Introduction to Danger Squiggles:
Basic EKG Interpretation

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Objectives

- Historical origins of the EKG
- Anatomy and physiology
- The EKG and lead placement
- The cardiac cycle
- Rate and calculating rate
- Sinus rhythm and a few important arrhythmias

History of the EKG

- 1790 - Galvani completes an electrical circuit using metal and a frog leg stimulating muscle movement

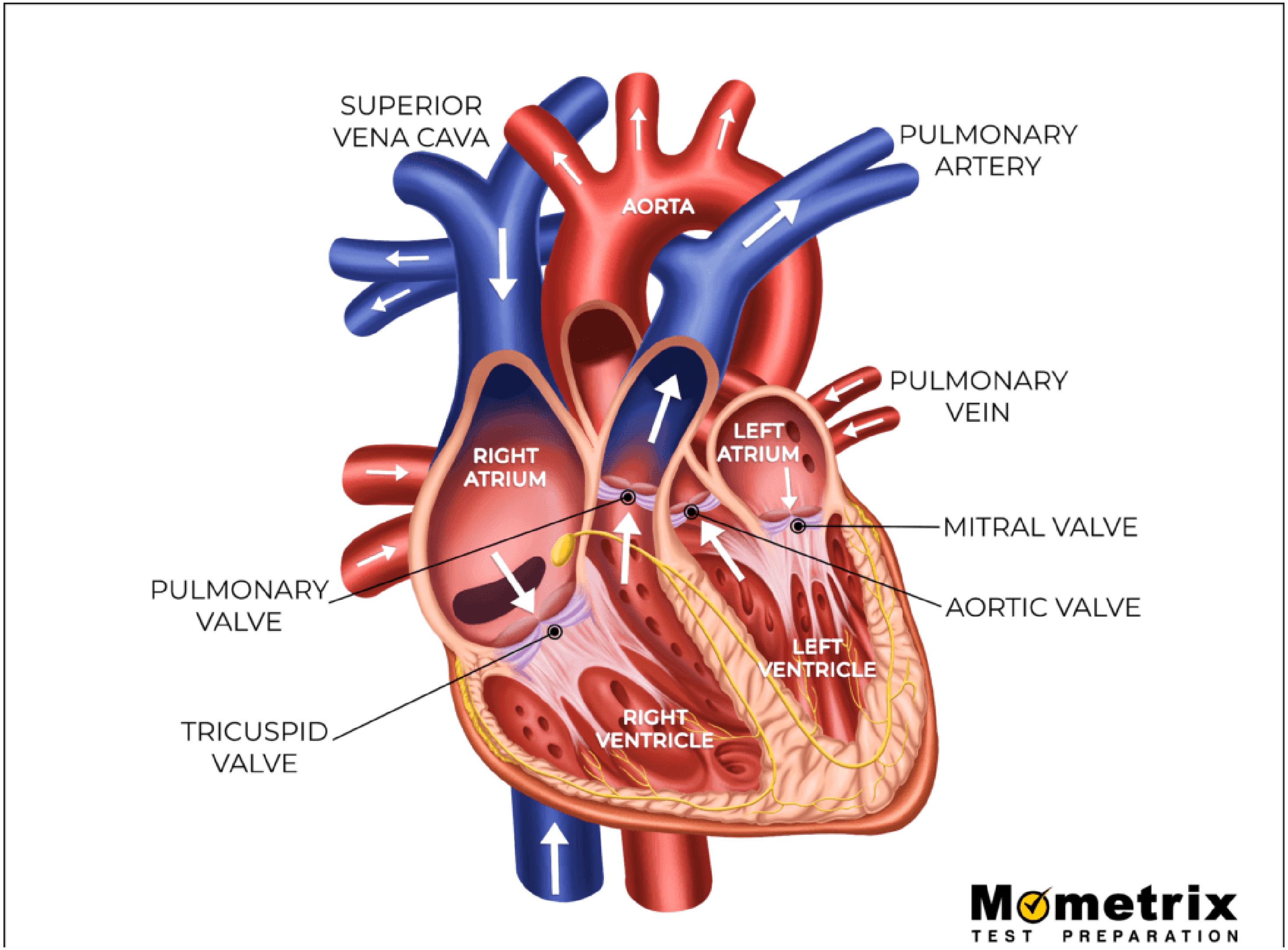
- 1855 - Kollicker and Mueller lay a motor nerve over an actively beating frog heart and the frog leg kicks

- Mid 1880's - Ludwig and Waller use a "capillary electrometer" and sensor electrodes to monitor faint electrical activity of the human heart

- 1901 - Einthoven used a magnet, light, and a wire to create the first EKG recording

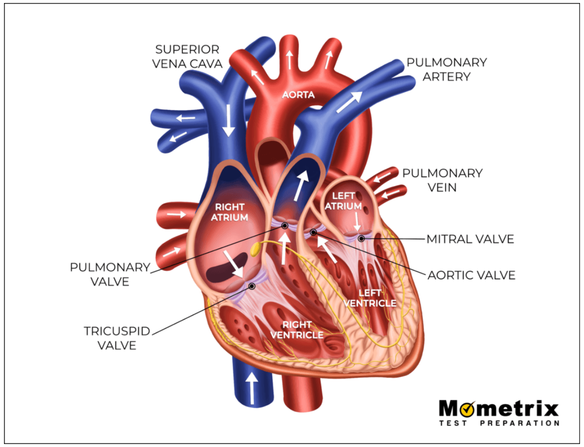
CAUTION

THIS MACHINE
HAS NO BRAIN
USE YOUR OWN


SUPERIOR VENA CAVA
AORTA
PULMONARY ARTERY
PULMONARY VEIN
RIGHT ATRIUM
LEFT ATRIUM
MITRAL VALVE
PULMONARY VALVE
AORTIC VALVE
LEFT VENTRICLE
TRICUSPID VALVE
RIGHT VENTRICLE
Mometrix
TEST PREPARATION

Anatomy and Cardiac Electrophysiology

- Blood travels
  - SVC→right atria→tricuspid valve→ right ventricle
  - Right ventricle→pulmonary valve→pulmonary artery (and lungs)
  - Lungs→pulmonary vein→left atria
  - Left atria→mitral valve→left ventricle
  - Left ventricle→aortic valve→aorta (and rest of the body)



- The EKG records electrical activity of heart muscle contracting in order to move blood through the heart

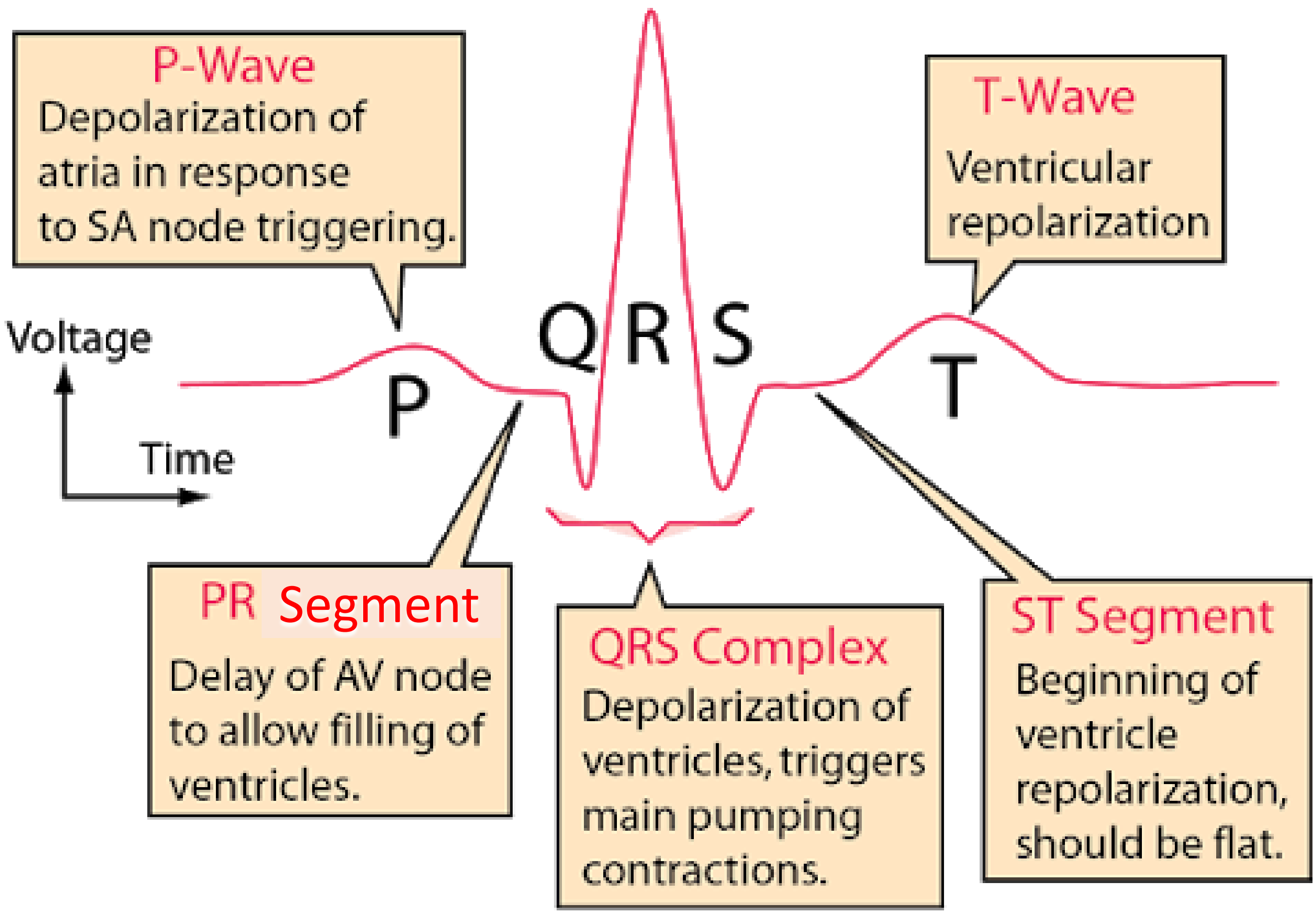
Anatomy and Cardiac Electrophysiology

- Cells signal to each other via electricity
  - Heart muscle cells are negatively polarized at rest
  - When DEPOLARIZED cells become POSITIVELY charged then myocytes ("heart muscle cells") contract
  - Cell to cell contraction of depolarization is carried by Na+ ions
  - REPOLARIZATION is the cell returning to its resting negative state
- Myocyte depolarization → muscle contraction

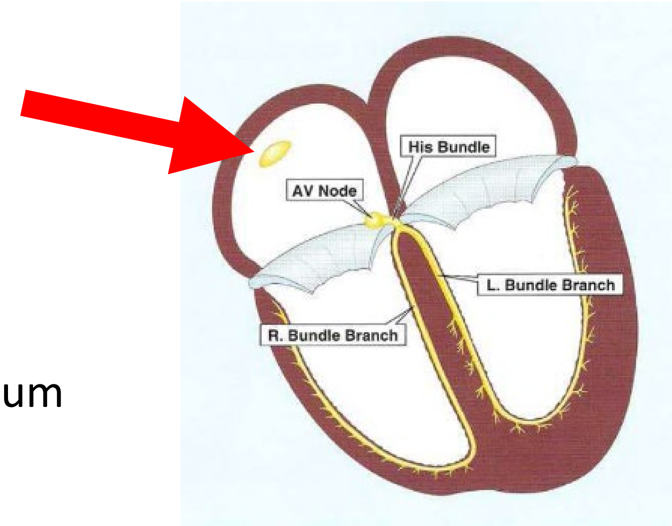
Electrodes

- Depolarization and repolarization is electricity
- Placing electrodes allows us to read the electricity
- Think of electrodes as positive or negative
  - Depolarization = positive charge = contraction = upward movement on EKG

