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## THE BASIC CARDIAC RHYTHMS COMPANION COURSE

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**NOTICE**

The criteria presented here are based upon a consensus of previously published information in addition to the author's own experiences and viewpoints. Readers should seek additional references regarding ECG interpretation to continually improve their skills. While topics presented may include causes and treatments where appropriate, the primary focus of this text will include the proper identification of selected cardiac rhythms. Readers should review package inserts and user manuals for any medications, therapeutic agents, or devices as directed by the USFDA. The author, editor, and publisher disclaim responsibility for adverse effects resulting from omissions and undetected errors or adverse results obtained from the use of the information in this book. Application of the information in any situation remains the professional responsibility of the licensed individual performing such interventions. Information presented in this text is not medical advice and it is the responsibility of the reader to verify accuracy of all materials presented.

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### Overview

- Introduction
- Cardiovascular principles as they pertain to cardiac rhythms
- Essentials of ECG monitoring
- The Cardiac Cycle
- Rhythm analysis progression & rhythm standardization
- Rhythms presented by site of origin with recap quizzes following each section
- Rhythms categorized by site of origin for targeted study:
  - Sinus origin
  - Atrial origin
  - Junctional origin
  - Ventricular origin
  - Atrioventricular (AV) blocks
  - Pacemakers
  - 60 second quick review videos for select popular topics

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### Introduction

- What is an electrocardiogram (ECG)?
- Methods for visualizing and/or characterizing cardiac activity
- ECG uses
- What are dysrhythmias and why do we care?

**ELECTROCARDIOGRAM (ECG)**

**3-LEAD ECG**

**SURFACE ELECTRODES**

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### Cardiovascular physiology

**CARDIAC OUTPUT INFLUENCE**

**PRELOAD**

1. Stroke volume
2. Cardiac output
3. Cardiac reserve
4. Stroke volume reserve
5. Stroke volume reserve

**CONTRACTILITY**

1. Stroke volume reserve
2. Cardiac output reserve
3. Cardiac reserve
4. Stroke volume reserve
5. Stroke volume reserve

**AFTERLOAD**

Left ventricle → Aortic valve → Aorta → Systemic circulation

Right ventricle → Pulmonary valve → Pulmonary artery → Pulmonary circulation

**CARDIAC OUTPUT**

**PRELOAD**

**AFTERLOAD**

**CONTRACTILITY**

**CO = HR x SV**

HR: Heart rate (b/min)

SV: Stroke volume (ml/beat)

CO: Cardiac output (l/min)

• #1 If average HR is 70 bpm

• #2 If average SV is 70ml per beat

• #3 Then, CO = 4.9 L/min (3.5L)

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### Blood flow

- How does blood flow through the heart?
- The relationship between electrical and myocardial cells
- Which came first: the chicken, or the egg?

**BLOOD FLOW**

Through the heart

**VALVE ORDER**

T - Tricuspid  
P - Pulmonic  
M - Mitral  
A - Aortic

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### CARDIAC OUTPUT

How do we measure the output of the heart?

- What is cardiac output?
- Stroke volume
- Heart rate

**CO = HR x SV**

#1) If average HR is 70 BPM  
 #2) And average SV is 70mL per beat (70bpm x 70mL = 4,900 mL/min)  
 #3) Then, CO = 4.9 Liters (L-SL)

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### Variables influencing cardiac output

- Preload
- Afterload
- Contractility
- How beta blocking medications work

**CARDIAC OUTPUT INFLUENCE**

**PRELOAD**  
 1. Venous return  
 2. End diastolic volume  
 3. Contractile force volume  
 4. Respiratory pressure  
 5. Ventricular pressure

**AFTERLOAD**  
 1. Systemic vascular resistance (SVR)  
 2. Aortic pressure  
 3. Left ventricular pressure

**CONTRACTILITY**  
 1. End diastolic pressure  
 2. Sympathetic nervous system stimulation  
 3. Ca<sup>2+</sup> supply

Handwritten notes:  
 Inspiration decreases left ventricular pressure  
 Mild hypoxemia stimulates contractility increases  
 Stroke volume  
 Hemodynamics  
 Medication: Epi/Neosynephrine, Dopamine

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### Impairments in cardiac output

**CARDIAC OUTPUT (HR X SV)**

**CO = HR x SV**

Signs of impaired cardiac output

- Hypotension
- Chest pain
- Weak peripheral pulses
- Hypoxia
- Cardiac dysrhythmias
- Palpitations
- Dyspnea, Fatigue, Dizziness
- Decreased urine output
- Cool, clammy skin

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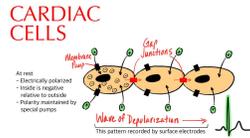
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### Cardiac cells: pacemaker and muscle

- Automaticity
- Excitability
- Conductivity
- Comparing pacemaker cells to myocardial cells
- Depolarization and positive deflections



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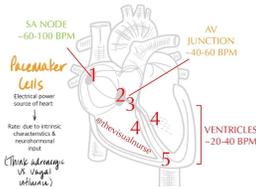
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### Impulse conduction: top to bottom

- Electrical versus plumbing
- Myocardial cells
- Pacemaker cells
- Inherent heart rate by location
- What does the natural conduction pathway look like?

### CONDUCTION PATHWAY



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### ECG RATES REFERENCE SHEET

SINUS:		JUNCTIONAL:		VENTRICULAR:	
BRADYCARDIA	<60	BRADYCARDIA	<40	INTRINSIC	20-40
INTRINSIC	60-100	ACCELERATED TACHYCARDIA	60-100	ACCELERATED TACHYCARDIA	50-100
TACHYCARDIA	>100	TACHYCARDIA	>100	TACHYCARDIA	>100
		SVT = Commonly >150 (dependent upon type/identification)			

\*WANDERING ATRIAL PACEMAKER <100 BPM

\*MULTIFOCAL ATRIAL TACHYCARDIA >100 BPM

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**3-LEAD ECG**

**RECORDING ELECTRICAL ACTIVITY**  
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**Cardiac vectors**

- What is the cardiac vector?
- Rule #1 of cardiac rhythm interpretation
- Natural path of electrical progression in the heart
- Positive vs. negative deflections
- The purpose of ECG graph paper

**CARDIAC VECTORS**

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**CARDIAC VECTORS**

**VOLTAGE**

**TIME**

0.20 sec  
0.04 sec

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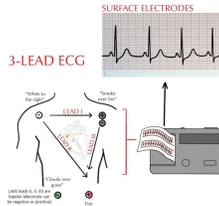
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### Leads: What are they reading?

- White to the right, smoke over fire
- Leads = camera angles
- Positive deflections in leads I & III
- Lead II: often preferred as the *rhythm lead/ rhythm strip*



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### Lessons 1 & 2: Review

- Blood flows through the heart's AV and semilunar valves in what order?
  - Tricuspid
  - Pulmonary
  - Mitral (bicuspid)
  - Aortic



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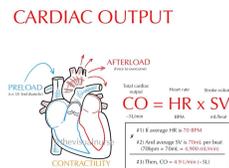
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### Lessons 1 & 2: Review

- Cardiac output is the product of what 2 variables?
  - Heart rate X Stroke volume
- Why is cardiac output equal to roughly ~5L on average?



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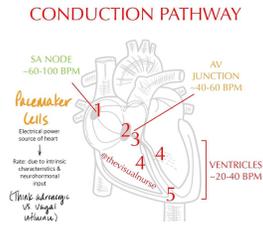
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### Lessons 1 & 2: Review

- Which of the following is correct regarding pacemaker sites and inherent rate of depolarization?
  - SA node: 60 – 100 BPM
  - Junctional: 20 – 40 BPM
  - Ventricular: 40 – 60 BPM




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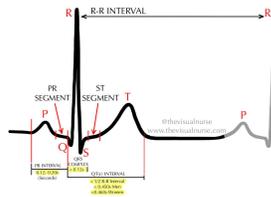
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### THE CARDIAC CYCLE



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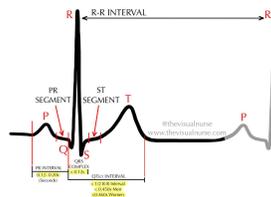
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### The cardiac cycle

- What is the cardiac cycle and what does it represent?
- Each cardiac cycle *should* produce a palpable pulse
- Danger associated with ventricular tachycardia



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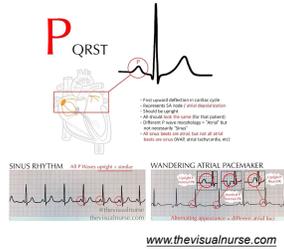
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### The P wave

- What does the P wave represent?
- What about differing P wave morphology?
- Sinus versus atrial
- The wandering atrial pacemaker




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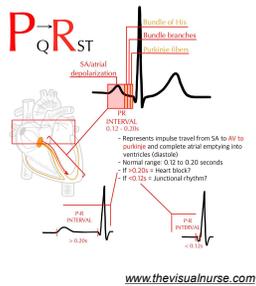
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### The PR interval and PR segment




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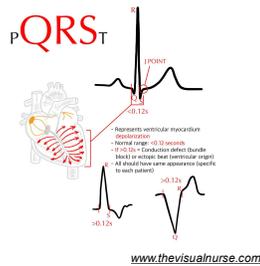
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### The QRS complex

- Represents what?
- Normal range?
- Wider than normal complexes




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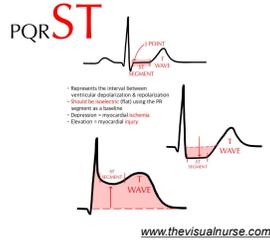
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### The J point and ST segment

- Significance of the J point
- Significance of the ST segment
- How to evaluate the ST segment and what the ST indicates
- How do we describe elevation or depression?



