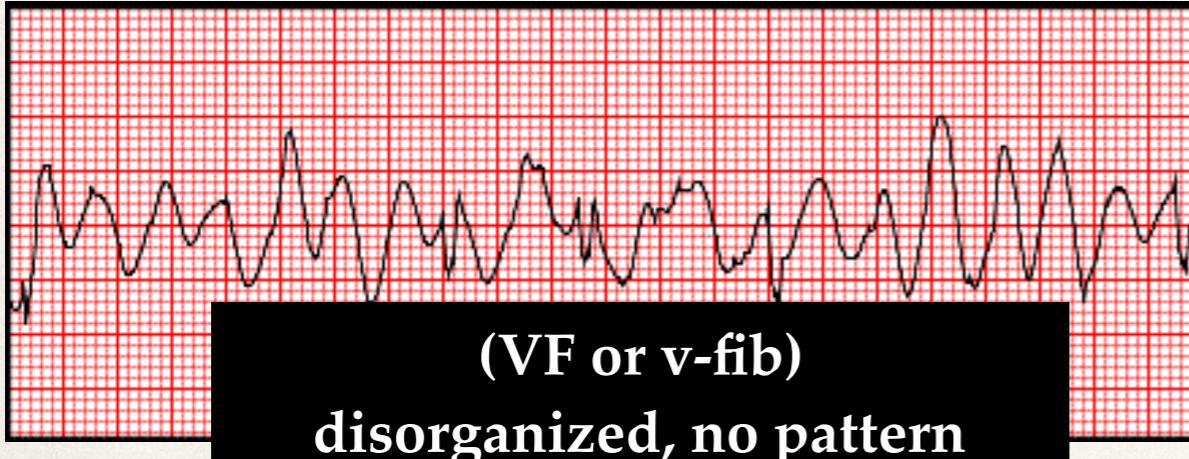


- ✿ "back up intrinsic pacemaker"
- ✿ usually no P wave (SA not active)
- ✿ may or may not have retrograde P