The EKG and Depolarizations/Repolarization

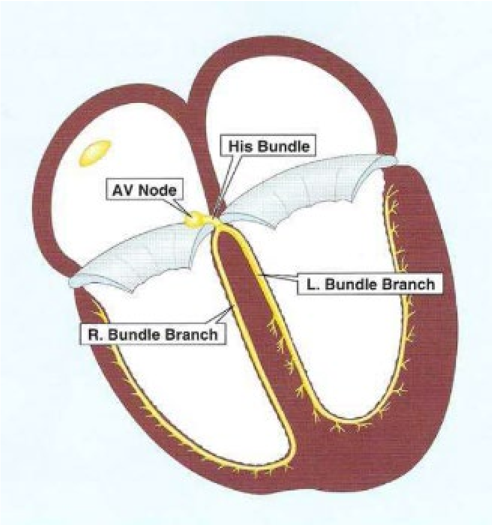


The SA Node and Conduction



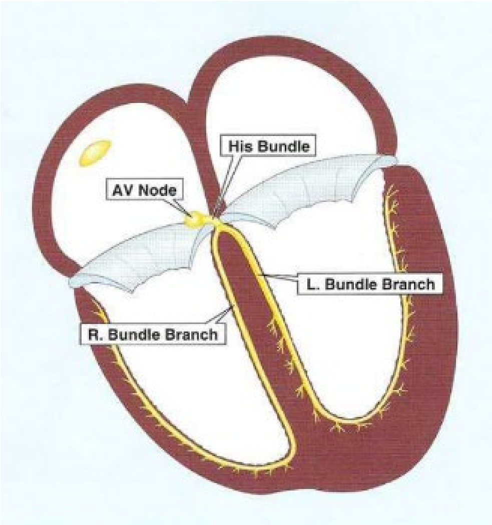
- The DOMINANT pacemaker
  - Located in the upper posterior wall of the right atrium
  - Automaticity → the ability to generate repeated depolarization

The AV Node and Conduction



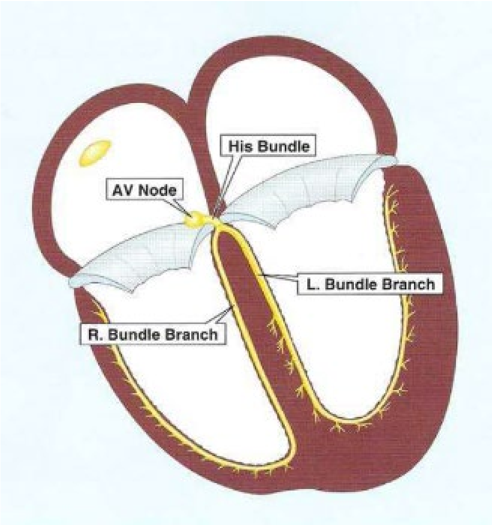
- Depolarization continues down until it hits the **AV valves** (both the tricuspid and mitral)
- The **AV node** sits between the **AV valves** and is the ONLY electrical connection between the atria and the ventricles!
- The **AV valves (tricuspid and mitral)** are also the gatekeepers of blood preventing backflow of blood into the atria during contraction

The AV Node and Conduction



- A pause occurs at the AV node as a result of slowed conduction after atrial depolarization
- This allows for blood to COMPLETELY empty from the atria into the ventricles
- Slowed conduction is a result of Ca++ movement instead of Na+ movement

Beyond the AV Node



- Conduction rapidly then goes through the ventricular conduction system
  - His Bundle →
  - Left and right bundle branches →
  - Terminates at purkinje fibers

Lead Placement and Recording the EKG

- Discuss what the EKG measures
- Learn how each lead is created and where it is placed anatomically
- Review anatomy
- Put it all together in terms of the EKG
- Look at the breakdown of the PQRST

Objectives

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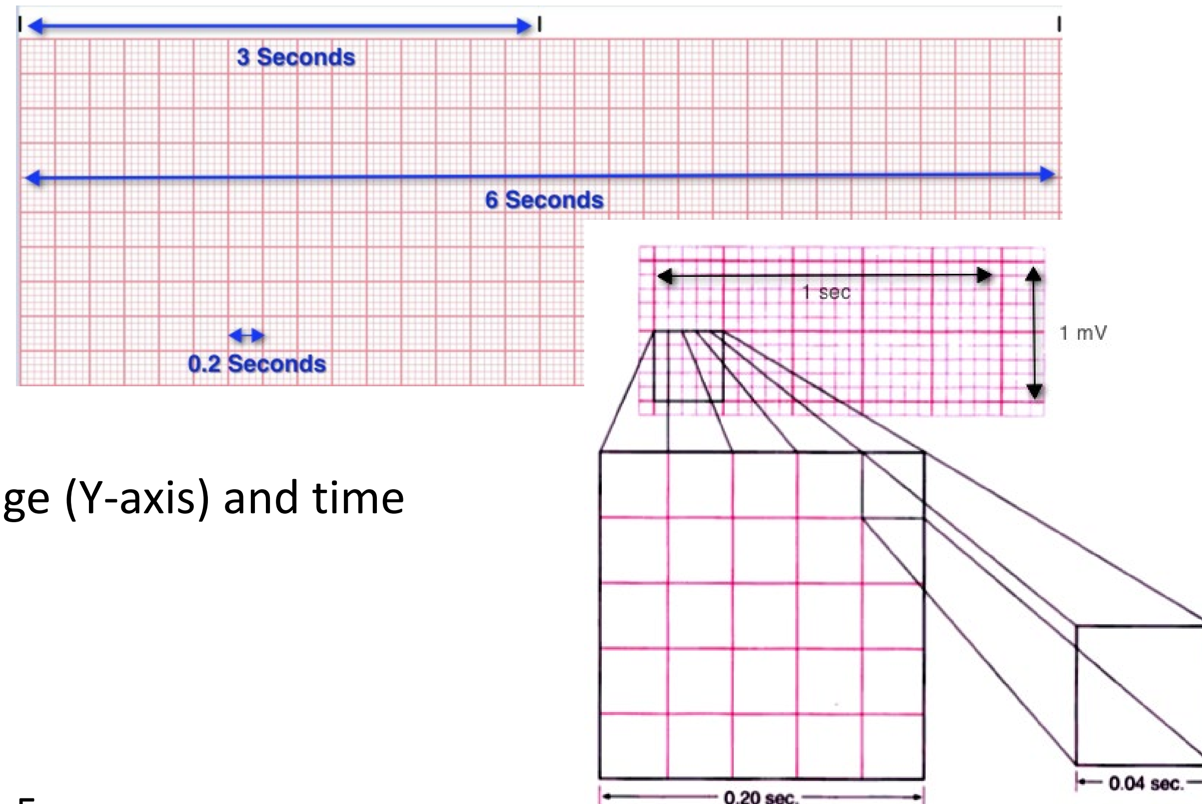
- The EKG and lead placement

The EKG

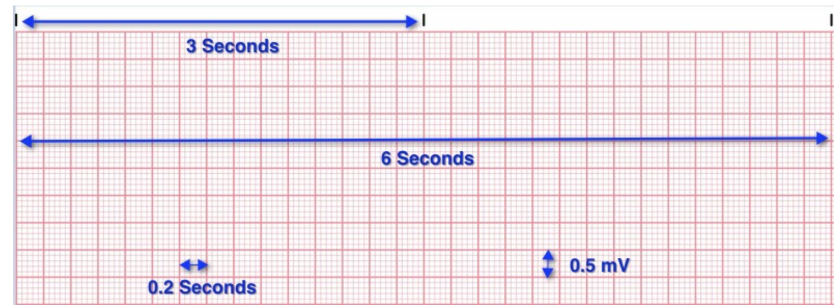


- Measurement of voltage (Y-axis) and time (X-axis)
- Amplitude (Y-axis)
    - Big box (heavy lines): 5 mm
    - Small box (thin lines): 1 mm