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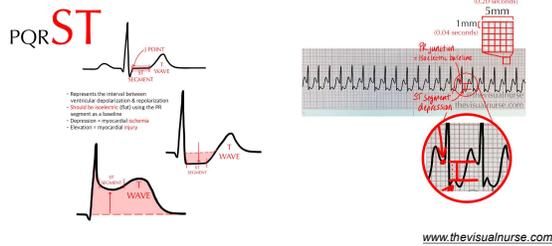
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### The J point and ST segment



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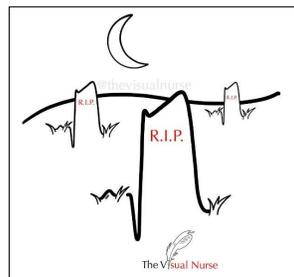
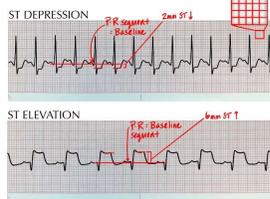
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### The T wave

- Repolarization
- Refractory state of the ventricles
- Abnormal T waves

**QTc**

- Represents ventricular repolarization
- Should be upright
- Flat, biphasic or inverted T wave indicates
- Ischemic changes or other imbalances
- Changes may be chronic
- May also be peaked

**BIPHASIC T WAVE ON ECG**

**T WAVE INVERSION ON ECG**

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### The QT interval

- Represents?
- Dangers of prolonged QTc
- Remember the T wave and the concept of refractory states

**QTc**

- Represents full ventricular cycle (depolarization to repolarization)
- Should be < 440 ms (M) or < 460 ms (F)
- < 0.440s in men
- < 0.460s in women
- < 0.500s during medication therapy
- Hereditary electrolyte, or drug induced
- Torsades VT

**QTc**

- S Sotalol
- H Haldol
- A Amiodarone
- Z Ziprasidone
- A Azoles
- M Macrolides

**TORSADES DE POINTES**

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### The QT interval

**QTc**

- Prolongation
- "SHAZAM"
- S Sotalol
- H Haldol
- A Amiodarone
- Z Ziprasidone
- A Azoles
- M Macrolides

**TORSADES DE POINTES**

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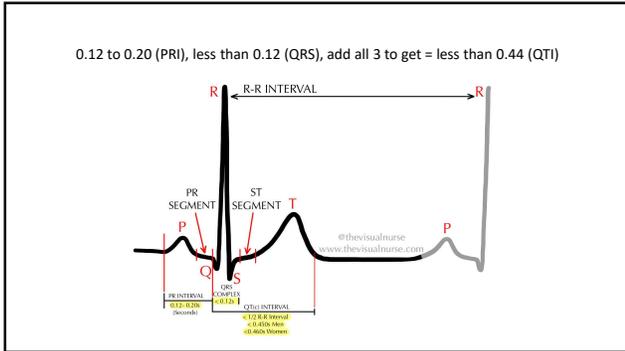
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### Review

- What is the normal range for the PR interval?
  - < 0.12 seconds
  - 0.12 to 0.20 seconds
  - < 0.44 seconds
  - < 0.46 seconds
- True or false:
  - If the PR interval is greater than 0.20 seconds, this may indicate an atrioventricular (AV) block, or AV delay.

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### Review

- The QRS complex should be:
  - ≤ 0.12 seconds
  - 0.12 to 0.20 seconds
  - < 0.44 seconds
  - < 0.46 seconds
- True or false:
  - A narrow QRS (≤ 0.12 seconds) indicates the impulse is coming from above the ventricles.

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### Review

- Generally speaking, ST segment depression may represent this until proven otherwise:
  - Myocardial ischemia
  - Myocardial injury
  - Nothing, this is an expected finding
- Generally, the QT interval should be:
  - < 0.12 seconds
  - < 0.44 seconds\*
  - > 0.80 seconds
  - > 1 second

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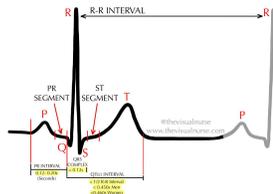
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### Review

- How do we easily remember normal values for cardiac cycle intervals?



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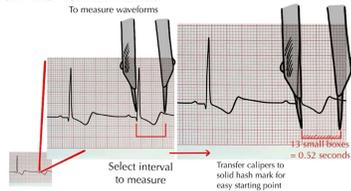
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### USING CALIPERS

To measure waveforms



### HOW DO WE STANDARDIZE RHYTHMS?

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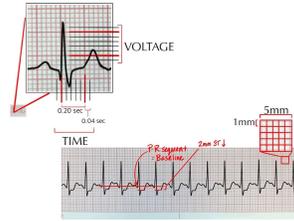
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### Special paper for waveform recording

- Purpose of ECG paper
- Smallest boxes in the paper
- "Big boxes"
- Using time as a constant



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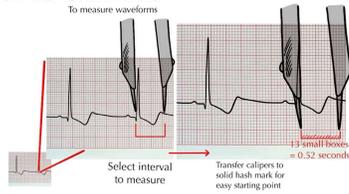
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### Measuring waveforms and intervals

#### USING CALIPERS



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### Standardizing rhythm evaluation

- Use the same progression *every single time*
- Use the analysis template to the right
- Practice daily

1. RATE: Atrial: \_\_\_ Ventricular: \_\_\_  
 2. RHYTHM: Atrial Regular Irregular Ventricular Regular Irregular  
 3. P WAVES: \_\_\_ 4. PR: \_\_\_ 5. QRS: \_\_\_ 6. QT: \_\_\_  
 7. ST SEGMENT: Okay Elevated Depressed 8. T WAVES: \_\_\_



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### Rhythm analysis progression

- Rate
- Rhythm
- P waves
- PR interval
- QRS complex
- QT interval
- ST segment
- T waves

**R** x2 →

**P** x2 →

**Q** x2 →

**STaT**

1 Rate &  
2 Rhythm

3 P waves &  
4 PR interval

5 QRS &  
6 QT interval

7 ST segment &  
8 T waves

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### Step 1: Calculating heart rate

- What is heart rate?
- Relation to cardiac output
- Significance of rapid heart rate determination

**ECG RATES**  
REFERENCE SHEET

**SINUS & ATRIAL\* ORIGIN**  
0-100: SINUS BRADYCARDIA; 100-160: SINUS TACHYCARDIA; 160-200: ATRIAL TACHYCARDIA

**JUNCTIONAL ORIGIN**  
0-100: JUNCTIONAL BRADYCARDIA; 100-180: JUNCTIONAL TACHYCARDIA; 180-250: SUPRAVENTRICULAR TACHYCARDIA

**VENTRICULAR ORIGIN**  
0-100: VENTRICULAR BRADYCARDIA; 100-200: VENTRICULAR TACHYCARDIA; 200-300: VENTRICULAR FIBRILLATION

\*Normal (60-100) & small (fast) (not depicted) (fast) simply mean the reference normal range for the particular rhythm.

\*\*Supraventricular tachycardia in this image and subsequent copies refers to paroxysmal SVT (PST), commonly an atrioventricular (AVNRT) or atrial tachycardia (AT) and not ventricular tachycardia (VT). Rates may range 150-250 but are commonly >150 beats per minute.

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### Rate: The 6 second method

- Preferred method for beginners
- What are we referring to here?
- Remember your big boxes
- Testing and exam purposes

**Step 1:**  
**RATE: The 6 second method**

ECG strip showing 6 seconds with 3 big boxes. Rhythms: Atrial, Ventricular, Regular, Irregular.

ST SEGMENT: Okay Elevated Depressed T WAVES: \_\_\_\_\_

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### Rate: The small box method

- What makes this method work?
- Each small box = 0.04 seconds
  - How many small boxes in 1 minute?
- Advantages
- Disadvantages

*Step 1:*  
**RATE:** The small box method

1500 divided by 14 small (0.04s) boxes

3 SECONDS      3 SECONDS

**RATE:** Atrial: \_\_\_\_\_ Ventricular: \_\_\_\_\_  
 RHYTHM: Atrial Regular Irregular    Ventricular Regular Irregular  
 P WAVES: \_\_\_\_\_ PR: \_\_\_\_\_ QRS: \_\_\_\_\_ QT: \_\_\_\_\_  
 ST SEGMENT: Okay Elevated Depressed    TWAVES: \_\_\_\_\_

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### Rate: The big box method

- Some memorization involved
- 300, 150, 100, 75, 60, 50
- Advantages and disadvantages
- Why does this method work?

