ECG MONITORING

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DEFINITION

Electrocardiography its a recording of the heart's electrical activity through repeated cardiac cycles. It is an electrogram of the heart which is a graph of voltage versus time of the electrical activity of the heart using electrodes placed on the skin

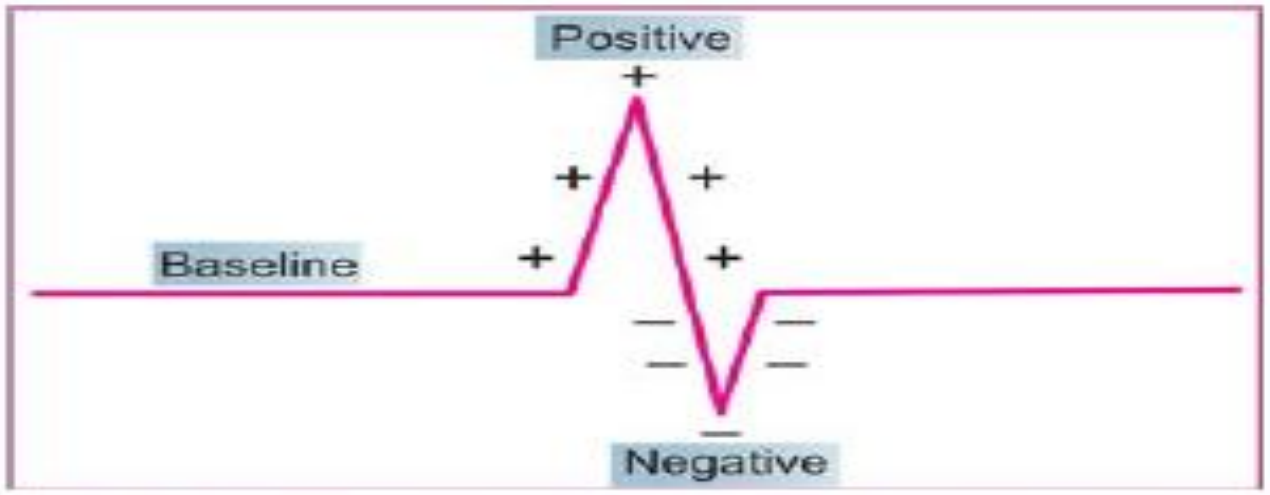


Fig. 1.1A: Direction of the deflection on ECG:
A. Above the baseline: positive deflection
B. Below the baseline: negative deflection

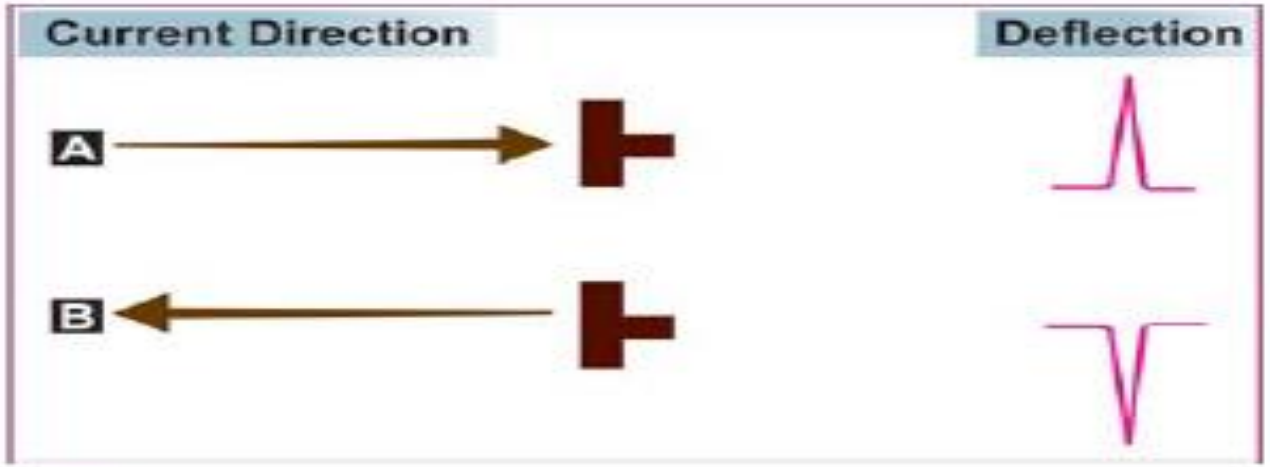


Fig. 1.1B: Effect of current direction on polarity of deflection:
A. Towards the electrode—upright deflection
B. Away from electrode—inverted deflection

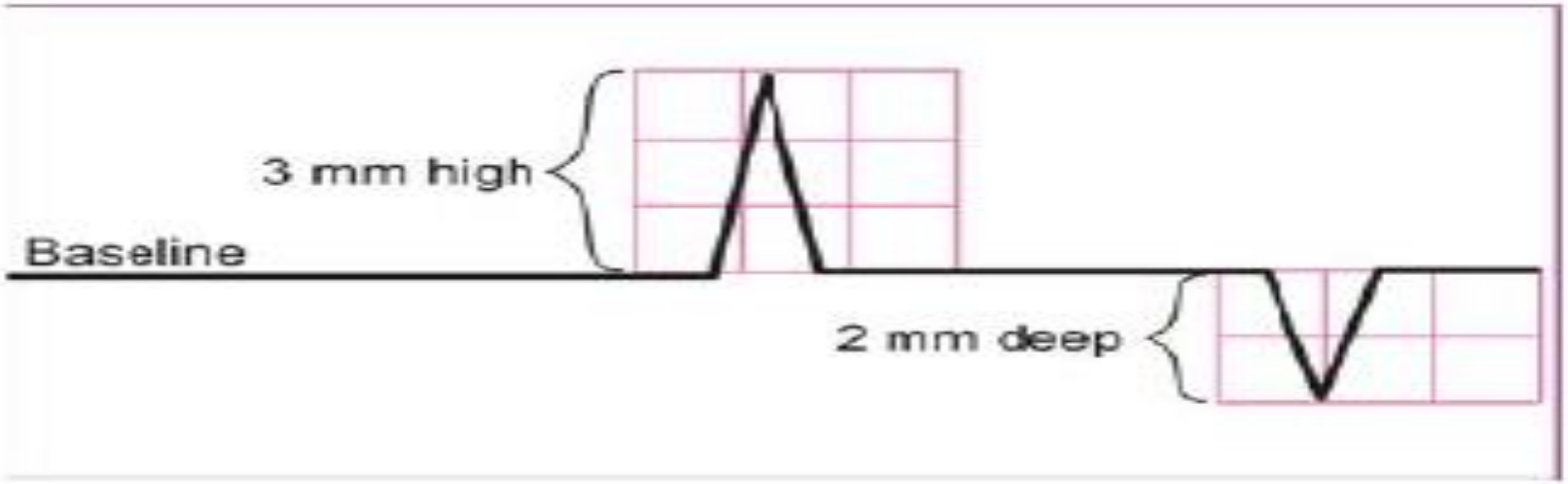


Fig. 1.3A: Magnitude of the deflection on ECG:
A. Positive deflection: height
B. Negative deflection: depth

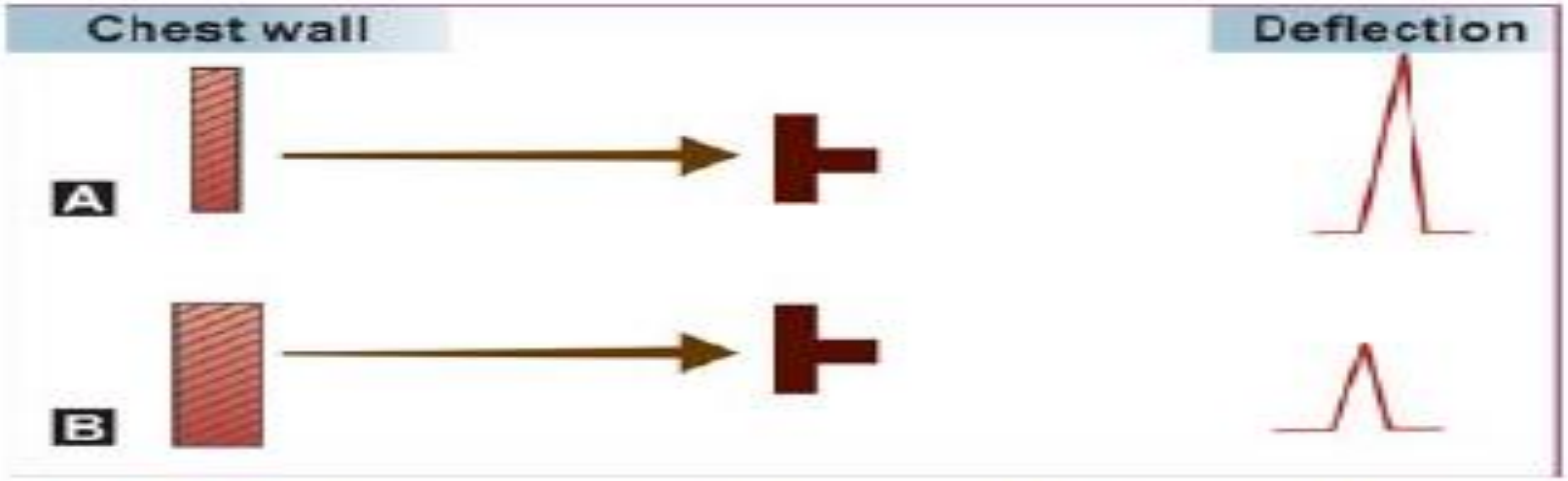


Fig. 1.3B: Effect of chest wall on magnitude of deflection
A. Thin chest—tall deflection
B. Thick chest—small deflection

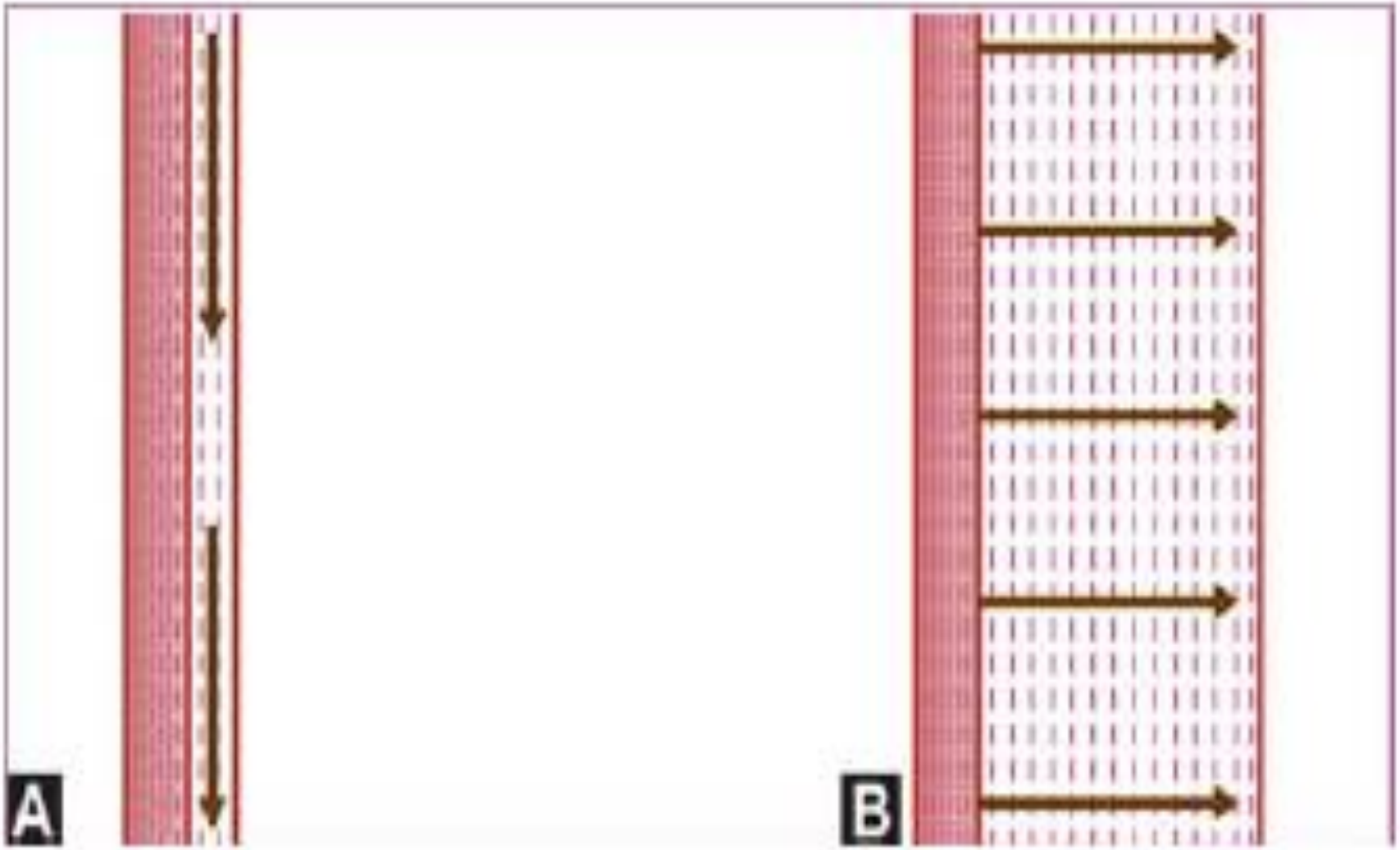
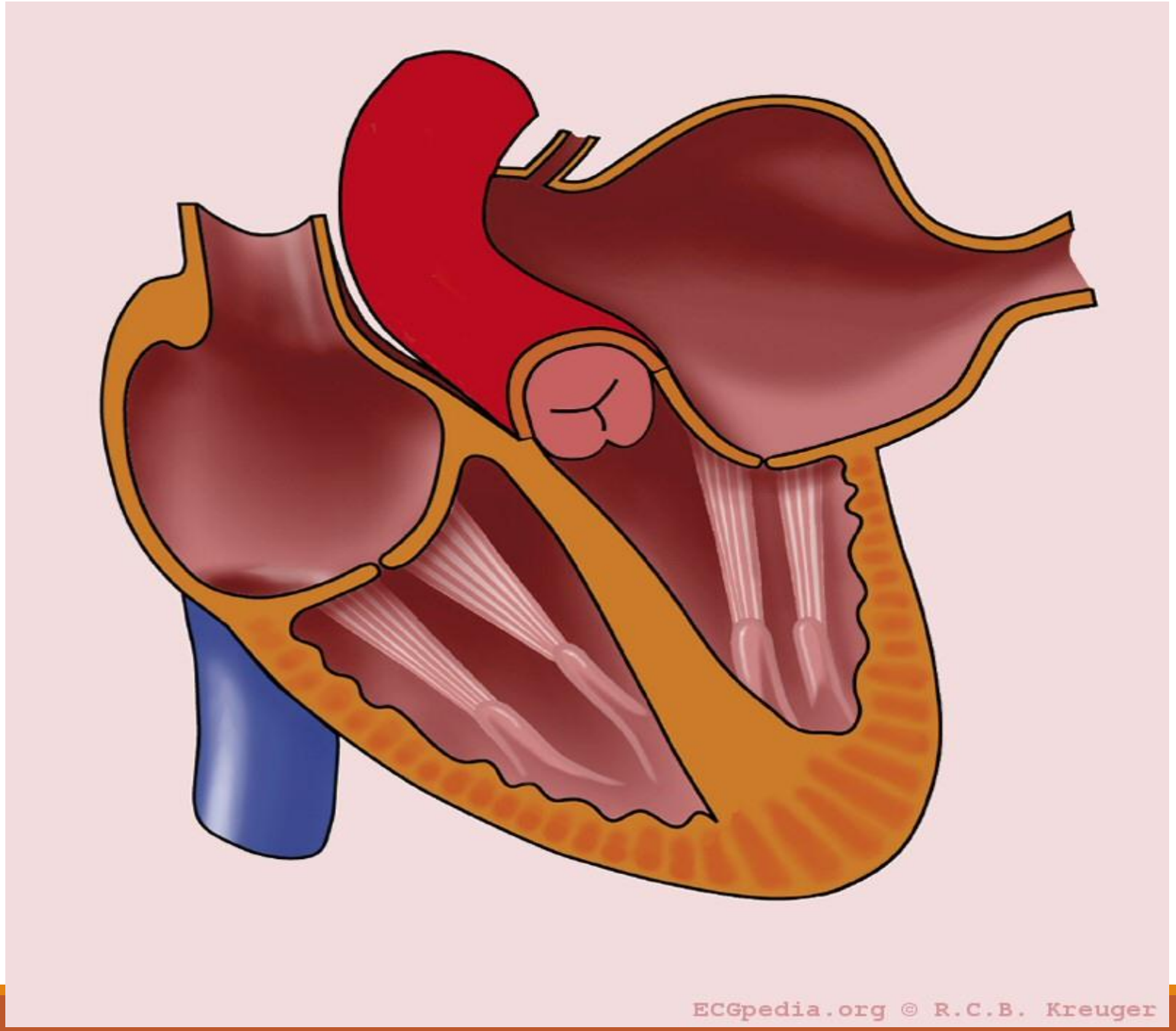