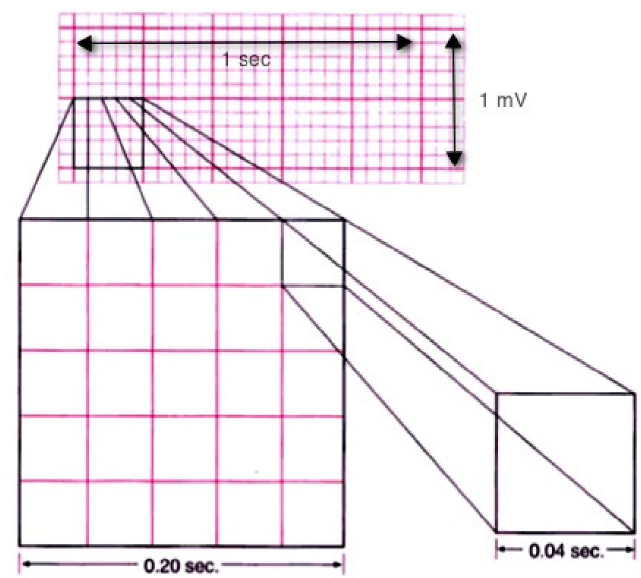
Deflections

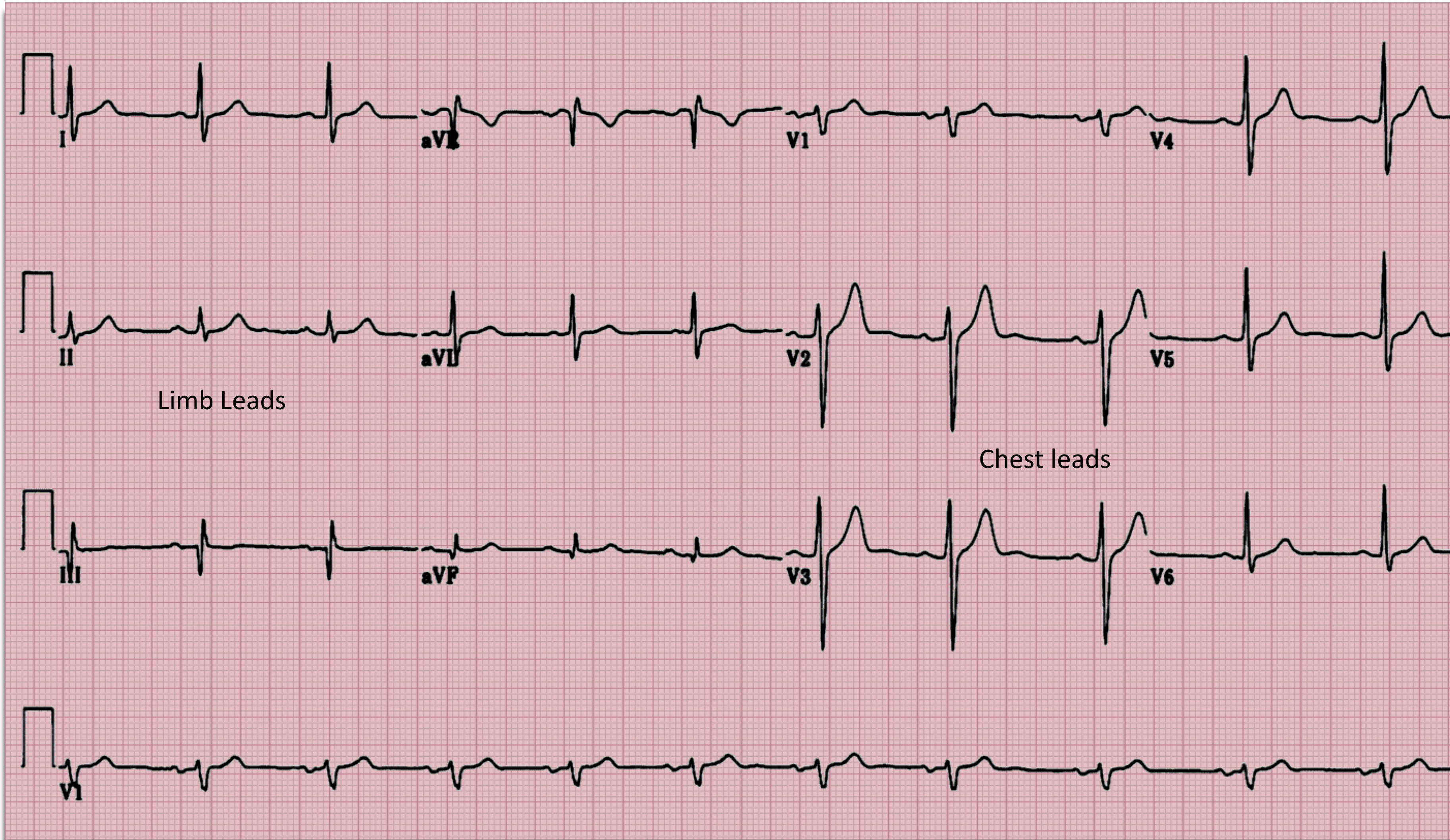
- Remember to think of the electrodes as positively or negatively charged
  - Upward deflection: depolarization TOWARD a positive electrode
  - Downward deflection: depolarization AWAY from a positive electrode
  - Measured in mm

Boxes and the X-Axis

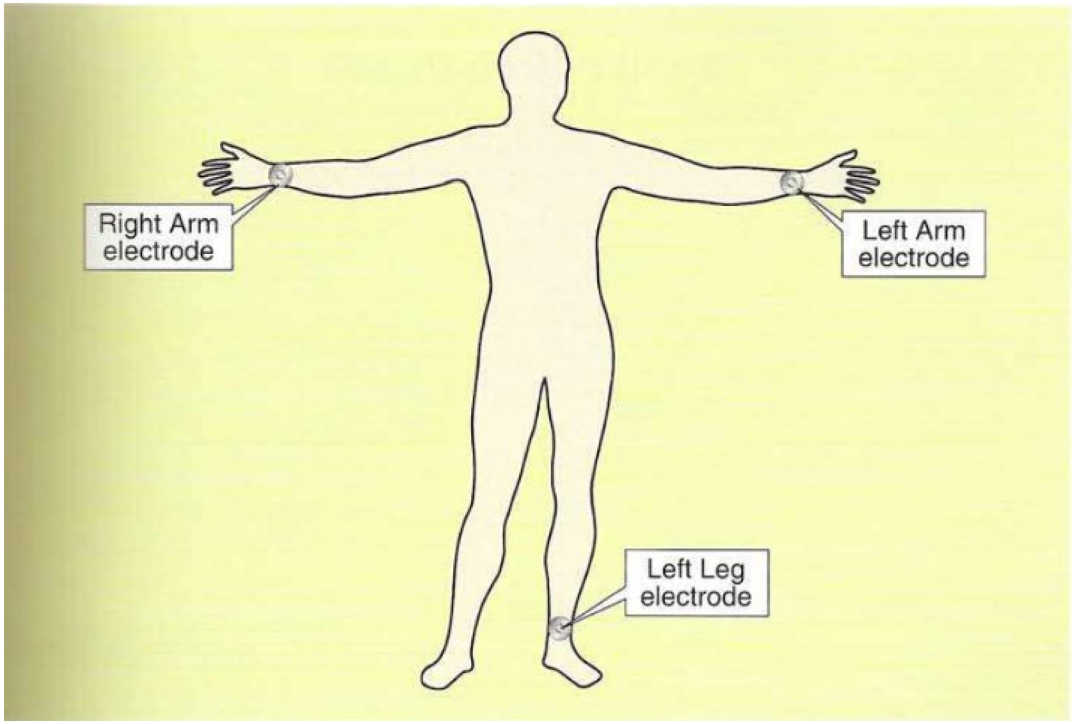


- **Heavy** lines: 0.2 of a second (or 5 mm)
- *Light* lines: 0.04 of a second (or 1 mm)
- There are 3 second tick marks on rhythm strips



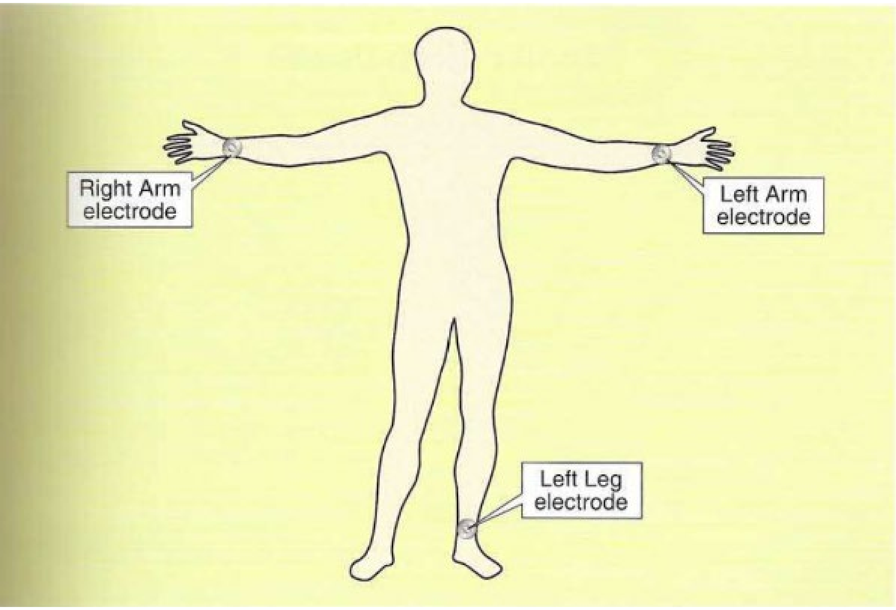

I
aVR
V1
V4
II
aVL
V2
V5
Limb Leads
Chest leads
III
aVF
V3
V6
V1

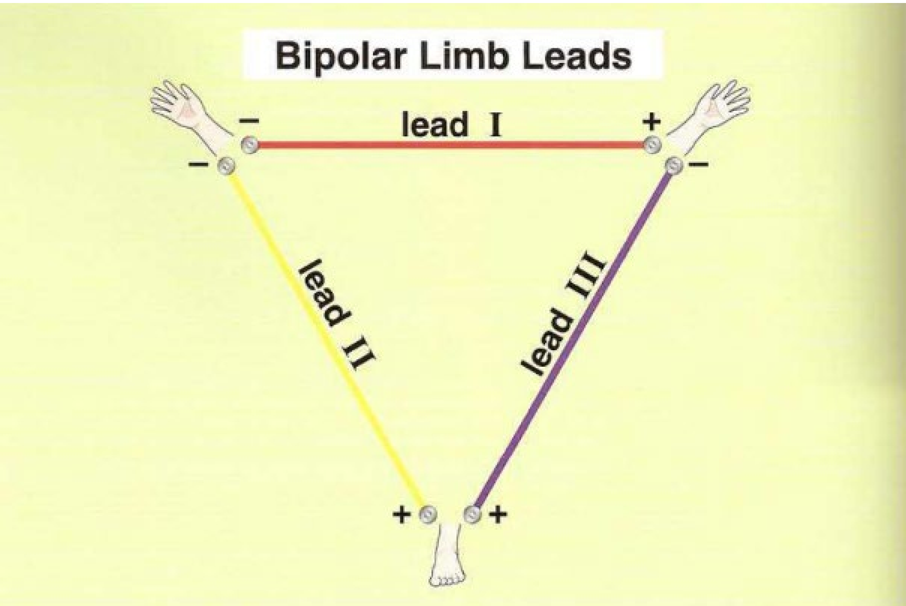
The Limb Leads (because they are literally on the limbs)



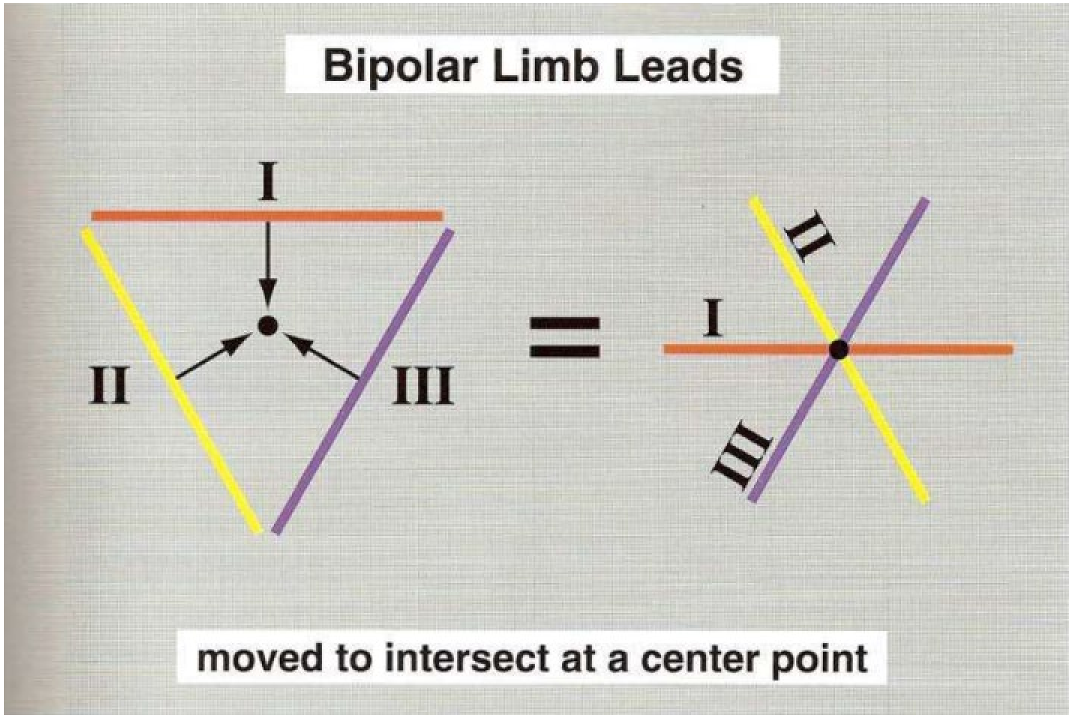
- Right arm
- Left arm
- Left leg

Two electrodes must be combined to create one lead
Each combined electrode needs a positive and negative end

