SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF BIOMEDICAL ENGINEERING

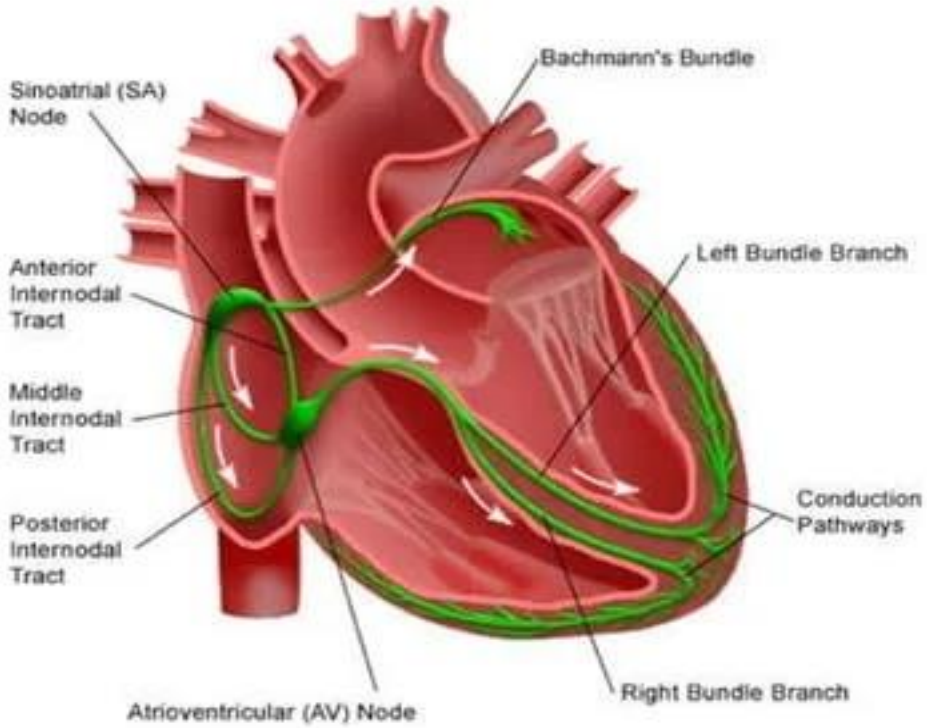
19BMB302 - BIOMEDICAL SIGNAL PROCESSING

III YEAR/ V SEMESTER

Unit IV : BIOSIGNALS AND THEIR CHARACTERISTICS

- Source of Bioelectric potential
- Resting and action potential
- Propagation of action potentials in nerves
- Characteristics of biomedical signals
- The ECG-Cardiac electrophysiology
- Relation of ECG components to cardiac events
- Clinical applications

Cardiac Electrophysiology



The Electrical Conduction Pathway

Nervous System Stimulation

Sympathetic Nervous System: causes an increase in heart rate, increase in AV conduction , and increase in ventricular contractility

The increase is caused a release of norepinephrine (catecholamine/neurotransmitter)

Nervous System Stimulation

Parasympathetic Nervous System: (from the vagus nerve) causes a slowing of the heart rate, a decrease in AV conduction, and a slight decrease in ventricular contractility

The decrease is caused a release of acetylcholine (catecholamine/neurotransmitter)

Pacemaker

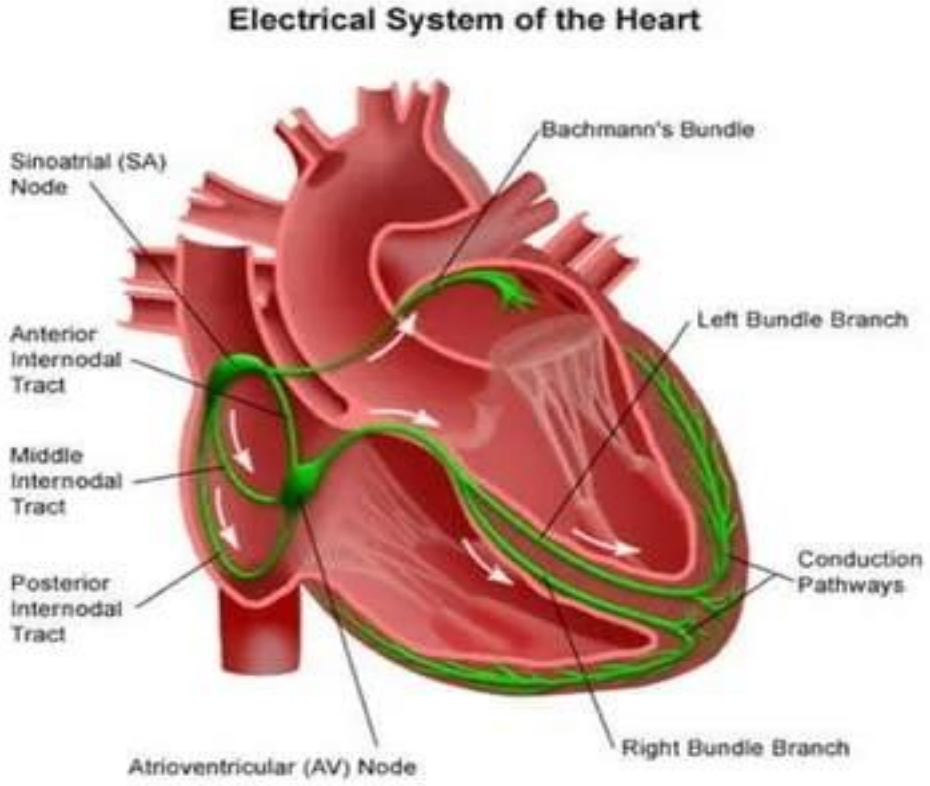
Pacemaker – the SA node is the natural/normal pacemaker of the heart.

Latent Pacemaker Cells – Cells in the electrical conduction system located below the SA node with the property of automaticity

These cells hold the property of automaticity in reserve in case the SA node fails to function properly or electrical impulses fail to be conducted.

a.k.a. – *Subsidiary pacemaker cells*

The Electrical Conduction Pathway



SA Node

- ie. Sinoatrial Node or Sinus Node
- Posesses the highest level of automaticity
- SA Node is the primary pacemaker of the heart
- If it fails to fire or slows down less than its inherent firing rate (60 – 100), another pacemaker that is lower in the conduction system will take over

AV Node *(The Gatekeeper)*

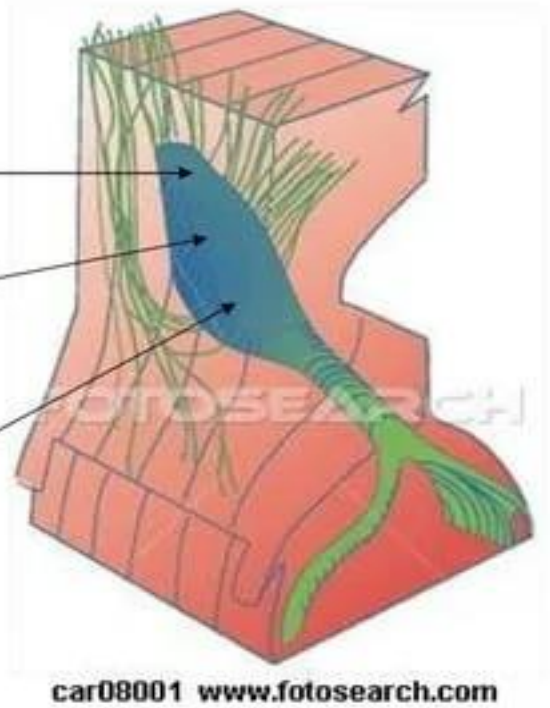
Three main functions:

- Slows conduction to allow time for the atria to contract & empty its contents (atrial kick) before the ventricles contract
- Secondary pacemaker (40 – 59 bpm)
- Blocks some of the impulses from being conducted to the ventricles when atrial rate is rapid

AV Node *(The Gatekeeper)*

Three Regions:

- Atrial-Nodal (upper region)
  Pacemaker cells
- Nodal (middle region)
  No pacemaker cells (area responsible for delay)
- Nodal-His (lower region)
  Pacemaker cells