Fig. 1.4: Direction of myocardial activation in atrium and ventricle:
A. Atrial muscle: longitudinal, from one myocyte to other
B. Ventricular: transverse, endocardium to epicardium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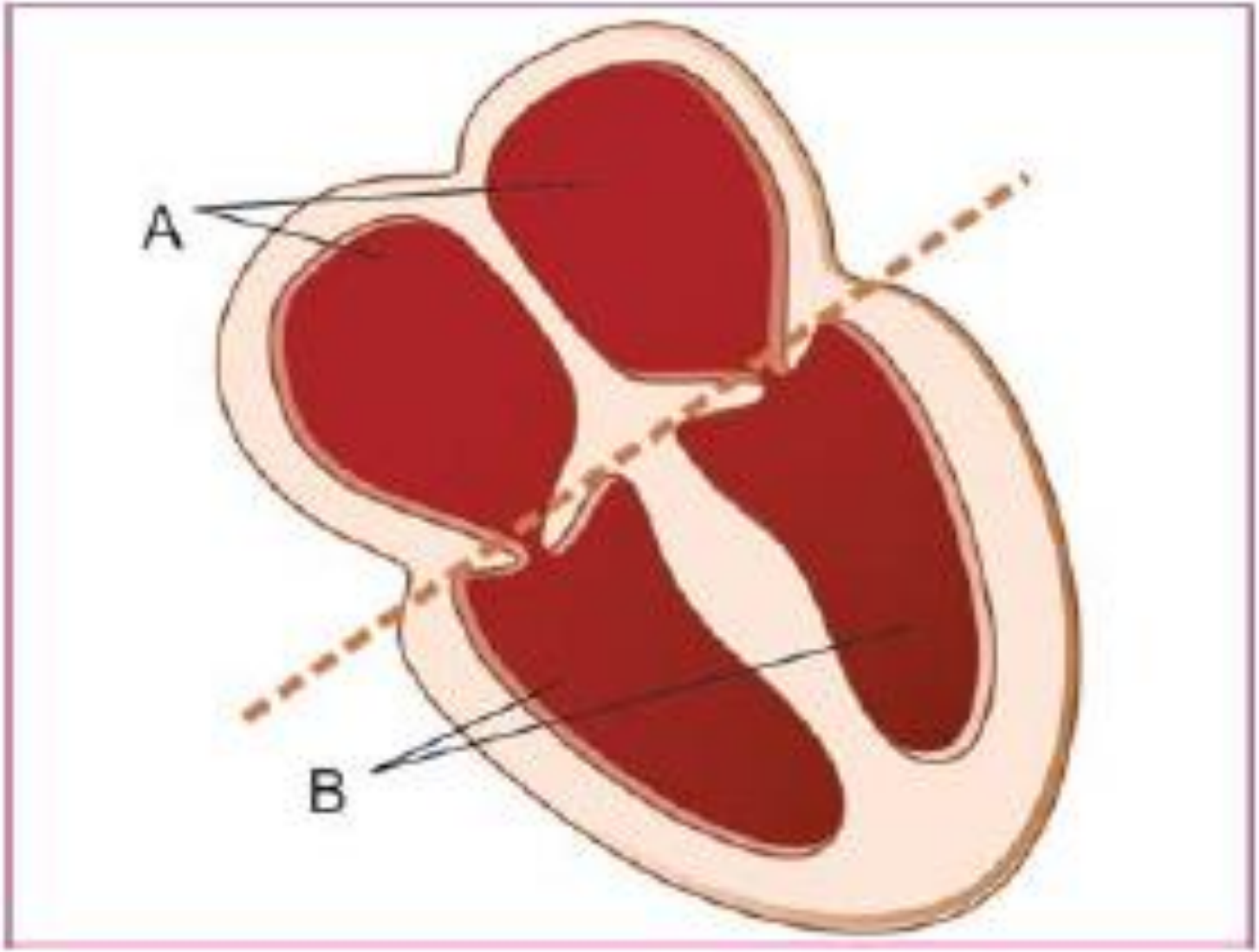
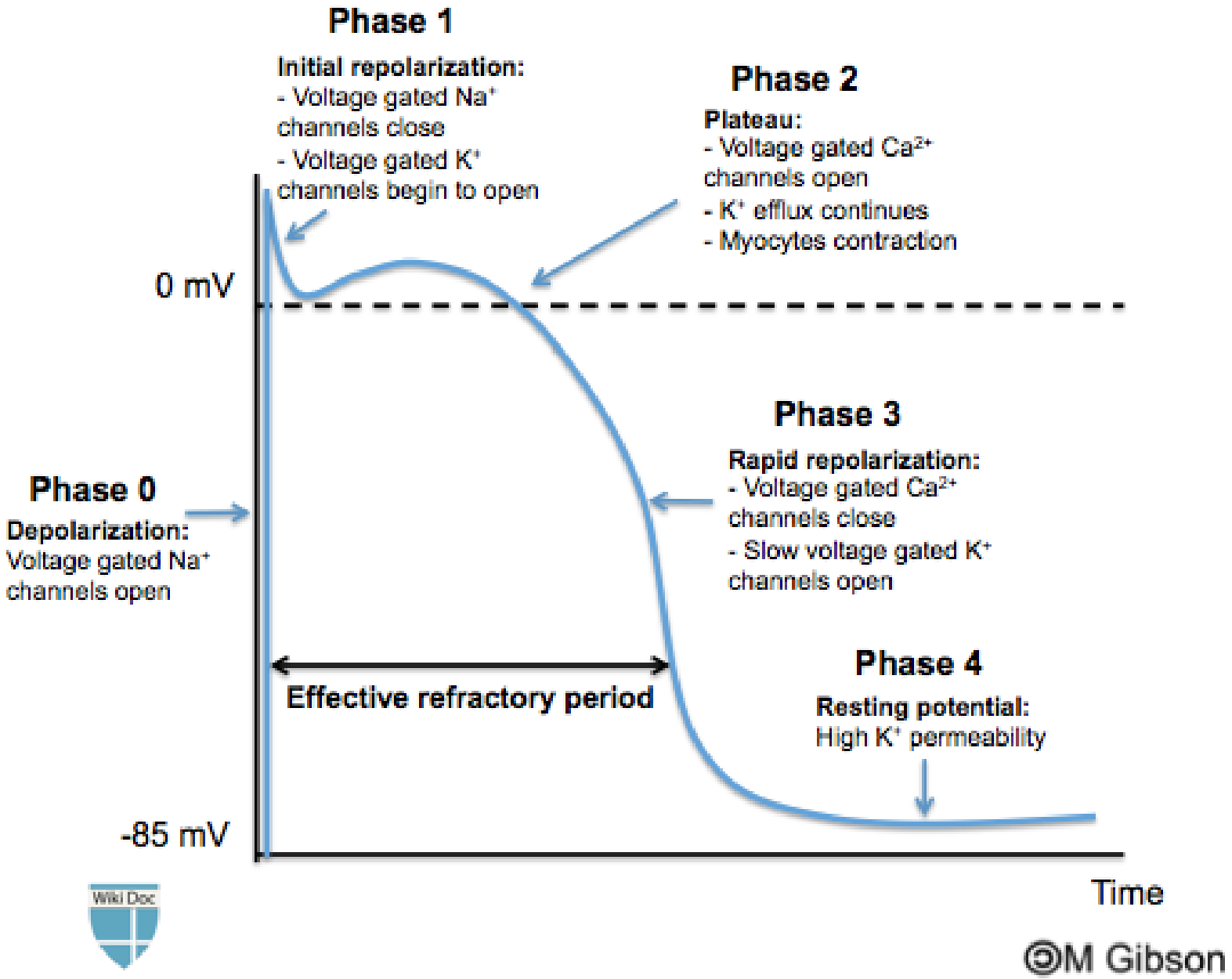


Fig. 1.5: The "dual-chamber" concept:
A. Biatrial chamber
B. Biventricular chamber


Phase 1
Initial repolarization:
- Voltage gated Na+ channels close
- Voltage gated K+ channels begin to open
Phase 2
Plateau:
- Voltage gated Ca2+ channels open
- K+ efflux continues
- Myocytes contraction
0 mV
Phase 3
Rapid repolarization:
- Voltage gated Ca2+ channels close
- Slow voltage gated K+ channels open
Phase 0
Depolarization:
Voltage gated Na+ channels open
Effective refractory period
Phase 4
Resting potential:
High K+ permeability
-85 mV
Time
Wiki Doc
©M Gibson

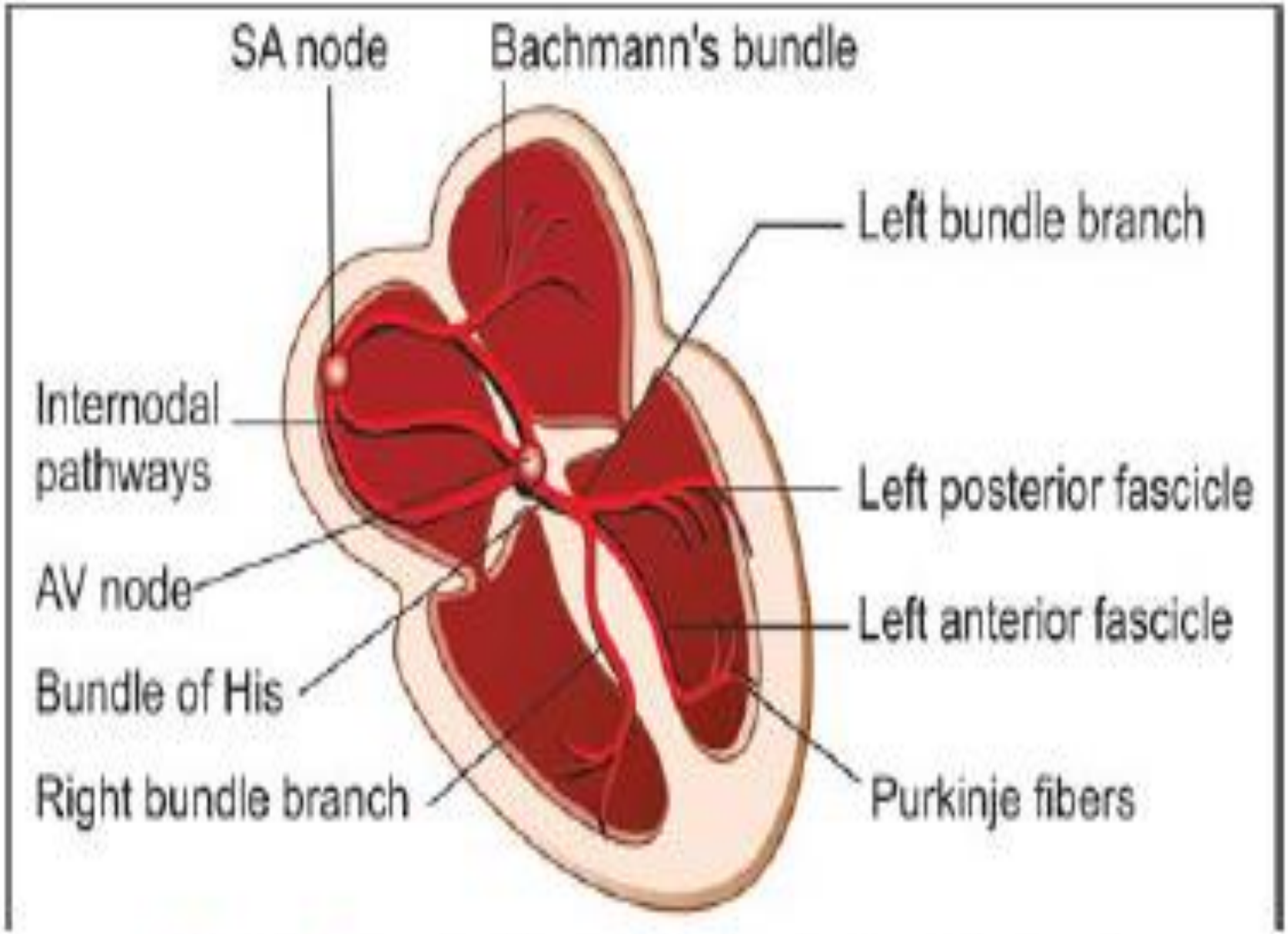
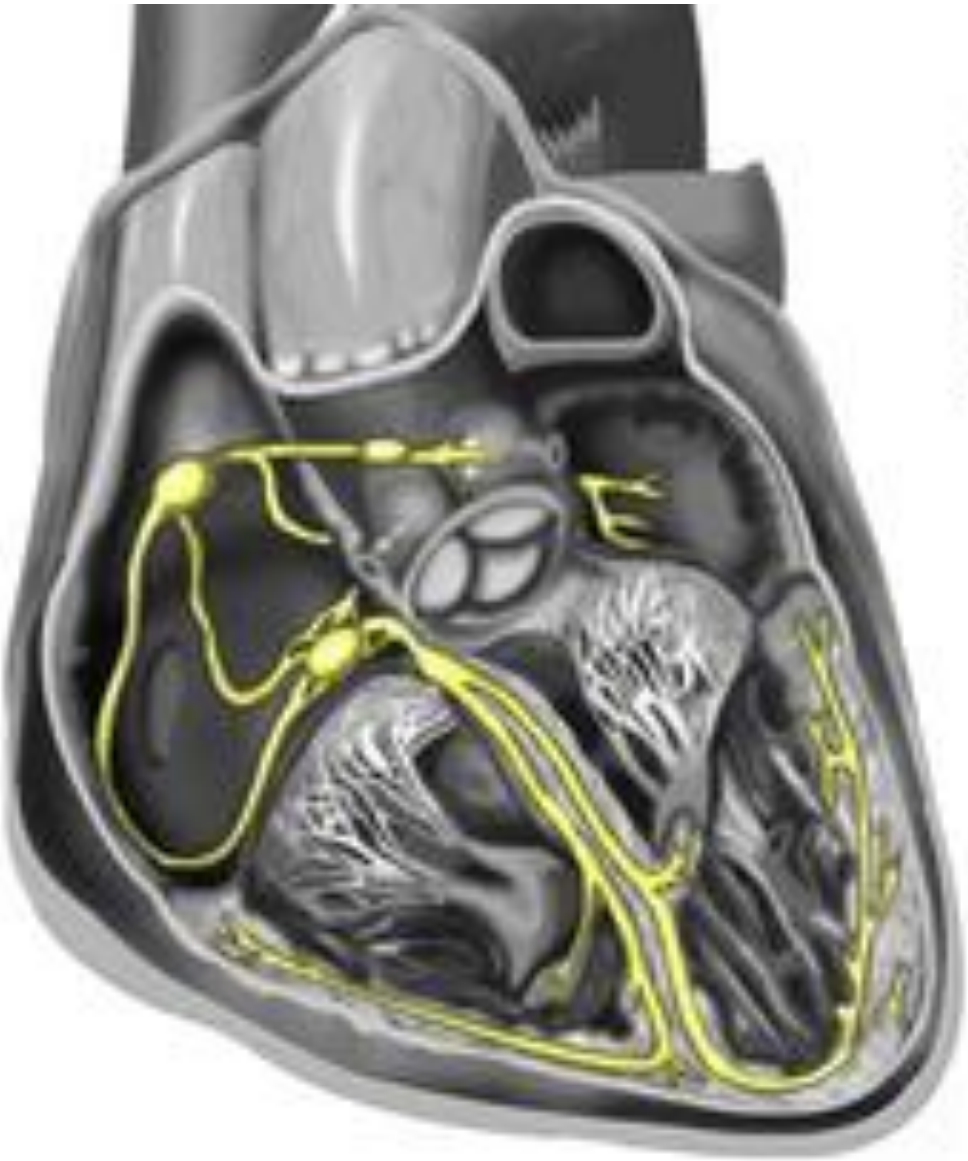


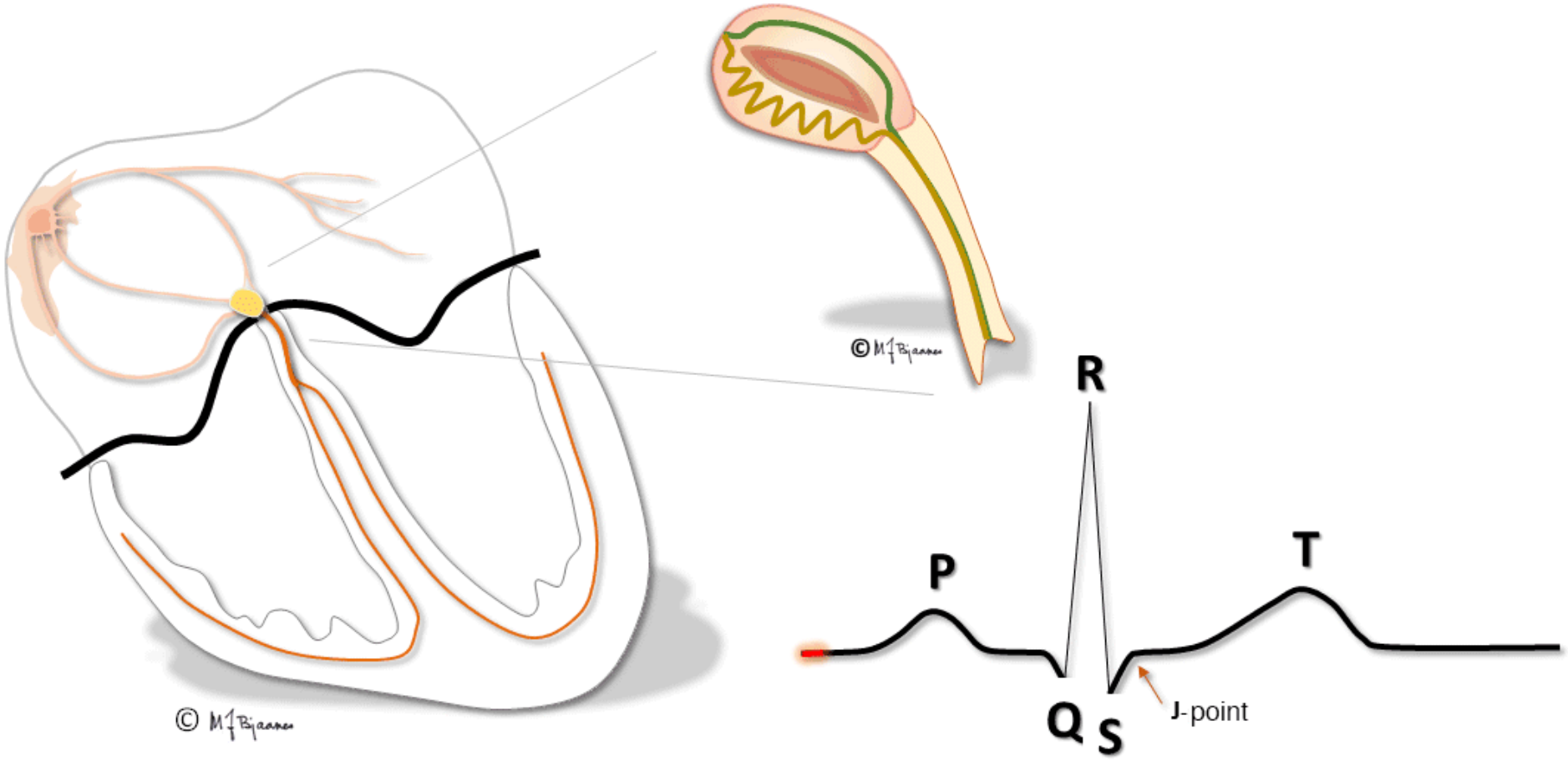
Fig. 1.7: The electrical 'wiring' network of the heart



ADAM

The AV node signals the ventricles to contract.