*Step 1:*  
**RATE:** The big box method

BPM START 300 150 100 75 50

R R R R R R

3 SECONDS      3 SECONDS

**RATE:** Atrial: \_\_\_\_\_ Ventricular: \_\_\_\_\_  
 RHYTHM: Atrial Regular Irregular    Ventricular Regular Irregular  
 P WAVES: \_\_\_\_\_ PR: \_\_\_\_\_ QRS: \_\_\_\_\_ QT: \_\_\_\_\_  
 ST SEGMENT: Okay Elevated Depressed    TWAVES: \_\_\_\_\_

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### Step 2: Rhythm regularity

- What does regularity describe?
- Why do we care?

*Step 2:*  
**RHYTHM (Regularity):** Are P-P & R-R same distance apart?

REGULAR

REGULARLY IRREGULAR

IRREGULARLY IRREGULAR

3 SECONDS      3 SECONDS

**RATE:** Atrial: \_\_\_\_\_ Ventricular: \_\_\_\_\_  
 RHYTHM: Atrial Regular Irregular    Ventricular Regular Irregular  
 P WAVES: \_\_\_\_\_ PR: \_\_\_\_\_ QRS: \_\_\_\_\_ QT: \_\_\_\_\_  
 ST SEGMENT: Okay Elevated Depressed    TWAVES: \_\_\_\_\_

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### Step 2: Rhythm regularity

*Step 2*  
**RHYTHM (Regularity):** Are P-P & R-R same distance apart?

**REGULAR**  
 (i.e. Normal Sinus Rhythm)

**IRREGULAR**  
 REGULARLY IRREGULAR (i.e. some forms of Atrial Flutter)  
 IRREGULARLY IRREGULAR (i.e. Atrial Fibrillation)

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### Putting it all together

- Use this formatted template for rate, rhythm regularity, segments and intervals
- Let's look at some actual rhythms!

**SAMPLE INTERPRETATION**

RATE: Atrial: 70 Ventricular: 70 (4 second method)

RHYTHM: Atrial: Regular Irregular Ventricular: Regular Irregular

P WAVES: Present PR: 0.16 QRS: 0.08 QT: 0.36

ST SEGMENT: (0.2mV) Elevated Depressed T WAVES: Present

FINAL INTERPRETATION: Normal sinus rhythm

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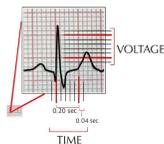
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### Review

- The smallest box on the ECG graph paper measures:
  - 0.04 seconds
  - 0.20 seconds
  - 1 second
  - 6 seconds
- The "big box" on the ECG paper measures:
  - 0.04 seconds
  - 0.20 seconds
  - 1 second
  - 6 seconds



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### Review

- This method of HR calculation involves counting the total number of complexes present and multiplying by 10:
  - Small box method
  - 6 second method
  - Big box method
- This method of HR calculation involves dividing 1500/# boxes between complexes:
  - Small box method
  - 6 second method
  - Big box method

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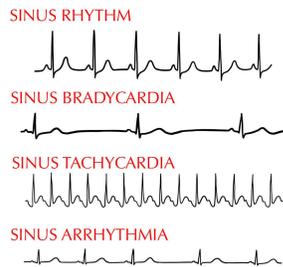
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### RHYTHMS OF SINUS ORIGIN



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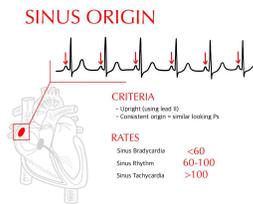
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### Rhythms of sinus origin

- What does sinus origin represent?
- Shared criteria of this group
- PR interval considerations
- P wave morphologies and appearance



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### "Normal" sinus rhythm

- What does normal indicate?

**NORMAL SINUS RHYTHM**



**HEART RATE** 60-100 BPM  
**REGULARITY** Regular  
**P WAVES** All upright & appear similar  
**PR INTERVAL** 0.12 to 0.20 seconds & constant  
**QRS COMPLEX** <0.12 seconds

**NORMAL SINUS RHYTHM**



**HEART RATE** 60-100 BPM  
**REGULARITY** Regular  
**P WAVES** All upright & appear similar  
**PR INTERVAL** 0.12 to 0.20 seconds & constant  
**QRS COMPLEX** <0.12 seconds

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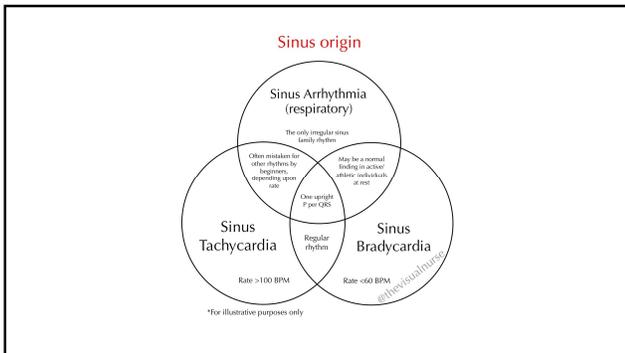
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### Sinus bradycardia

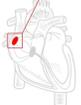
- Rate less than 60 BPM
- May be symptomatic or asymptomatic
- "Athlete's heart"
- Additional causes

**SINUS BRADYCARDIA**



**CRITERIA**

- One upright P for each QRS in 1:1 ratio
- PR interval must be constant
- Consistent origin = similar looking Ps
- Heart rate <60



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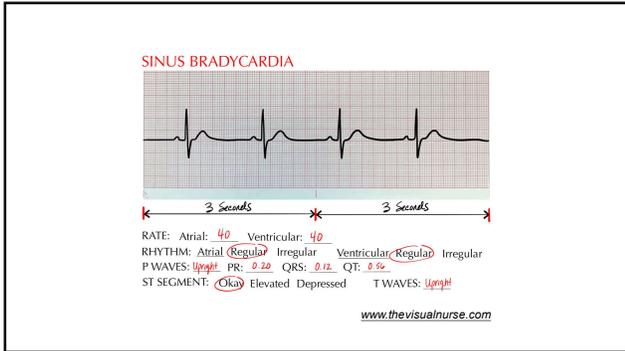
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**Sinus tachycardia**

- Rate considerations
- Sinus versus atrial tachycardia
- The clue is in the T wave
- Treatment = identification of causative factors

**SINUS TACHYCARDIA**

**CRITERIA**

- One upright P for each QRS in 1:1 ratio
- PR interval must be constant
- Consistent origin = similar looking Ps
- Heart rate >100

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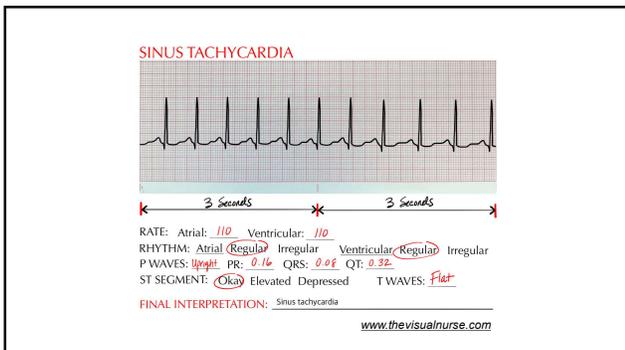
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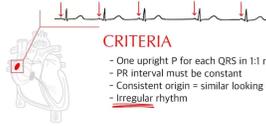
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### Sinus arrhythmia

- Two common *irregularly irregular* rhythms...
- Pressure changes in the thoracic cavity with breathing
- Diaphragm influence
- Do not confuse with atrial fibrillation

#### SINUS ARRHYTHMIA



#### CRITERIA

- One upright P for each QRS in 1:1 ratio
- PR interval must be constant
- Consistent origin = similar looking Ps
- Irregular rhythm

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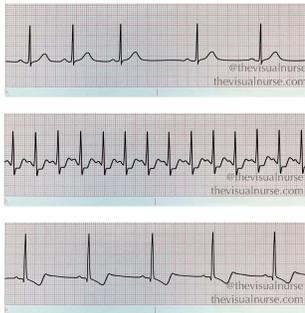
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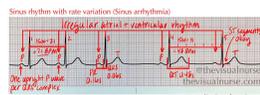
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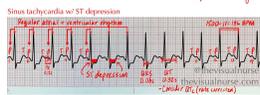
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(6 second method)  
 RATE: Atrial: 50 Ventricular: 50  
 RHYTHM: Atrial Regular (regular) Ventricular Regular (regular)  
 P WAVES: Upright PR: 0.16s QRS: 0.08s QT: 0.35s  
 ST SEGMENT: Okay Elevated Depressed T WAVES: Upright  
 \* In this example we can see why the 6 second method is preferred for rapid interpretation



(6 second method) (Small box method)  
 RATE: Atrial: 100 Ventricular: 100  
 RHYTHM: Atrial (regular) Irregular Ventricular (regular) Irregular  
 P WAVES: Upright PR: 0.16s QRS: 0.08s QT: 0.35s (smaller QT (less))  
 ST SEGMENT: Okay Elevated (depressed) T WAVES: Upright



(6 second method) (Small box method)  
 RATE: Atrial: 50 Ventricular: 50  
 RHYTHM: Atrial (regular) Irregular Ventricular (regular) Irregular  
 P WAVES: Upright PR: 0.16s QRS: 0.08s QT: 0.35s  
 ST SEGMENT: Okay Elevated (depressed) T WAVES: Upright

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**ARRHYTHMIAS OF ATRIAL ORIGIN**

ATRIAL TACHYCARDIA  
 ATRIAL FLUTTER  
 WANDERING ATRIAL  
 ATRIAL FIBRILLATION

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**What do we mean by Atrial?**

- Are sinus and atrial similar?
- How are they different?