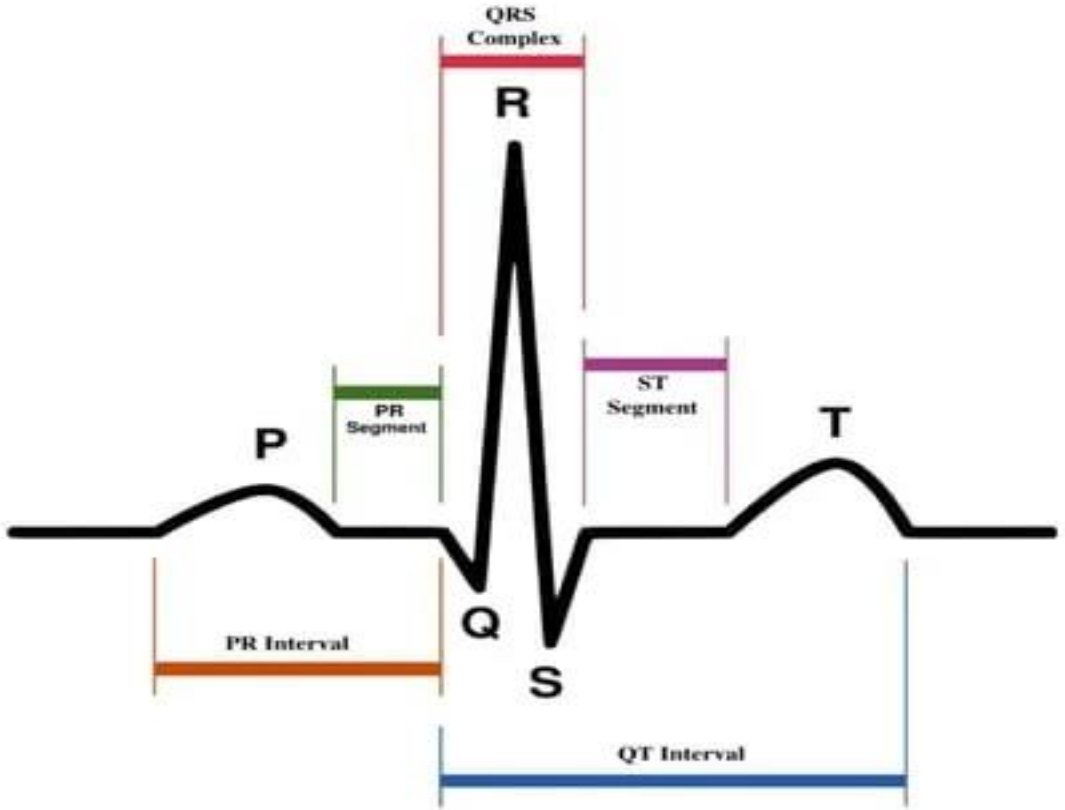
Ventricular Conduction

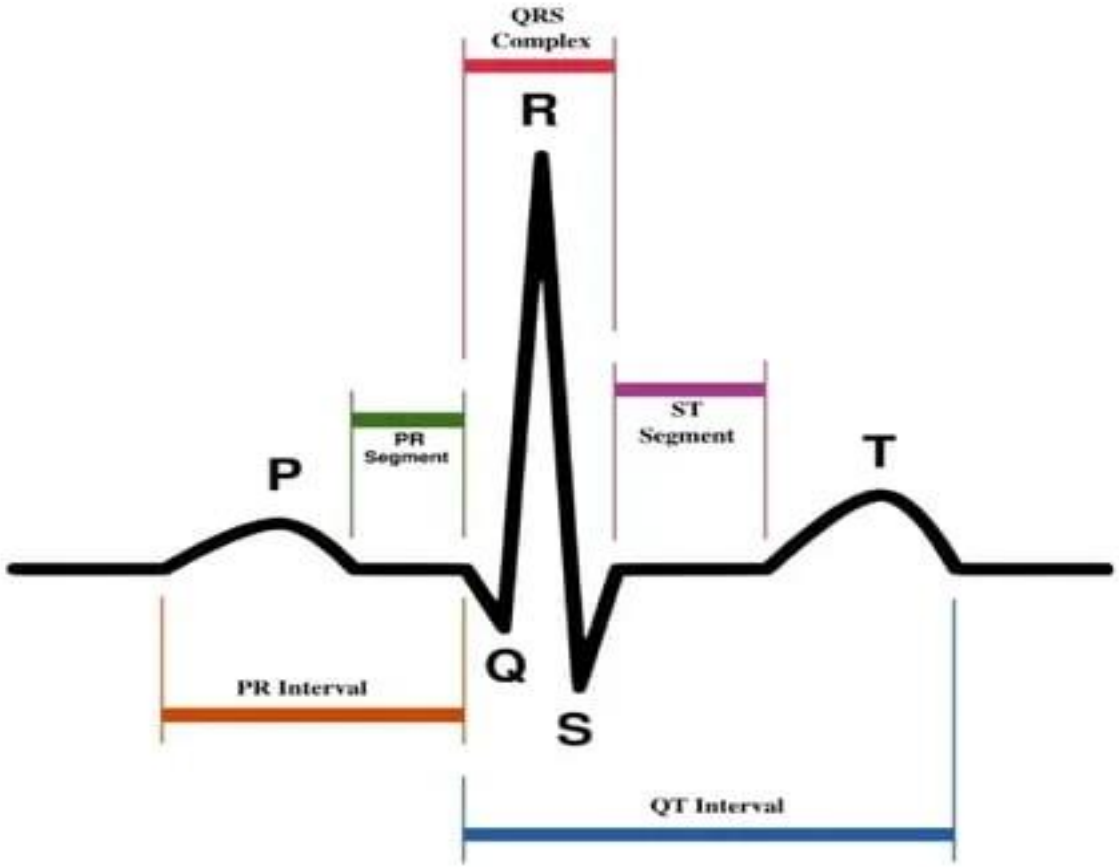
Impulses moves rapidly through the ventricles:

- Bundle of His
- Left & Right Bundle branches (LBB divides into the anterior fascicle and posterior fascicle)
- Purkinje fibers

Tertiary pacemaker (20 – 39)

EKG COMPLEX


QRS
Complex
R
PR
Segment
ST
Segment
P
T
Q
S
PR Interval
QT Interval

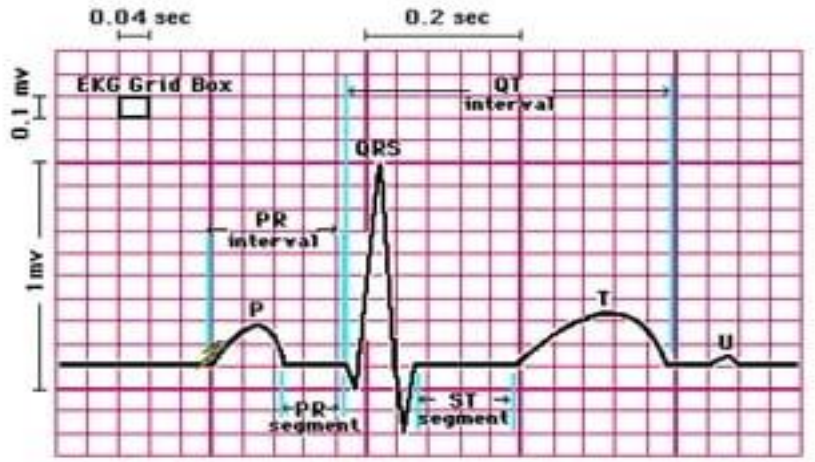


PQRST = One EKG complex = One Cardiac Cycle

Total Duration of a Cardiac Cycle = _____ seconds

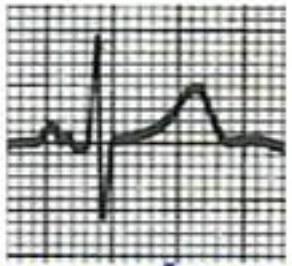
P Wave

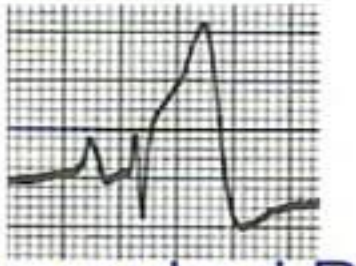
- Depicts the firing of the SA node and atrial depolarization (contraction).
- P waves are upright & rounded (in Lead II).
- Precedes a QRS
- Both atria depolarize simultaneously.