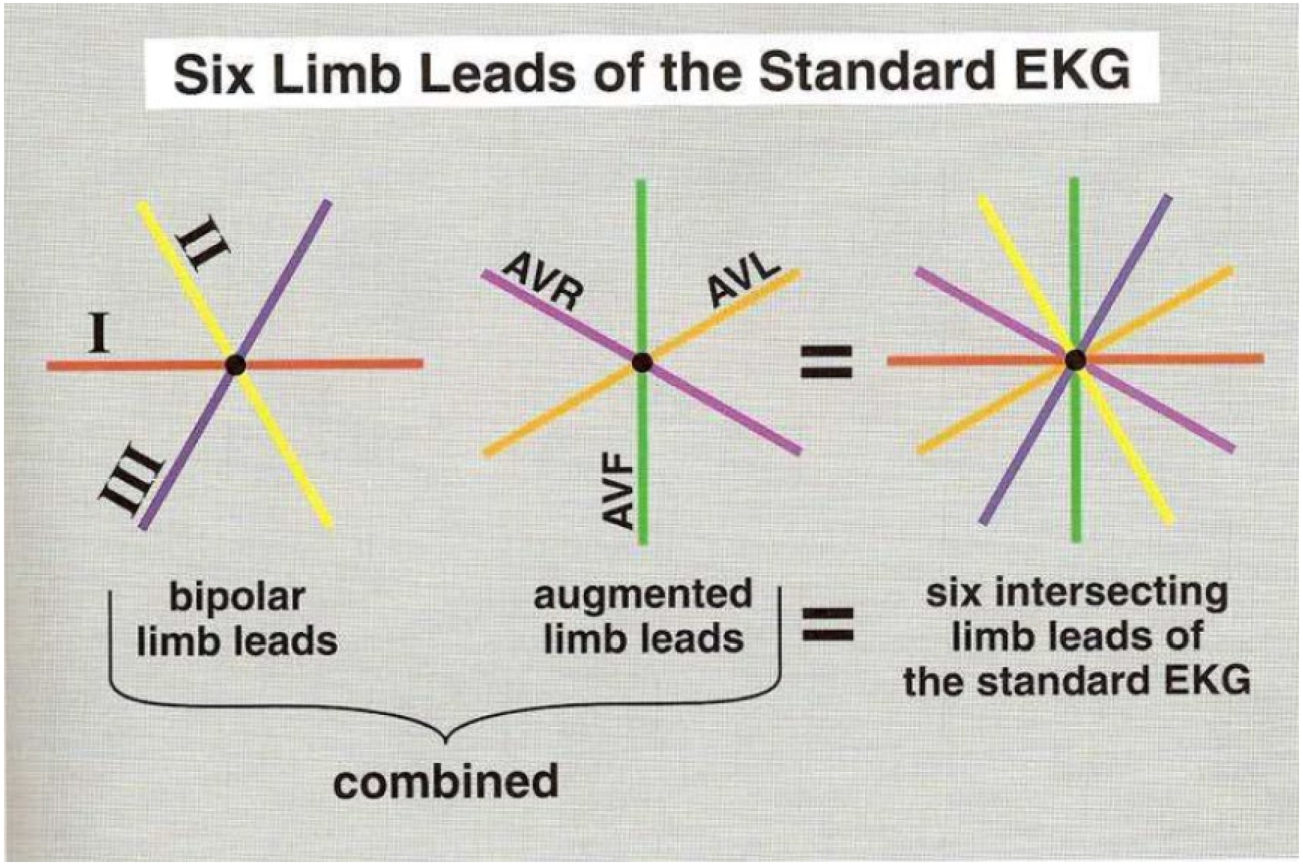




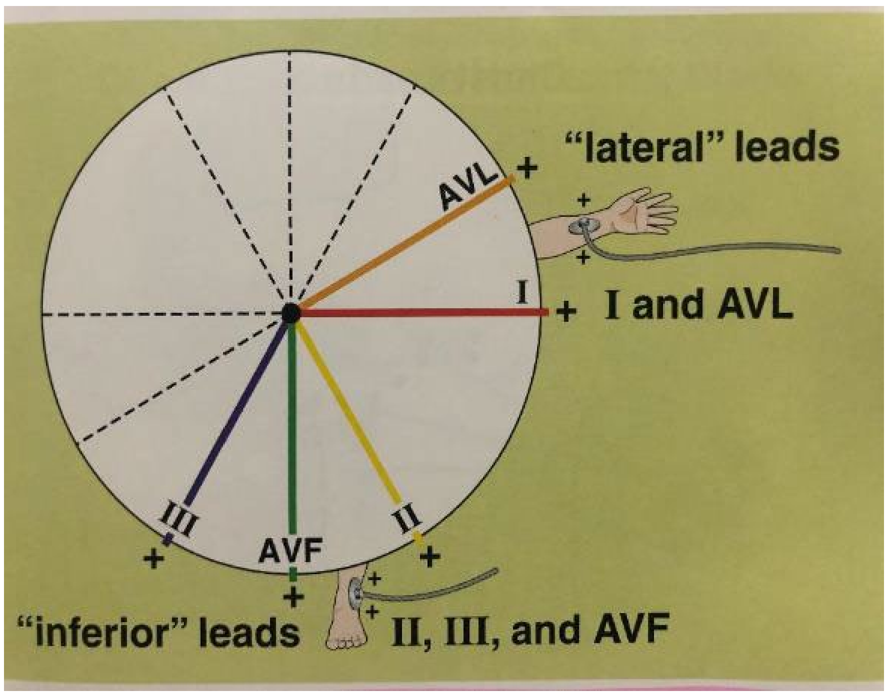
NEXT…


Bipolar Limb Leads
I
II
III
I
II
III
moved to intersect at a center point

Augmented Limb Leads



Now think of it in real life…

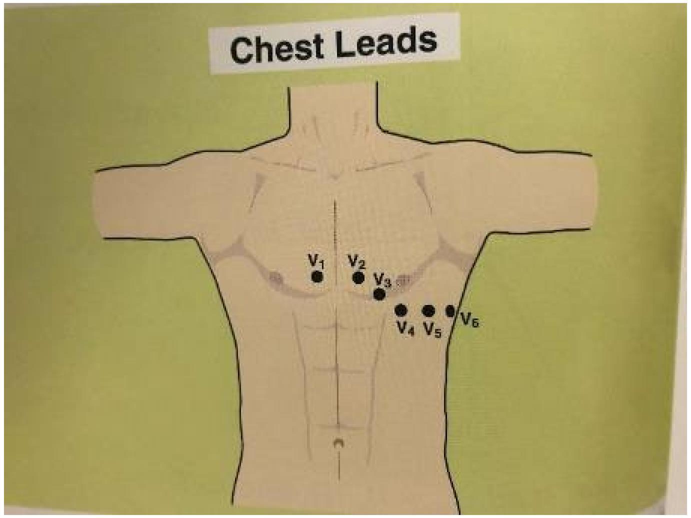


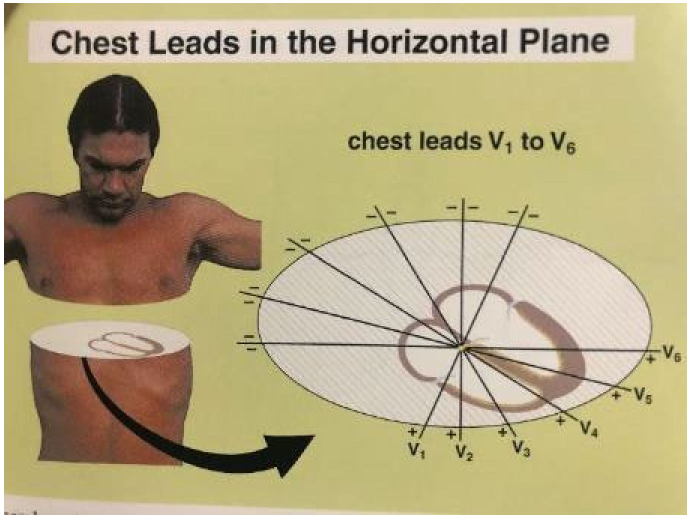
Lateral leads: I and aVL

Inferior leads: II, III, and aVF

Chest Leads

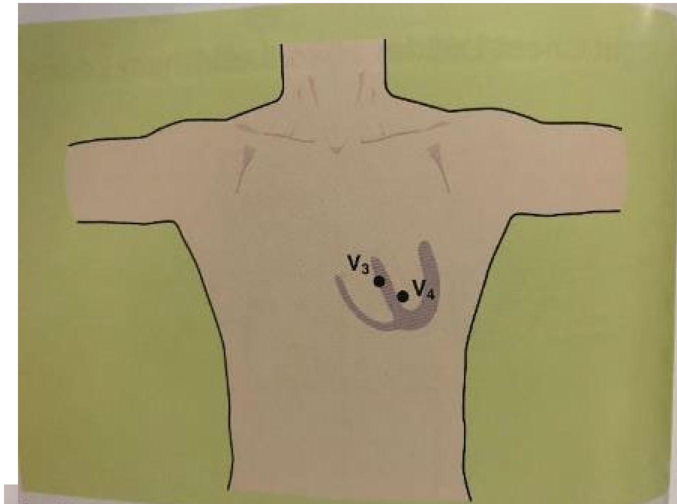
- Six leads with each electrode/lead placed from right to left on the chest
- Each electrode is the POSITIVE end

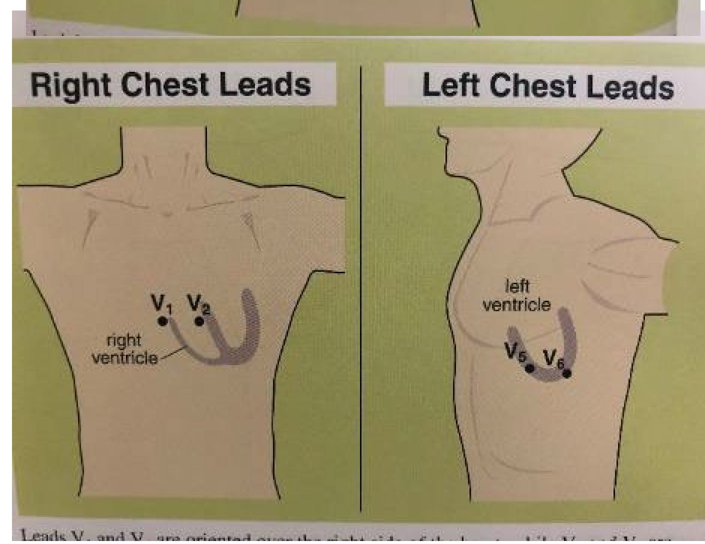




Chest Leads

- Think about anatomy again…
  - V1, V2: right sided leads
  - V3, V4: septal leads
  - V5, V6: left sided leads