ATRIAL ECTOPIC RHYTHM  
 Limb lead II

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**Premature atrial contractions**

- Introduction to ectopy
- Origin of PACs
- P wave should still be upright
- Possible causes

PREMATURE ATRIAL CONTRACTION (PAC)

**PACs**  
 - Ectopic sinus node or other atrial tissue discharges early  
 - A single early beat with preceding P is seen  
 - Normal ventricular conduction results in a narrow QRS

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### PREMATURE HEARTBEATS

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### PREMATURE ATRIAL CONTRACTION

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### Wandering atrial pacemaker & Multifocal atrial tachycardia

WANDERING ATRIAL PACEMAKER

MULTIFOCAL ATRIAL TACHYCARDIA

**CRITERIA**

- One P for each QRS in 1:1 ratio
- P wave appearance differs based upon where in the atria they originate
- PR intervals will likely vary due to this
- 100 bpm is threshold of determination for WAP versus MAT

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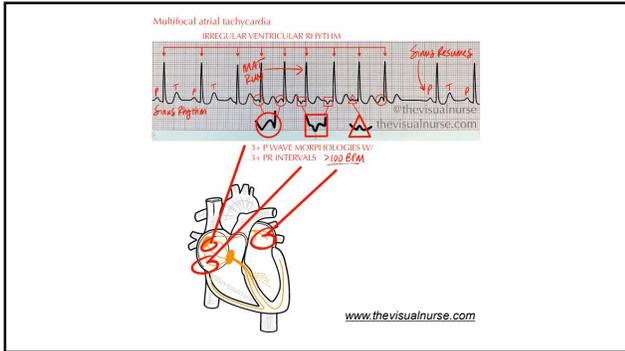
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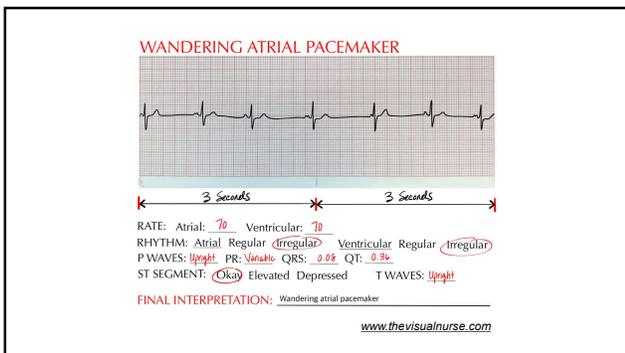
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### Atrial fibrillation

- Chaotic and disorganized atrial contraction
- Atrial blood pooling is a major problem
- Sporadic ventricular response
- Two most important characteristics
  - Irregularly irregular rhythm
  - No discernible P waves
- *Controlled vs. uncontrolled*

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### Atrial flutter

- Classic sawtooth appearance
- Flutter waves outnumber QRS complexes
- Remember cardiac output effects

**ATRIAL FLUTTER**

**CRITERIA**

- Flutter waves should outnumber QRS
- Atrial rhythm regular due to circuit re-entry (left)
- Ventricular conduction ratio will determine regularity or irregularity (2:1, 3:1, 4:1, 5:1, or variable)

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### ATRIAL FLUTTER Conduction Possibilities

**REGULAR**

Expected conduction pattern of 2:1, 3:1, 4:1, etc.

**REGULARLY IRREGULAR**

Alternating conduction pattern. Example: 2:1 conduction to 3:1 conduction alternating.

**IRREGULARLY IRREGULAR**

No pattern, variable conduction. Example: 2:1, 3:1, 2:1, 4:1

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### ATRIAL FLUTTER

RATE: Atrial: 280 Ventricular: 70

RHYTHM: Atrial (Regular) Irregular Ventricular (Regular) Irregular

P WAVES: Upright PR: <0.20 QRS: 0.06 QT: N/A

ST SEGMENT: Okay-Elevated-Depressed- T WAVES: N/A  
Unable to determine

**FINAL INTERPRETATION:** Atrial flutter (controlled) with 4:1 conduction

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### Atrial tachycardia

- Sinus versus atrial tachycardia
- Possible causes
- Keys to identification
- Humped T waves

**CRITERIA**

- One upright P for each QRS in 1:1 ratio (exceptions exist)
- PR interval might not be evident
- Consistent origin = similar looking P's
- Rate -100-250 bpm
- Impulse originates from atrial tissue other than the SA node
- A complicated umbrella term

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### ATRIAL TACHYCARDIA

RATE: Atrial: 170 Ventricular: 170  
 RHYTHM: Atrial: Regular Irregular Ventricular: Regular Irregular  
 P WAVES: Upright PR: N/A QRS: 0.08 QT: N/A  
 ST SEGMENT: Okay Elevated Depressed T WAVES: Upright

**FINAL INTERPRETATION:** Atrial tachycardia

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Uncontrolled atrial fibrillation

Handwritten notes: *Rate 200 BPM*, *Atrial Fibrillation*, *No identifiable P waves*, *No T waves*, *No PR intervals*

6 second method  
 RATE: Atrial: N/A Ventricular: 170  
 RHYTHM: Atrial: Irregular Ventricular: Regular (irregular)  
 P WAVES: N/A PR: N/A QRS: 0.08s QT: N/A QTd: N/A  
 ST SEGMENT: CC&D Elevated Depressed T WAVES: Flat/Upright  
 QTd: None to measure

Wandering atrial pacemaker

Handwritten notes: *Wandering atrial pacemaker*, *Regular atrial & ventricular rhythm*, *5 P wave morphologies with 7 PR intervals*

6 second method  
 RATE: Atrial: 70 Ventricular: 70  
 RHYTHM: Atrial: Regular Ventricular: Regular  
 P WAVES: Present PR: Variable QRS: 0.08s QT: 0.34s  
 ST SEGMENT: CC&D Elevated Depressed T WAVES: Upright

Atrial flutter with 3:1 conduction

Handwritten notes: *Atrial flutter with 3:1 conduction*, *Regular atrial & ventricular rhythm*, *Rate 150 BPM*, *Atrial Flutter*, *3 P waves missing*, *3:1 conduction ratio*

6 second method  
 RATE: Atrial: 450 Ventricular: 150  
 RHYTHM: Atrial: Regular Ventricular: Regular  
 P WAVES: None PR: PTD QRS: 0.08s QT: PTD  
 ST SEGMENT: None Elevated Depressed T WAVES: PTD  
 QTd: None to measure

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### ARRHYTHMIAS OF JUNCTIONAL ORIGIN

JUNCTIONAL RHYTHM

ACCELERATED JUNCTIONAL

JUNCTIONAL TACHYCARDIA

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### Junctional overview

**JUNCTIONAL RHYTHMS**

- Sinus & atrial > junctional
- Location
- Retrograde depolarization
- Still with narrow QRS

CHARACTERISTICS

- Inherent rate less than sinus
- Normal conduction to ventricles results in narrow QRS

JUNCTIONAL P WAVES

RATES

- Junctional: 40-60 BPM
- Accelerated Junctional: 60-100 BPM
- Junctional Tachycardia: 100-250 BPM
- Supraventricular tachycardia: >150 BPM

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### Junctional rhythm

- Key characteristics
- Rhythm is coming from a defined pacemaker site *unlike* atrial fibrillation
- Difference between the two is regularity (junctional) versus irregularity (A-fib)

**JUNCTIONAL RHYTHM**



**CRITERIA**

- Narrow QRS = origin above ventricles
- Regular rhythm (marches out)
- P waves that are inverted before or after the QRS, or buried within the QRS
- Rate 40-60 BPM