MakeAGIF.com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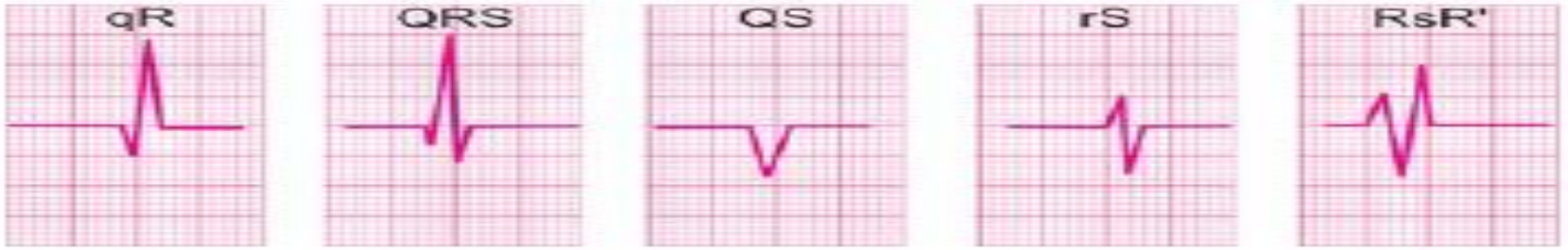
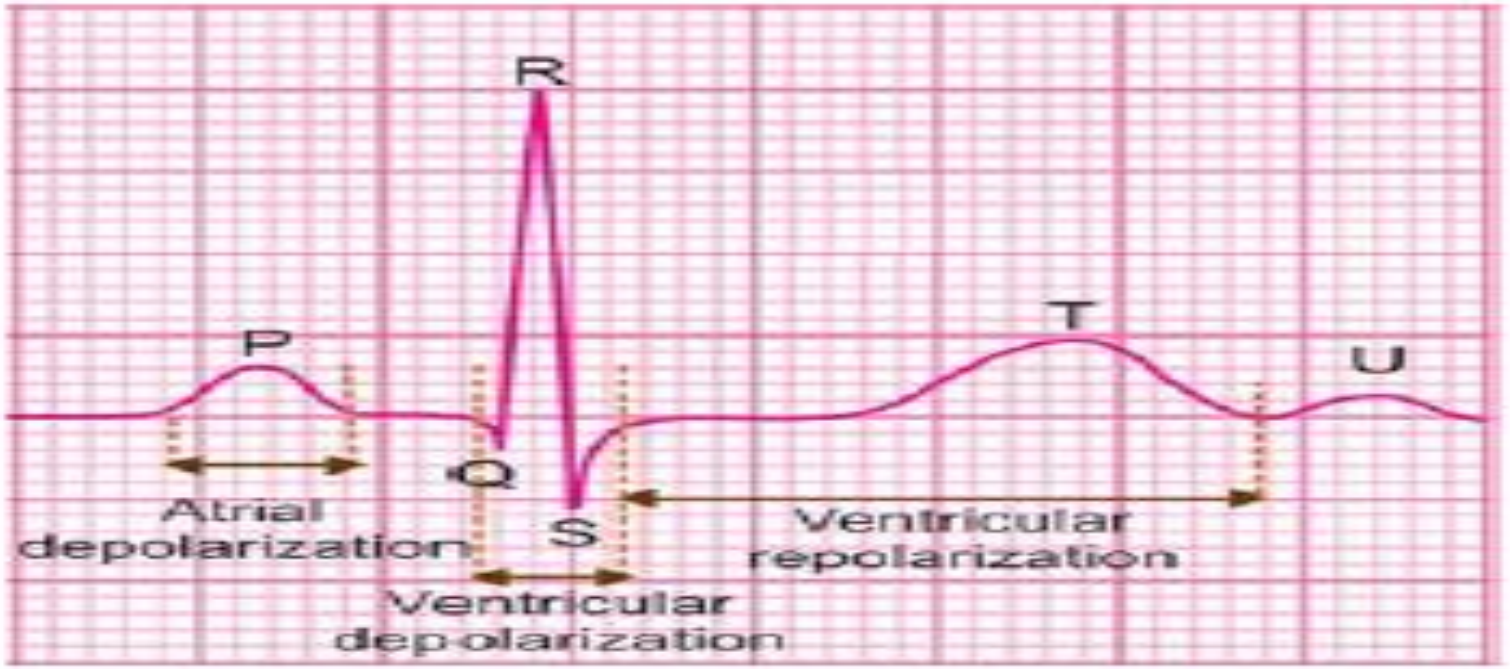


Fig. 1.9: Various configurations of the QRS complex



ECG LEADS

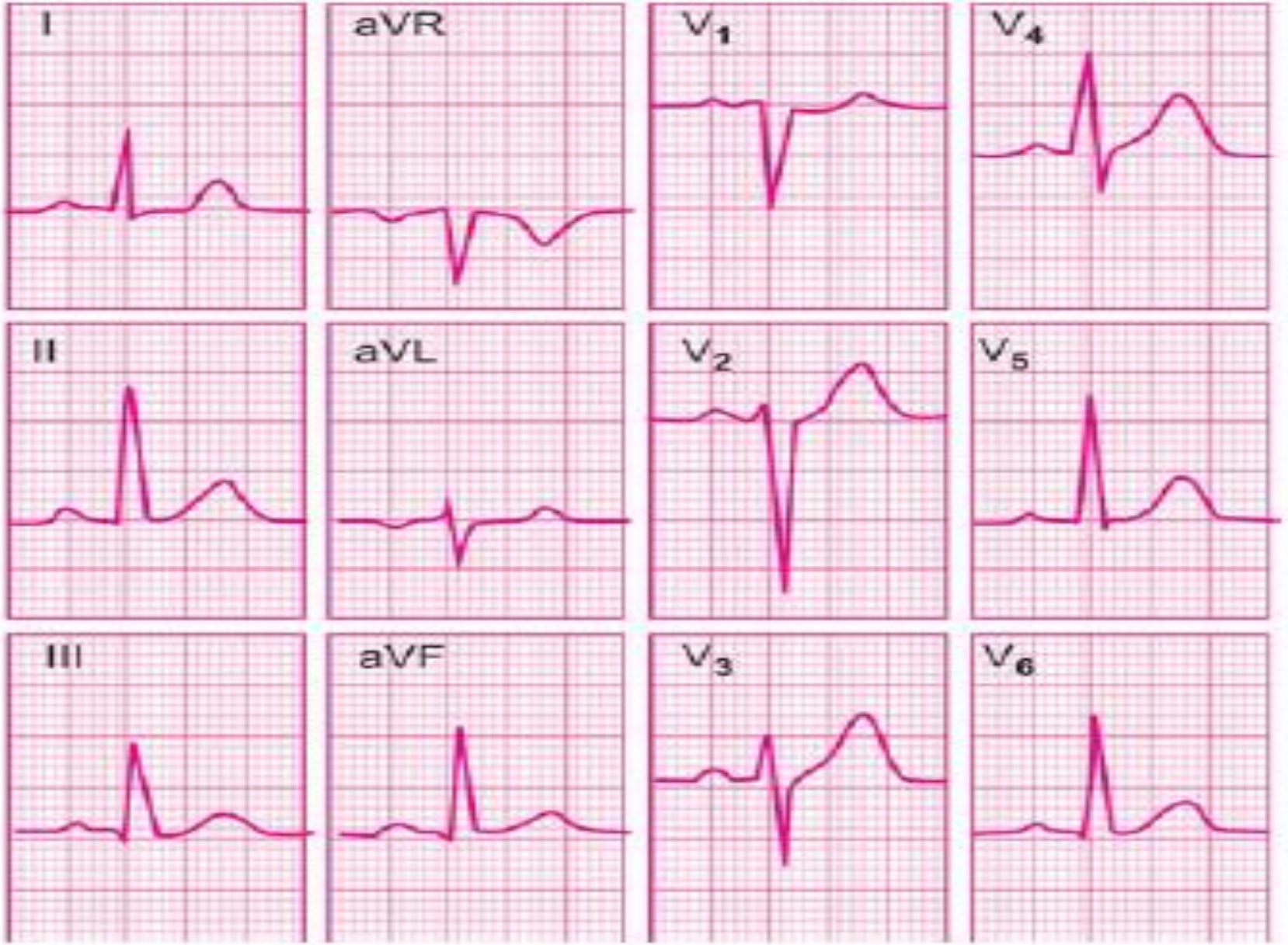


Fig. 2.1: The conventional 12-lead electrocardiogram

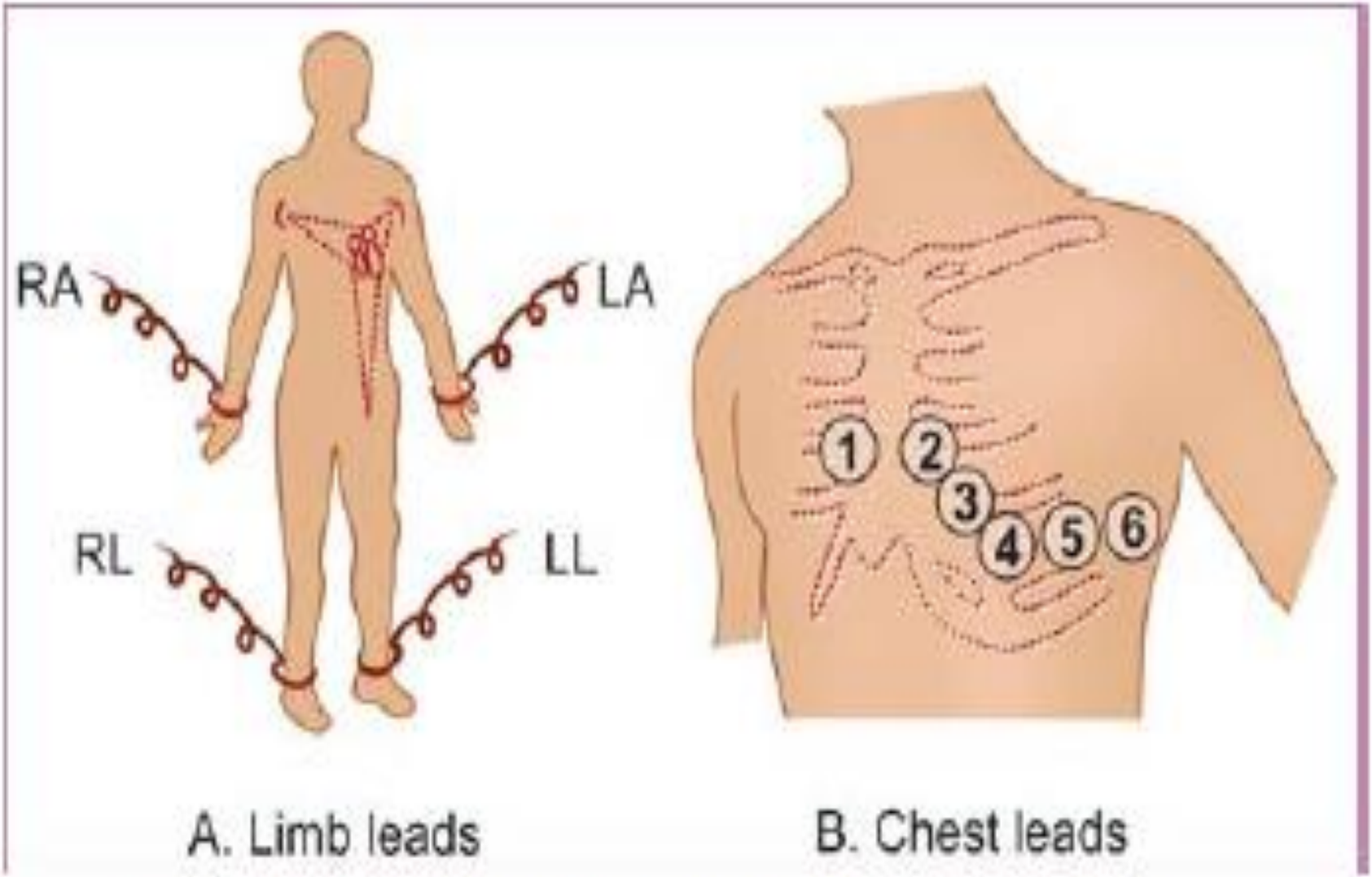
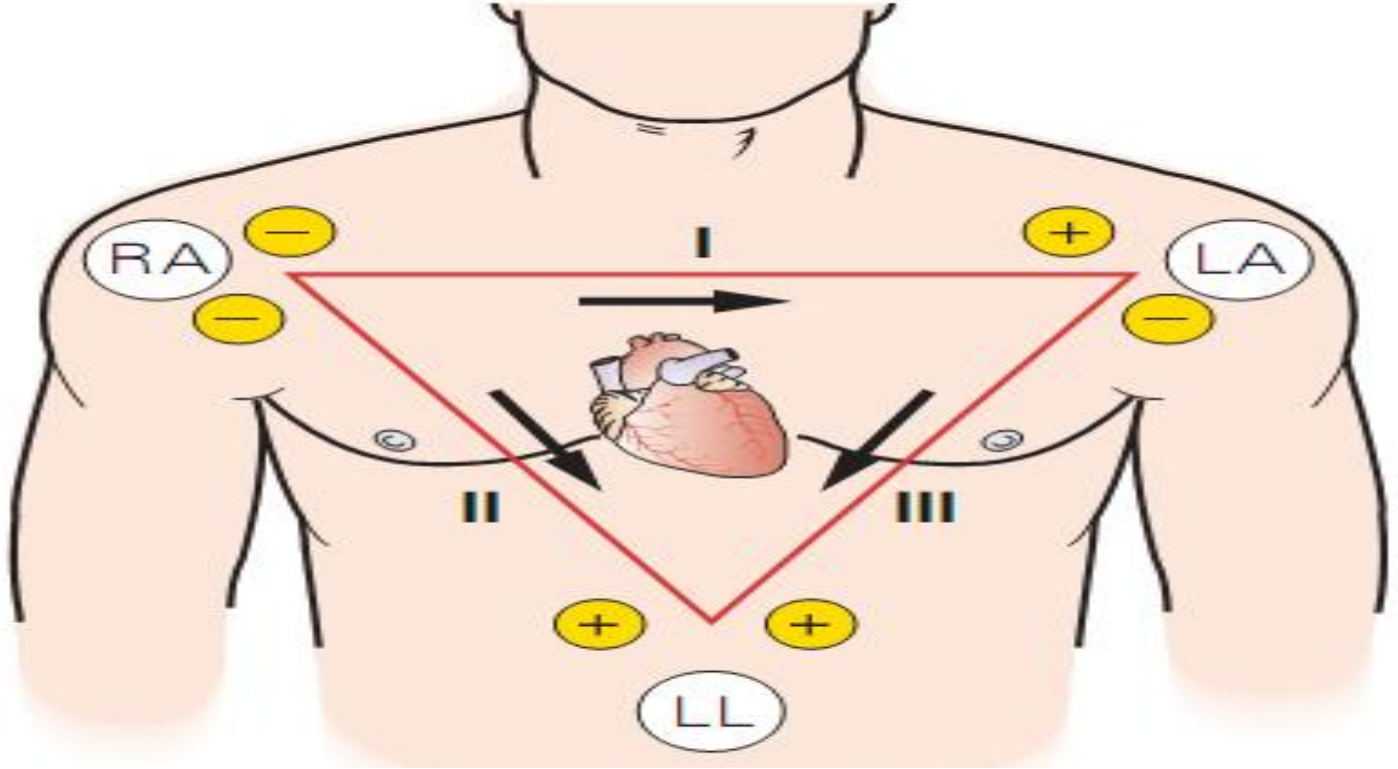


Fig. 2.2: Electrode placement for ECG recording

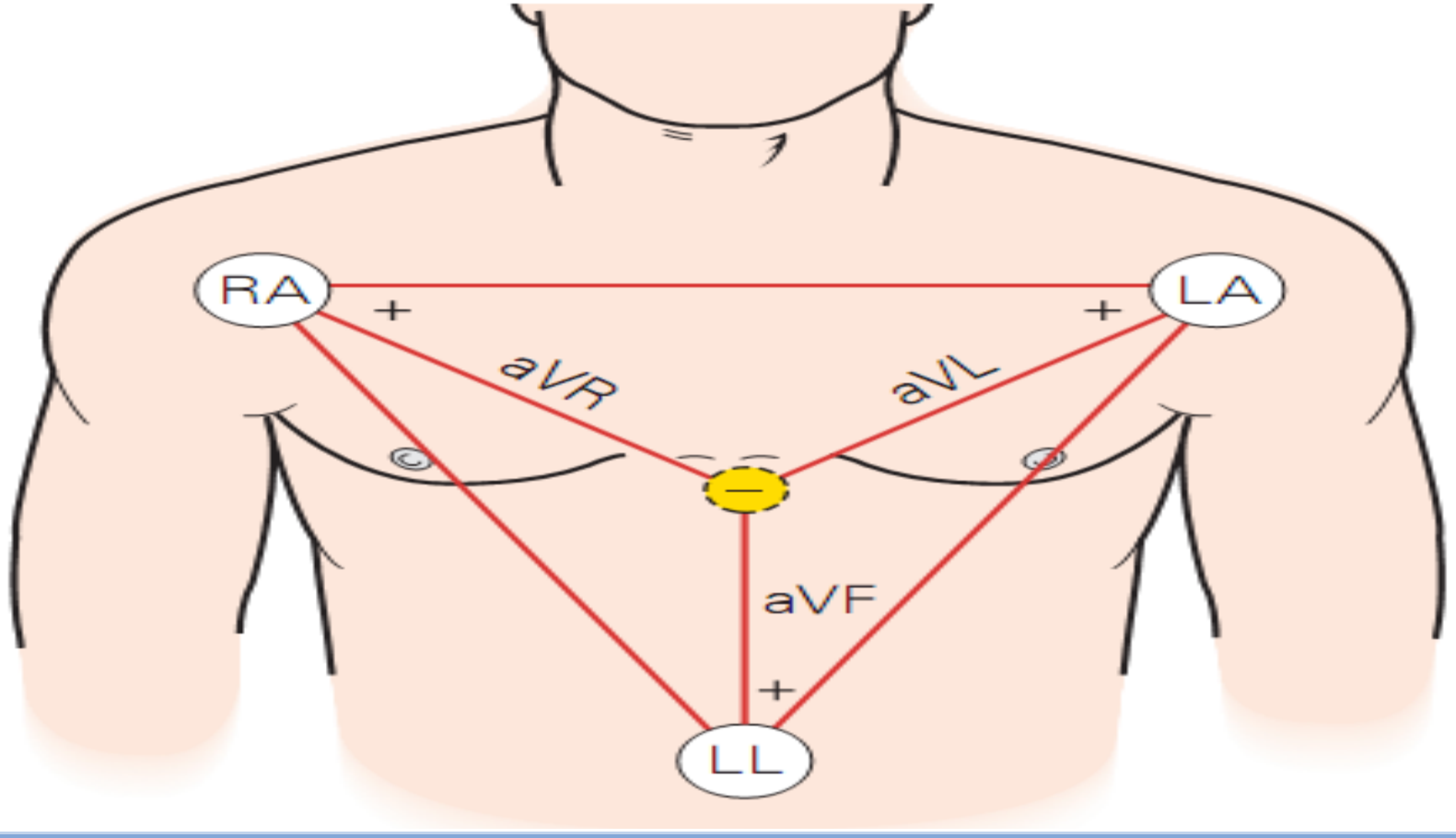
Standard Limb Leads



Elements of Standard Limb Leads

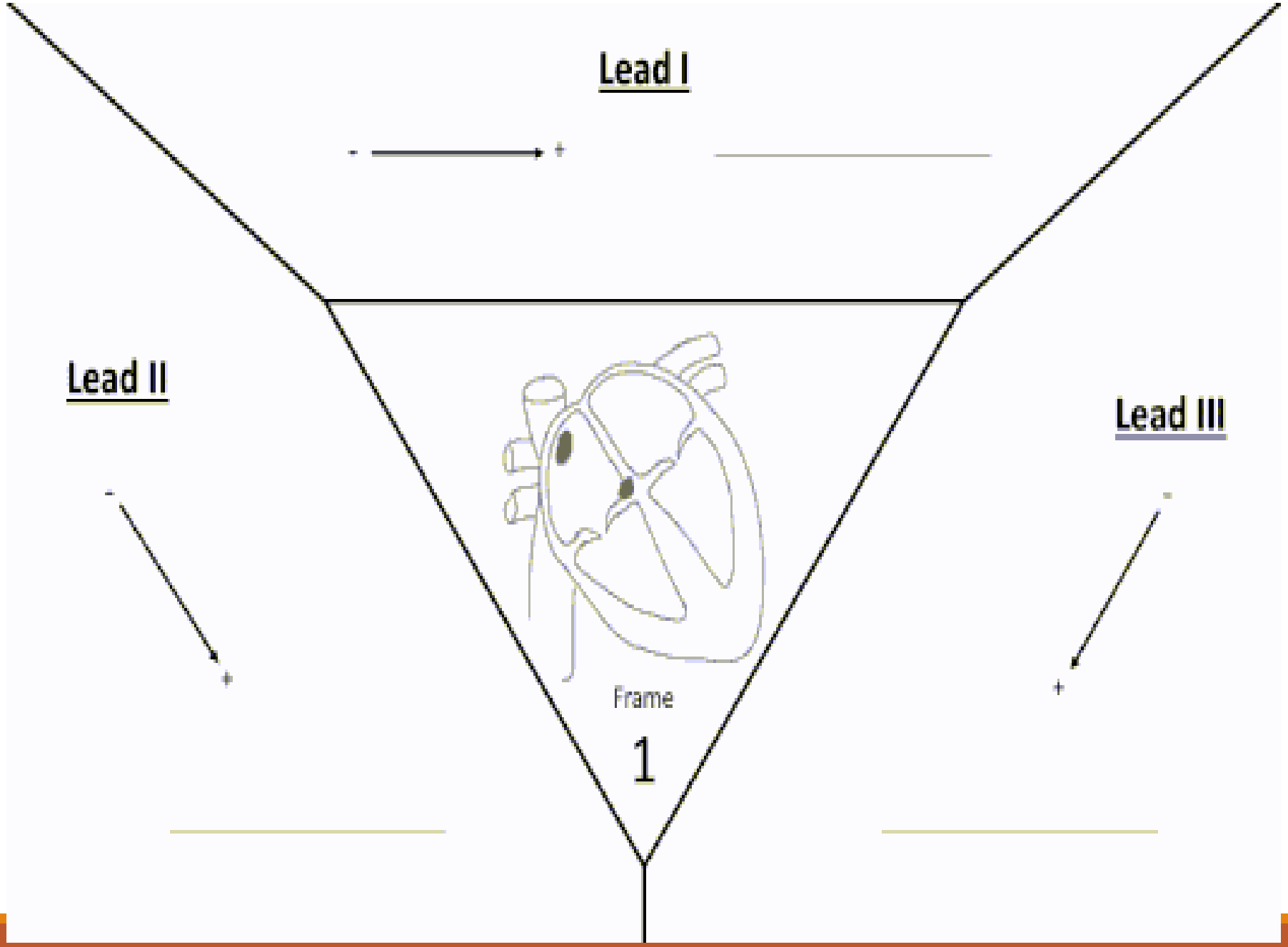
Lead	Positive Electrode	Negative Electrode	View of Heart
I	LA	RA	Lateral
II	LL	RA	Inferior
III	LL	LA	Inferior