P Wave Abnormalities

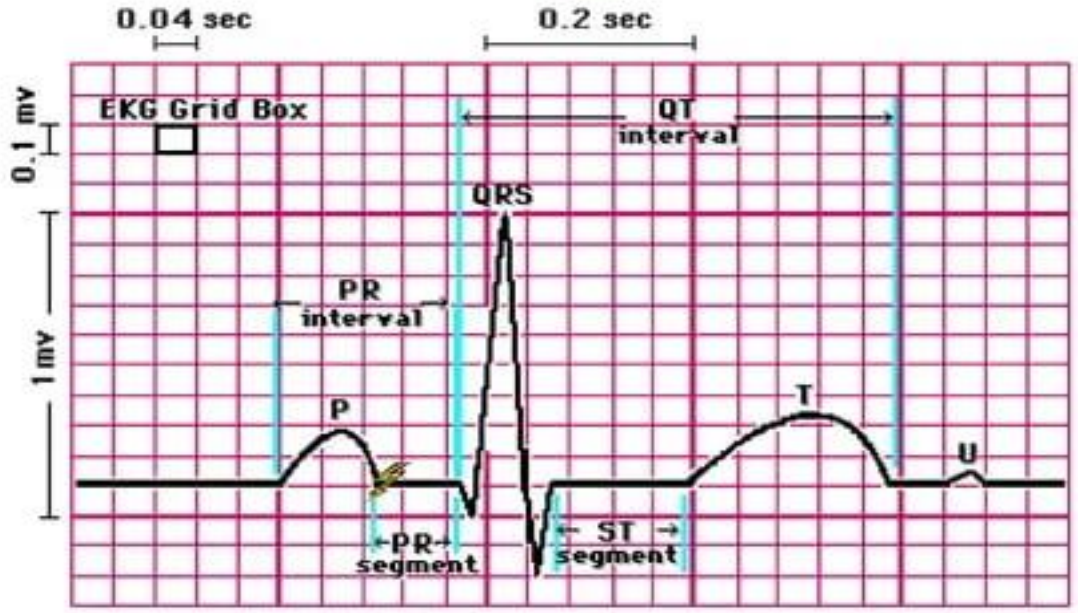
p mitrale = Wide & Notched P wave





p pulmonale = Tall, peaked P wave

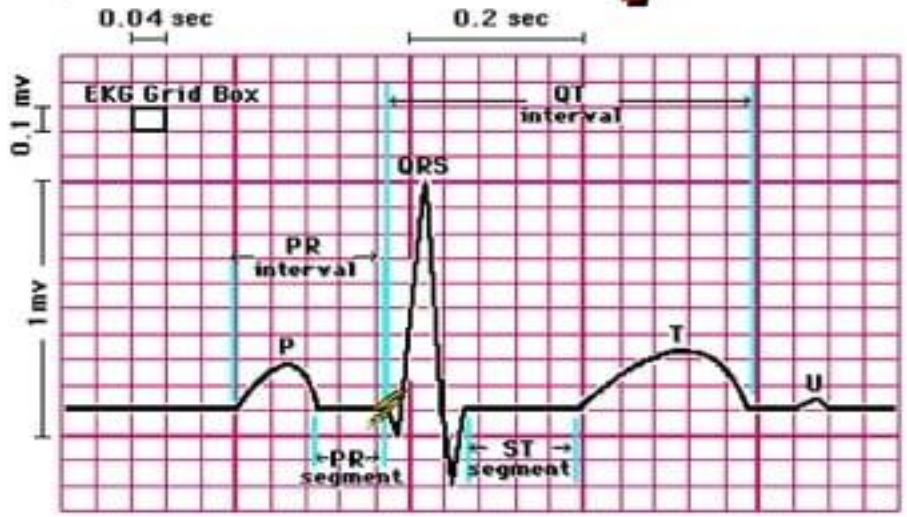
PR Segment



The PR segment represents delay in the AV node

Flat = Baseline

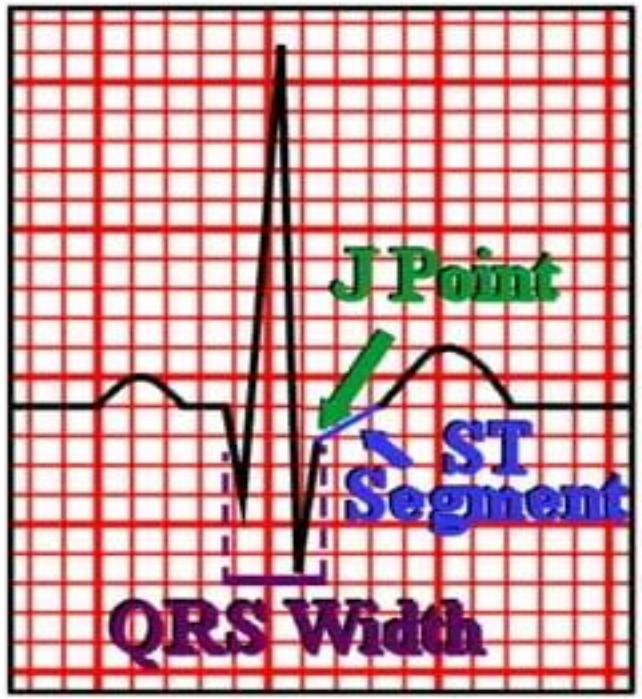
QRS Complex



Depicts the electrical impulse traveling through the ventricles and ventricular depolarization (contraction).

Not all QRS complexes have a Q, R, and S.

QRS Complex



See Overhead Slide 1-3

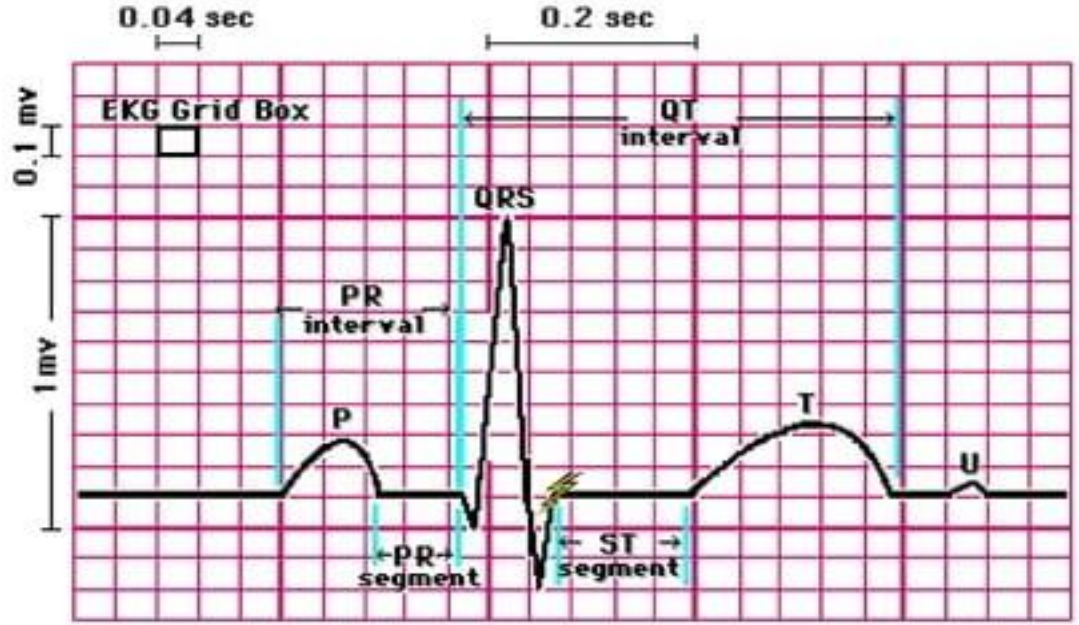
Q wave is the FIRST negative deflection

R wave is the FIRST positive deflection

S wave is the negative deflection that follows the R wave

J Point is the point where the QRS complex ends

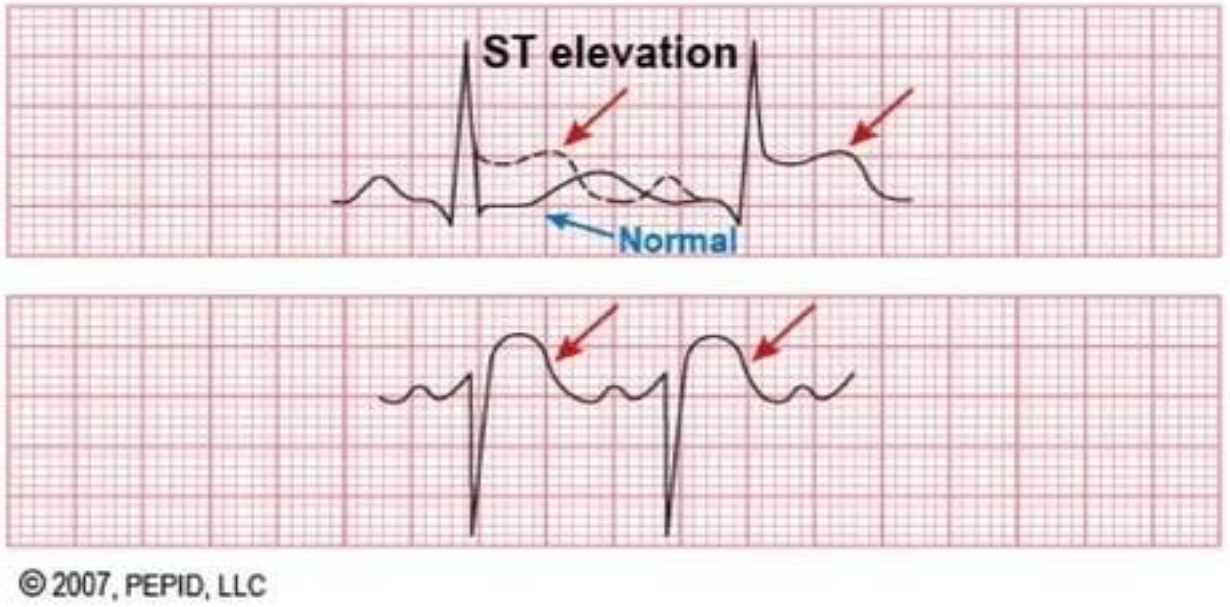
ST-Segment



The ST-segment represents ventricular contraction and period before ventricular repolarization. No electricity is flowing. The ST segment is therefore usually even with the baseline.

ST-Segment Elevation & Depression

To be considered a significant elevation or depression the ST must deviate at least 1 mm above or below the baseline (in at least 2 or more correlating leads)



ST-Segment Depression

Most often seen with acute myocardial ischemia

Other Causes:

Left and right ventricular hypertrophy
Left and Right BBB
Hypokalemia
Drug Effects (i.e. digitalis)

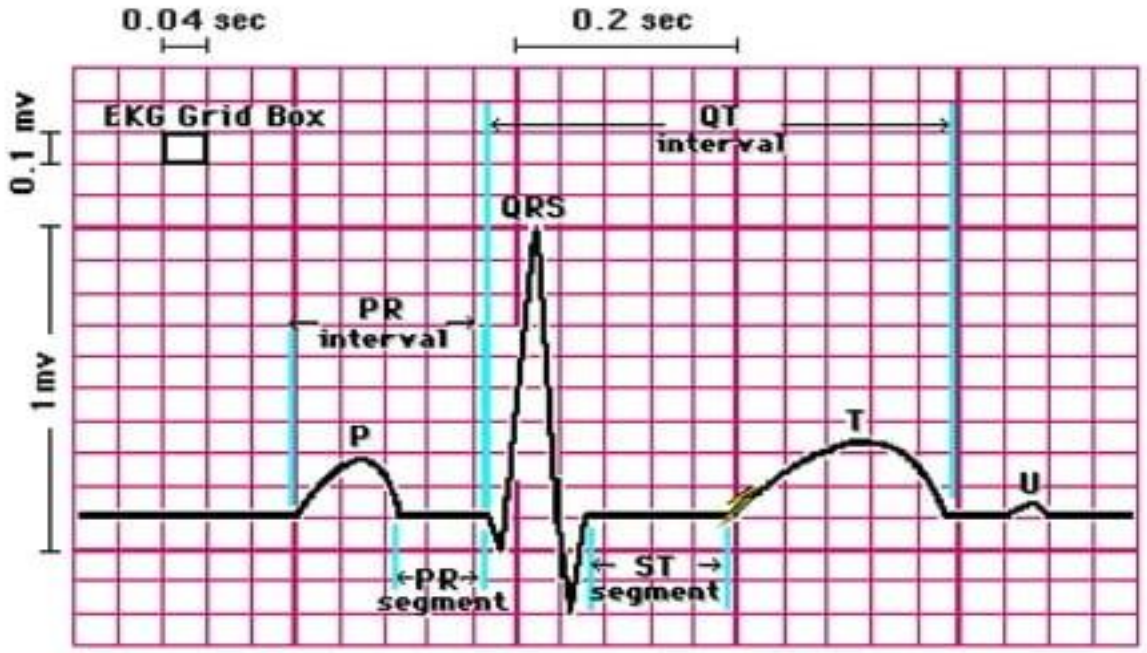
ST-Segment Elevation

Most often seen with acute myocardial injury or infarction

Other Causes:

Coronary vasospasm (Prinzmetal's Angina)
Pericarditis
Ventricular Aneurysm
Hyperkalemia
Early repolarization (a normal variant)

T Wave



Depicts ventricular repolarization

Refractory Period

T Waves

Positive Deflection

(above baseline < 5 mm)