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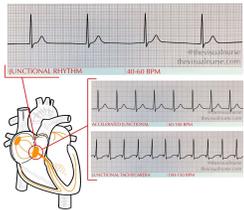
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ATRIAL FIBRILLATION	JUNCTIONAL RHYTHM
Irregularly irregular rhythm No predictable R wave pattern "Controlled" rate <100 BPM	Typically regular rhythm Relatively predictable R wave pattern Inverted P wave before or after QRS Inherent rate ~40-60 BPM
No identifiable P waves Supraventricular origin "Narrow" QRS complex	No identifiable P waves Relatively predictable R wave pattern Inverted P wave before or after QRS Inherent rate ~40-60 BPM



\*Not including aberrant conduction  
\*If before: PR interval is <0.12s

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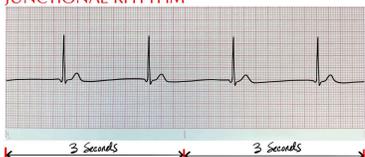
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### JUNCTIONAL RHYTHM



RATE: Atrial: N/A Ventricular: 40

RHYTHM: Atrial-Regular-Irregular- Ventricular (Regular) Irregular

P WAVES: Inverted PR: 0.04 QRS: 0.08 QT: 0.32

ST SEGMENT: (OK) Elevated Depressed T WAVES: Upright

FINAL INTERPRETATION: Junctional rhythm

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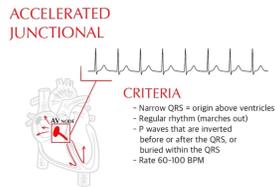
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### Accelerated junctional rhythm

- The older brother to normal junctional rhythms
- HR is the differentiating factor
- Understanding inherent pacemaker rate according to location



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### ACCELERATED JUNCTIONAL RHYTHM



RATE: Atrial: N/A Ventricular: 80  
 RHYTHM: Atrial—Regular—Irregular— Ventricular Regular Irregular  
 P WAVES: Inverted pr: 0.04 QRS: 0.08 QT: 0.40  
 ST SEGMENT: Okay Elevated Depressed T WAVES: Upright  
 FINAL INTERPRETATION: Accelerated junctional rhythm

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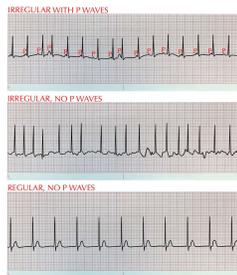
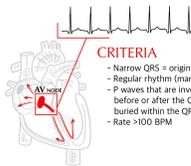
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### Junctional tachycardia

#### JUNCTIONAL TACHYCARDIA



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### Supraventricular tachycardia

- An umbrella term encompassing a few rhythms
- Hallmark of SVT
- Not always regular rhythm but often will be for testing purposes

**SUPRAVENTRICULAR TACHYCARDIA**

**CRITERIA**

- Umbrella term encompassing many arrhythmias
- Narrow QRS - origin above ventricles
- Regular rhythm (sometimes not)
- Exceptions exist
- Rate 100 to >150 bpm depending on the particular form of SVT

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**SUPRAVENTRICULAR TACHYCARDIAS**

**SUPRAVENTRICULAR TACHYCARDIA**

**CRITERIA**

- Narrow QRS
- Rates range >100 to 250+ based on type
- Origin above ventricles
- \*Excludes aberrant conduction

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**SINUS TACHYCARDIA** vs **SVT**

\*Including aberrant conduction  
\*\*Including rapid Atrial flutter  
\*\*\*Excludes aberrant conduction

**RAPID A-FIB** vs **\*SVT**

\*SVT in this case refers to AVNRT/AVRT  
\*\*Including aberrant conduction

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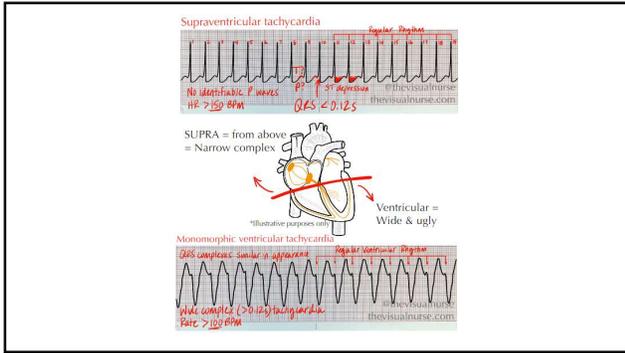
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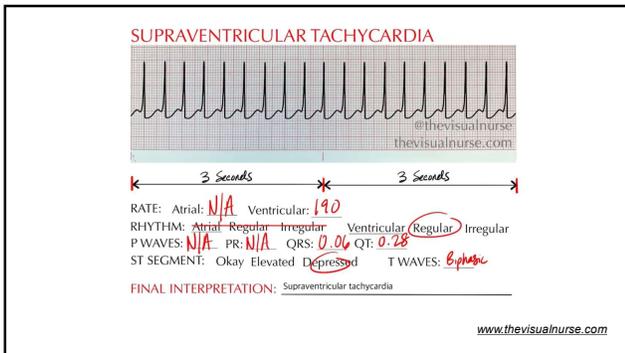
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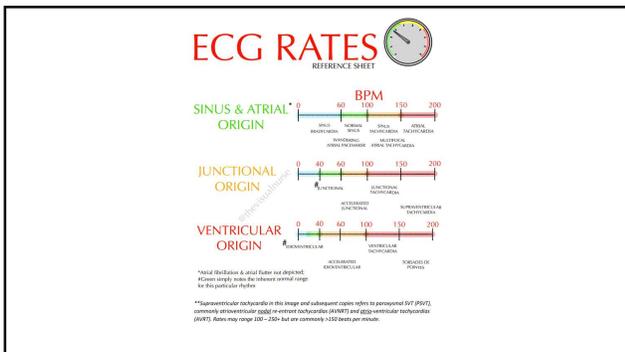
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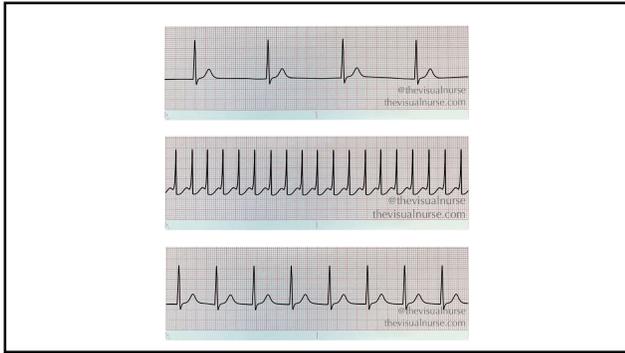
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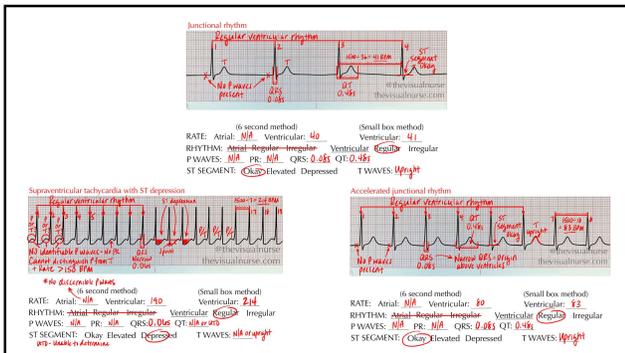
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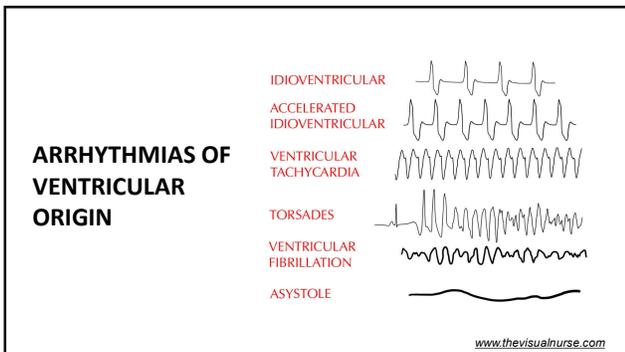
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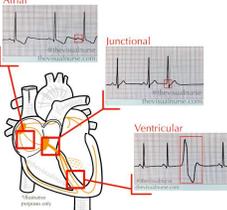
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### Ventricular origin overview

- Can be categorized as single or multiple site
- Inherent rate ~20-40 BPM
- Key characteristics
- Let's begin with ventricular ectopy before transitioning into ventricular rhythms



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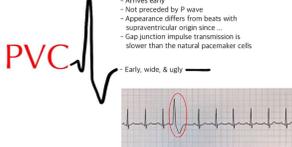
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### Premature ventricular contractions

- Early, wide, and ugly
- Why is the impulse wide?
- Potential causes



**PVC**

- Arrives early
- Not preceded by P wave
- Appearance differs from beats with supraventricular origin since...
- Gap junction impulse transmission is slower than the natural pacemaker cells