Augmented Limb Leads



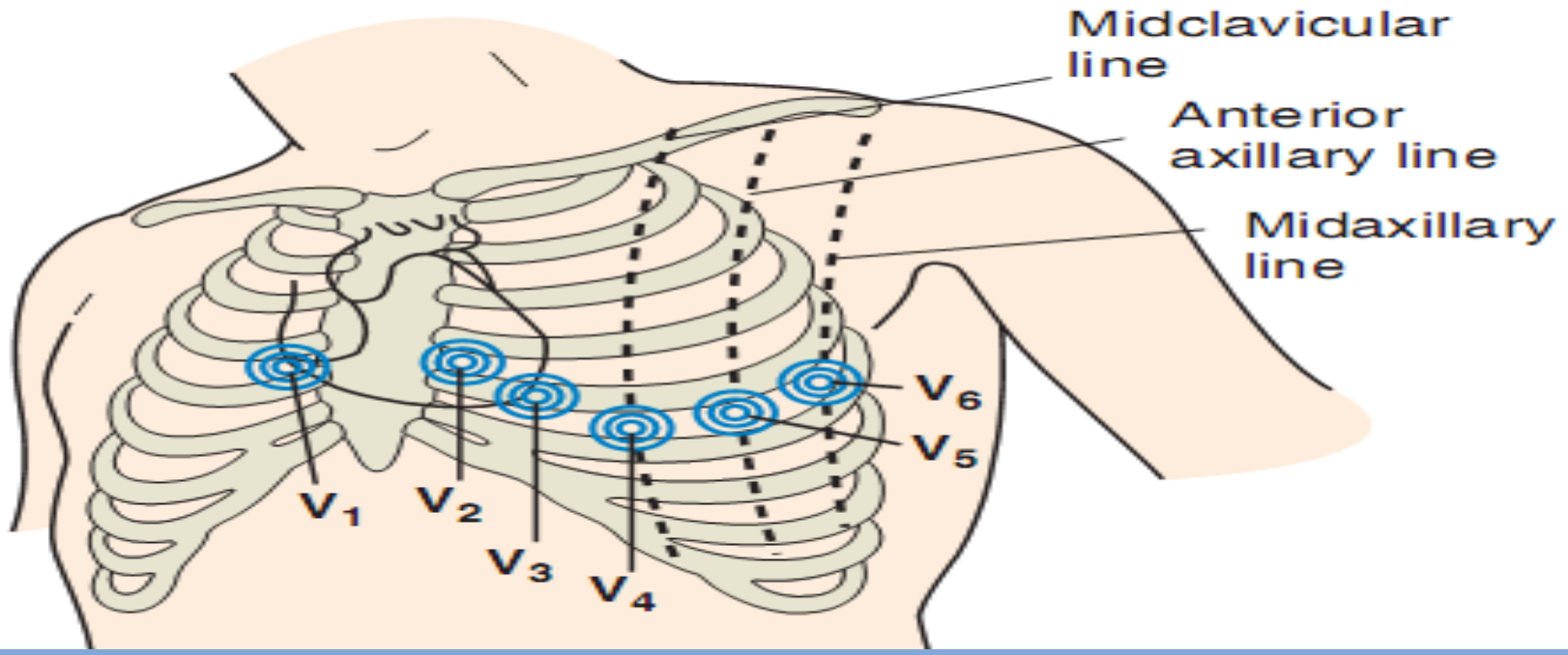
Elements of Augmented Limb Leads

Lead	Positive Electrode	View of Heart
aVR	RA	None
aVL	LA	Lateral
aVF	LL	Inferior


Lead I
Lead II
Lead III
Frame
1

Chest Leads

Standard Chest Lead Electrode Placement



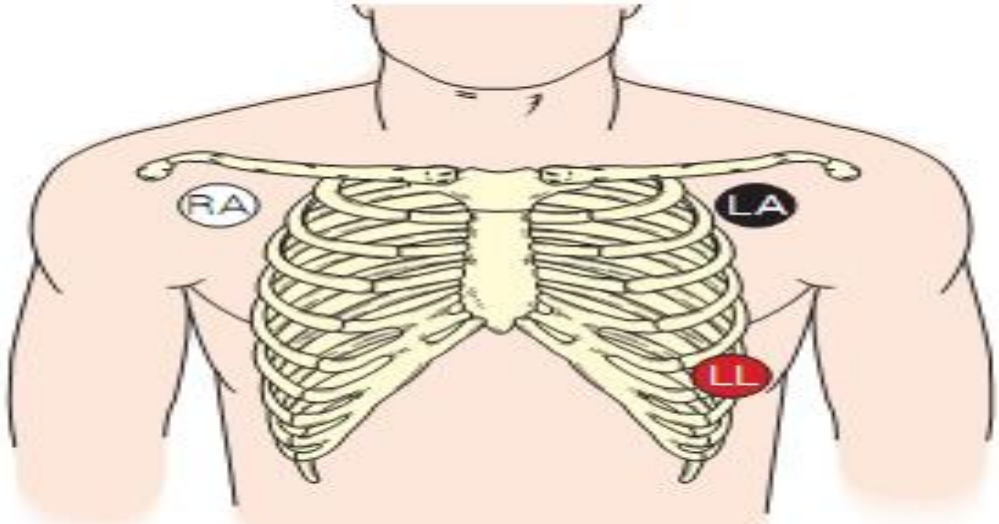
Elements of Chest Leads

Lead	Positive Electrode Placement	View of Heart
V_1	4th Intercostal space to right of sternum	Septum
V_2	4th Intercostal space to left of sternum	Septum
V_3	Directly between V_2 and V_4	Anterior
V_4	5th Intercostal space at left midclavicular line	Anterior
V_5	Level with V_4 at left anterior axillary line	Lateral
V_6	Level with V_5 at left midaxillary line	Lateral

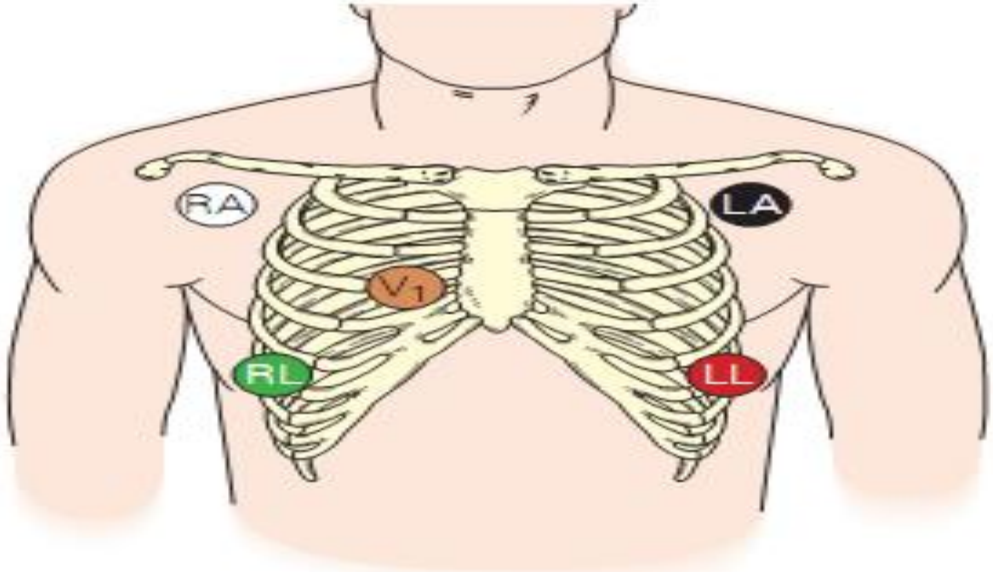
Table 2.1: Region of left ventricle represented on ECG

ECG leads	*Region of left ventricle*
V_1, V_2	Septal
V_3, V_4	Anterior
V_5, V_6	Lateral
V_1 to V_4	Antero-septal
V_3 to V_6	Antero-lateral
L_I, aVL	High lateral
L_{II}, L_{III}, aVF	Inferior

Electrode Placement Using a 3-Wire Cable



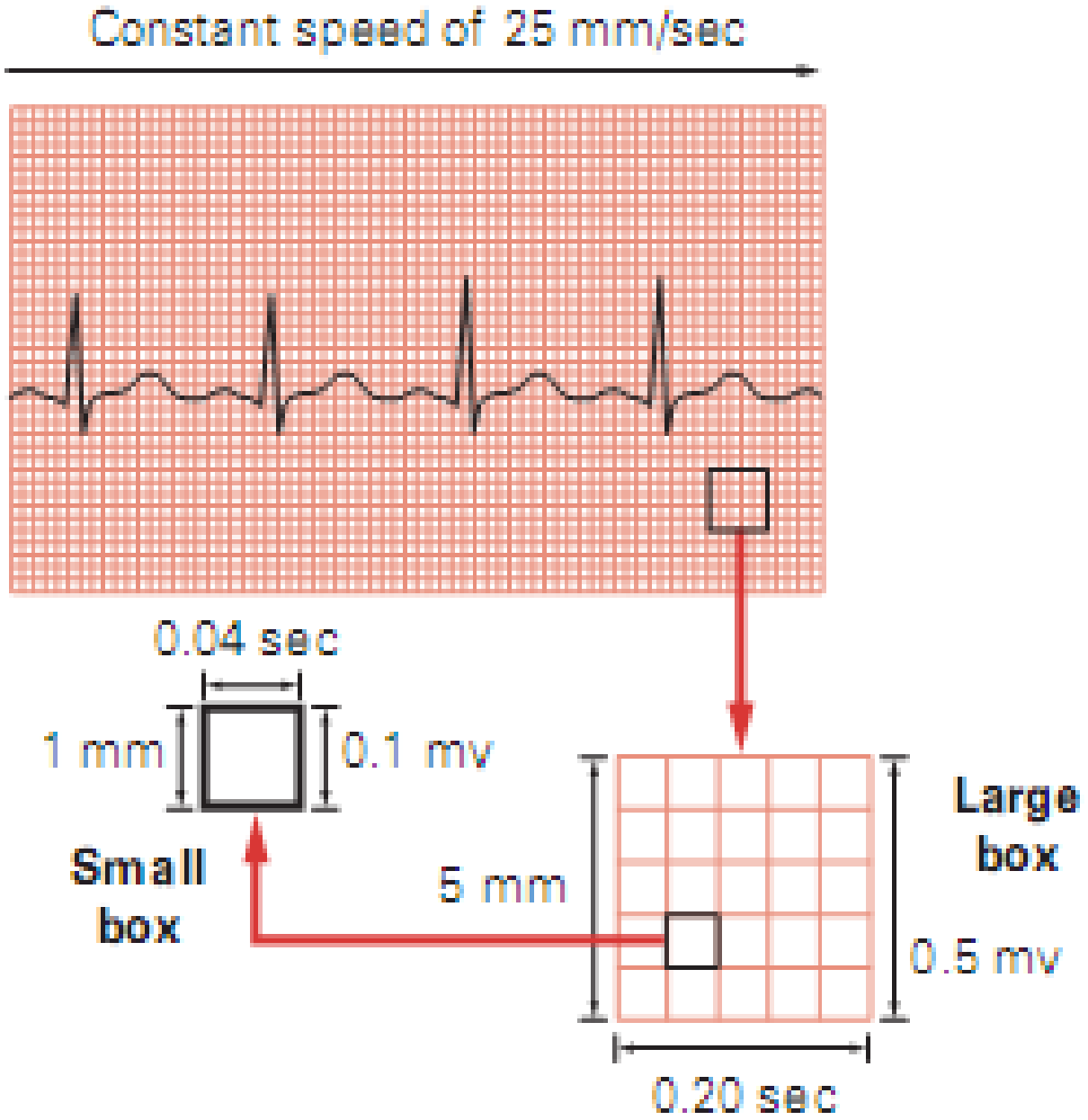
Electrode Placement Using a 5-Wire Cable

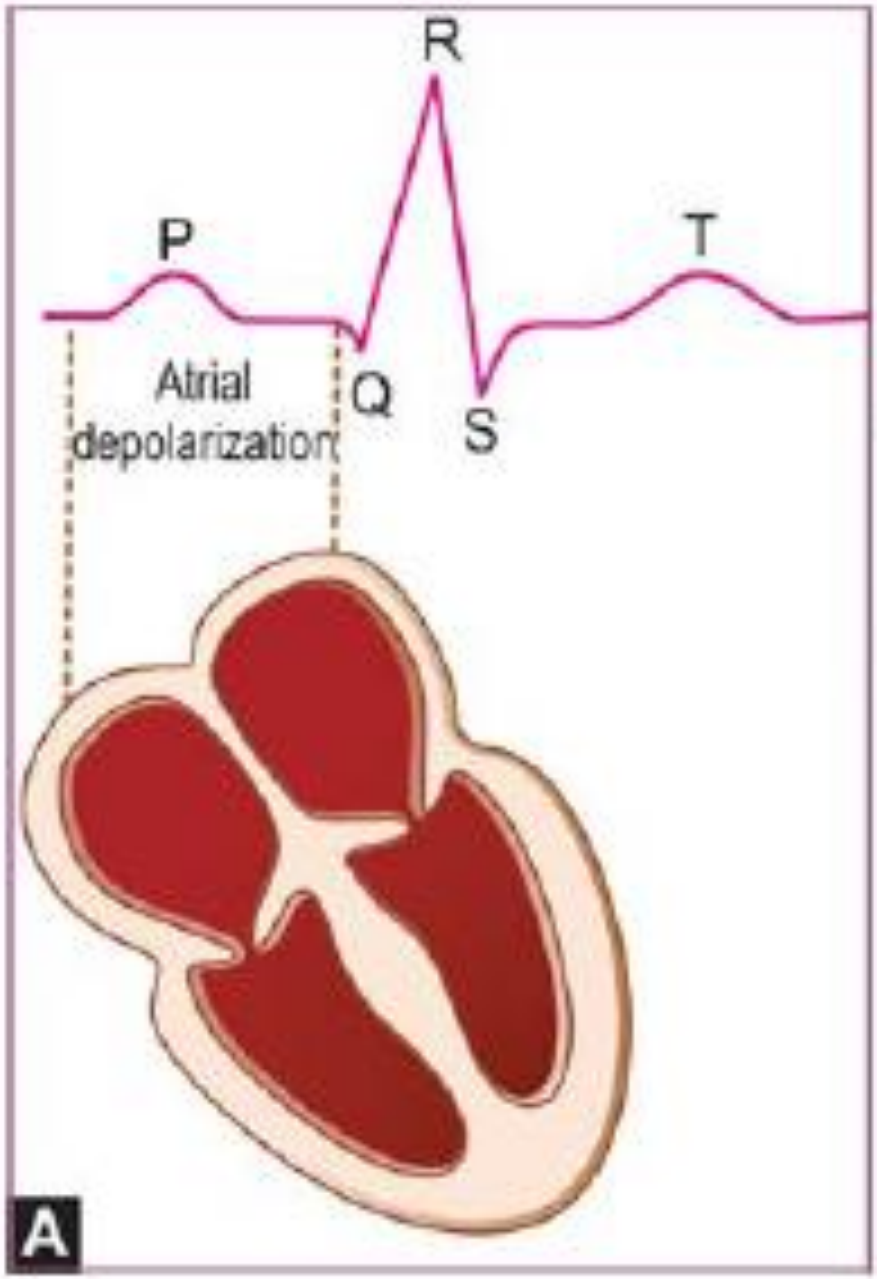


♥ **Clinical Tip:** Five-wire telemetry units are commonly used to monitor leads I, II, III, aVR, aVL, aVF, and V_1 in critical care settings.

THE ECG GRID

Recording of the ECG





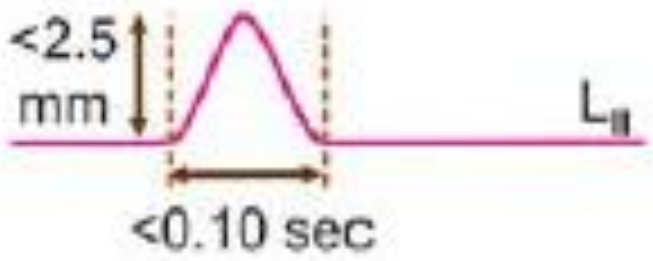


Fig. 3.2: A. Atrial depolarization
B. The normal P wave

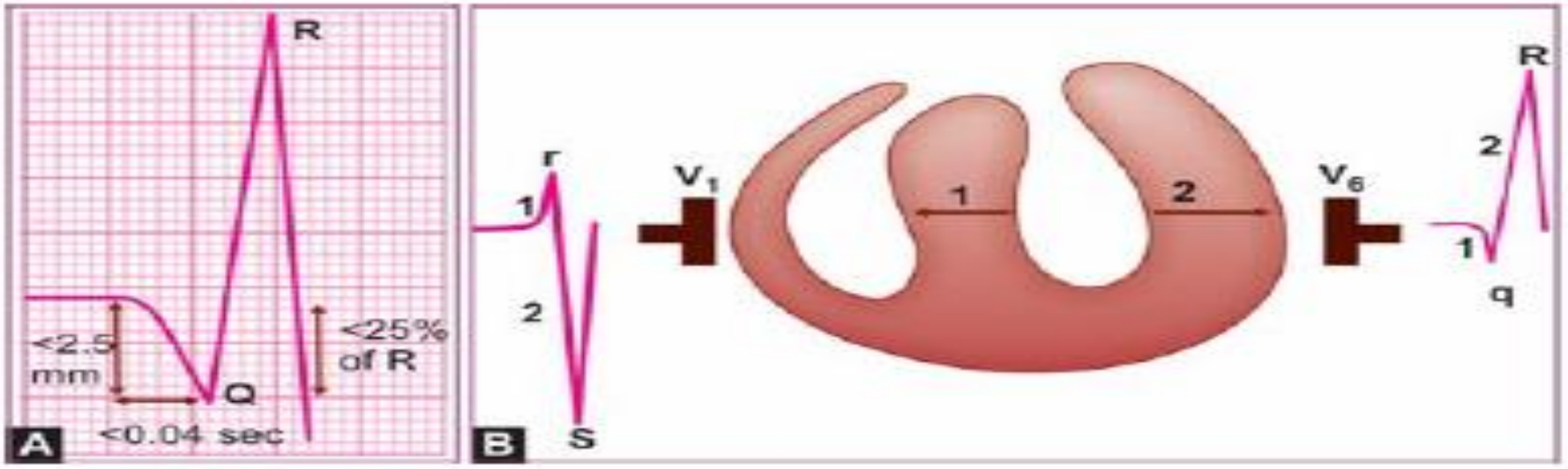


Fig. 3.3: A. The normal Q wave
B. Septal depolarization (1)