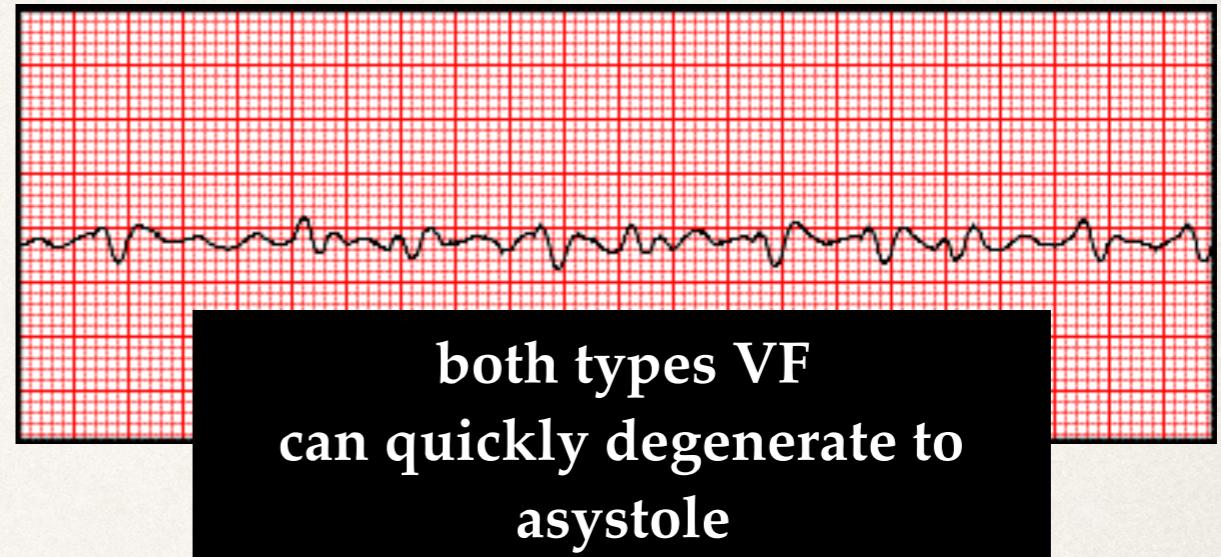
Ventricular Rhythms

wide QRS
(QRS duration >0.12)
needs immediate care

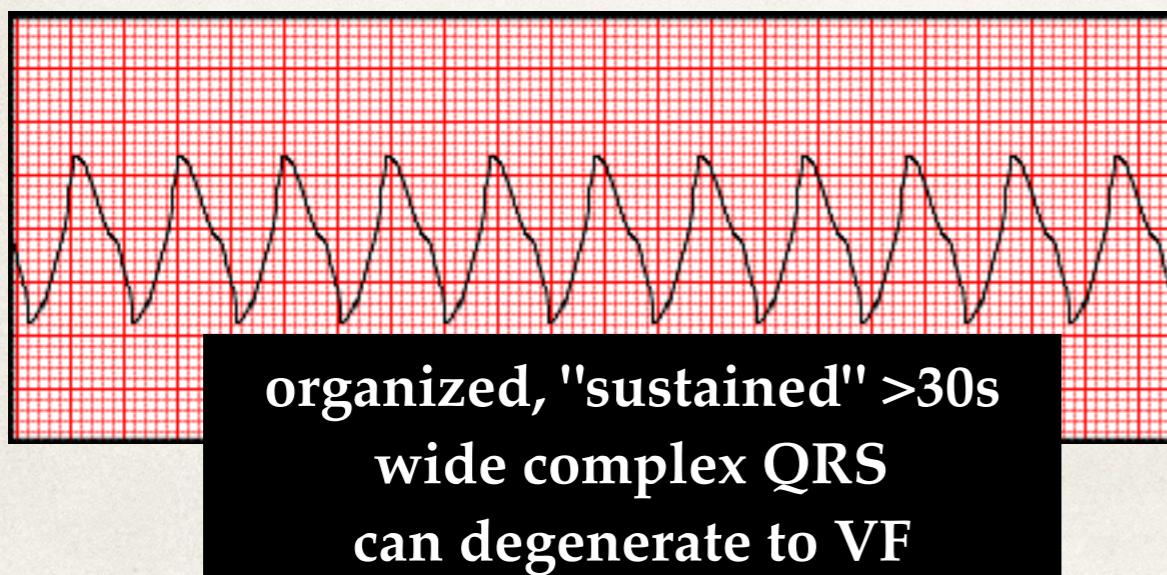
Ventricular Fibrillation (coarse)



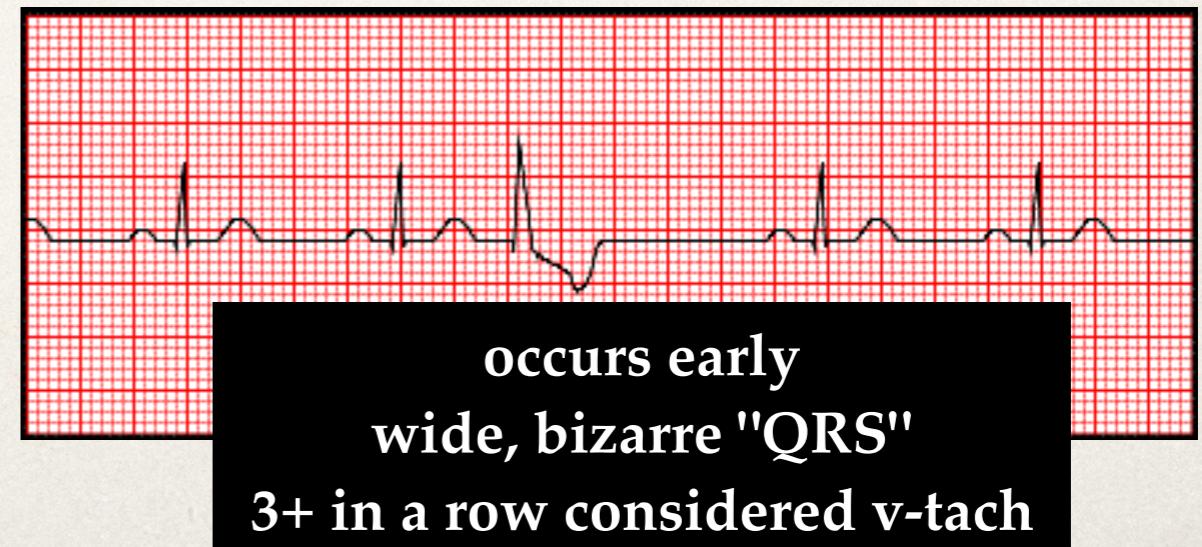
Ventricular Fibrillation (fine)