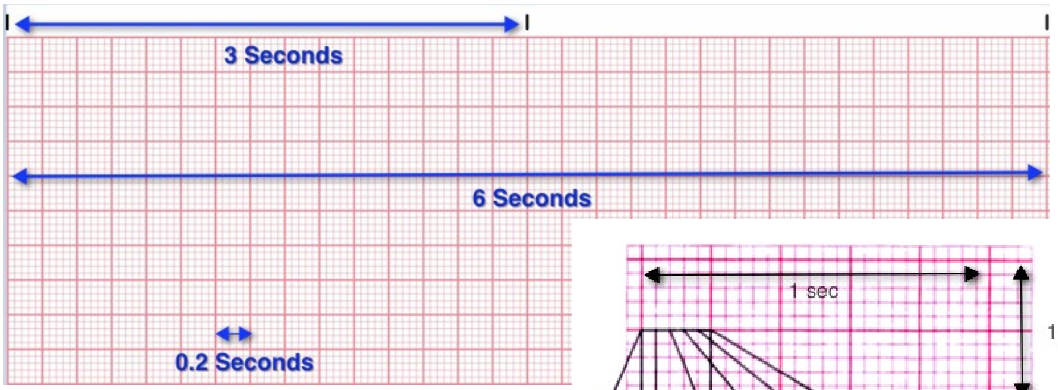


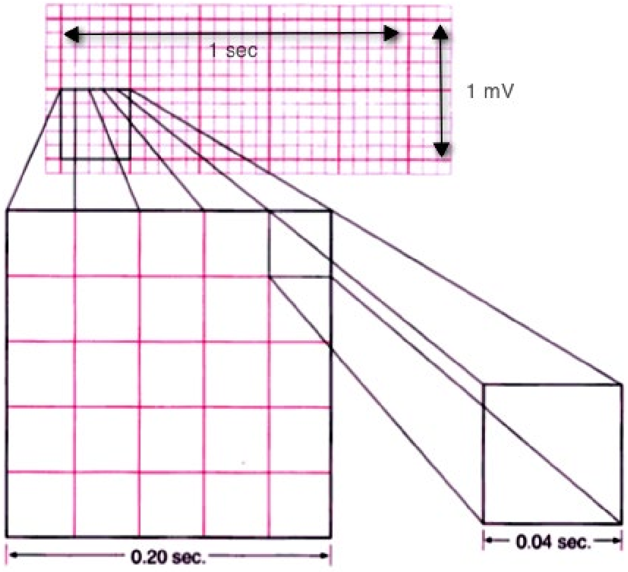


Put It All Together

- Now you have a picture of the heart from many different angles
- 2 planes provided by the limb leads and the precordial leads show a snapshot from different angles

EKG Basics





1 small box = 1 mm tall/wide

Source: www.practicalclinicalskills.com

EKG Basics – Pop Quiz!

- Width:
  1 small box =
  3 small boxes =
  1 big box =
- Height:
  1 small box =
  1 big box =
  12 small boxes =

EKG Basics – Pop Quiz!

- Width: 1 small box = **0.04 s**
  3 small boxes = **0.12 s**
  1 big box = **0.20 s**

- Height: 1 small box = **0.1 mV**
  1 big box = **0.5 mV**
  12 small boxes = **1.2 mV**

Objectives

- Historical origins of the EKG
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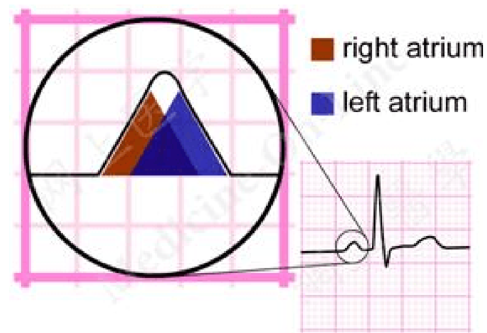
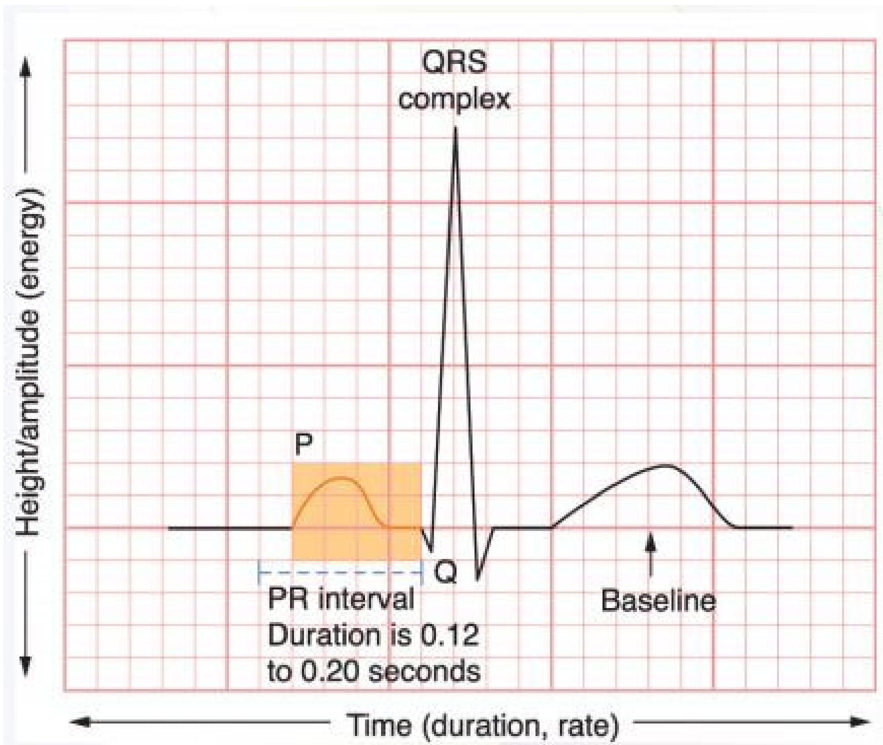
- The cardiac cycle

The P Wave

- Atrial depolarization = atrial contraction
- Look at lead II
  - Height should be LESS THAN 2.5 mm (or 2.5 small boxes)
  - Width should be LESS THAN 0.11 seconds (or 3 small boxes)
- Should be upright except in aVR
- Tall or notched P wave in lead II is a sign of atrial hypertrophy


2.5 mm
120 ms


right atrium
left atrium



Source: *Fast & Easy ECGs*, Shade & Wesley

The PR Interval

- Not to be confused with the PR segment
- From the start of the P wave to the start of the QRS complex
- It is the measure of time between atrial and ventricular activation
- Normal PR interval: 0.12 - 0.2 seconds (or less than 1 BIG box)

PR Segment

- End of the P wave to the start of the QRS
- Technically, a “segment” is a measure of baseline and an “interval” includes a wave

QRS

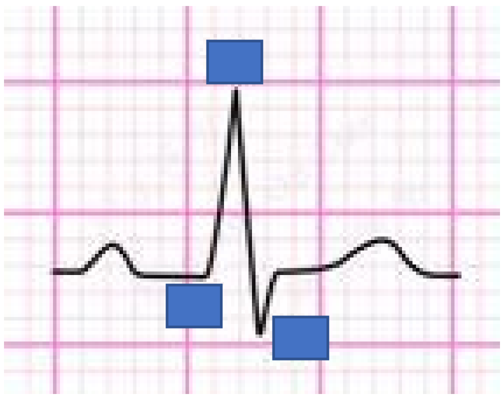
- Ventricular depolarization = ventricular contraction

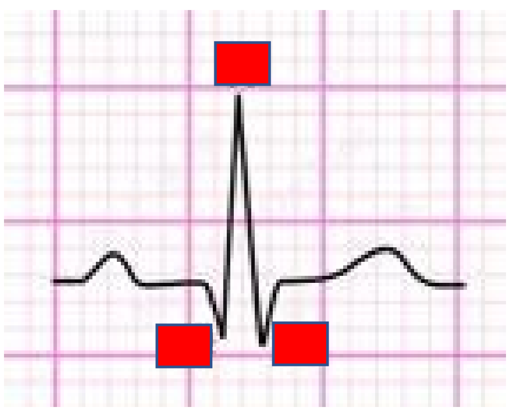
- Remember:
  - Q wave: First downward deflection (does not have to exist)
  - R wave: first upward deflection
  - S wave: first downward deflection AFTER the R wave

- Normal QRS LESS THAN 0.12 seconds (or 3 small boxes)

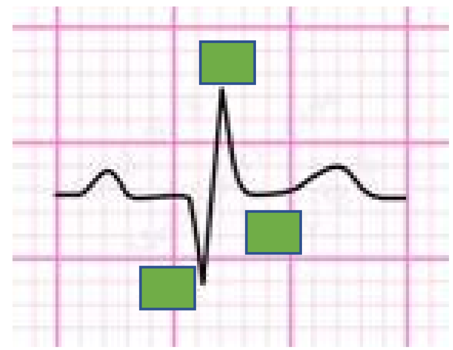
- Wide QRS?
  - Some kind of conduction delay through the ventricles
  - Rhythm originating below the AV node

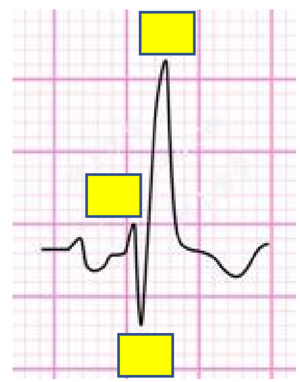
Waves: QRS Complex





?





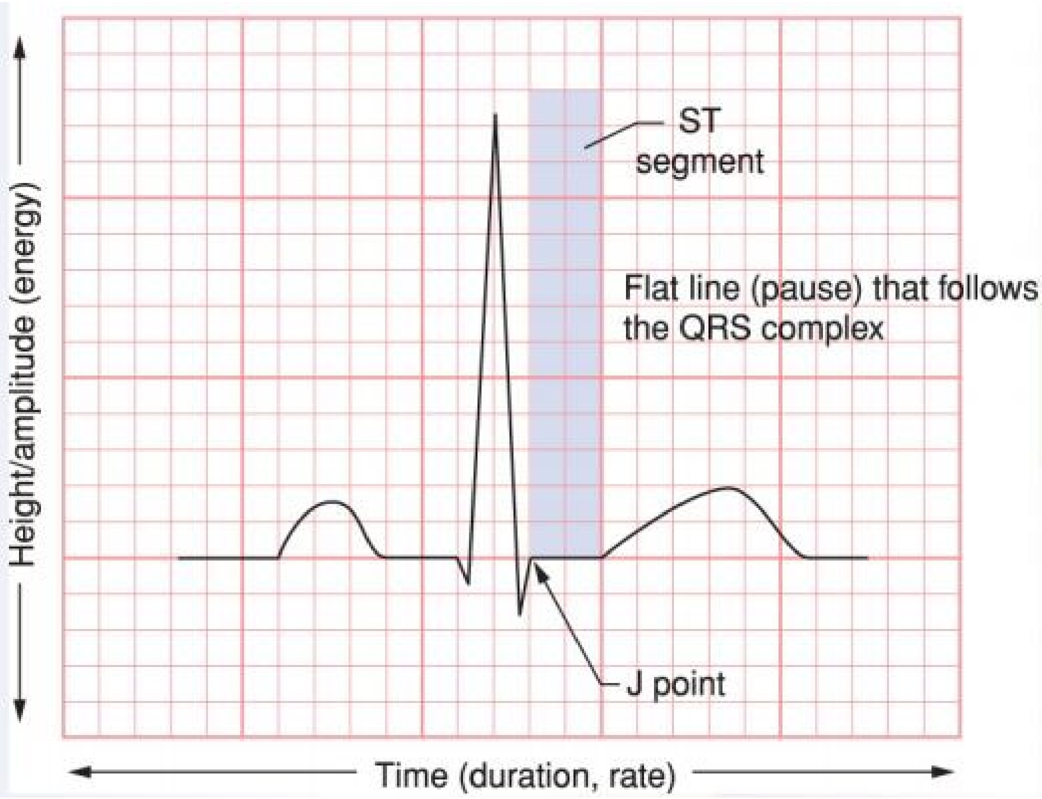
Source: www.medicine-on-line.com

ST Segment

- The time between the end of ventricular activation (QRS complex) and beginning of ventricular recovery (T wave)

- No matter what the QRS complex looks like, the term is still "ST segment"

- J Point: the point between the QRS and the ST segment



Source: *Fast & Easy ECGs*, Shade & Wesley

Intervals & Segments – Pop Quiz!