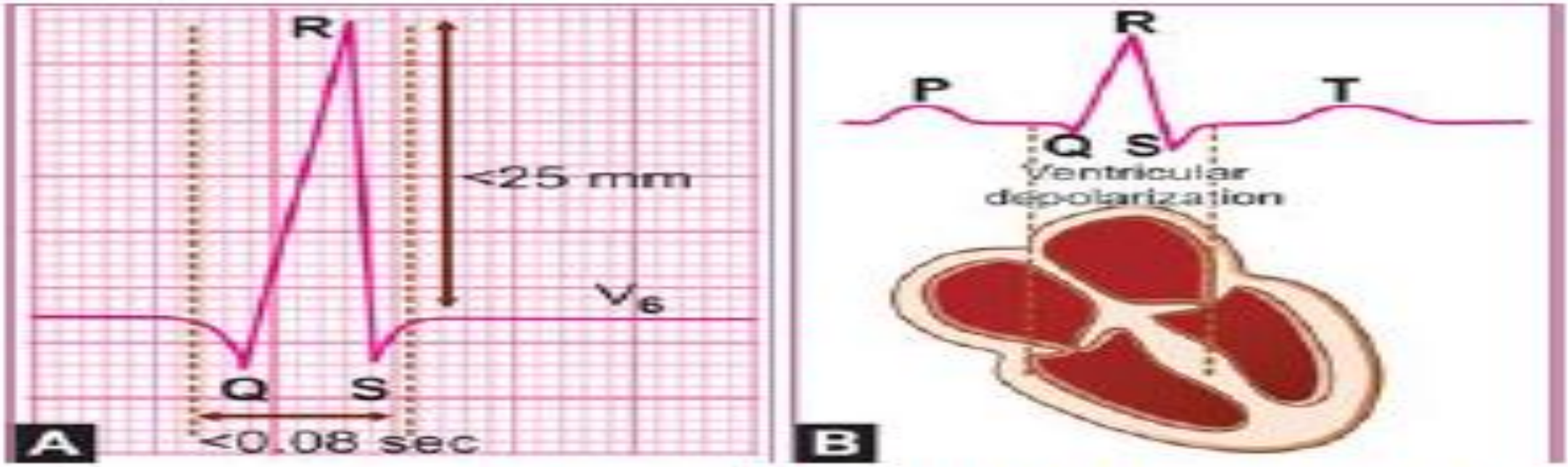


Fig. 3.4: A. The normal QRS complex
B. Ventricular depolarization

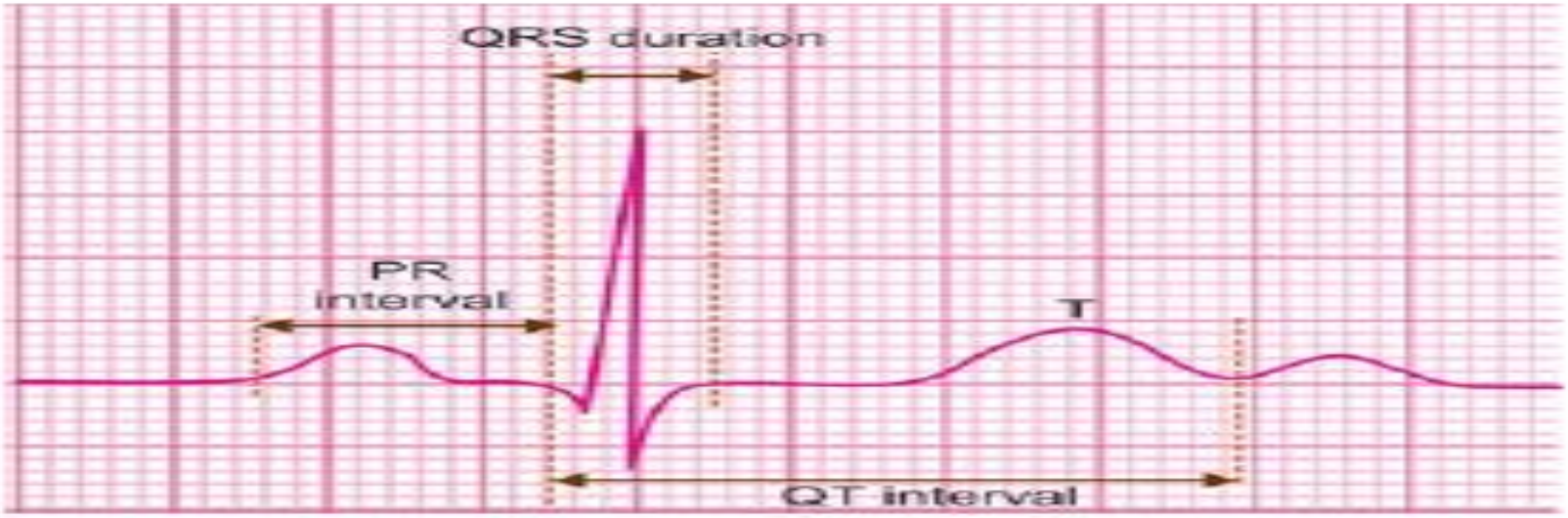


Fig. 1.11: The normal ECG intervals

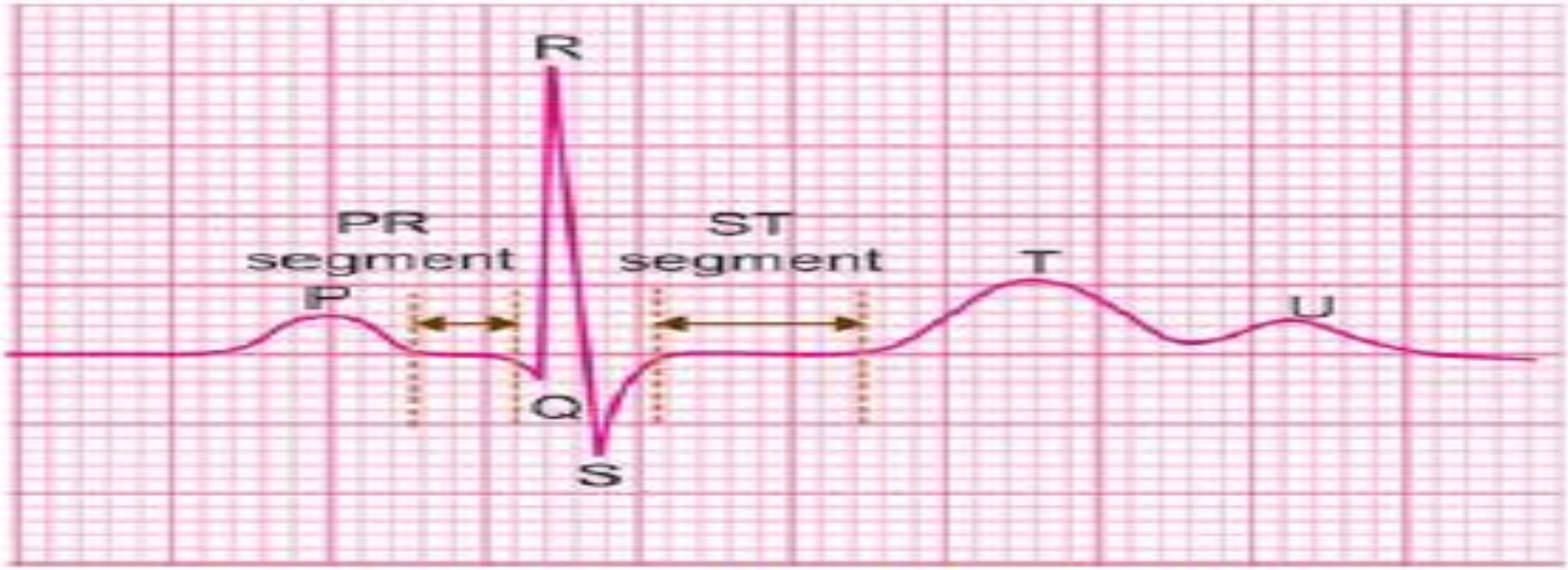


Fig. 1.12: The normal ECG segments

The normal P-R interval is in the range of 0.12 to 0.20 sec.
The normal Q-T interval is in the range of 0.35 to 0.43 sec

Fig. 5.1: Calculation of the heart rate from R-R interval, if R-R interval = 25 mm; Heart rate = 60/min

THE HEART RHYTHM

The rhythm of the heart can be classified on the basis of the following criteria:

- Rate of impulse origin
- Focus of impulse origin
- Pattern of rhythm regularity
- Atrioventricular relationship.

Rate of impulse :

The normal heart rate varies from 60 to 100 beats per minute. A cardiac rhythm at a rate less than 60 beats per minute constitutes bradycardia. A cardiac rhythm at a rate exceeding 100 beats per minute constitutes tachycardia.

Origin of impulse:

A cardiac rhythm originating from the SA node is called sinus rhythm. The SA node normally discharges at a rate of 60 to 100 beats per minute. A sinus rhythm at this rate is called normal sinus rhythm.

Besides the SA node, there are other potential pacemakers in the heart such as in the atria, atrioventricular junction and the ventricles. They are known as ectopic or subsidiary pacemakers. The subsidiary pacemakers can discharge at a slower rate than the SA node.

For instance, an atrial or junctional pacemaker can fire 40 to 60 impulses per minute while a ventricular pacemaker can fire 20 to 40 impulses per minute. It is for this reason that the SA node governs the cardiac rhythm by silencing these subsidiary pacemakers

Pattern of Regularity:

The normal cardiac rhythm is regular that is, the interval between the different beats is the same (equally spaced QRS complexes). At times, however, the cardiac rhythm may be irregular that is, the QRS complexes are not equally spaced. Irregularity of cardiac rhythm is further of two types, regular irregularity and irregular irregularity.

Atrioventricular Relationship:

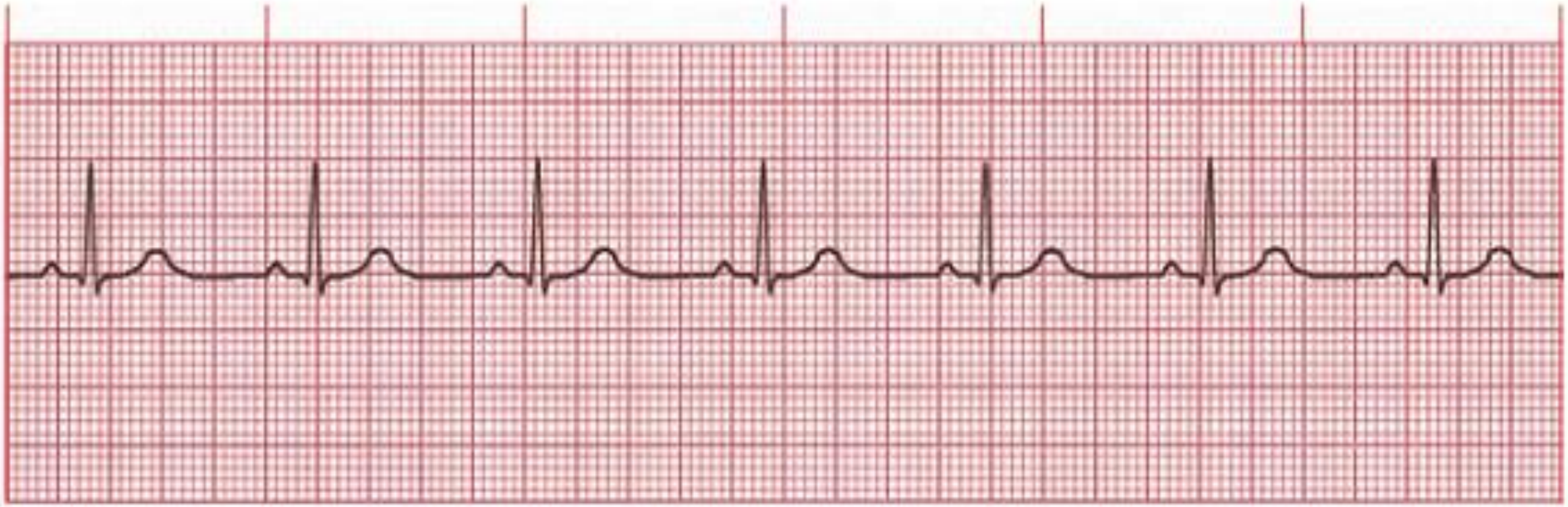
The normal cardiac activation sequence is such that the electrical impulse from the SA node first activates the atria and then travels downwards through the conducting system to activate the ventricles. We know that atrial depolarization is represented by the P wave and ventricular depolarization is represented by the QRS complex. Therefore, the P wave is followed by the QRS complex and the two are related to each other

Sinoatrial (SA) Node Arrhythmias

- Upright P waves all look similar.
- PR intervals and QRS complexes are of normal duration.

Note: All ECG strips in this tab were recorded in lead II.

Normal Sinus Rhythm (NSR)

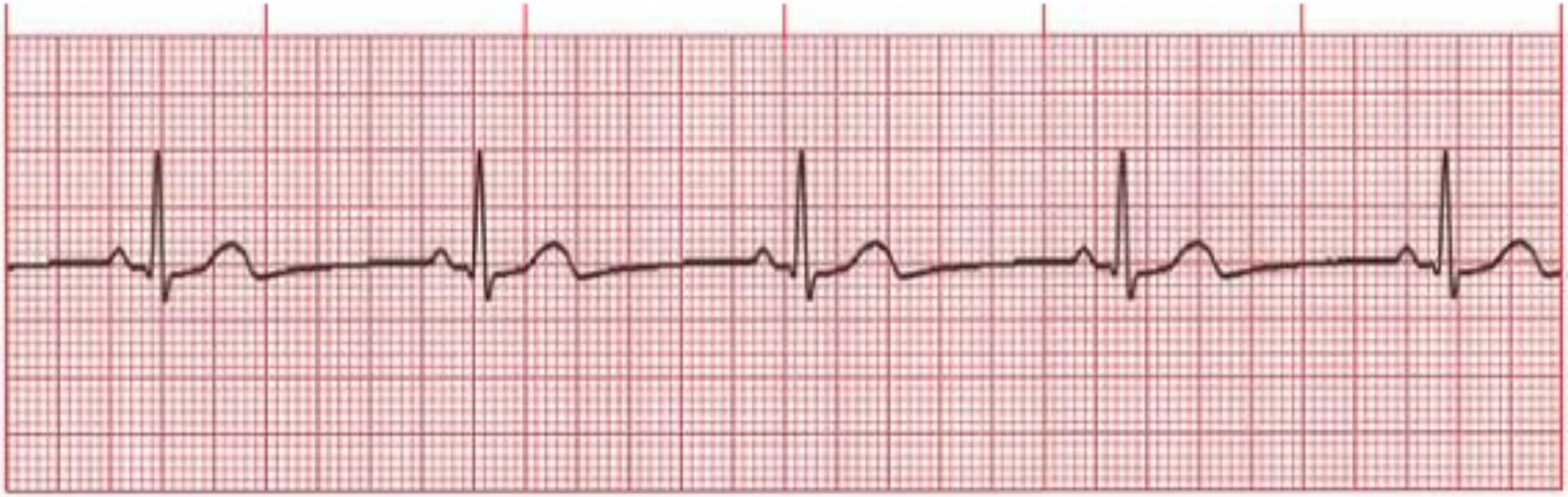


Rate: Normal (60–100 bpm)
Rhythm: Regular
P Waves: Normal (upright and uniform)
PR Interval: Normal (0.12–0.20 sec)
QRS: Normal (0.06–0.10 sec)

♥ **Clinical Tip:** A normal ECG does not exclude heart disease.

Sinus Bradycardia

- Results from slowing of the SA node.

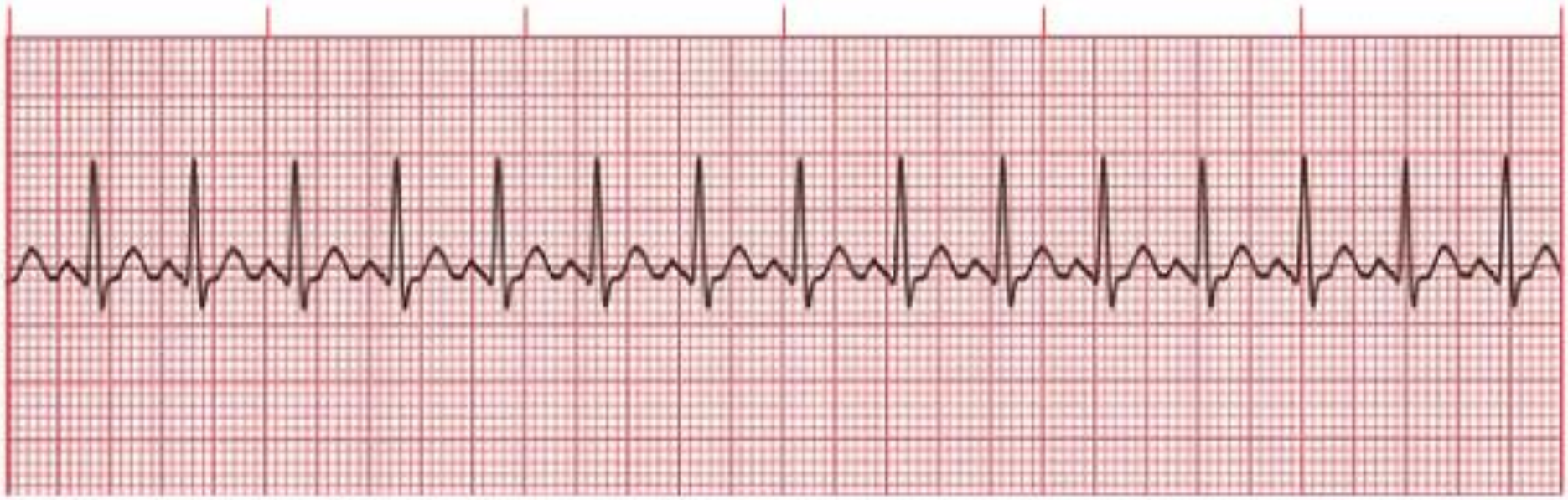


Rate: Slow (<60 bpm)
Rhythm: Regular
P Waves: Normal (upright and uniform)
PR Interval: Normal (0.12–0.20 sec)
QRS: Normal (0.06–0.10 sec)

♥ **Clinical Tip:** Sinus bradycardia is normal in athletes and during sleep. In acute MI, it may be protective and beneficial or the slow rate may compromise cardiac output. Certain medications, such as beta blockers, may also cause sinus bradycardia.

Sinus Tachycardia

- Results from increased SA node discharge.



Rate: Fast (>100 bpm)
Rhythm: Regular
P Waves: Normal (upright and uniform)
PR Interval: Normal (0.12–0.20 sec)
QRS: Normal (0.06–0.10 sec)

♥ **Clinical Tip:** Sinus tachycardia may be caused by exercise, anxiety, fever, hypoxemia, hypovolemia, or cardiac failure.