Should appear rounded and symmetrical

Peak is closer to the end of the wave

Elevated T Waves

Positive Deflection

(above baseline ≥ 5 mm)

Tall, peaked (tented)

HYPERKALEMIA

or MYOCARDIAL INJURY

Inverted T Waves

Negative Deflection
(below baseline)

Causes:

Myocardial Ischemia

Myocardial Infarction

Pericarditis

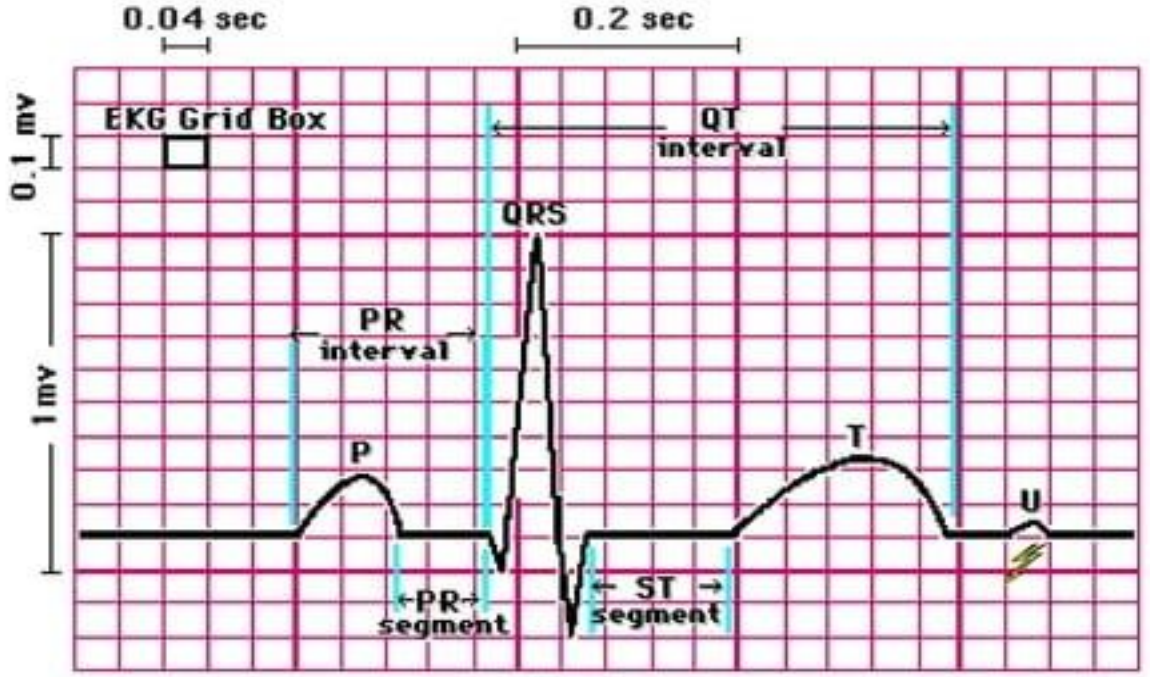
Ventricular Enlargement

Bundle Branch Block

Subarachnoid Hemorrhage

Certain Drugs (quinidine or procainamide)

U Wave



Depicts last phase of ventricular repolarization or endocardial repolarization???

U Wave

U Wave < 2 mm

Seen most commonly with BRADYCARDIC rate

Can cause inaccuracies when measuring QT intervals

U Wave

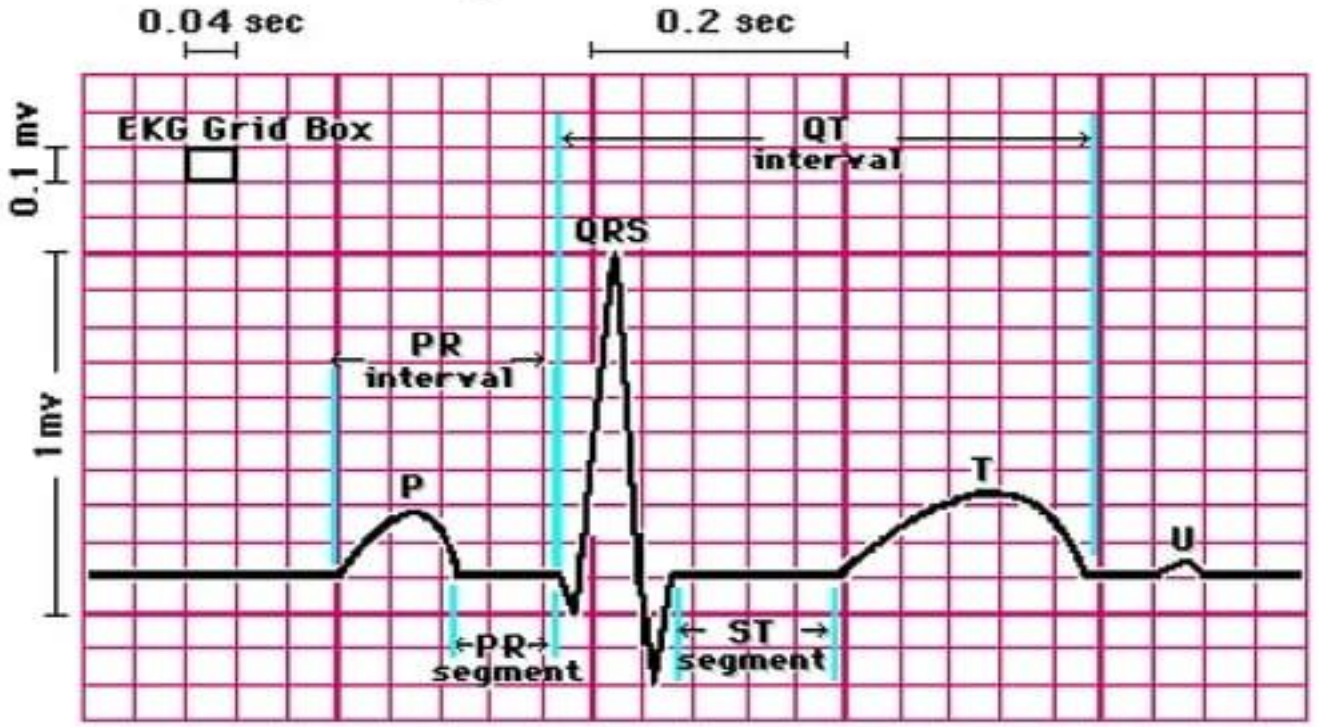
U Wave < 2 mm

Large = hypokalemia, cardiomyopathy, LV enlargement

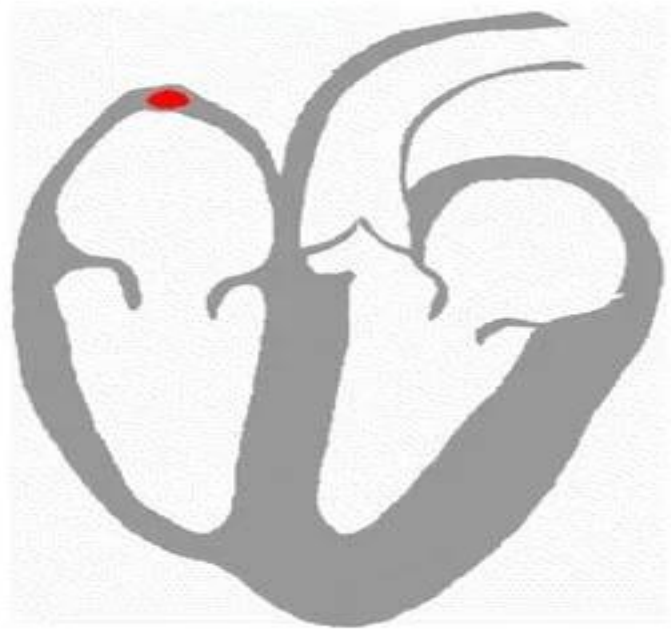
Some drugs may cause a large U wave

May cause Torsades de Pointes

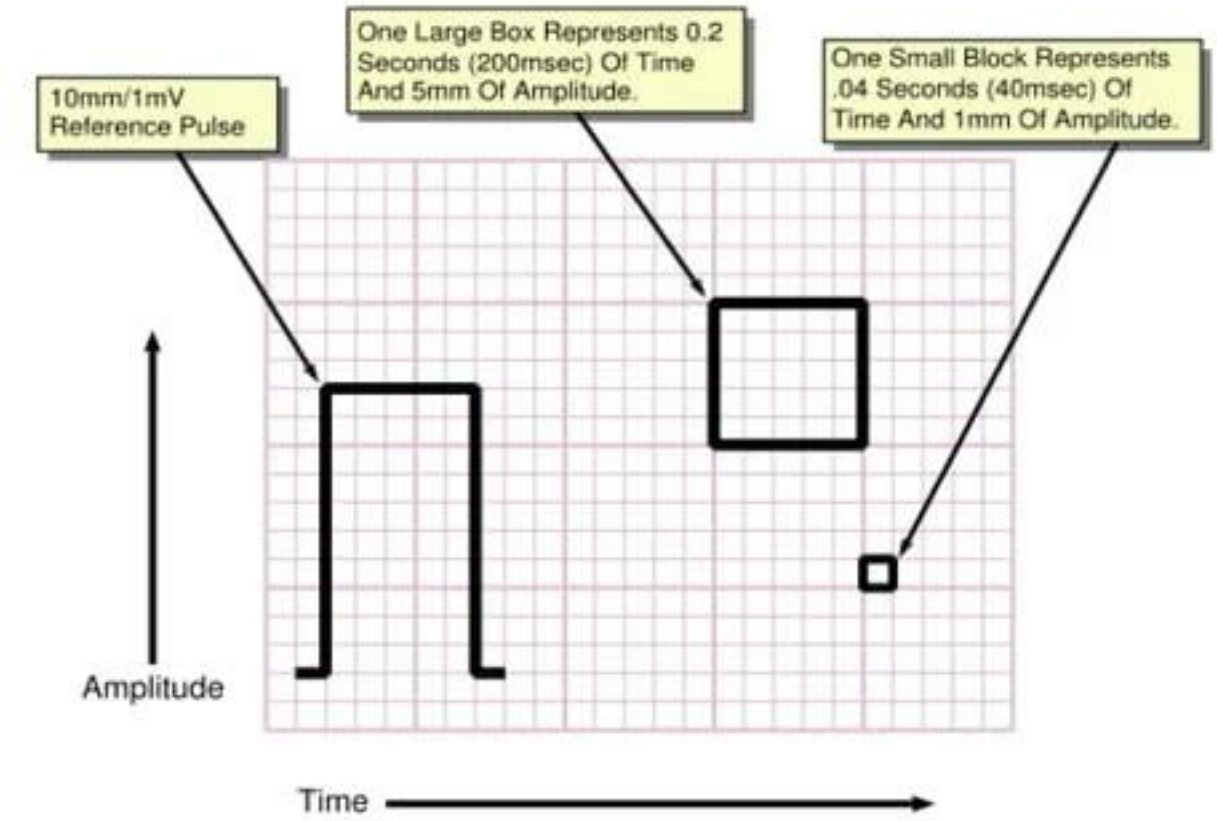
Atrial Repolarization ???