- PR interval:
  - Starts:
  - Ends:
  - Equivalent to:

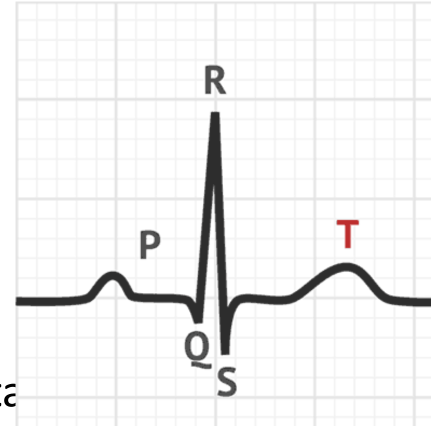
- ST segment:
  - Starts:
  - Ends:
  - Equivalent to:

Intervals & Segments – Pop Quiz!

- PR interval:
  - Starts: **<u>Start of P wave</u>**
  - Ends: **<u>Start of R wave</u>**
  - Equivalent to: **<u>Atrial contraction + AV node delay</u>**

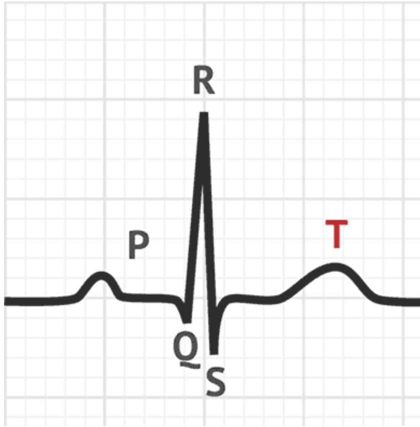
- ST segment:
  - Starts: **<u>End of S wave</u>**
  - Ends: **<u>Start of T wave</u>**
  - Equivalent to: **<u>Plateau phase of ventricular repolarization</u>**

T wave



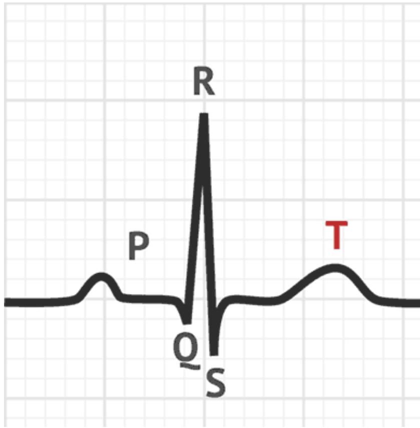
- Ventricular repolarization
  - Remember, cells need to return to the "negative" (or resting) sta
  - Typically, the deflection is in the same directed as the QRS
  - Multiple different things can cause abnormalities in the T wave
    - MI, electrolyte abnormalities, conduction delays, various drugs

Ventricular Repolarization



- The initial repolarization is the ST segment
- The rapid phase of repolarization is the T wave
- ST segment + T wave = ventricular repolarization = ventricular diastole

QT Interval



- The complete cycle of the ventricles (ventricular depolarization+ ventricular repolarization)
- Start of the QRS to the END of the T wave
- QTc: estimated QT interval at a heart rate of 60 bpm (=QT/square root of RR interval)
- Prolonged QT has many causes
  - Hypothermia, drugs, electrolytes, etc

Rate

- This is the first step when looking at the EKG

1) **RATE**
2) rhythm
3) P waves
4) PR interval
5) QRS
6) axis
7) atrial and ventricular hypertrophy
8) ST segment and T waves

Rate

- Measured in cycles (or beats) per minute

- Automaticity: the heart's ability to create a series of pacing stimuli

- SA Node: the dominant pacemaker
  - Rate: 60-100 bpm
  - Sinus bradycardia: <60 bpm
  - Sinus tachycardia: >100 bpm

Automaticity Foci

- There are other "potential" pacemakers in the event of an emergency
  - The SA node **SHOULD** supersede all other potential pacemakers (AKA the dominant pacemaker)
  - Pacemaker cells:
    - SA Node
    - Atrial cells
    - His Bundle
    - Right and left bundles
    - Ventricular purkinje cells

Automaticity Foci

- Each foci has a different pacemaking rate
  - If the SA node fails, the atrial foci will take over
    - 60-80 bpm
  - If the atrial foci take over, the AV junction foci take over
    - 40-60 bpm
  - If the AV junction foci fail, the ventricular foci take over
    - 20-40 bpm

Overdrive Suppression

- The fastest foci sets the rate and overrides any slower foci
- Consequently, the slower foci only take over if the faster foci fail!
- REMEMBER: SA node > atrial foci > junctional foci > ventricular foci

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- Historical origins of the EKG
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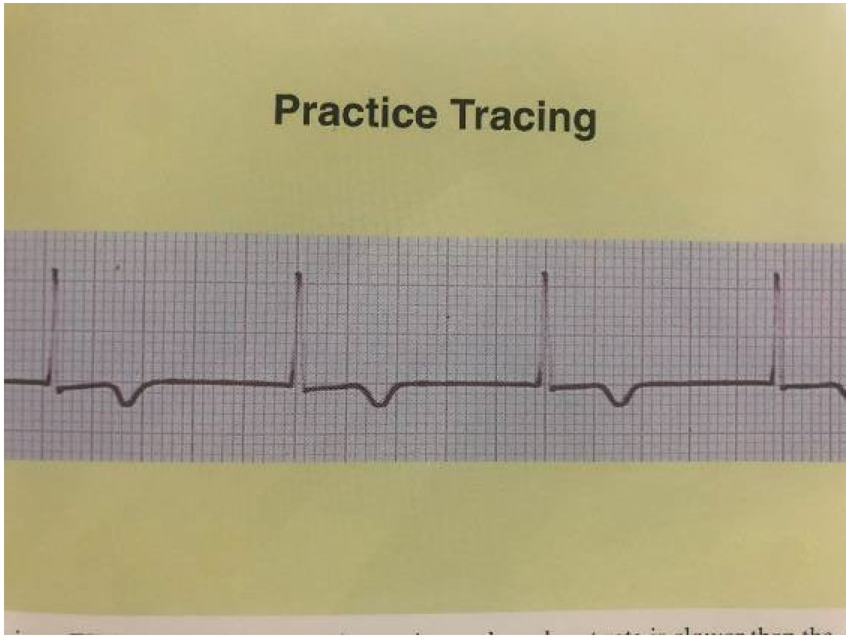
Calculating Rate

- MEMORIZE THIS

300, 150, 100, 75, 60, 50

Calculating Rate

- Find an R wave on a **thick black line**
- Now use your new memorized rule…



Why does this work?

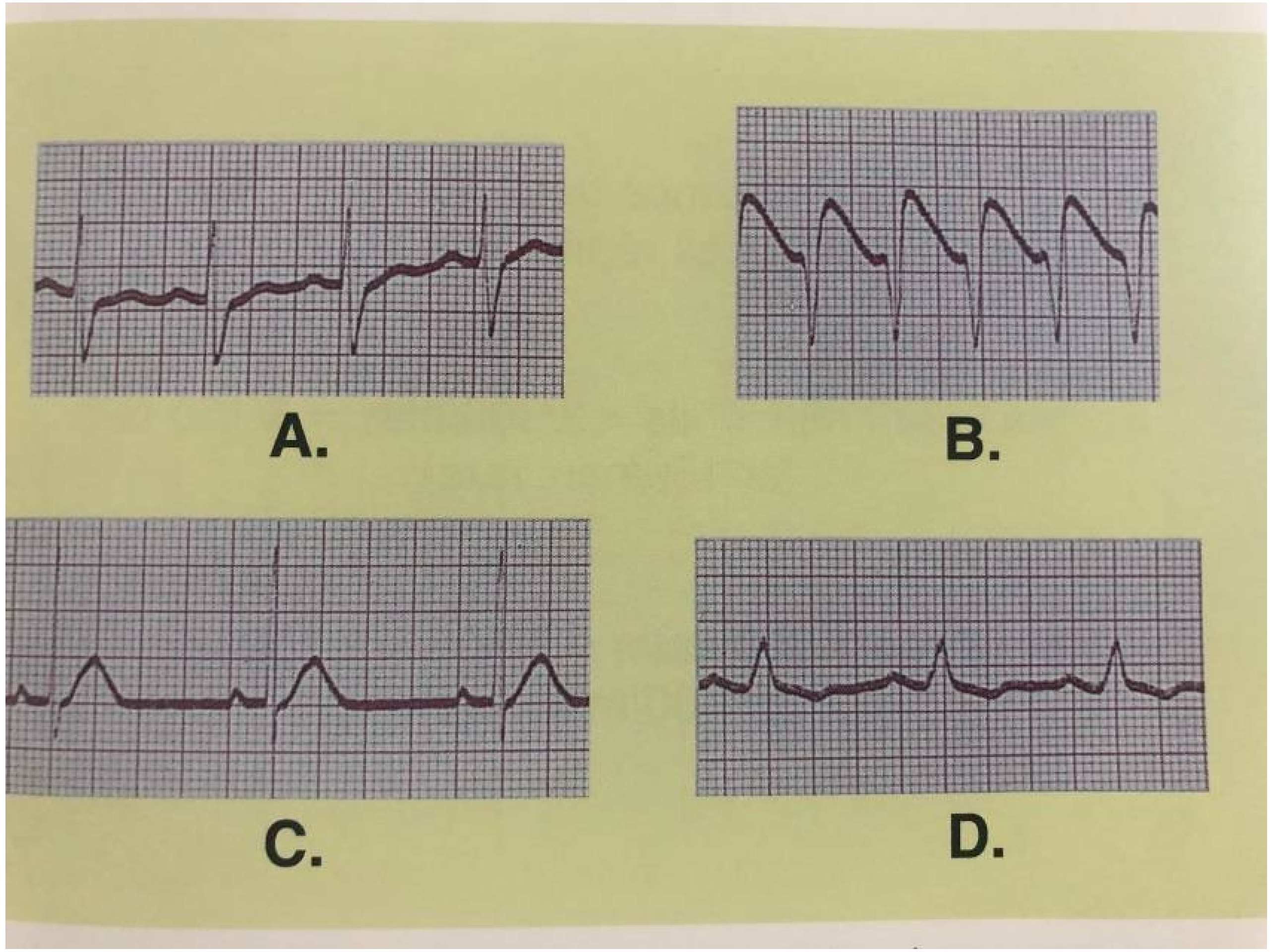
- If each big box is 0.2 seconds, then 300 big boxes is 1 minute
- If you have a line that is 300 big boxes long, you can count X number of big boxes between the QRS complexes
- 300/ X big boxes= rate in bpm

Why does this work?