Ventricular Tachycardia



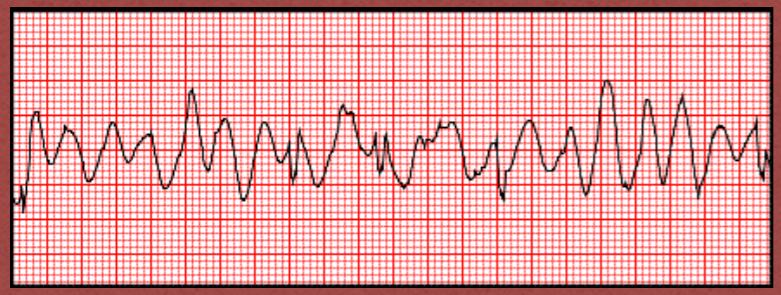
Premature Ventricular Complex (PVC)



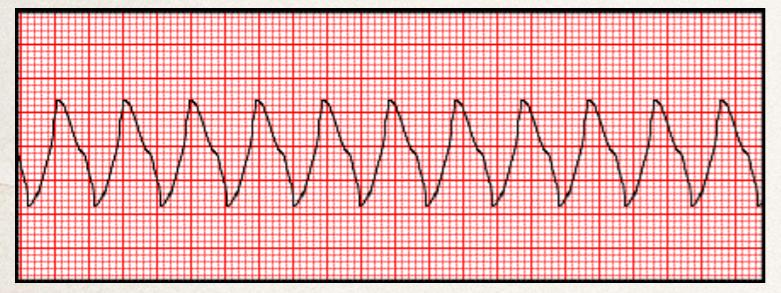
Ventricular Fibrillation (fine)



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.**

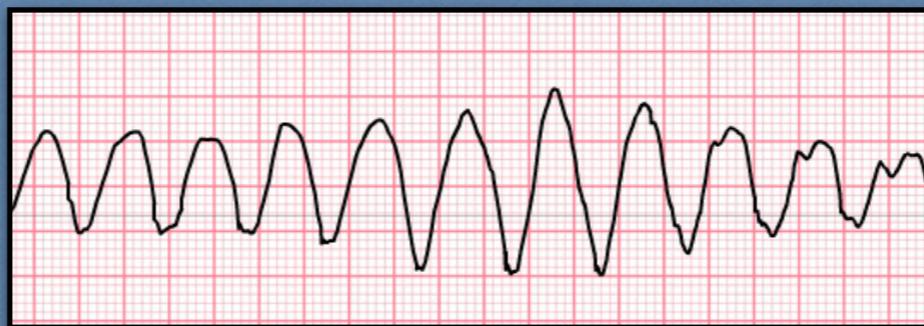
Pt: "baseball hitting the back or chest"

Handler/CG: "tingle" or "static shock"