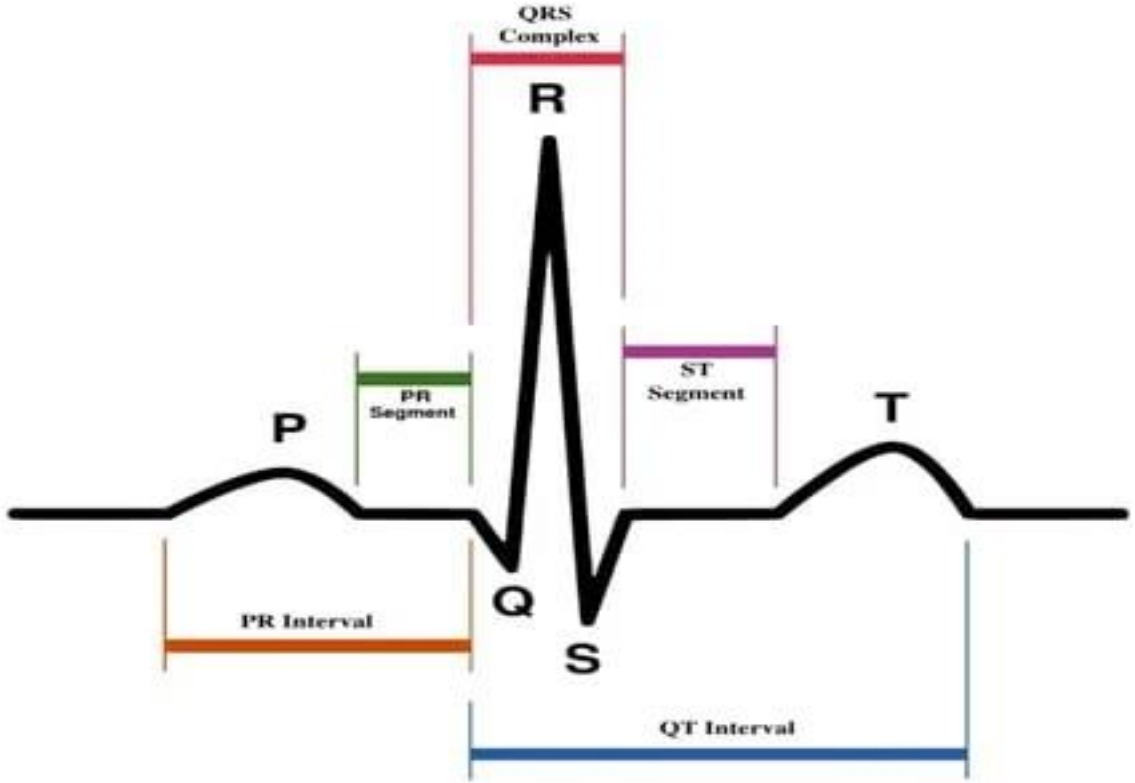
Hidden beneath the QRS complex.



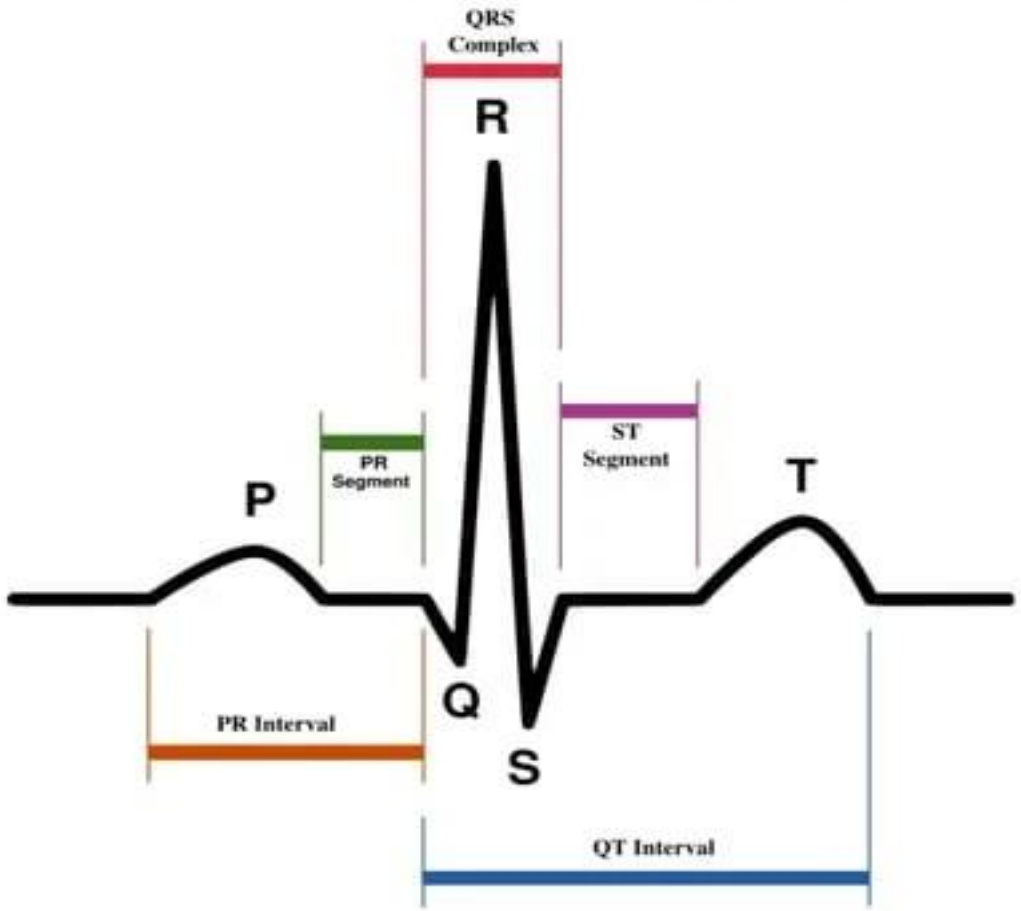
EKG Graph Paper



Waveform Measurements



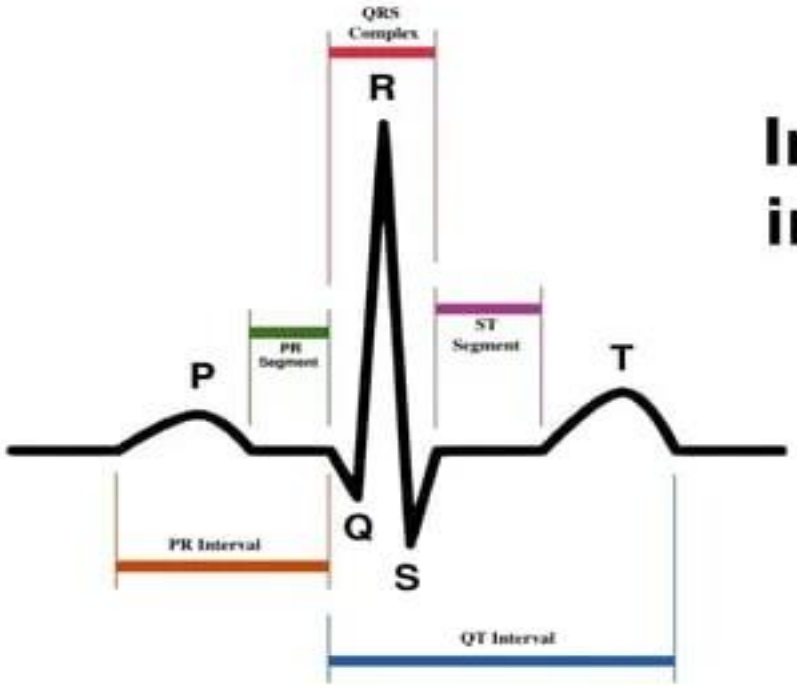
PR Interval



Measurement: 0.12 – 0.20 seconds

Represents the time from SA node firing to the end of AV node delay

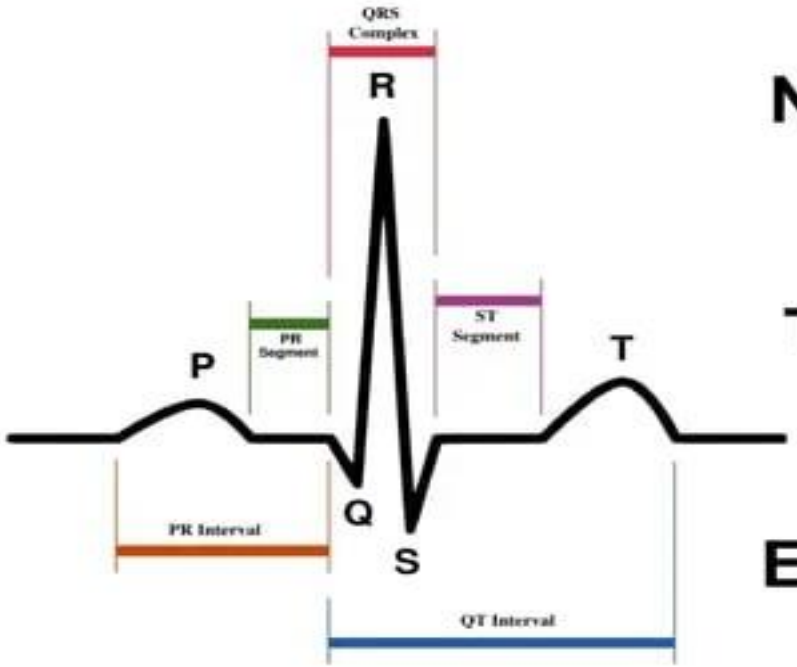
PRI Abnormalities



Prolonged or Inconsistent PRI's may indicate a type of heart block:

1st degree AVB
Mobitz 1 or Mobitz 2
Complete AVB

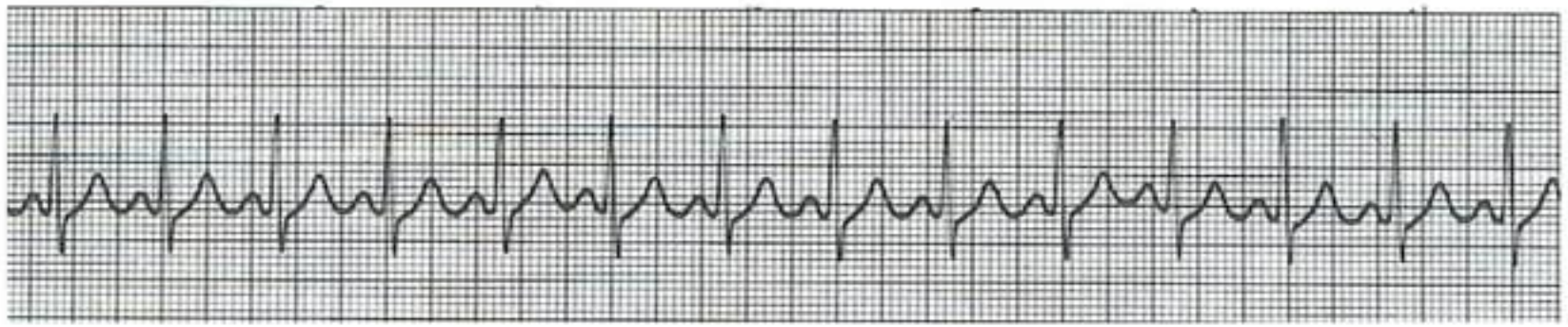
PRI Abnormalities



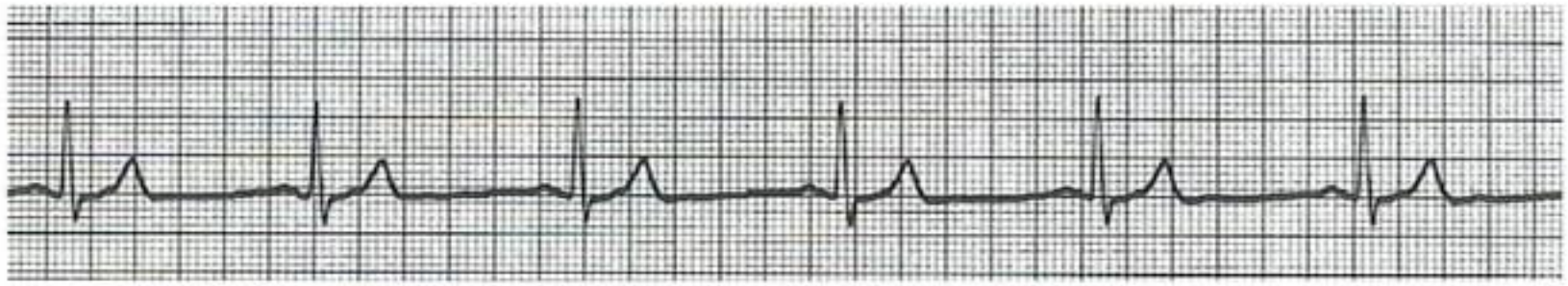
Shortened or Nonexistent PRI's may indicate:

Tachycardic Rhythms
WPW Syndrome
Junctional Rhythms
Ectopic Atrial Rhythms
Ventricular Rhythms

PR Interval

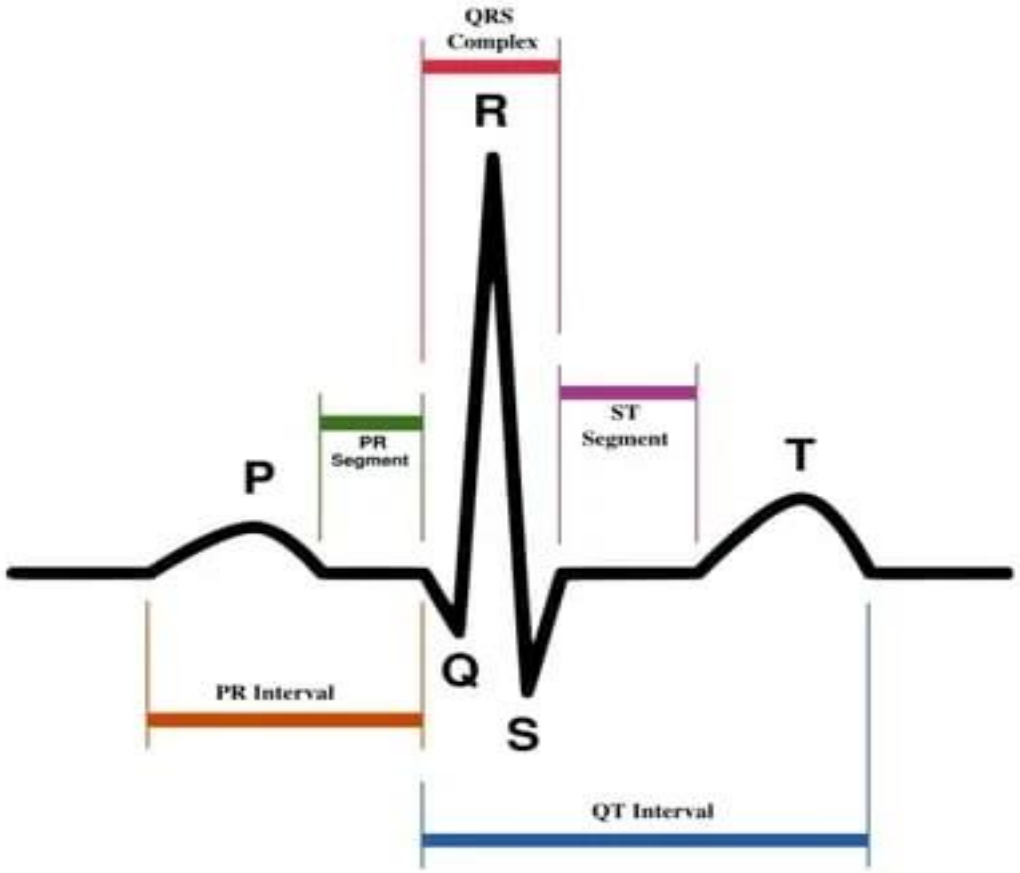


PRI=



PRI=

QRS Duration



Measurement: 0.04 – 0.10 seconds

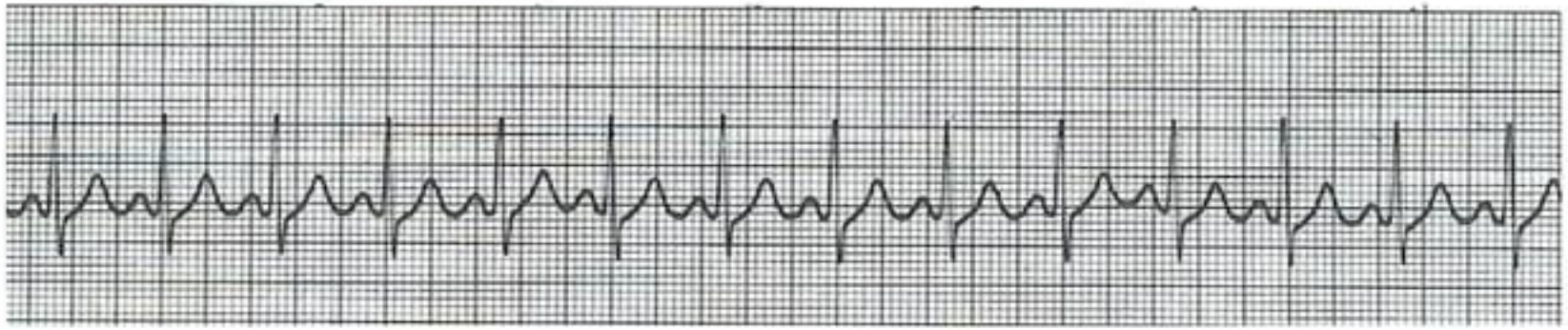
Represents the travel time of electrical activity through the ventricles

QRS Complex Variations

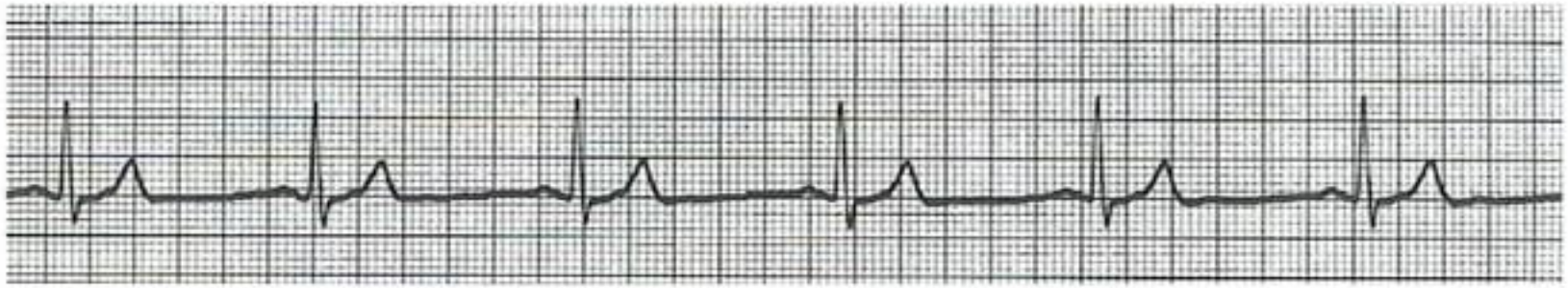
Wide and/or notched QRS complexes:

- BBB's
- Aberrant ventricular conductivity
- Rhythms with Ventricular Focus

QRS Duration

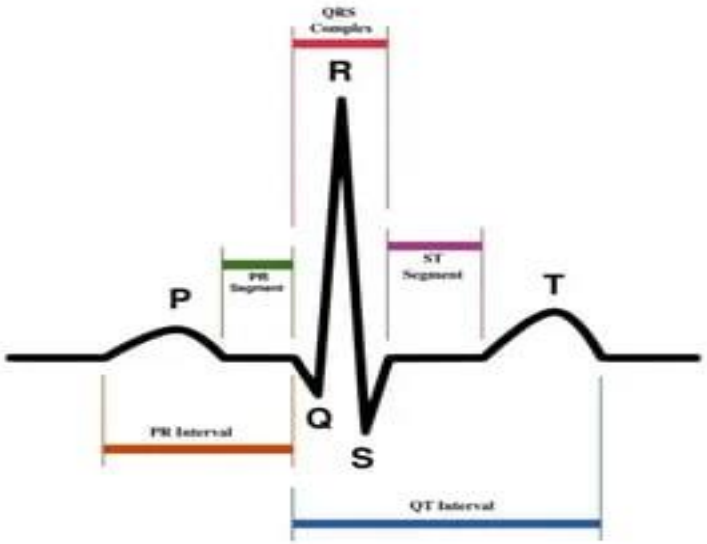


QRS=



QRS=

QT Interval



Measurement:
< ½ the distance of the preceding R-R interval

Represents travel time through ventricles to the end of ventricular repolarization

Normally varies according to age, sex, and particularly heart rate

QT Rate Corrected

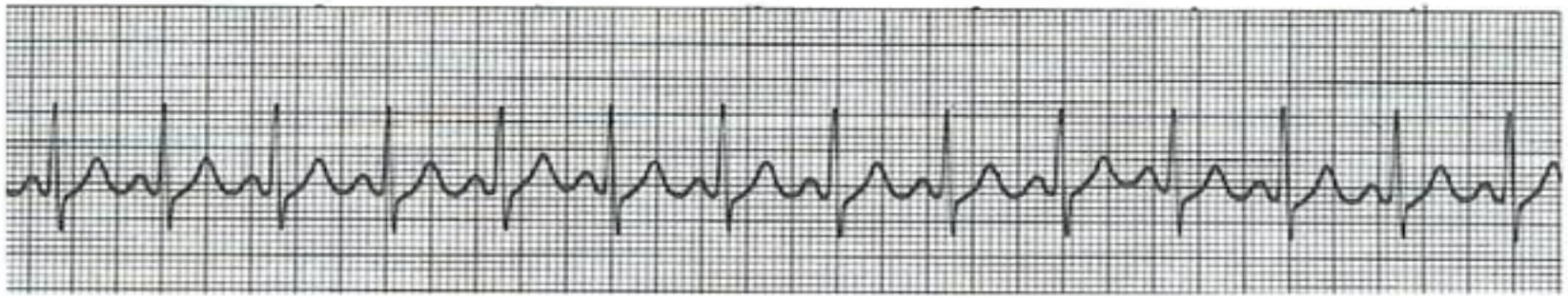
HR ↑ = QT interval ↓

HR ↓ = QT interval ↑

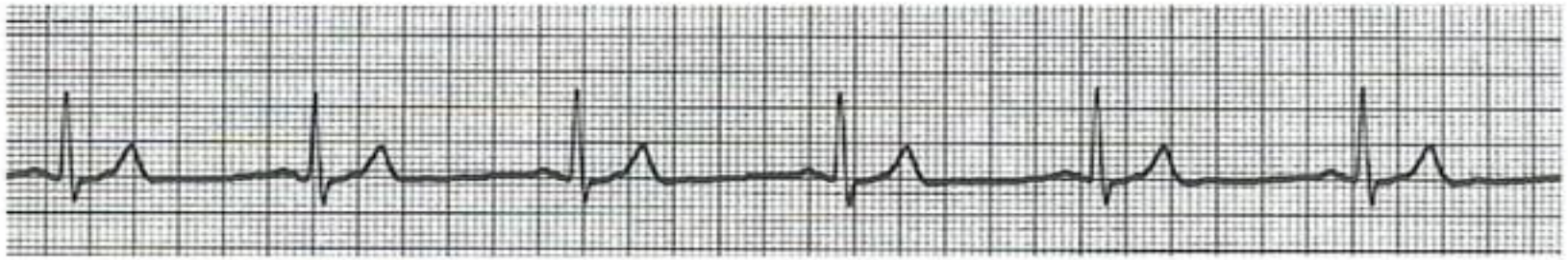
QTc =

QT + 1.75 (ventricular rate – 60)

QT Interval

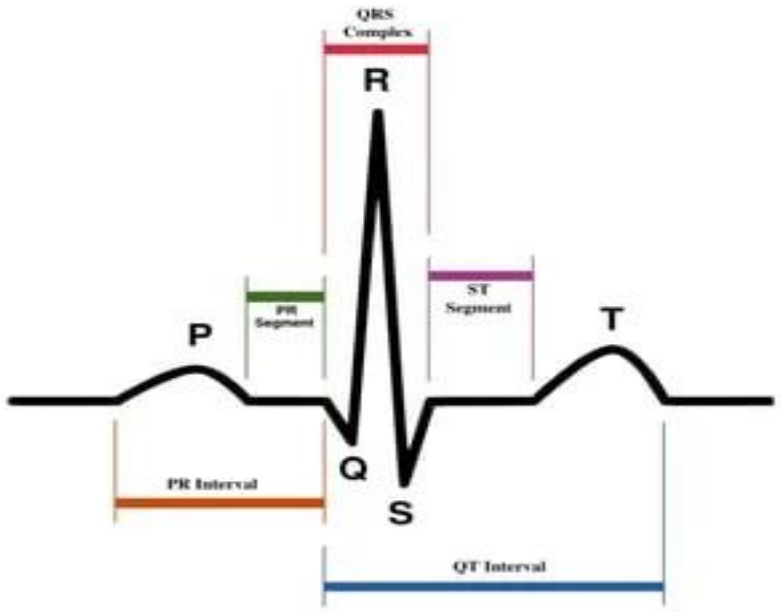


QT= QTc=



QT= QTc=

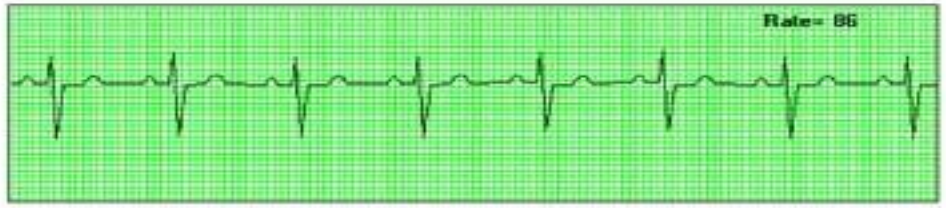
Prolonged QT Intervals



Represents a prolonged time to repolarization

May lead to R-on-T Phenomenon and ventricular dysrhythmias!!!

Basics to Interpreting Strips



Rhythm

Rate

P Wave

PR Interval (PRI)

QRS Duration

RHYTHM

Determine regularity or irregularity

Use calipers for accuracy

Measure distance from R-R wave

Regular Rhythm = R-R distance does not vary (less than 3 small boxes of variation does not count)

Irregular Rhythm = R-R distance varies (3 small small boxes or greater)

HEART RATE

Use 1500-rule and the 6-second rule for all ***regular*** rhythms

6-second rule only for ***irregular*** rhythms

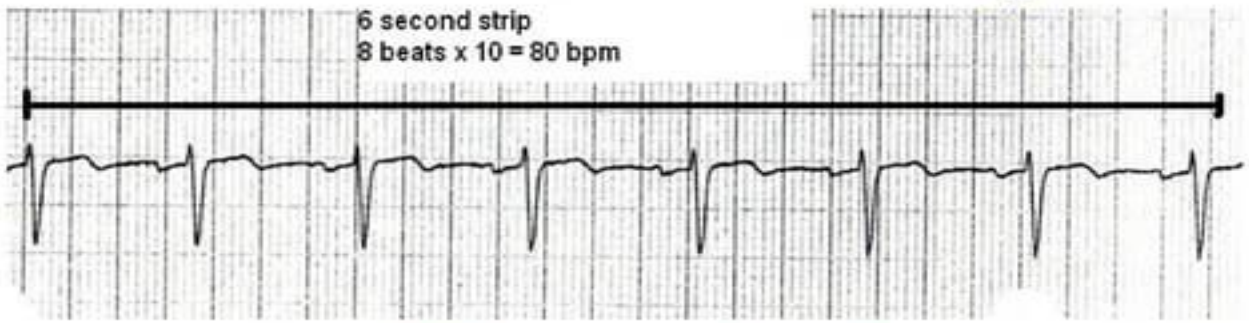
Calculating Heart Rates

The 6-Second Rule

The Rule of 300's

The 1500 Rule

6-Second Strip



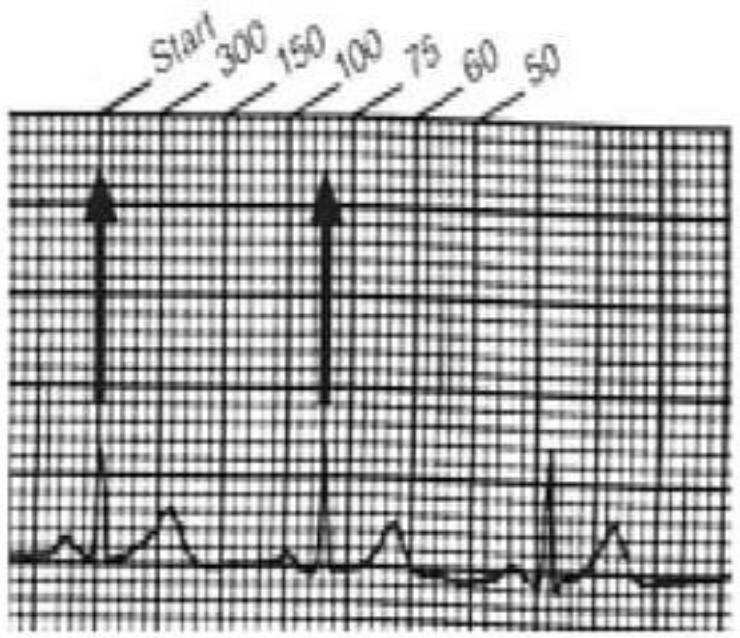
Count number of R waves in a 6-second strip and multiply by 10