- 300/1= 300 bpm
- 300/2=150 bpm
- 300/3=100 bpm
- 300/4=75 bpm
- 300/5=60 bpm
- 300/6=50 bpm

Or you can just trust me that this works…

Practice



So, What do you do if the rate is less than 50?

- 3 second marks
  - Each EKG strip is marked with 3 second marks
- Count the beats in a 3 second cycle and multiple by 20
  - Or count a 6 second run to make it easy!
    - This gives the amount of paper used in 6 second (which is 1/10 of a minute)
- So then
  - # of 3 second mark cycles x 20= beats per minute

    OR
  - # of 6 second mark cycles x 10= beats per minute

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Sinus Rhythm

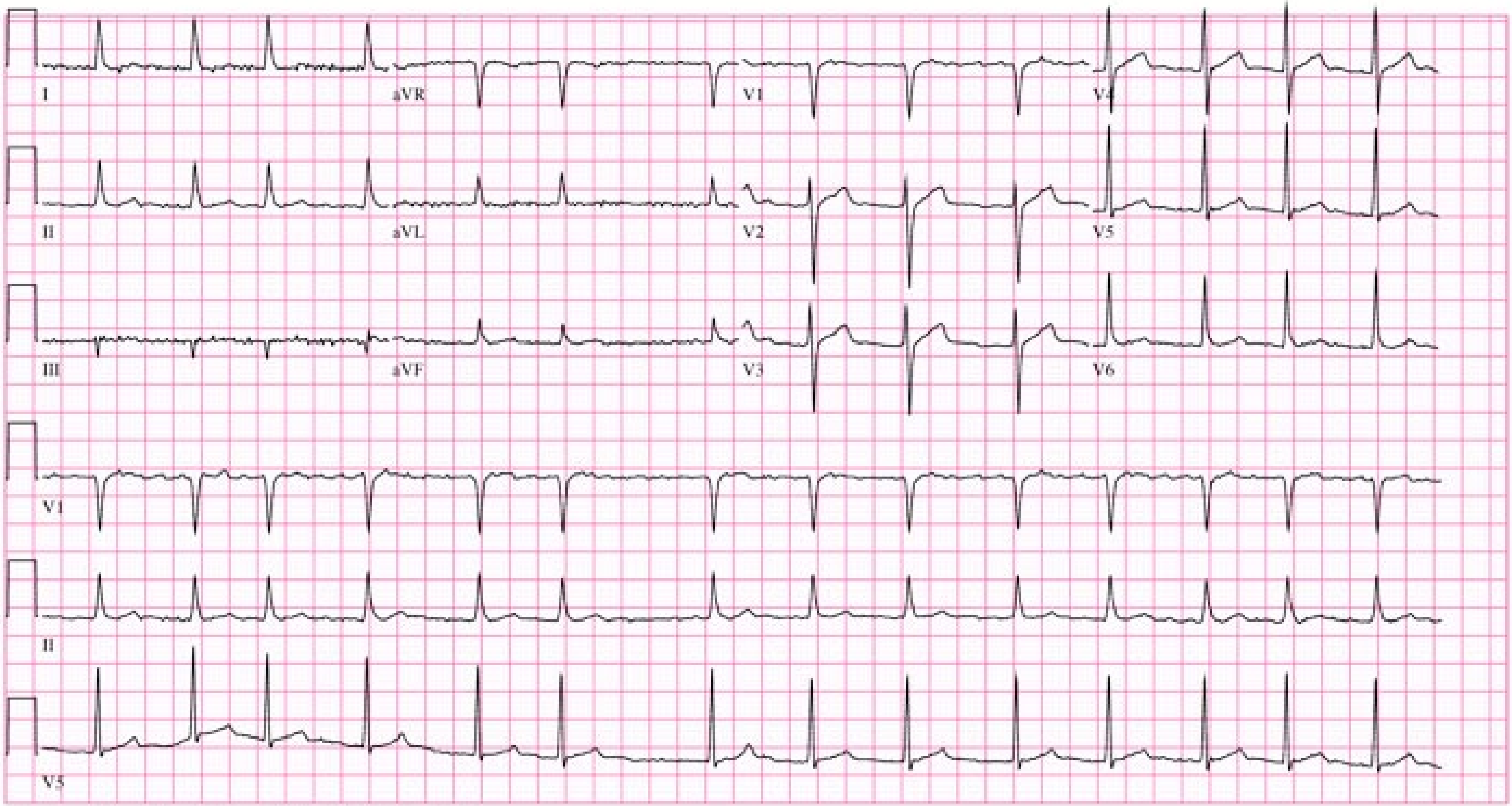
- A “regular” rhythm with pacing from the SA node
- Remember: inherent rate 60-100
- Automaticity of the SA node creates regular depolarization
- Normal Sinus Rhythm: a regular rate between 60-100 bpm

Sinus Arrhythmia

- Rate between 60-100 **minimal** variation in SA node's pacing
- This is not a true arrhythmia
- Varies slightly with breathing
  - Inspiration-slightly increased heart rate from increased sympathetic firing
  - Expiration- slightly decreased heart rate from increased parasympathetic activity

Atrial Fibrillation

- Rapid firing of multiple atrial pacemaker cells
- Continuous chaotic atrial spikes trying to be the dominant pacemaker
- This leads to:
  - No complete atrial depolarization so no real P wave
  - Intermittent conduction through the AV node to the ventricles
- Results in random and irregular ventricular response



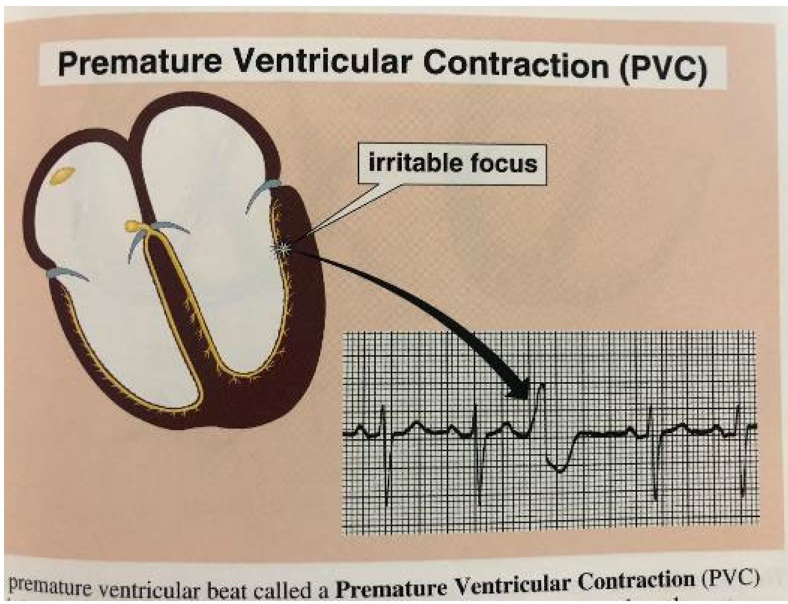
25mm/s 10mm/mV 100Hz 005E 12SL 233 CID: 1

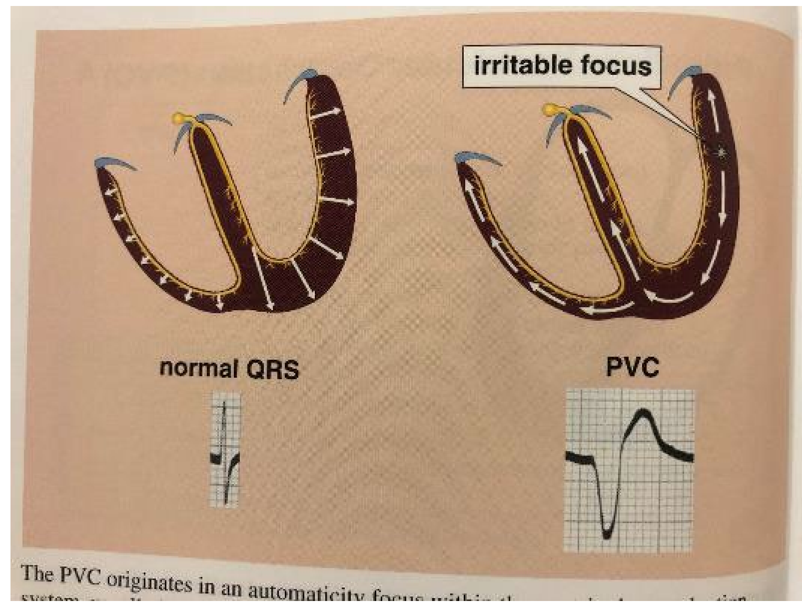
Premature Ventricular Contractions

- AKA PVCs

- EKG shows:
  - PVC occurs early in the cycle
  - QRS is widened and taller than normal
  - Absence of preceding P waves

PVCs


Premature Ventricular Contraction (PVC)
irritable focus
premature ventricular beat called a Premature Ventricular Contraction (PVC)


irritable focus
normal QRS
PVC
The PVC originates in an automaticity focus within th

PVCs

- PVCs only depolarize the ventricles
  - There is no retrograde depolarization of the SA node

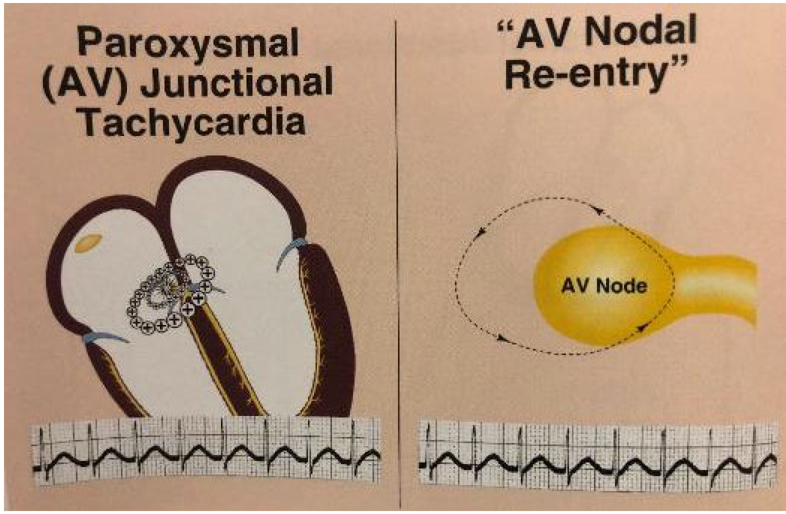
- The pause that occurs after the PVC is for ventricles to repolarize not the SA node!