- Early, wide, & ugly

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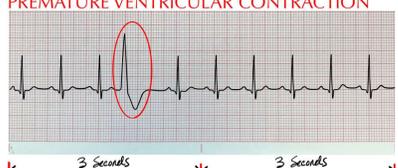
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### PREMATURE VENTRICULAR CONTRACTION



RATE: Atrial: 90 Ventricular: 90  
 RHYTHM: Atrial (Regular) Irregular Ventricular (Regular) Irregular  
 P WAVES: Upright PR: 0.16 QRS: 0.12 QT: 0.32  
 ST SEGMENT: Okay Elevated Depressed T WAVES: Upright  
**FINAL INTERPRETATION:** Sinus rhythm with a PVC

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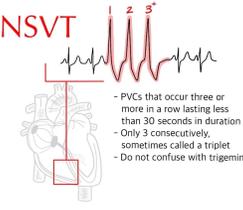
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### Non-sustained ventricular tachycardia

- What is the term “non-sustained” indicating?
- Sustained VT
- May be monomorphic or polymorphic (multifocal)
- Assess and report



**NSVT**

- PVCs that occur three or more in a row lasting less than 30 seconds in duration
- Only 3 consecutively, sometimes called a triplet
- Do not confuse with trigeminy

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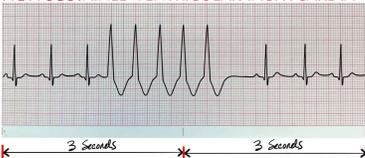
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### NON-SUSTAINED VENTRICULAR TACHYCARDIA



Note: rate of underlying rhythm based on small box method (500/15 = 100 BPM)

RATE: Atrial: 100 Ventricular: 100

RHYTHM: Atrial (Regular) Irregular Ventricular (Regular) Irregular

P WAVES: Upright PR: 0.16 QRS: 0.10 QT: 0.36

ST SEGMENT: (Okay) Elevated Depressed T WAVES: Upright

**FINAL INTERPRETATION:** Sinus rhythm with a run of non-sustained ventricular tachycardia

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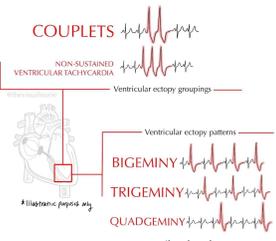
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### Ventricular groupings → patterns

- Couplets versus bigeminy
- Triplets versus trigeminy
- Just remember to ask yourself: *“Is it a grouping or a pattern?”*



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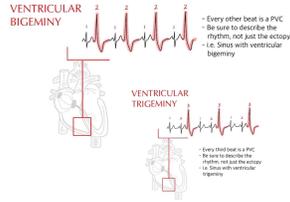
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### Bigeminy, trigeminy, & quadgeminy

- **Bigeminy:** every *second* beat is a PVC
- **Trigeminy** = every *third*
- **Quadrigeminy** = every *fourth*
- Describing the underlying rhythm
- Assess and report



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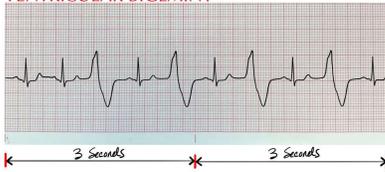
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### VENTRICULAR BIGEMINY



RATE: Atrial: 60 Ventricular: 60  
 RHYTHM: Atrial Regular irregular Ventricular Regular irregular  
 P WAVES: Upright PR: 0.16 QRS: 0.12 QT: 0.36  
 ST SEGMENT: OKay Elevated Depressed T WAVES: Upright  
 FINAL INTERPRETATION: Sinus rhythm with ventricular bigeminy

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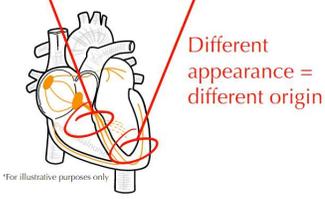
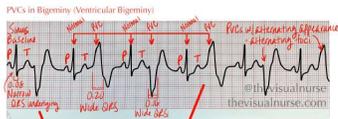
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Different appearance = different origin

\*For illustrative purposes only

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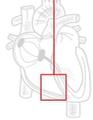
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### Ventricular rhythms & arrhythmias

- Single site rhythms
- Multi-site rhythms

**VENTRICULAR ORIGIN**



**OVERVIEW**

- Inherent rate is much slower than upstream sites 20-40 BPM
- Thick muscle cells depolarize slowly = wide, slow QRS

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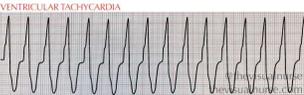
**IDIOVENTRICULAR RHYTHM**



**ACCELERATED IDIOVENTRICULAR RHYTHM**



**VENTRICULAR TACHYCARDIA**



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### Idioventricular rhythm & AIVR

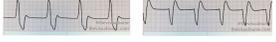
- Share similar characteristics seen in the image to the right
- Rate is the major difference between the two
- Often transient

**IDIOVENTRICULAR RHYTHM**



**CRITERIA**

- A wide complex (QRS)
- Regular R-R rhythm
- With no discernible P waves
- At a rate of 20-40 BPM



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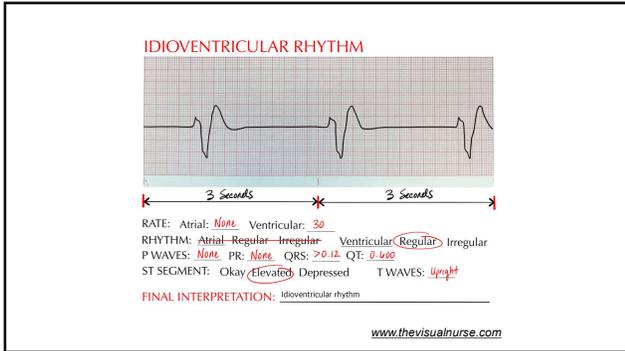
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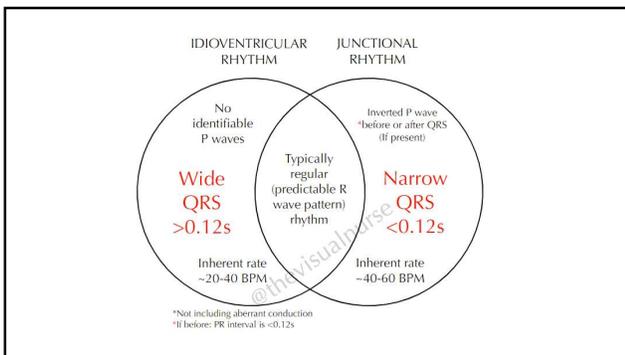
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### Ventricular tachycardia

- Monomorphic versus polymorphic
- Impaired filling and contraction
- Cardiac workloads
- Patient may or may not have a pulse

**VENTRICULAR TACHYCARDIA**  
(Monomorphic)

**CRITERIA**

- A wide complex (QRS) tachycardia with a
- Regular R-R rhythm/interval
- With no discernible P waves
- At a rate greater than 100 BPM

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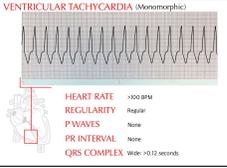
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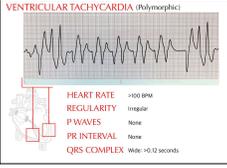
### Ventricular tachycardia

VENTRICULAR TACHYCARDIA (Monomorphic)



**HEART RATE** >100 bpm  
**REGULARITY** Regular  
**P WAVES** None  
**PR INTERVAL** None  
**QRS COMPLEX** Wide >0.12 seconds

VENTRICULAR TACHYCARDIA (Polymorphic)



**HEART RATE** >100 bpm  
**REGULARITY** Irregular  
**P WAVES** None  
**PR INTERVAL** None  
**QRS COMPLEX** Wide >0.12 seconds

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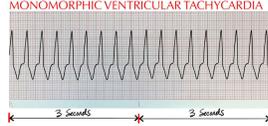
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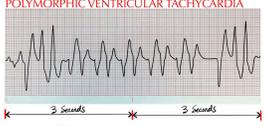
### Ventricular tachycardia

MONOMORPHIC VENTRICULAR TACHYCARDIA



**RATE:** Atrial: *N/A* Ventricular: 160  
**RHYTHM:** Atrial: Regular - Irregular Ventricular: Regular - Irregular  
**P WAVES:** *N/A* **PR:** *N/A* **QRS:** >0.12 **QT:** *N/A*  
**ST SEGMENT:** Okay Elevated - Depressed **T WAVES:** *Inverted*  
**FINAL INTERPRETATION:** Monomorphic ventricular tachycardia