A.K.A. Rapid Rate Calculation

HR = # R waves x 10

- *Not very accurate*
- *Used only for very quick estimate*

Rule of 300's

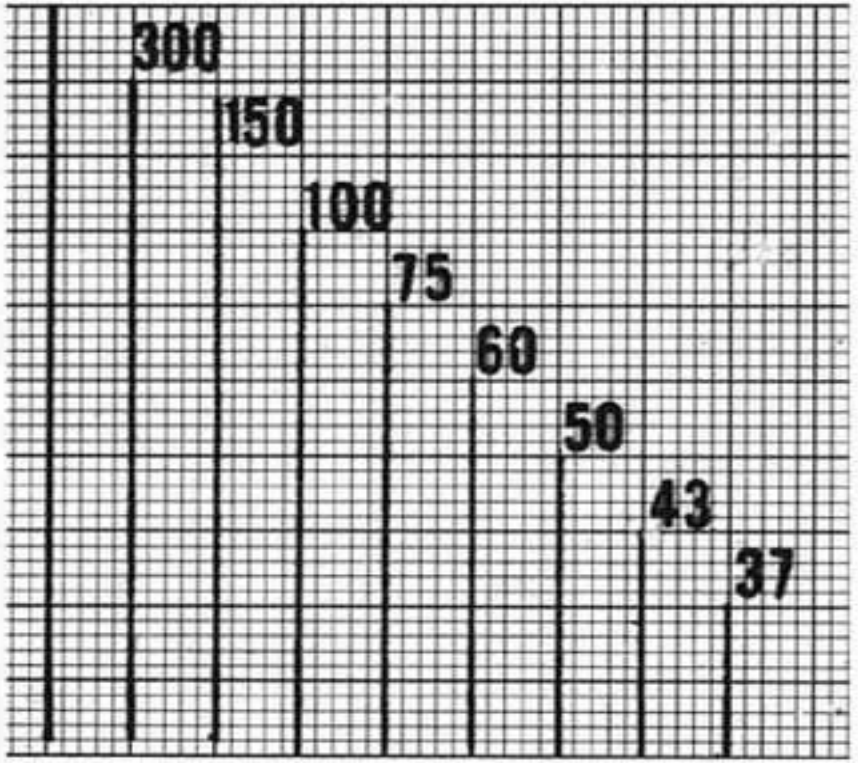


Count number of large squares between 2 consecutive R waves and divide into 300.

HR = 300 / # large squares

- Very quick
- Used only with regular rhythms
- Not very accurate with fast rates

Rule of 300's



Scale of 300

1 large square = 300 bpm
2 large squares = 150 bpm
3 large squares = 100 bpm
4 large squares = 75 bpm
5 large squares = 60 bpm
6 large squares = 50 bpm

1500 Rule

Count number of small squares between 2 consecutive R waves and divide into 1500

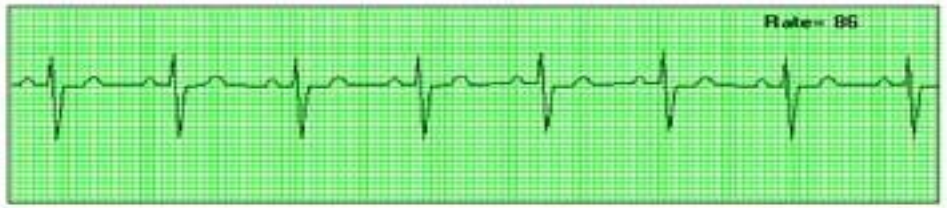
A.K.A. – Precise Rate Calculation

- Most accurate
- Used only with regular rhythms
- Time-consuming

P Waves

- Upright
- Uniform
- Precedes each QRS complex
- Any extra P waves

PRI



- Measure from beginning of P wave to the end of the PR segment
- 0.12 – 0.20 seconds
- Constant

QRS Complex

- Measure from beginning to the end of QRS complex (1st deflection from baseline after the PR segment to the beginning of the ST segment)
  - 0.04 – 0.10 seconds
  - Notched???, Wide, etc.

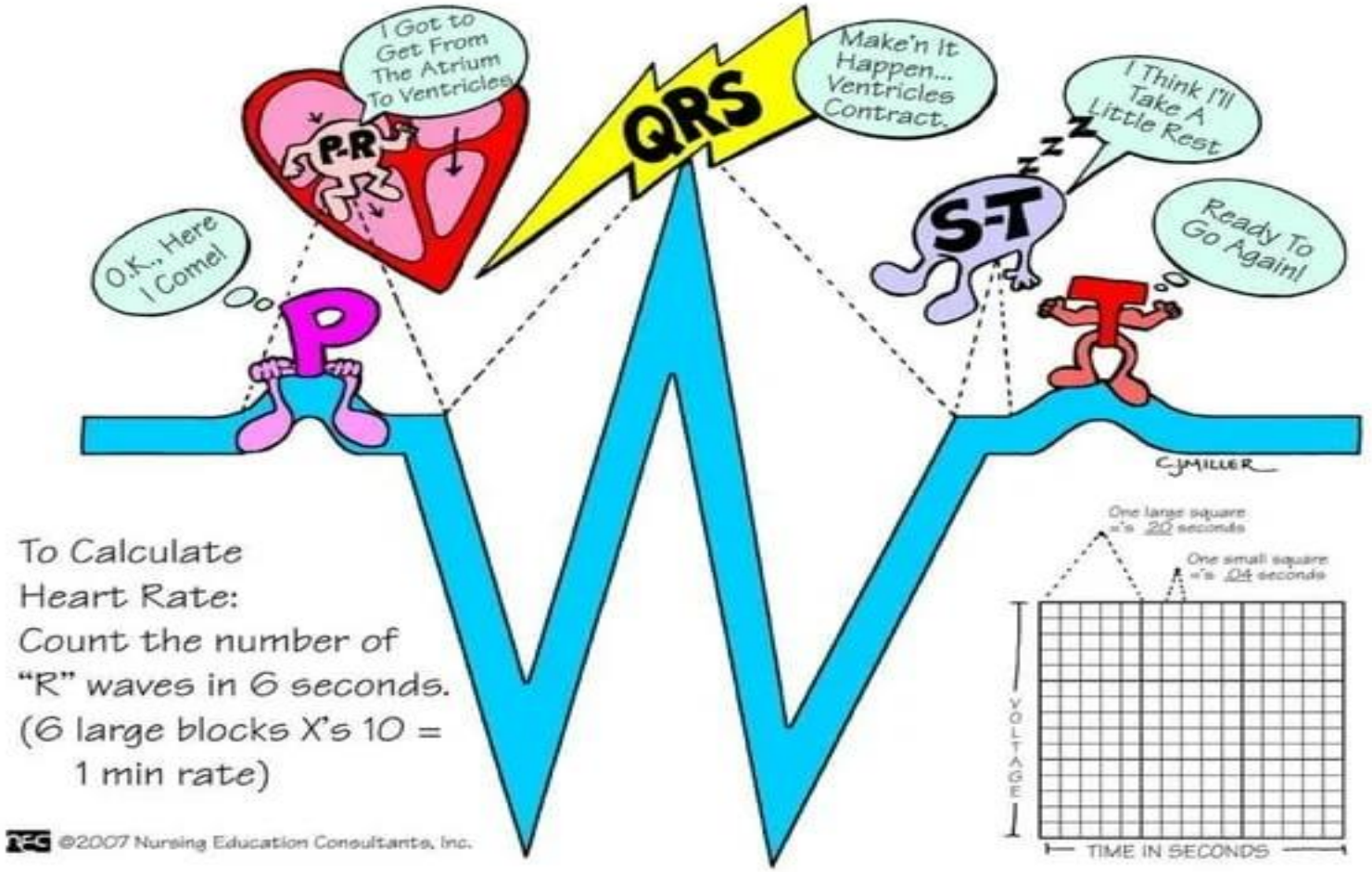
QT Interval or QTc

- QT Interval = Count the # of small boxes from beginning QRS complex to the end of the T wave. Should be less than ½ the distance of the preceding R-R interval

- QTc = *QT + 1.75 (ventricular rate – 60)*

Extras???

- P waves without QRS complexes
- ST-segment depression or elevation


I Got to Get From The Atrium To Ventricles
P-R
QRS
Make'n It Happen... Ventricles Contract.
I Think I'll Take A Little Rest
S-T
Z Z Z
Ready To Go Again!
O.K., Here I Come!
P
T
C.J.MILLER
To Calculate Heart Rate:
Count the number of "R" waves in 6 seconds.
(6 large blocks X's 10 = 1 min rate)
©2007 Nursing Education Consultants, Inc.
One large square =.20 seconds
One small square =.04 seconds
VOLTAGE
TIME IN SECONDS

Thank You!