- Each ventricular pacemaker cell has its own signature just like atrial pacemaker cells

- Poor oxygenation can be the cause of multiple PVCs

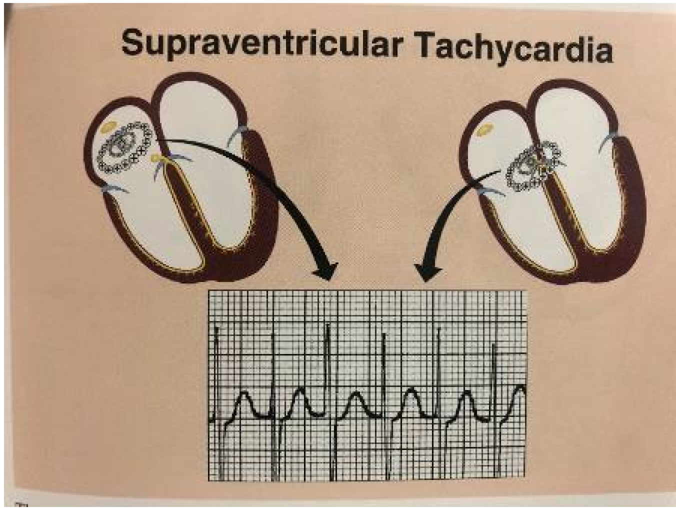
”AV Nodal Re-entry”

- Another type of junctional tachycardia
- Theory is that a continuous loop forms between lower portion of the atria and the AV node
  - Loop rapidly fires both the atria & ventricles



Supraventricular Tachycardia

- Another name for paroxysmal atrial / junctional tachycardia
- Vague name for tachycardia that originates above the ventricles (aka narrow complex tachycardia)
- Why do we call it this?
  - Can be difficult to determine which it is due to P' waves being buried in the T waves due to rate



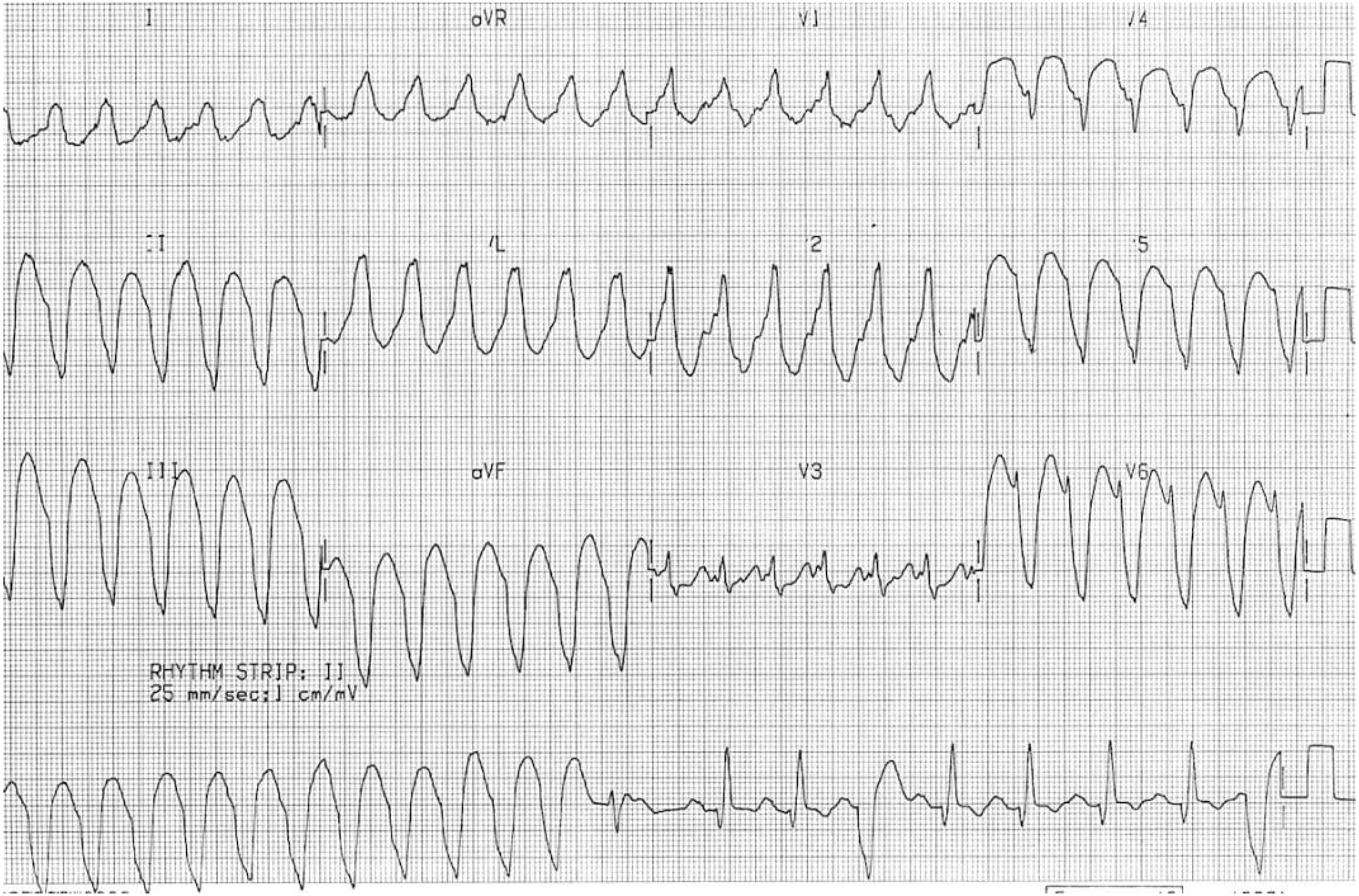
Ventricular Tachycardia

- Irritable ventricular pacemaker cells fire in rapid succession to each other

- This happens typically because of serious reasons!

- VTACH: any three PVCs in a row without any other conduction

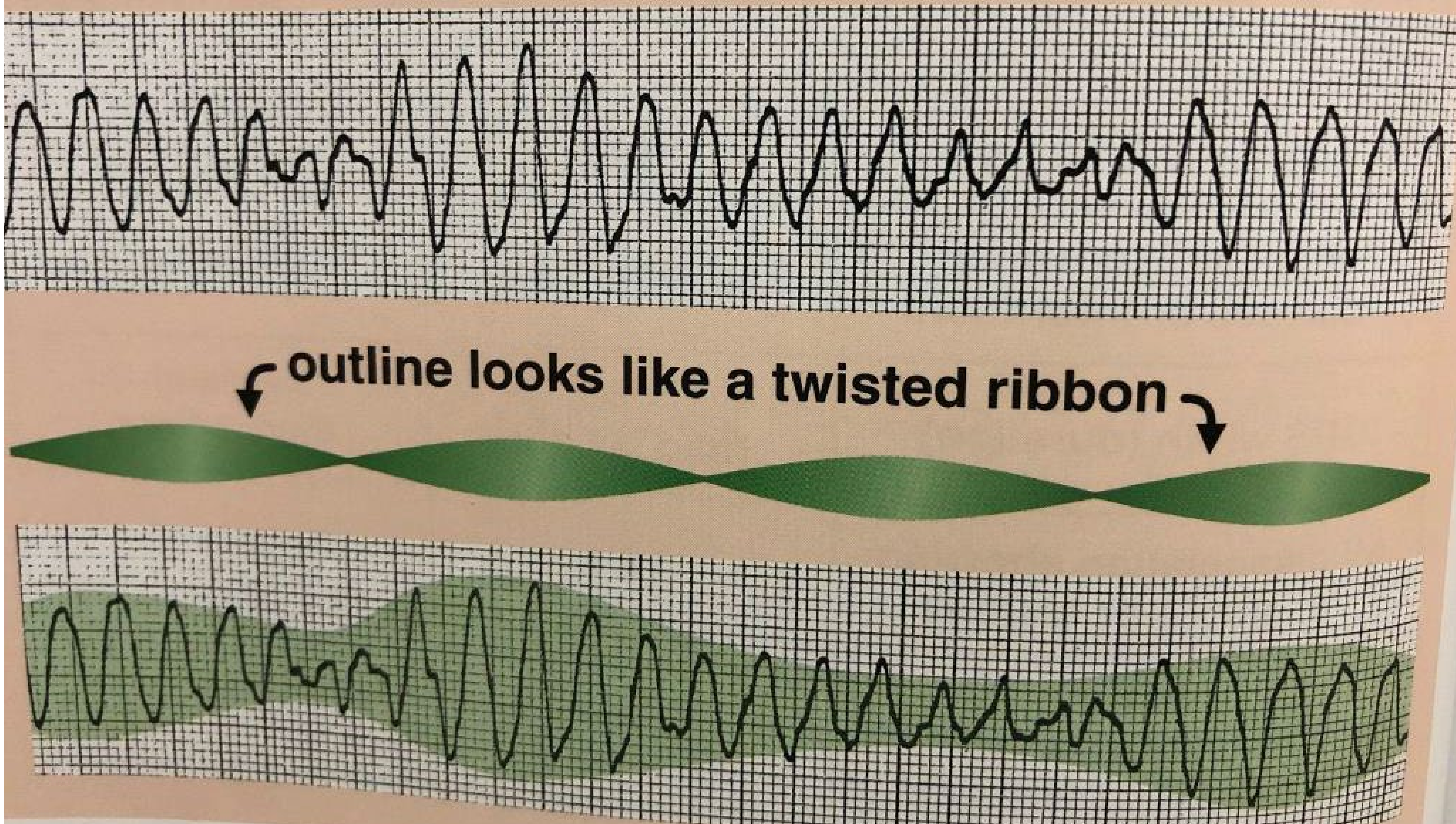
- Sustained VTACH: vtach lasting >30 seconds


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
RHYTHM STRIP: II
25 mm/sec;1 cm/mV

Torsades de Pointes

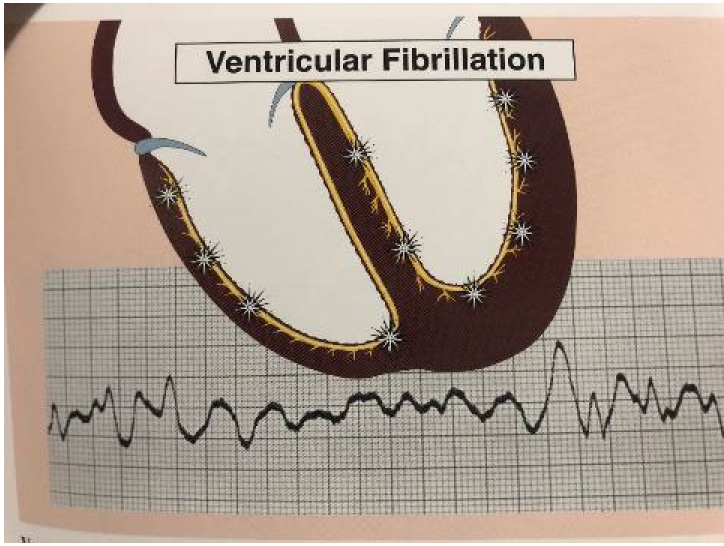
- AKA “twisting of points”
- Specific rapid ventricular rhythm
- Caused by
    - Congenital abnormalities such as Long QT Syndrome, hypokalemia
- Rate classically 250-350 bpm

Torsades de Pointes



Ventricular Fibrillation

- Rapid firing of many irritable ventricular automaticity foci
- Results in poor contraction and again bad
  blood movement through the heart
- These patients are always dead
- How do you treat vfib? Defib!



Objectives

- Historical origins of the EKG
- Anatomy and physiology
- The EKG and lead placement
- The cardiac cycle
- Rate and calculating rate
- Sinus rhythm and a few important arrhythmias

Questions?

(Before some final slides)

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TOTAL EM

Podcast #206 - ATLS Episode 0: The Beginning of an Adventure

6/30/2020

1 COMMENT

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Parting Thoughts

- The EKG measures electrical conduction through the heart
- We must interpret these measurements with the clinical context of the patient in front of us
- Understanding cardiac anatomy and lead placement can help us think through abnormalities
- Must thoroughly know "normal" to detect abnormal

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