Sinus Arrhythmia

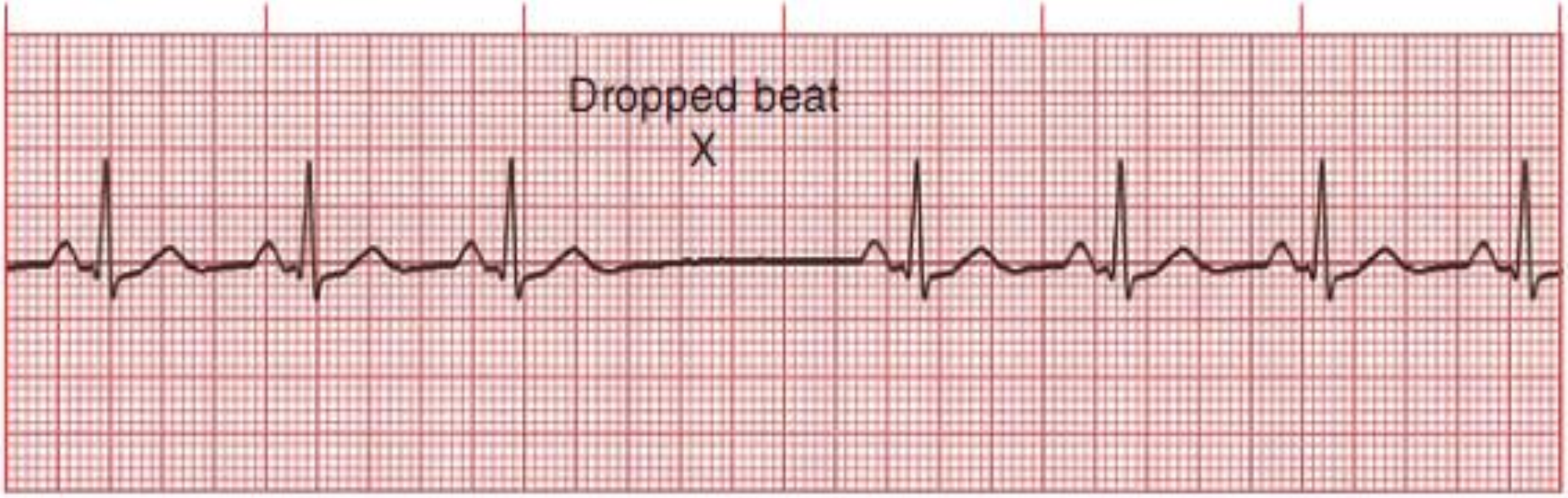
- The SA node discharges irregularly.
- The R-R interval is irregular.

Rate: Usually normal (60–100 bpm); frequently increases with inspiration and decreases with expiration
Rhythm: Irregular; varies with respiration
P Waves: Normal (upright and uniform)
PR Interval: Normal (0.12–0.20 sec)
QRS: Normal (0.06–0.10 sec)

♥ **Clinical Tip:** The pacing rate of the SA node varies with respiration, especially in children and elderly people.

Sinoatrial (SA) Block

- The block occurs in some multiple of the P-P interval.
- After the dropped beat, cycles continue on time.

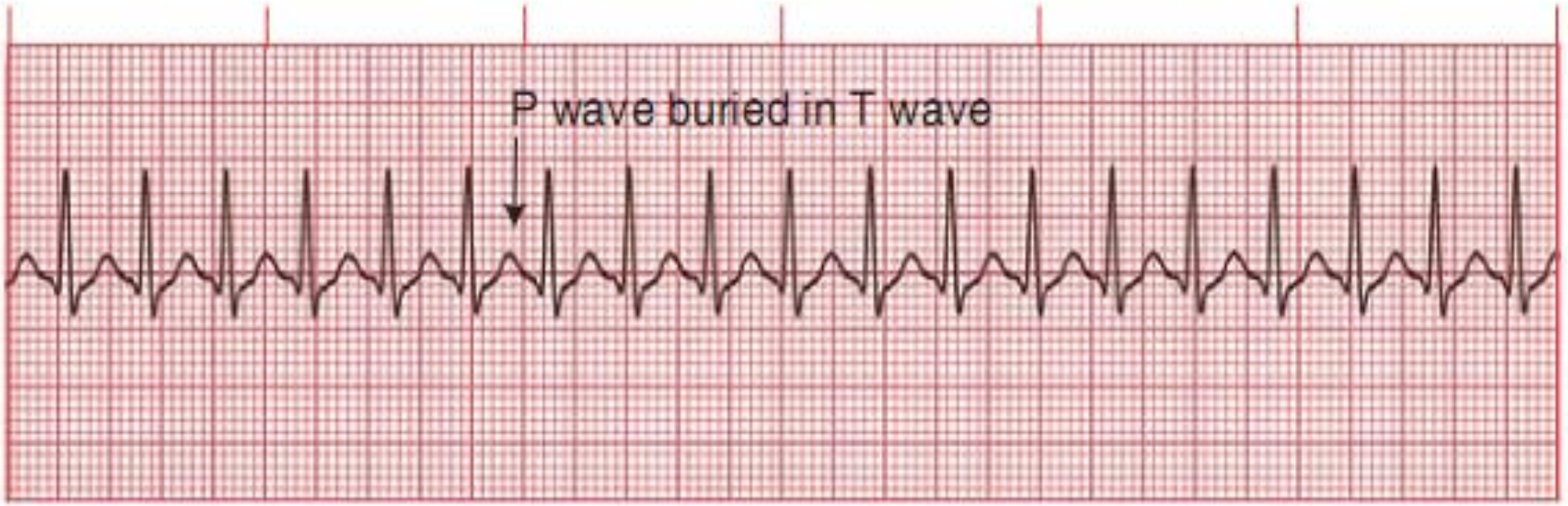


Rate: Normal to slow; determined by duration and frequency of SA block
Rhythm: Irregular whenever an SA block occurs
P Waves: Normal (upright and uniform) except in areas of dropped beats
PR Interval: Normal (0.12–0.20 sec)
QRS: Normal (0.06–0.10 sec)

♥ **Clinical Tip:** Cardiac output may decrease, causing syncope or dizziness.

Supraventricular Tachycardia (SVT)

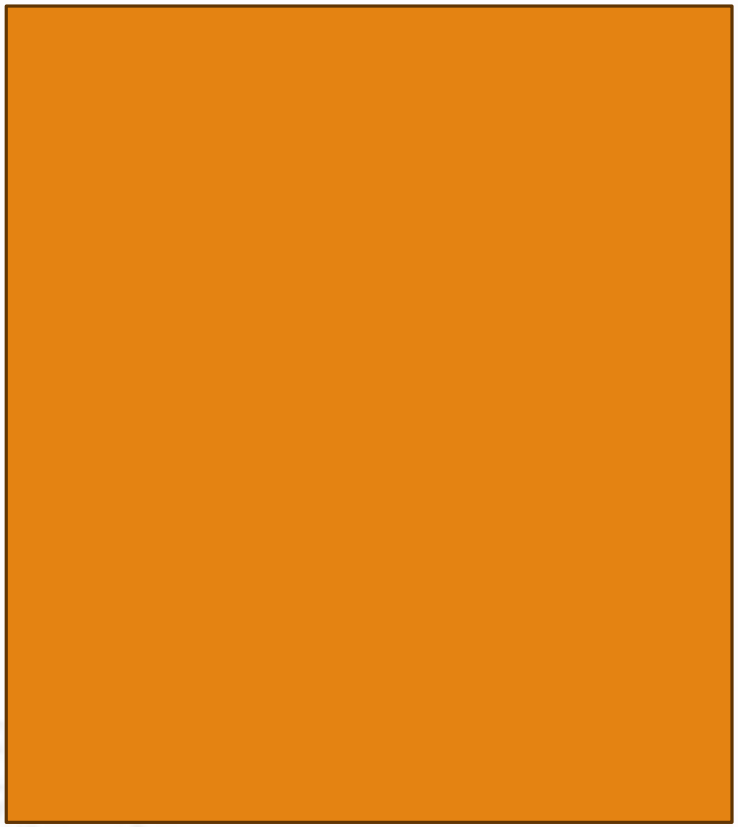
- This arrhythmia has such a fast rate that the P waves may not be seen.

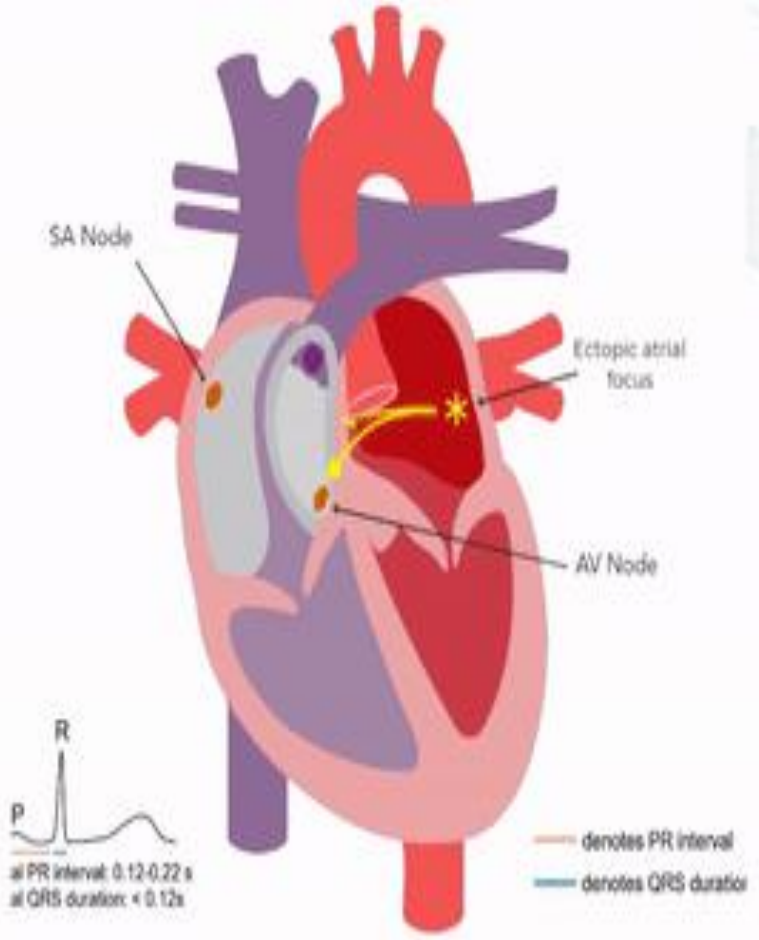


Rate: 150–250 bpm
Rhythm: Regular
P Waves: Frequently buried in preceding T waves and difficult to see
PR Interval: Usually not possible to measure
QRS: Normal (0.06–0.10 sec) but may be wide if abnormally conducted through ventricles

♥ **Clinical Tip:** SVT may be related to caffeine intake, nicotine, stress, or anxiety in healthy adults.

Pathophysiology





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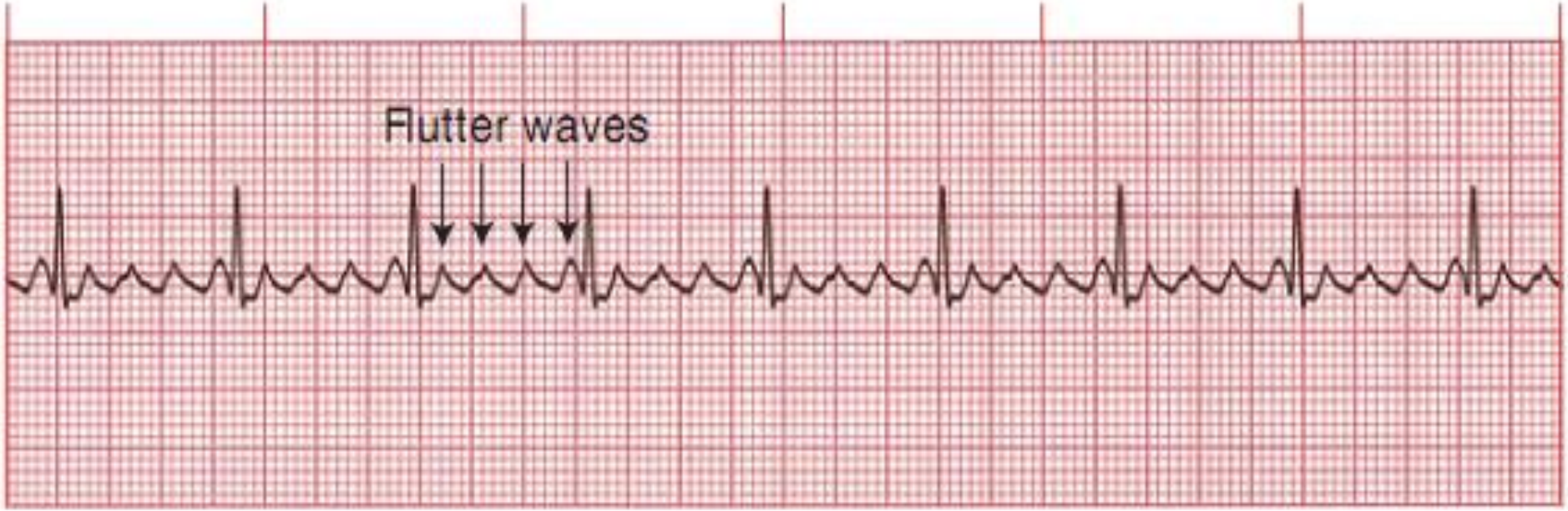
Atrial Flutter (A-flutter)

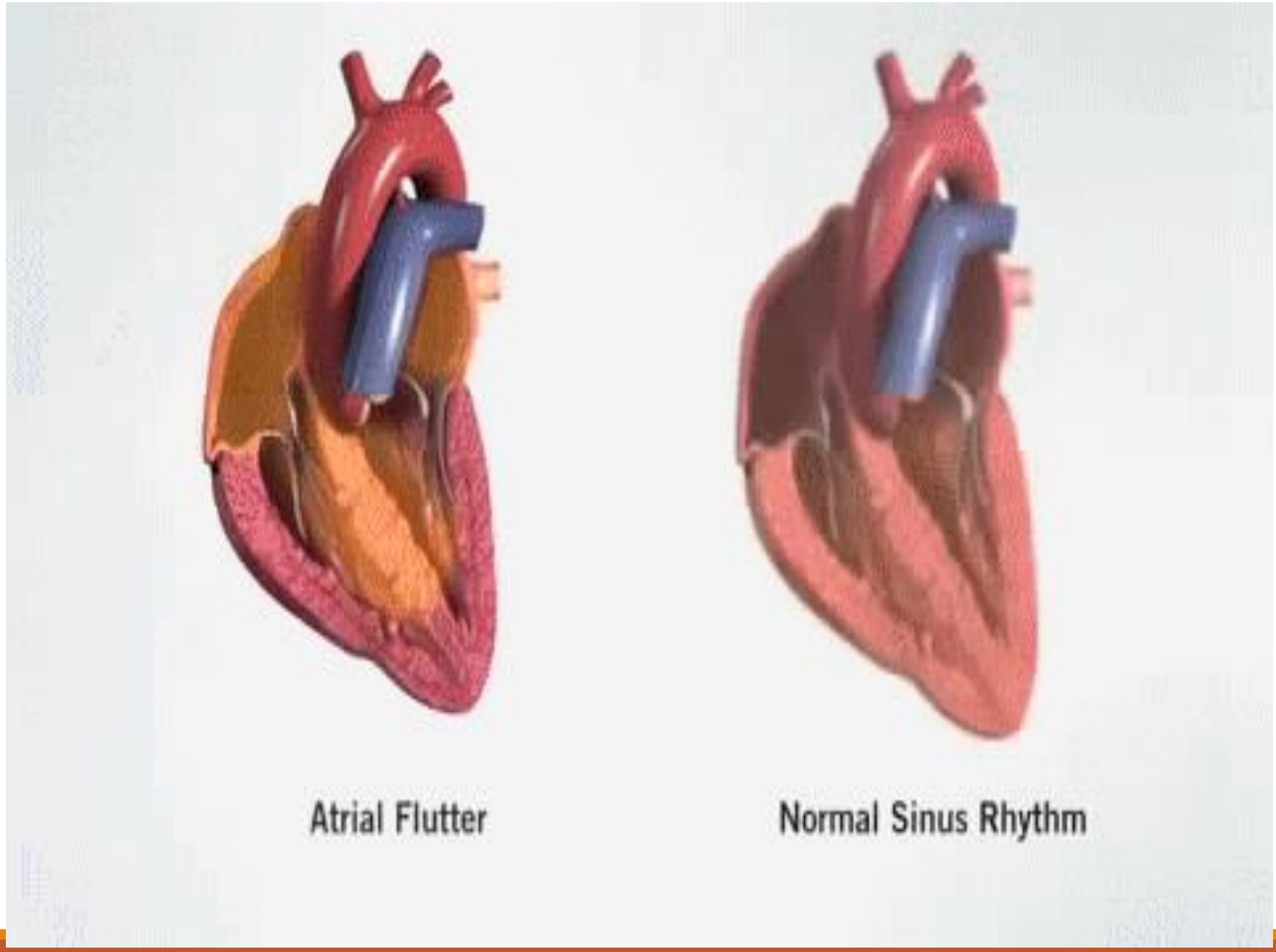
- AV node conducts impulses to the ventricles at a 2:1, 3:1, 4:1, or greater ratio (rarely 1:1).
- Degree of AV block may be consistent or variable.



Rate: Atrial: 250–350 bpm; ventricular: slow or fast
Rhythm: Usually regular but may be variable
P Waves: Flutter waves have a saw-toothed appearance
PR Interval: Variable
QRS: Usually normal (0.06–0.10 sec), but may appear widened if flutter waves are buried in QRS

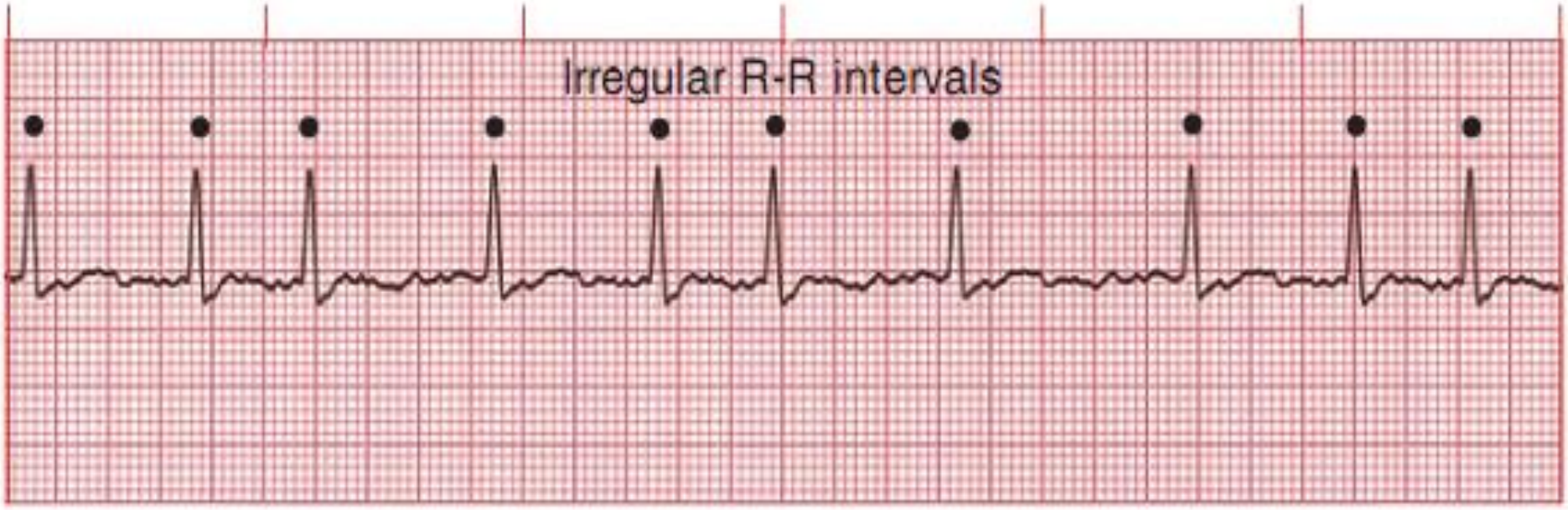
♥ **Clinical Tip:** The presence of A-flutter may be the first indication of cardiac disease.

♥ **Clinical Tip:** Signs and symptoms depend on ventricular response rate.


Atrial Flutter
Normal Sinus Rhythm

Atrial Fibrillation (A-fib)

- Rapid, erratic electrical discharge comes from multiple atrial ectopic foci.
- No organized atrial contractions are detectable.