POLYMORPHIC VENTRICULAR TACHYCARDIA



**RATE:** Atrial: *N/A* Ventricular: 170  
**RHYTHM:** Atrial: Regular - Irregular Ventricular: Regular (Irregular)  
**P WAVES:** *N/A* **PR:** *N/A* **QRS:** >0.12 **QT:** *N/A*  
**ST SEGMENT:** Okay - Elevated - Depressed **T WAVES:** *N/A*  
**FINAL INTERPRETATION:** Polymorphic ventricular tachycardia

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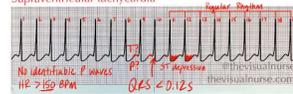
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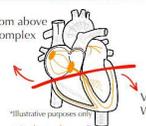
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### Supraventricular tachycardia



No identifiable P waves P ST depression QRS < 0.12s

SUPRA = from above  
= Narrow complex



Ventricular =  
Wide & ugly

\*Illustrative purposes only

Monomorphic ventricular tachycardia

QRS complexes similar in appearance Regular Ventricular Rhythm

Wide complex (>0.12s) Irregular Rate > 100 bpm

Polymorphic Ventricular Rhythm

QRS complexes similar in appearance Regular Ventricular Rhythm

Wide complex (>0.12s) Irregular Rate > 100 bpm

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### Torsades de pointes

- A form of polymorphic VT
- Electrical focus is rotating around the heart
- Remember your cardiac vectors
- Bowtie appearance
- Hallmark causes
- Long QT syndromes
- R on T phenomenon

**TORSADES DE POINTES**

**CRITERIA**

- No P wave
- Wide QRS, variable shape
- Classic, bowtie appearance
- HR ~200-250 bpm
- Form of polymorphic VT
- Must have evidence of prolonged QT interval

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### Ventricular fibrillation

- Fibrillation = quivering
- Cardiac output is next to zero
- Immediate CPR and ACLS
- Defibrillation and early shocking
- H's & T's

**VENTRICULAR FIBRILLATION**

**OVERVIEW**

- Disorganized & chaotic impulses = "quivering" of ventricles = no cardiac output
- No P waves
- Inconsistent pseudo QRS, if any
- May be coarse or fine

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### VENTRICULAR FIBRILLATION

RATE: Atrial: N/A Ventricular: ~220

RHYTHM: Atrial-~~Regular~~-~~Irregular~~ Ventricular Regular Irregular

P WAVES: N/A PR: N/A QRS: >0.12 QT: N/A

ST SEGMENT: ~~Okay~~-~~Elevated~~-~~Depressed~~ T WAVES: N/A

FINAL INTERPRETATION: Ventricular fibrillation

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## Asystole

- Absence of electrical and mechanical activity
- Confirm in more than one lead
- ACLS protocols
- H's & T's

**ASYSTOLE**



**OVERVIEW**

- Absence of electrical and mechanical (systole) activity
- Absence of cardiac output
- The famed "flat-line"

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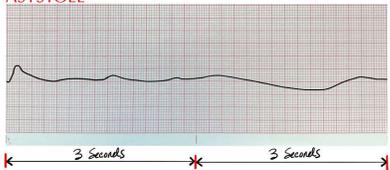
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## ASYSTOLE



RATE: Atrial: N/A Ventricular: N/A  
 RHYTHM: Atrial: Regular Irregular: Ventricular Regular: Irregular  
 P WAVES: N/A PR: N/A QRS: N/A QT: N/A  
 ST SEGMENT: Okay Elevated: Depressed T WAVES: N/A  
 FINAL INTERPRETATION: Asystole

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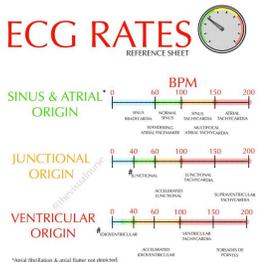
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## ECG RATES REFERENCE SHEET



**SINUS & ATRIAL ORIGIN**  
 60-100 BPM (Normal)  
 100-150 BPM (Sinus Tachycardia)  
 150-200 BPM (Sinus Bradycardia)

**JUNCTIONAL ORIGIN**  
 40-100 BPM (Normal)  
 100-150 BPM (Junctional Tachycardia)  
 150-200 BPM (Junctional Bradycardia)

**VENTRICULAR ORIGIN**  
 40-100 BPM (Normal)  
 100-150 BPM (Ventricular Tachycardia)  
 150-200 BPM (Ventricular Bradycardia)

\*Atrial fibrillation & atrial flutter not depicted.  
 †Cases simply note the reference normal range for this particular rhythm.  
 \*\*Supraventricular tachycardia in this image and subsequent copies refers to paroxysmal SVT (PSVT), commonly atrioventricular (AVB) or atrioventricular (AVNRT) and also ventricular tachycardia (VT). Refer to my course 100-200 for an extremely 100 beats per minute.

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### Review

- Non-sustained ventricular tachycardia (NSVT) is defined as 3 or more successive ventricular-origin beats lasting *less than*:
  - 15 beats
  - 20 beats
  - 30 seconds
  - 1 minute
- This pattern describes a rhythm in which every *second* beat is a premature ventricular contraction (PVC):
  - Ventricular couplets
  - Ventricular bigeminy
  - Ventricular trigeminy
  - Ventricular quadgeminy

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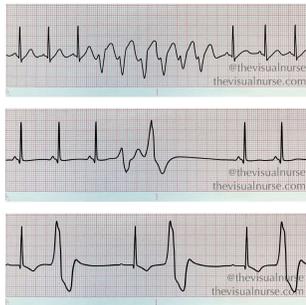
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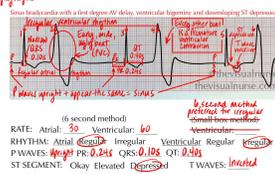
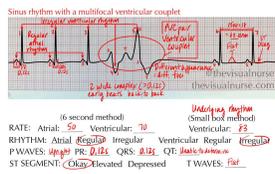
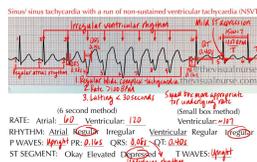
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**FIRST DEGREE AV BLOCK**

RATE: Atrial: 60 Ventricular: 60  
 RHYTHM: Atrial (Regular) Irregular Ventricular (Regular) Irregular  
 P WAVES: Upright PR: 0.36 QRS: 0.12 QT: 0.44  
 ST SEGMENT: (Ok) Elevated Depressed T WAVES: Upright  
 FINAL INTERPRETATION: Sinus rhythm with first degree AV block

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**Second degree Type I AVB**

- Normal conduction review
- Common causes
- A fatiguing AV node?
- Differentiating between Type II

**SECOND DEGREE AV BLOCK TYPE I**

**OVERVIEW**

- More P waves than QRS
- Variable and progressively lengthening PR interval
- "Dropped" QRS beats
- Irregular ventricular (R to R) rhythm
- Also called Wenckebach phenomenon
- Also called Mobitz I

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**SECOND DEGREE AV BLOCK (Type 1)**

RATE: Atrial: 90 Ventricular: 70  
 RHYTHM: Atrial (Regular) Irregular Ventricular Regular (Irregular)  
 P WAVES: Upright PR: Variable QRS: 0.12 QT: 0.44  
 ST SEGMENT: (Ok) Elevated Depressed T WAVES: Upright  
 FINAL INTERPRETATION: Sinus rhythm with second degree type I AV block

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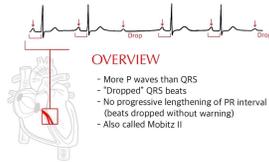
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### Second degree Type II AVB

- Comparing to Type I
- Rapid identification
- Patient presentation

#### SECOND DEGREE AV BLOCK TYPE 2



#### OVERVIEW

- More P waves than QRS
- "Dropped" QRS beats
- No progressive lengthening of PR interval (beats dropped without warning)
- Also called Mobitz II

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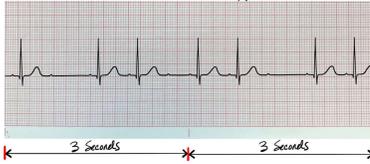
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### SECOND DEGREE AV BLOCK (Type 2)



RATE: Atrial: 100 Ventricular: 70  
 RHYTHM: Atrial Regular Irregular Ventricular Regular Irregular  
 P WAVES: Upright PR: 0.12 QRS: 0.09 QT: 0.42  
 ST SEGMENT: Okay Elevated Depressed T WAVES: Upright

FINAL INTERPRETATION: Sinus rhythm with second degree type 2 AV block

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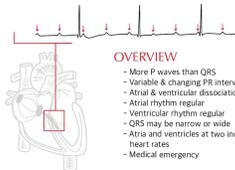
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### Third degree AVB (Complete heart block)

- Sinus & ventricular rate review
- Independent upper and lower activity
- Result
- Careful PR interval consideration

#### COMPLETE HEART BLOCK (3rd Degree)



#### OVERVIEW

- More P waves than QRS
- Variable & changing PR interval
- Atrial & ventricular dissociation
- Atrial rhythm regular
- Ventricular rhythm regular
- QRS may be narrow or wide
- Atria and ventricles at two independent heart rates
- Medical emergency