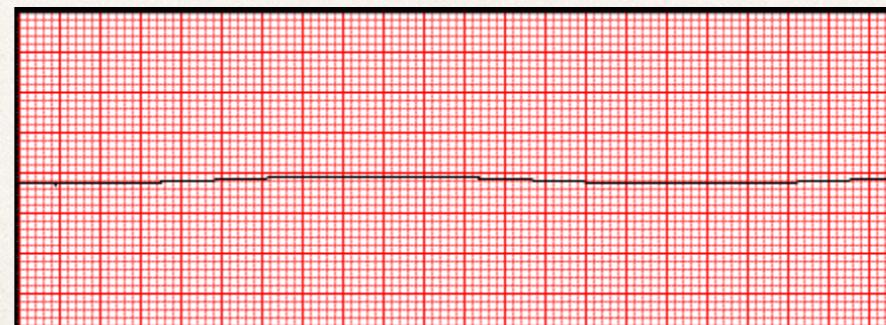
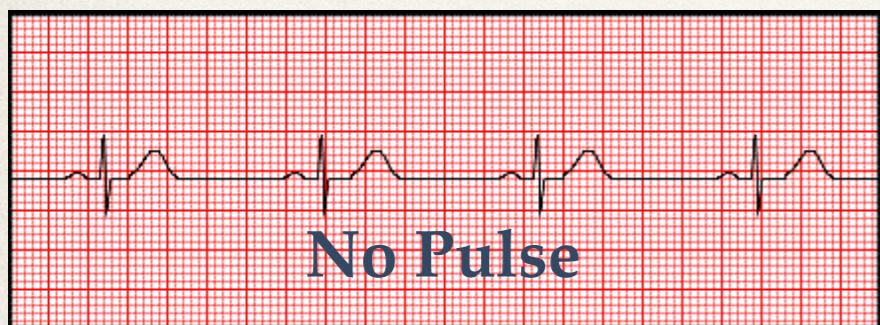
according to morphology, duration (sustained >30 secs), symptomatic/pulseless	Pt may be asymptomatic. Regardless, need immediate cardioversion	TX: Synchronized CARDIOVERSION (with pulse) if no pulse, defib as VT may lead to ventricular fibrillation, asystole, and sudden death
Be concerned if 30% of complexes 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	"R on T" phenomenon can trigger VTach May have CO compromise (I.e, ventricular Bigeminy where rate is 70 but actual PR / beats could be 35