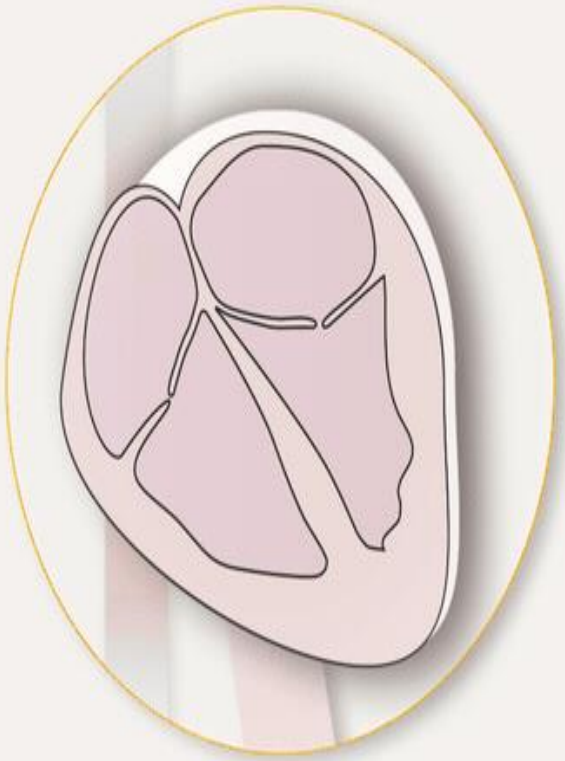


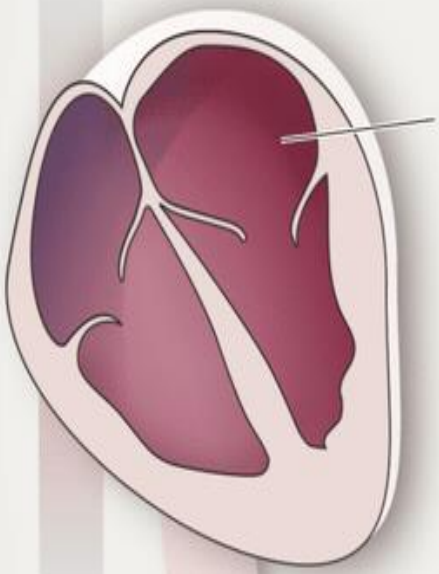
Rate: Atrial: 350 bpm or greater; ventricular: slow or fast
Rhythm: Irregular
P Waves: No true P waves; chaotic atrial activity
PR Interval: None
QRS: Normal (0.06–0.10 sec)

♥ **Clinical Tip:** A-fib is usually a chronic arrhythmia associated with underlying heart disease.

♥ **Clinical Tip:** Signs and symptoms depend on ventricular response rate.

Atrial fibrillation (AFib) is the most common type of heart arrhythmia.





AFib occurs when the upper chambers and lower chambers are not coordinated, causing the heart to beat too slowly, too quickly, or irregularly.

Normal heartbeat

Irregular heartbeat

CDC

Ventricular Arrhythmias

- QRS complex is >0.10 sec. P Waves are absent or, if visible, have no consistent relationship to the QRS complex.

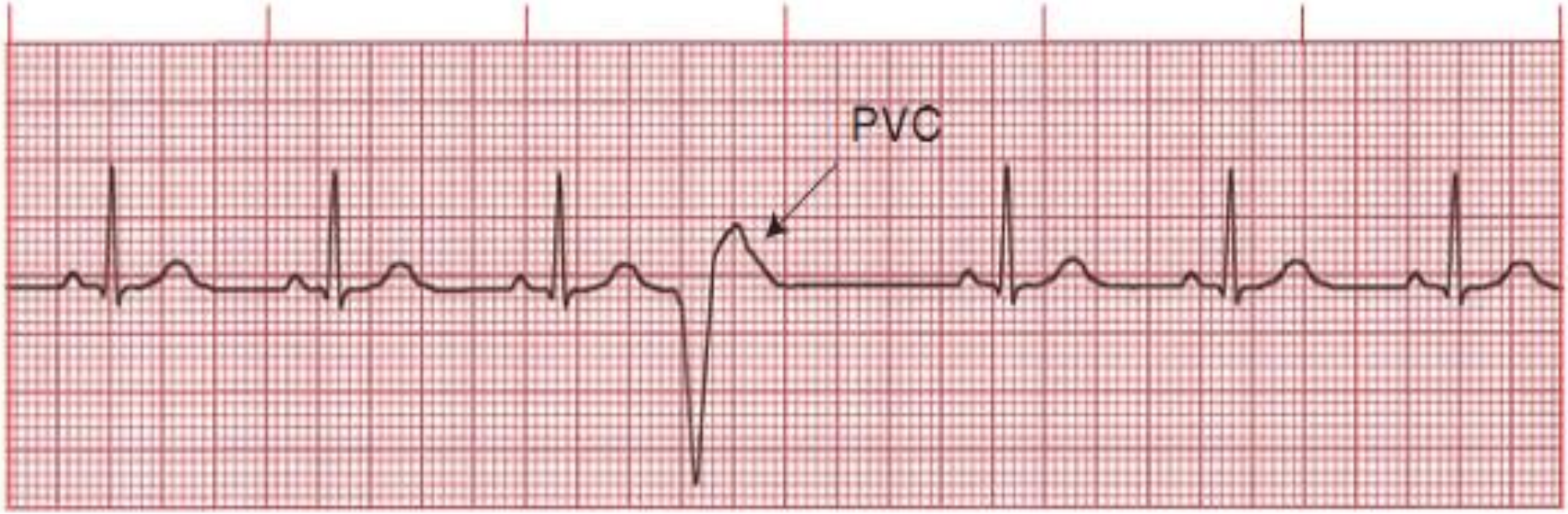
Idioventricular Rhythm

Rate: 20–40 bpm
Rhythm: Regular
P Waves: None
PR Interval: None
QRS: Wide (>0.10 sec), bizarre appearance

♥ **Clinical Tip:** Idioventricular rhythm may also be called agonal rhythm.

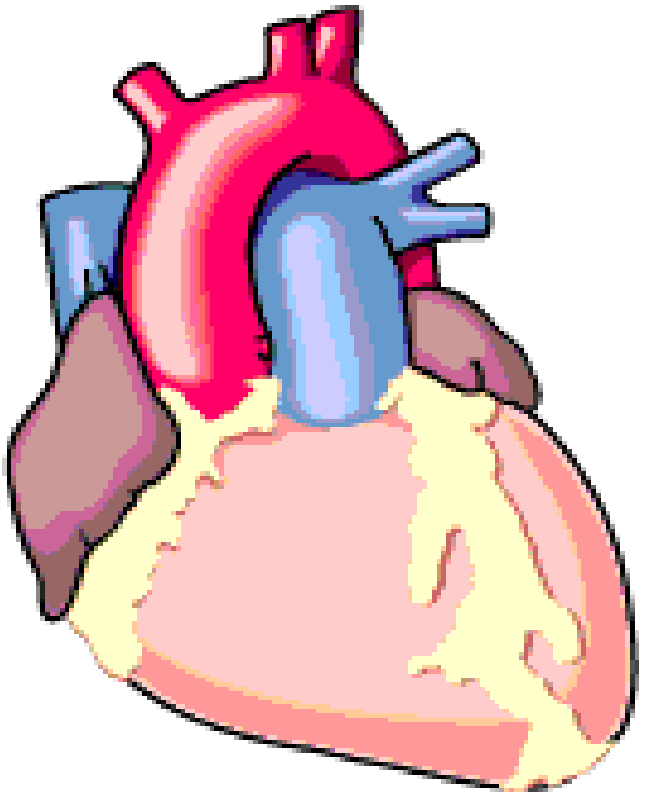
Premature Ventricular Contraction (PVC)

- Usually PVCs result from an irritable ventricular focus.
- PVCs may be uniform (same form) or multiform (different forms).
- The pause following a PVC may be compensatory or noncompensatory.

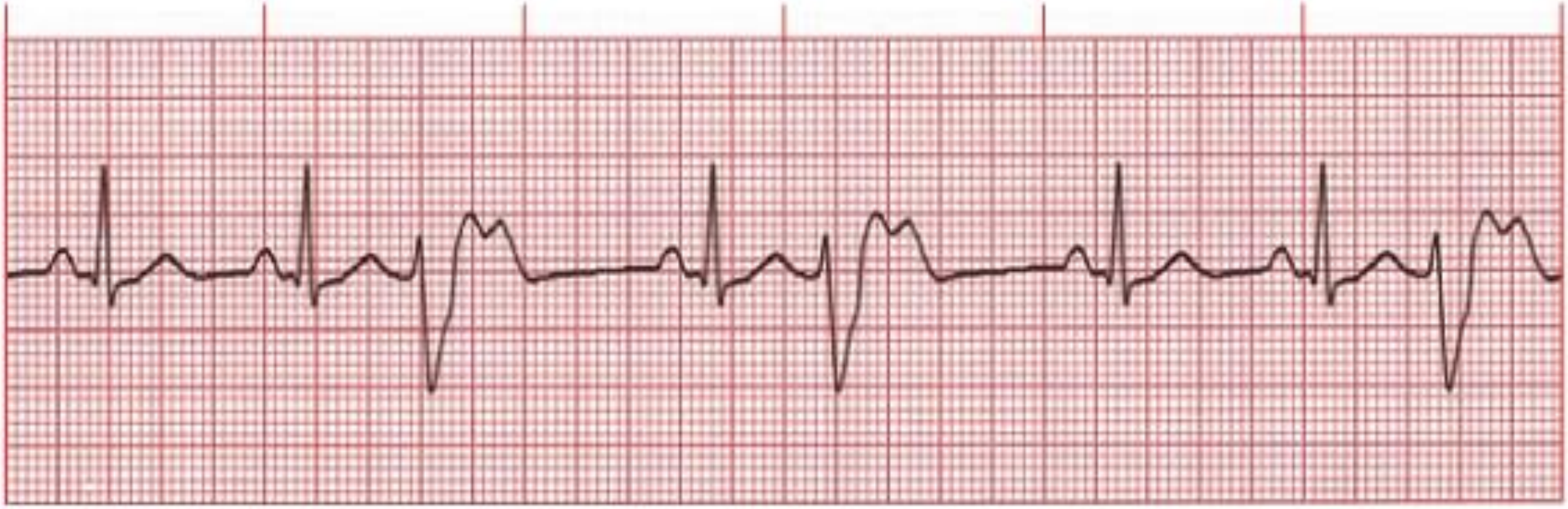


Rate: Depends on rate of underlying rhythm
Rhythm: Irregular whenever a PVC occurs
P Waves: None associated with the PVC
PR Interval: None associated with the PVC
QRS: Wide (>0.10 sec), bizarre appearance

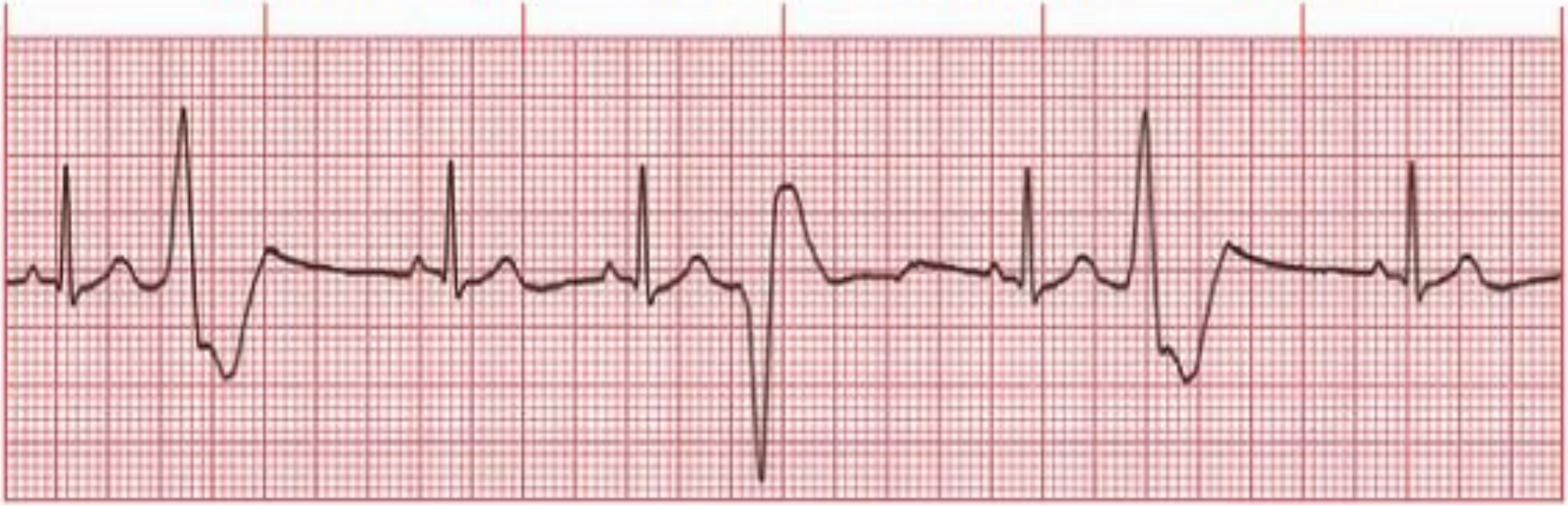
♥ **Clinical Tip:** Patients may sense the occurrence of PVCs as skipped beats. Because the ventricles are only partially filled, the PVC frequently does not generate a pulse.



Premature Ventricular Contraction: Uniform (same form)



Premature Ventricular Contraction: Multiform (different forms)

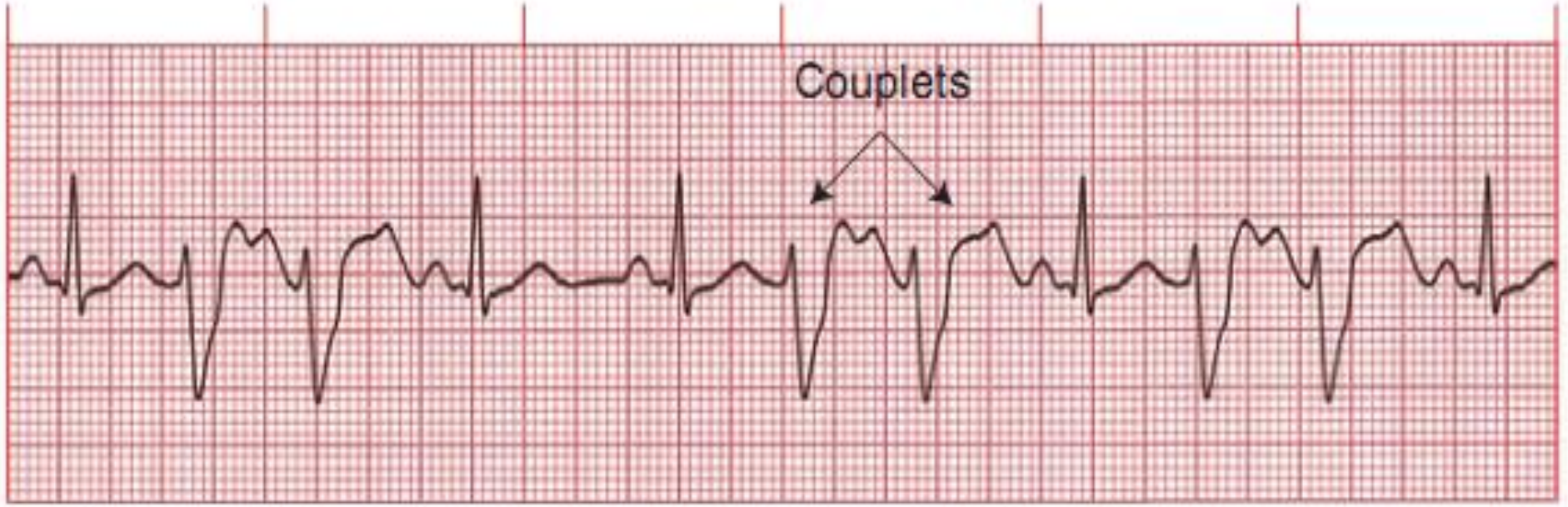


Premature Ventricular Contraction: Ventricular Bigeminy (PVC every other beat)

Premature Ventricular Contraction: Ventricular Trigeminy (PVC every 3rd beat)

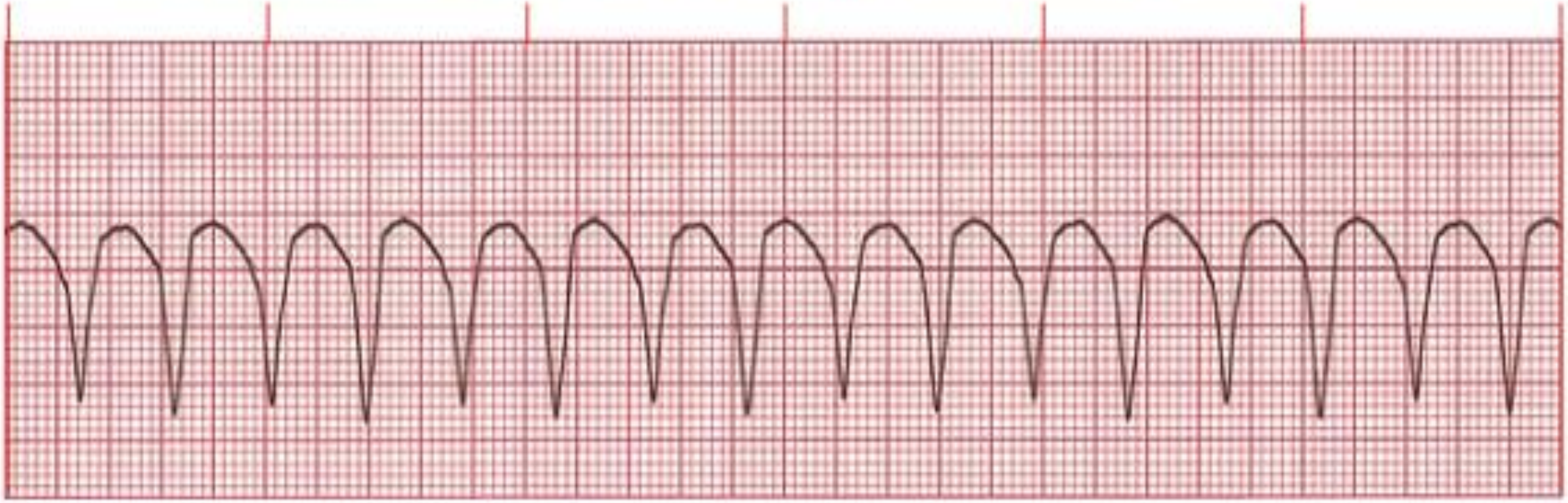
Premature Ventricular Contraction: Ventricular Quadrigeminy (PVC every 4th beat)

Premature Ventricular Contraction: Couplets (paired PVCs)



Ventricular Tachycardia (VT): Monomorphic

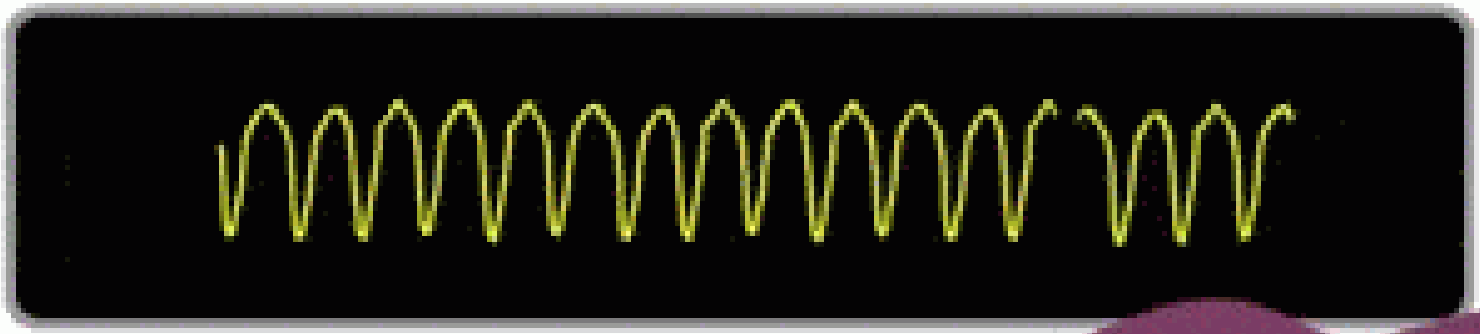
- QRS complexes in monomorphic VT have the same shape and amplitude.