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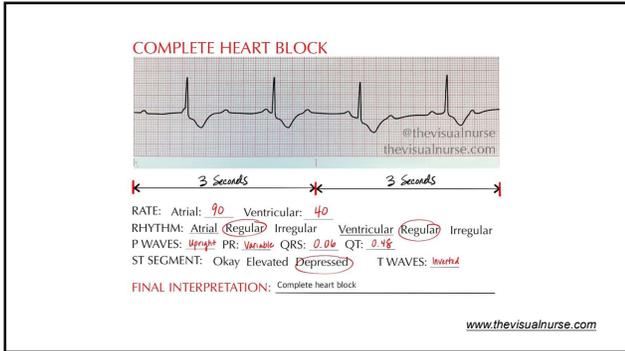
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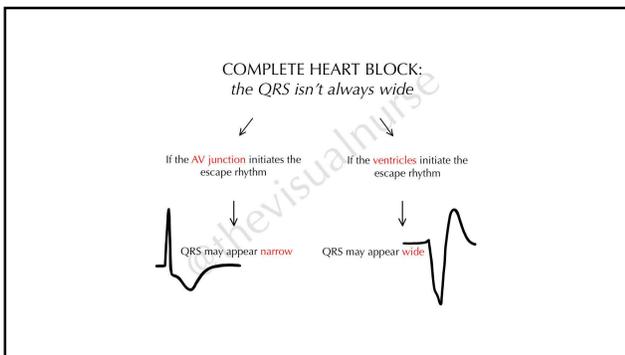
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### Review

- Which of the following heart (AV) blocks are associated with a variable (changing) PR interval?
  - First degree
  - Second degree Type I
  - Second degree Type II
  - Third degree (CHB)

**ATRIOVENTRICULAR (HEART) BLOCKS ON THE ECG**

**WHAT IS A HEART BLOCK?**  
 Occurs when an atrial impulse is delayed or fails to reach the ventricles normally.  
 May be permanent or transient.  
 Classically is categorized by severity: first, second, or third degree.

**ON THE ECG**  
 1. Is there a normal P wave present before QRS?  
 2. Evaluate the PR interval for clues to relationship between atria and ventricles.

**CONDUCTION SYSTEM**  
 Can occur at many places along the conduction pathway including the root fibers to the atria, the main bundle of His (B), or bundle branches (L).

**HEART BLOCK DECISION TREE**

More P's than Q's (QRS) → Yes → Is the PR variable or fixed (constant)?  
 Variable → First degree or type II (Mobitz II)  
 Fixed → Second degree Type I (Mobitz I)  
 No → Does it progressively lengthen before a dropped QRS? → Yes → First degree dropped QRS (complete)  
 No → Second degree Type I (Mobitz I)

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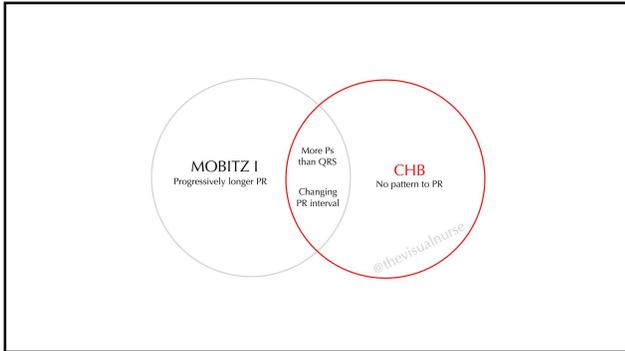
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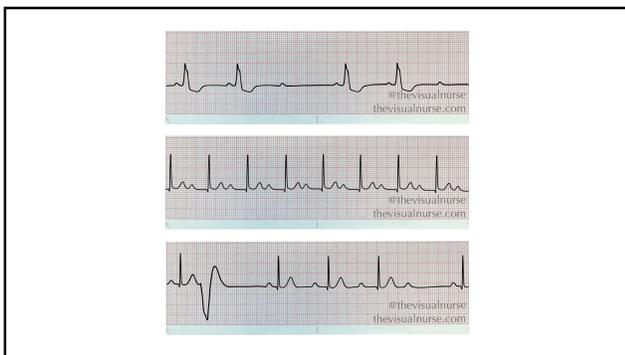
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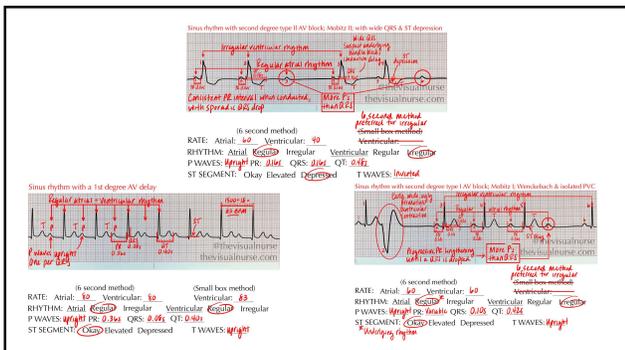
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**PACEMAKERS**

The diagram shows two views of a pacemaker system. The left view shows a pacemaker unit connected to RA and RV leads. The right view shows a pacemaker unit connected to RA, RV, and LA leads. Below the diagrams is an ECG strip showing a regular rhythm with narrow QRS complexes, characteristic of ventricular pacing. The text 'www.thevisualnurse.com' is visible at the bottom.

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**Pacemakers**

- Types of pacemakers
- Uses
- Artificial pacemakers
- Capture

The diagram shows two views of a pacemaker system. The left view shows a pacemaker unit connected to SA and RV leads. The right view shows a pacemaker unit connected to RA, RV, and LA leads. Below the diagrams is an ECG strip showing a regular rhythm with narrow QRS complexes, characteristic of ventricular pacing. The text 'www.thevisualnurse.com' is visible at the bottom.

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**ATRIAL PACED**

The diagram shows a pacemaker unit connected to an SA lead. The ECG strip shows a regular rhythm with narrow QRS complexes, characteristic of atrial pacing. The text 'www.thevisualnurse.com' is visible at the bottom.

**VENTRICULAR PACED**

The diagram shows a pacemaker unit connected to an RV lead. The ECG strip shows a regular rhythm with wide QRS complexes, characteristic of ventricular pacing. The text 'www.thevisualnurse.com' is visible at the bottom.

**ATRIOVENTRICULAR PACED**

The diagram shows a pacemaker unit connected to RA and RV leads. The ECG strip shows a regular rhythm with narrow QRS complexes, characteristic of atrioventricular pacing. The text 'www.thevisualnurse.com' is visible at the bottom.

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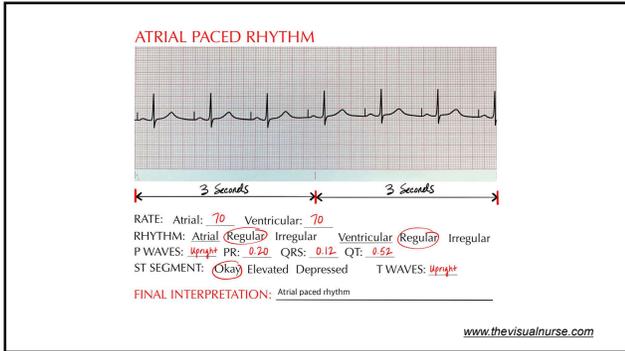
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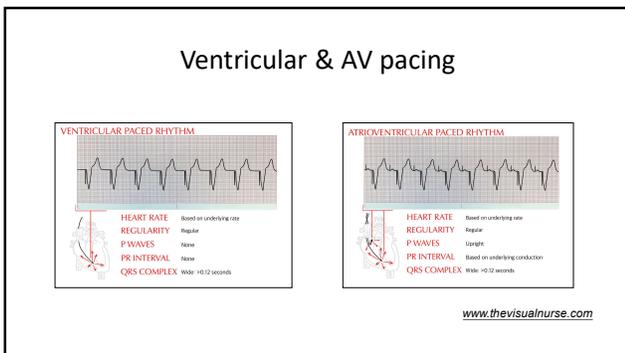
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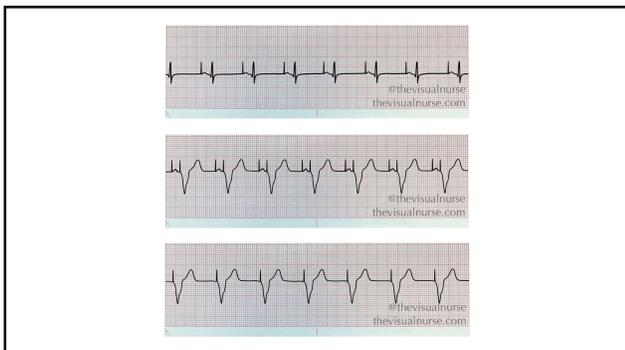
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