- ❖ Unresponsive
- ❖ Pulseless

BEGIN CPR 30:2



SHOCKABLE
defibrillate



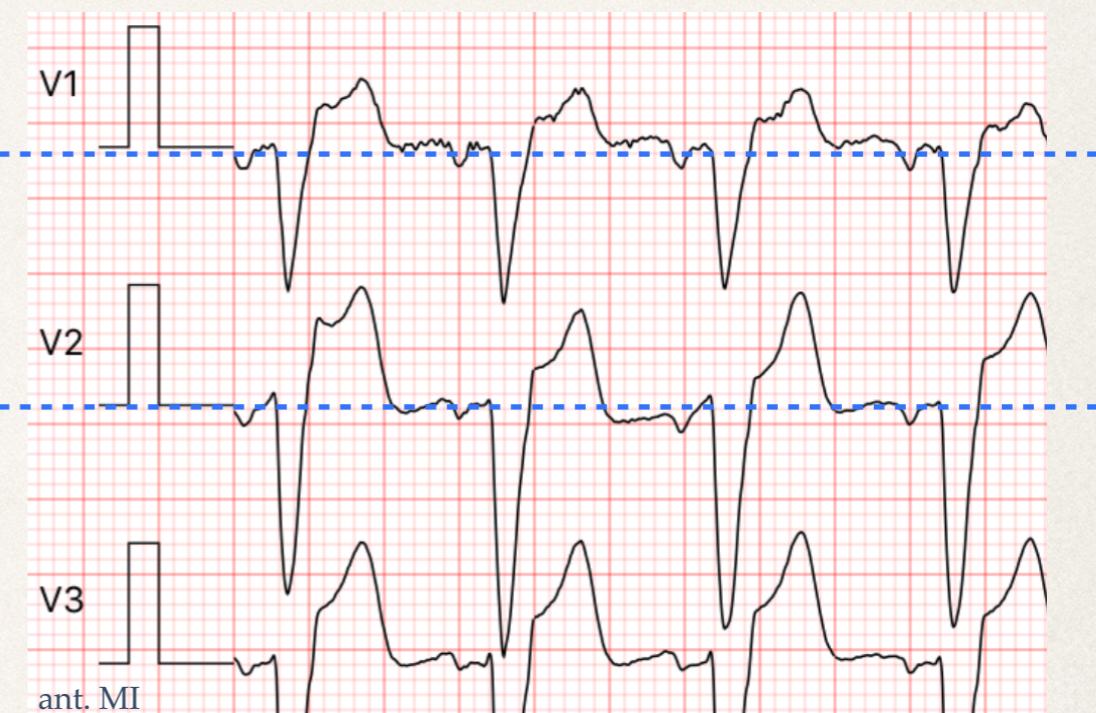
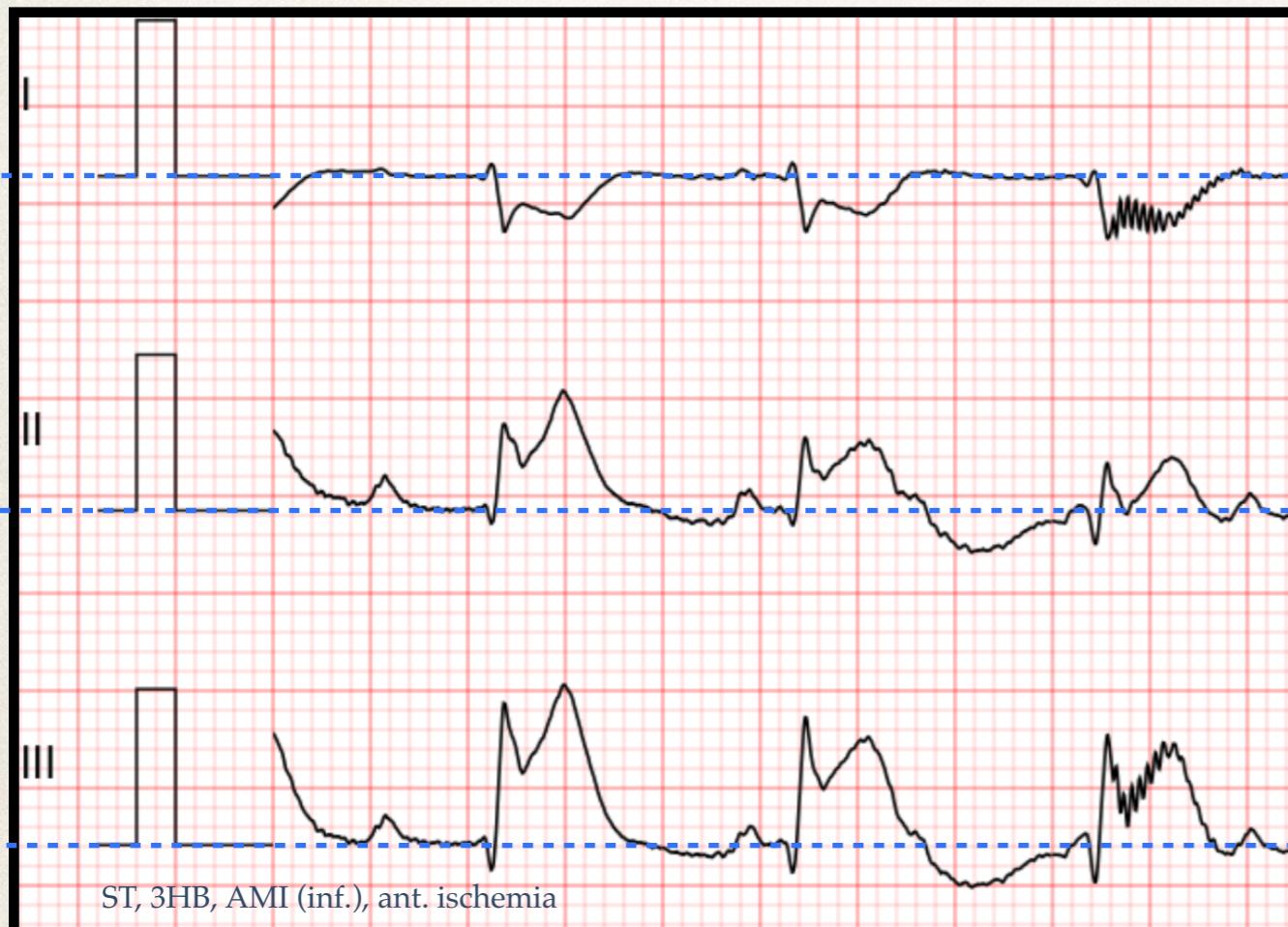
High Quality
CPR 30:2

Practice!

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

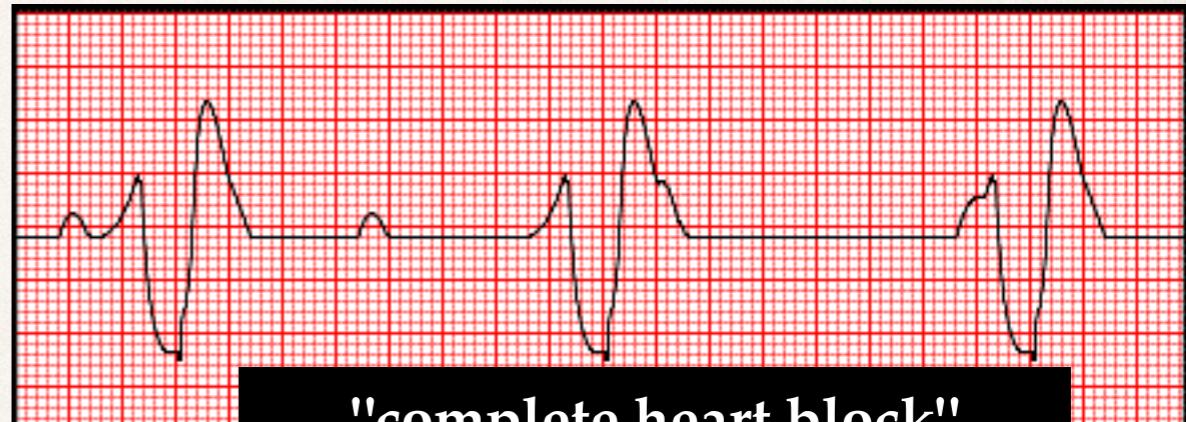
Heart Blocks (Conduction blocks)

1st degree AV block



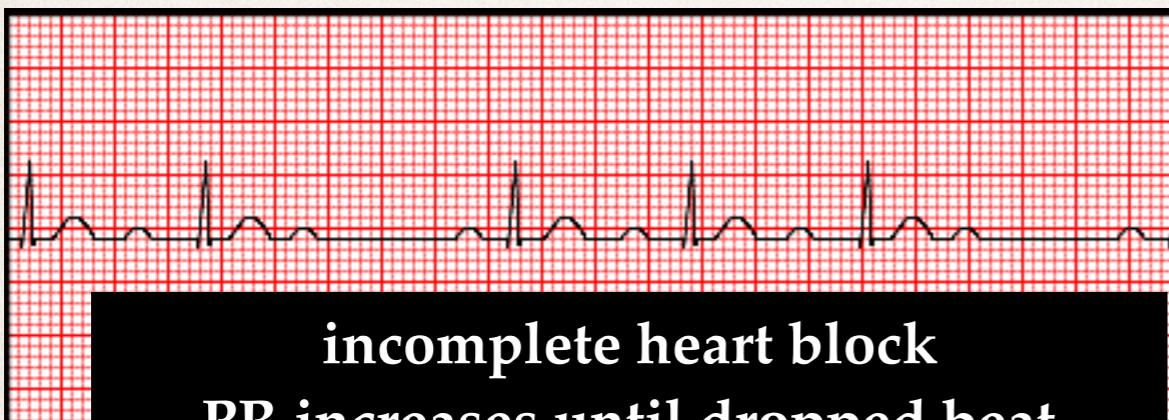
PR >0.2
no hemodynamic disturbance

3rd degree (complete) AV block



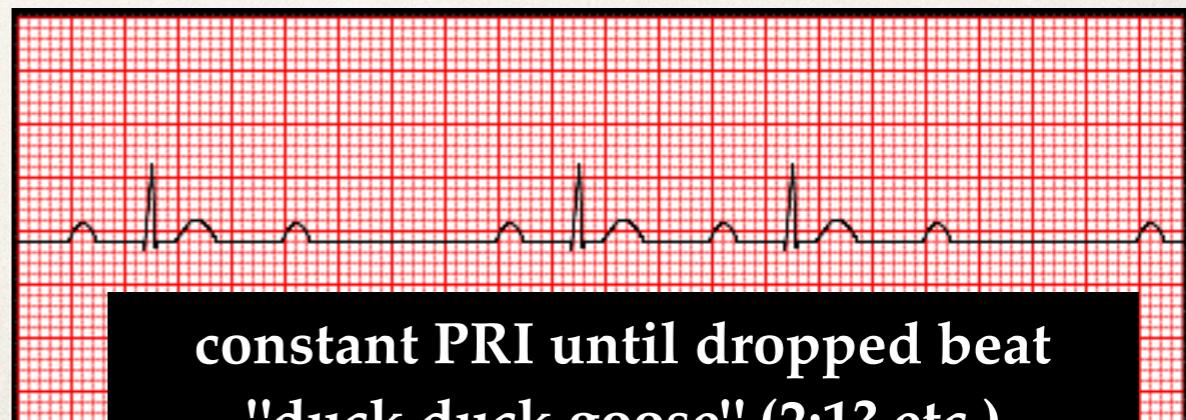
"complete heart block"
atria & ventricles divorced

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

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



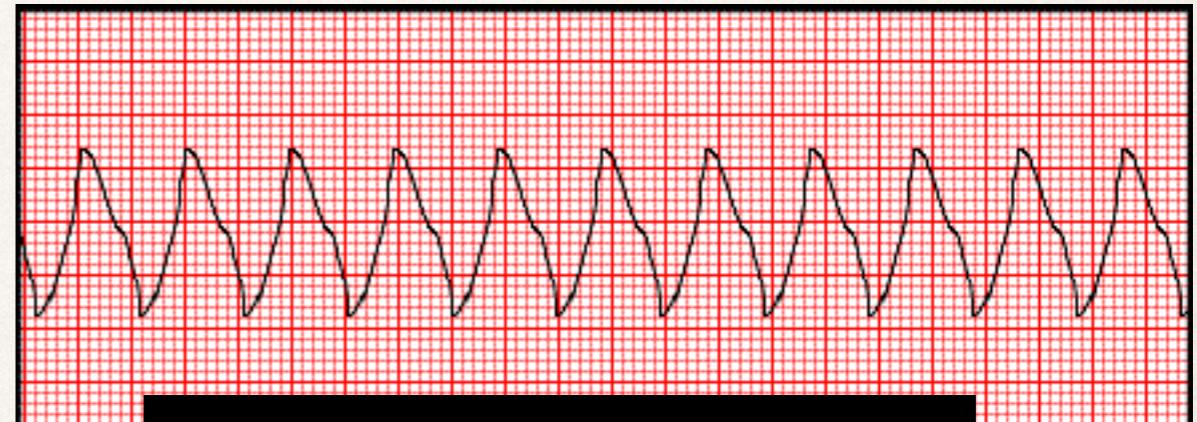
May be seen in: Inferior MI, AV nodal blocking drugs, progression of Type II blocks

TX: Urgent Pacing, Pacemaker Placement

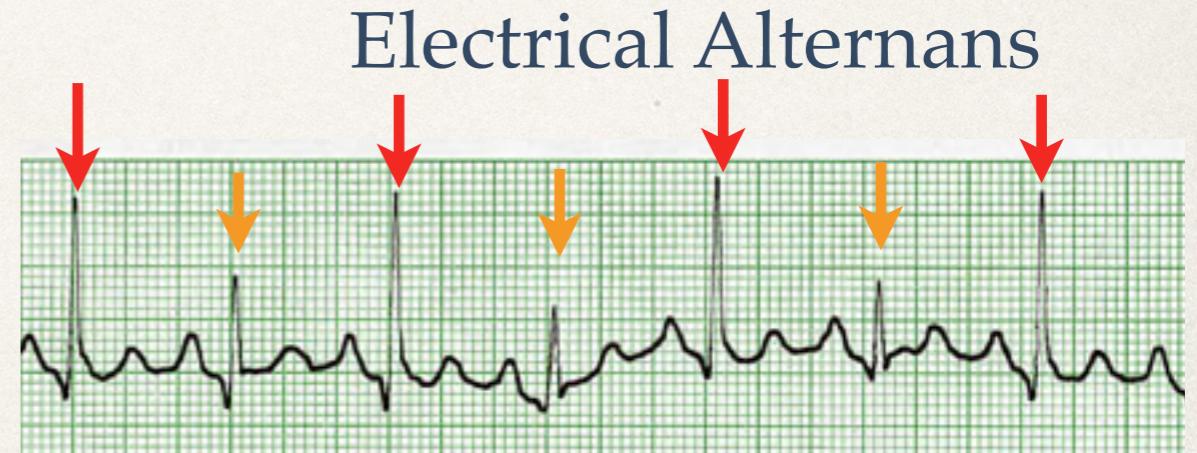
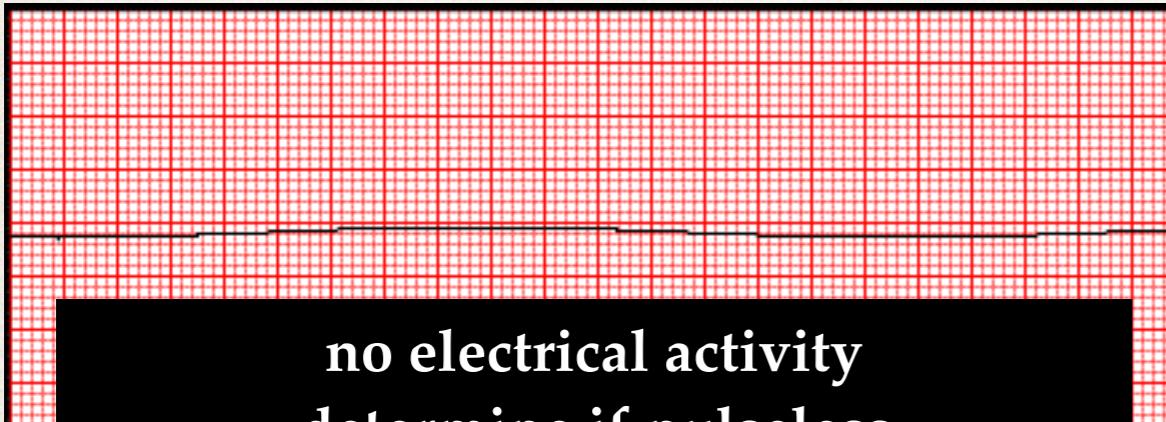
**•SYNCOPE (self-terminating)
•SUDDEN CARDIAC DEATH (prolonged)**

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!

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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