Rate: 100–250 bpm
Rhythm: Regular
P Waves: None or not associated with the QRS
PR Interval: None
QRS: Wide (>0.10 sec), bizarre appearance

♥ **Clinical Tip:** It is important to confirm the presence or absence of pulses because monomorphic VT may be perfusing or nonperfusing.

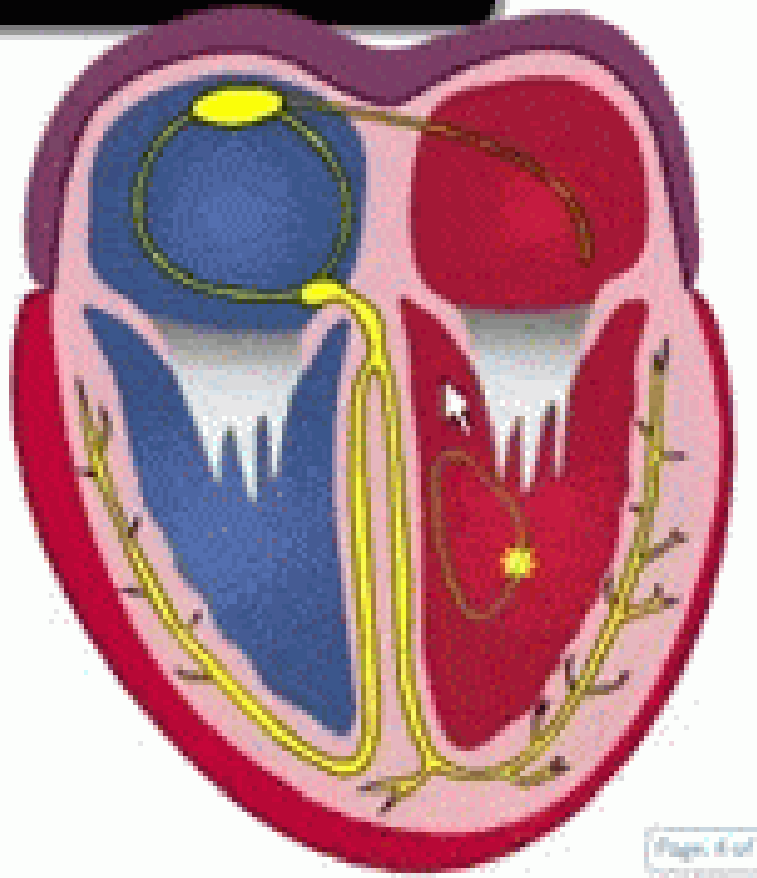
♥ **Clinical Tip:** Monomorphic VT will probably deteriorate into VF or unstable VT if sustained and not treated.



Next Rhythm

Previous Rhythm

Ventricular Tachycardia



Ventricular Tachycardia

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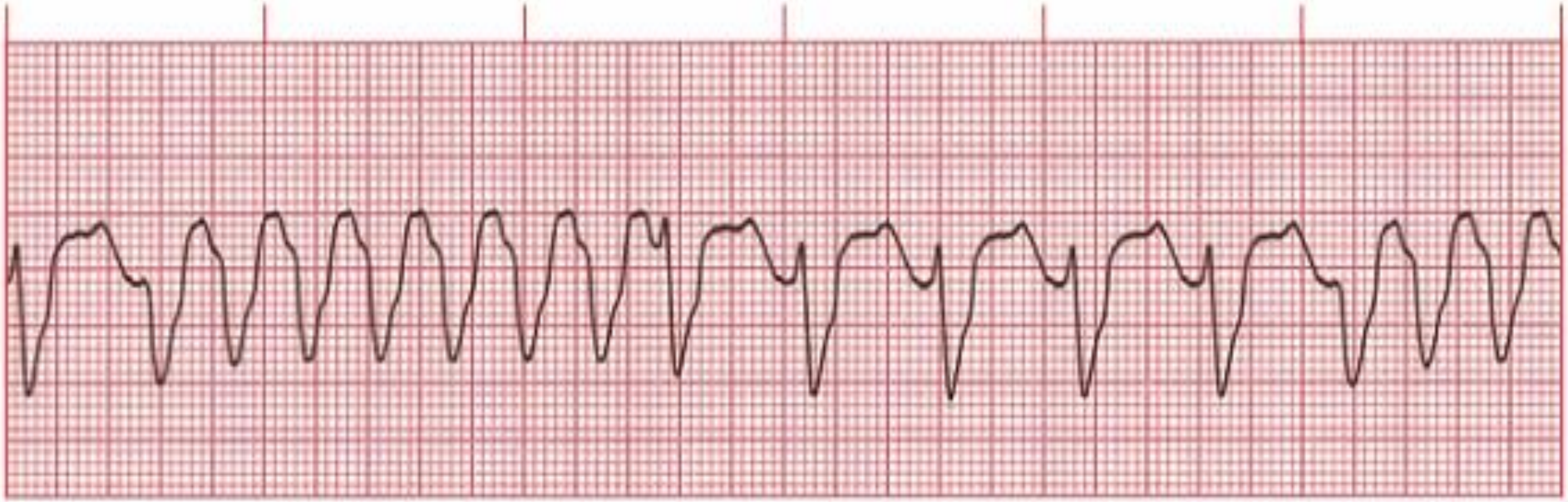
Ventricular Tachycardia (VT): Polymorphic

- QRS complexes in polymorphic VT vary in shape and amplitude.
- The QT interval is normal or long.



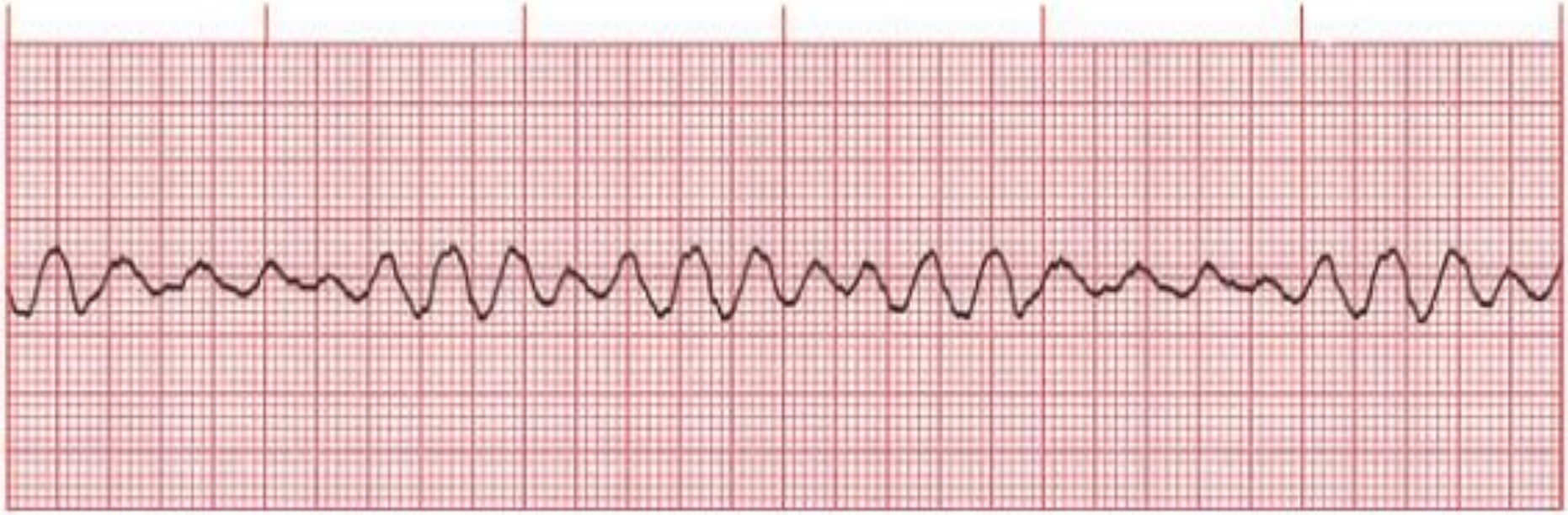
Rate: 100–250 bpm
Rhythm: Regular or irregular
P Waves: None or not associated with the QRS
PR Interval: None
QRS: Wide (>0.10 sec), bizarre appearance

♥ **Clinical Tip:** It is important to confirm the presence or absence of pulses because polymorphic VT may be perfusing or nonperfusing.

♥ **Clinical Tip:** Consider electrolyte abnormalities as a possible etiology.

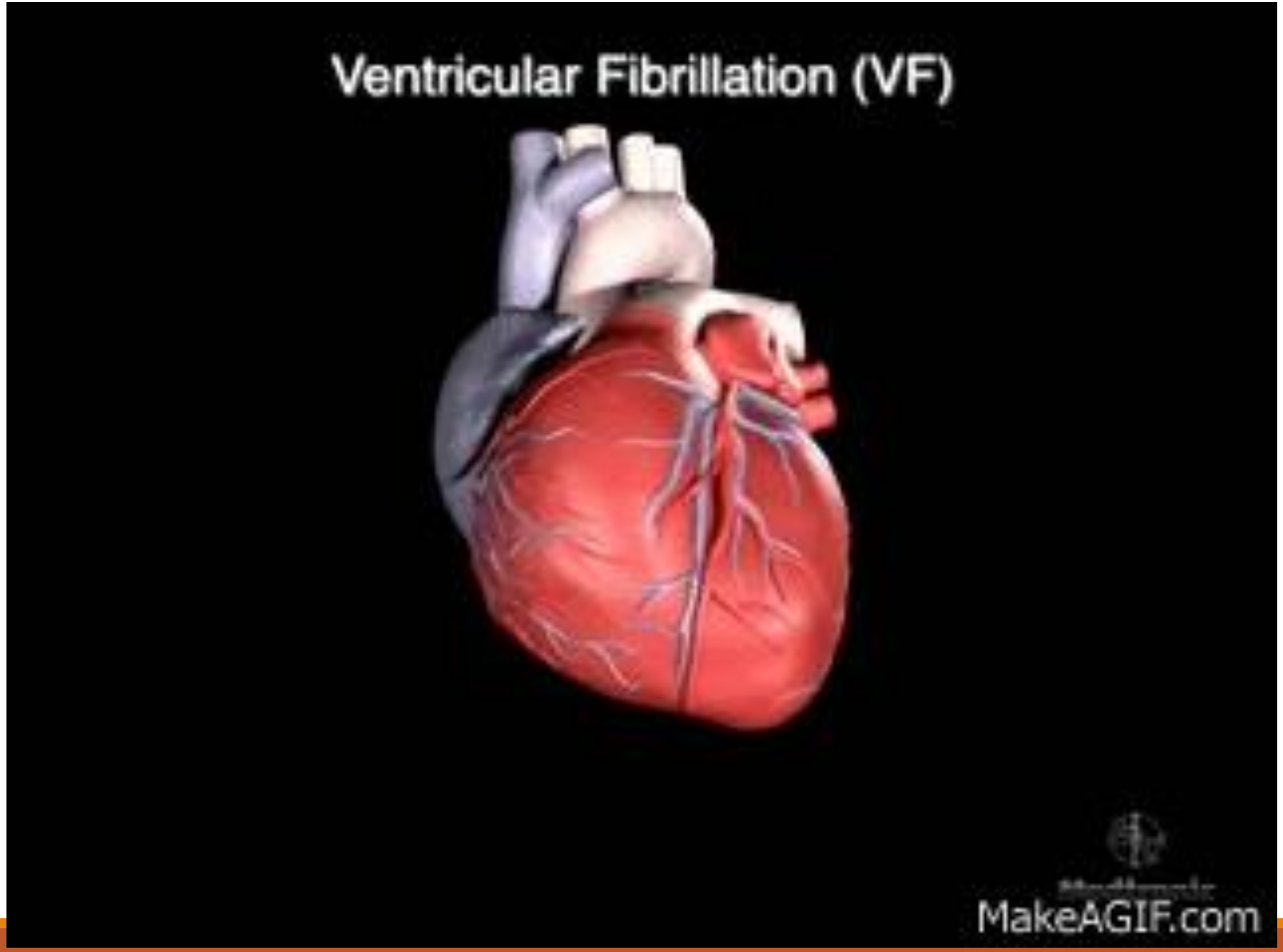
Ventricular Fibrillation (VF)

- Chaotic electrical activity occurs with no ventricular depolarization or contraction.
- The amplitude and frequency of the fibrillatory activity can be used to define the type of fibrillation as coarse, medium, or fine.



Rate: Indeterminate
Rhythm: Chaotic
P Waves: None
PR Interval: None
QRS: None

♥ **Clinical Tip:** There is no pulse or cardiac output. Rapid intervention is critical. The longer the delay, the less the chance of conversion.


Ventricular Fibrillation (VF)
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Pulseless Electrical Activity (PEA)

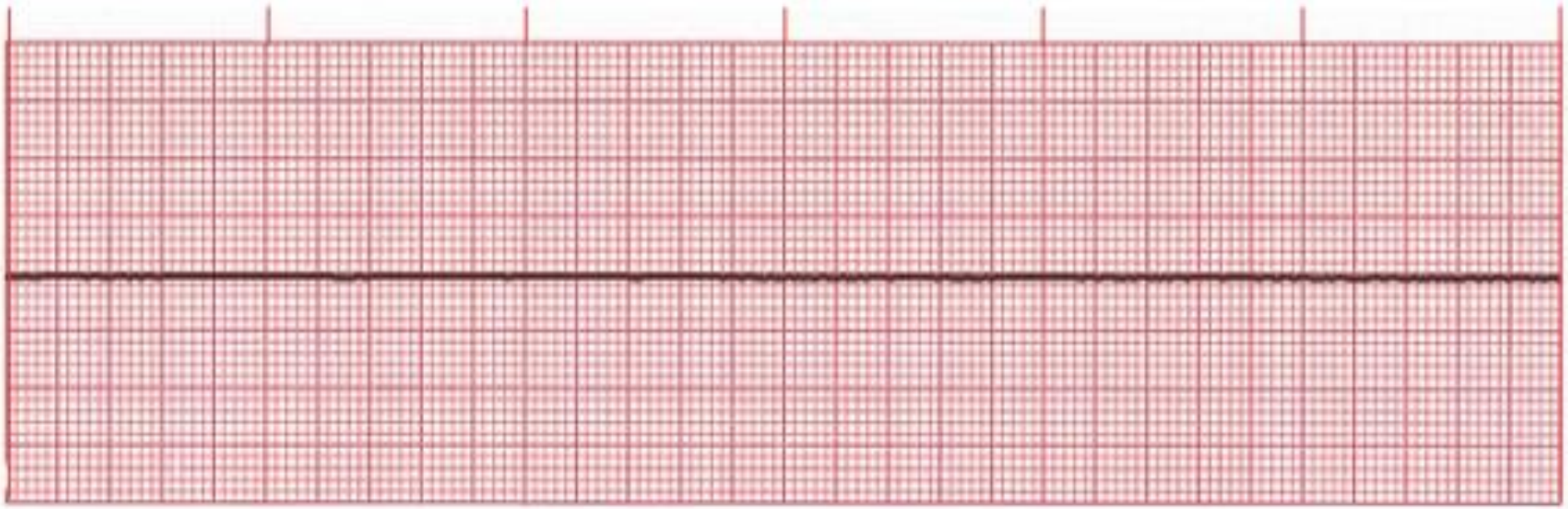
- Monitor shows an identifiable electrical rhythm, but no pulse is detected.
- Rhythm may be sinus, atrial, junctional, or ventricular in origin.
- PEA is also called electromechanical dissociation (EMD).

Rate, rhythm, P waves, P-R interval, and QRS: Reflect underlying rhythm.

♥ **Clinical Tip:** Potential causes of PEA are pulmonary embolism, MI, acidosis, tension pneumothorax, hyper- and hypokalemia, cardiac tamponade, hypovolemia, hypoxia, hypothermia, and drug overdose (i.e., cyclic antidepressants, beta blockers, calcium channel blockers, digoxin).

Asystole

- Electrical activity in the ventricles is completely absent.



Rate: None
Rhythm: None
P Waves: None
PR Interval: None
QRS: None

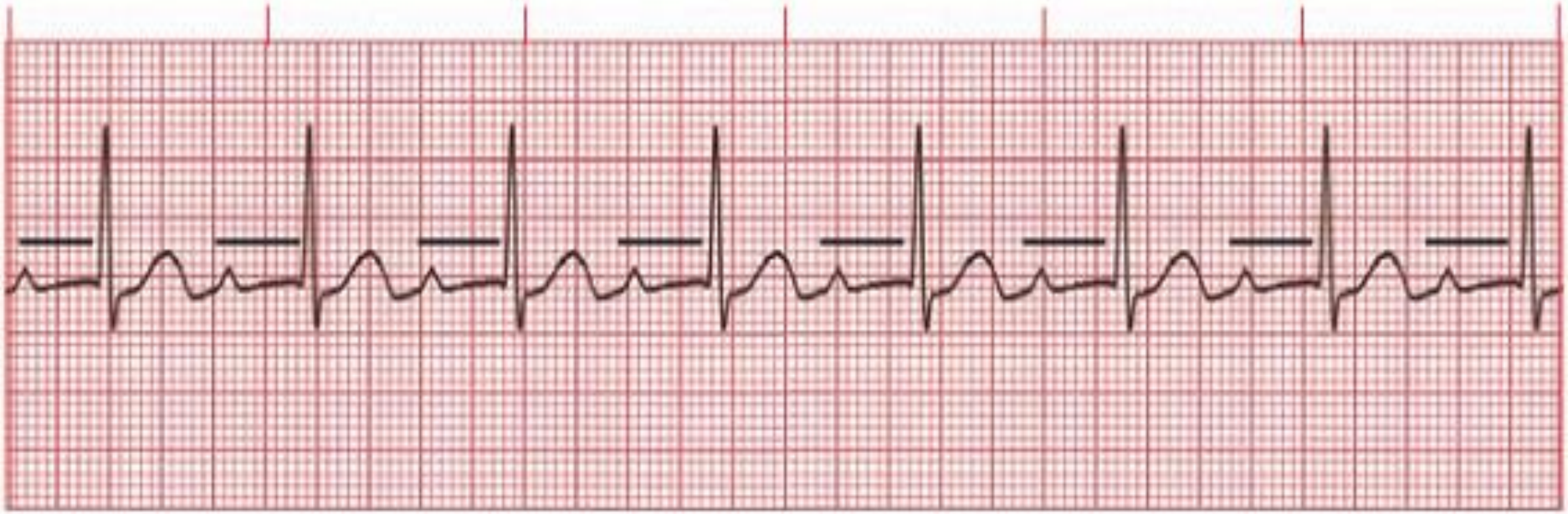
♥ **Clinical Tip:** Always confirm asystole by checking the ECG in two different leads. Also, search to identify underlying ventricular fibrillation.

♥ **Clinical Tip:** Seek to identify the underlying cause as in PEA.

Atrioventricular (AV) Blocks

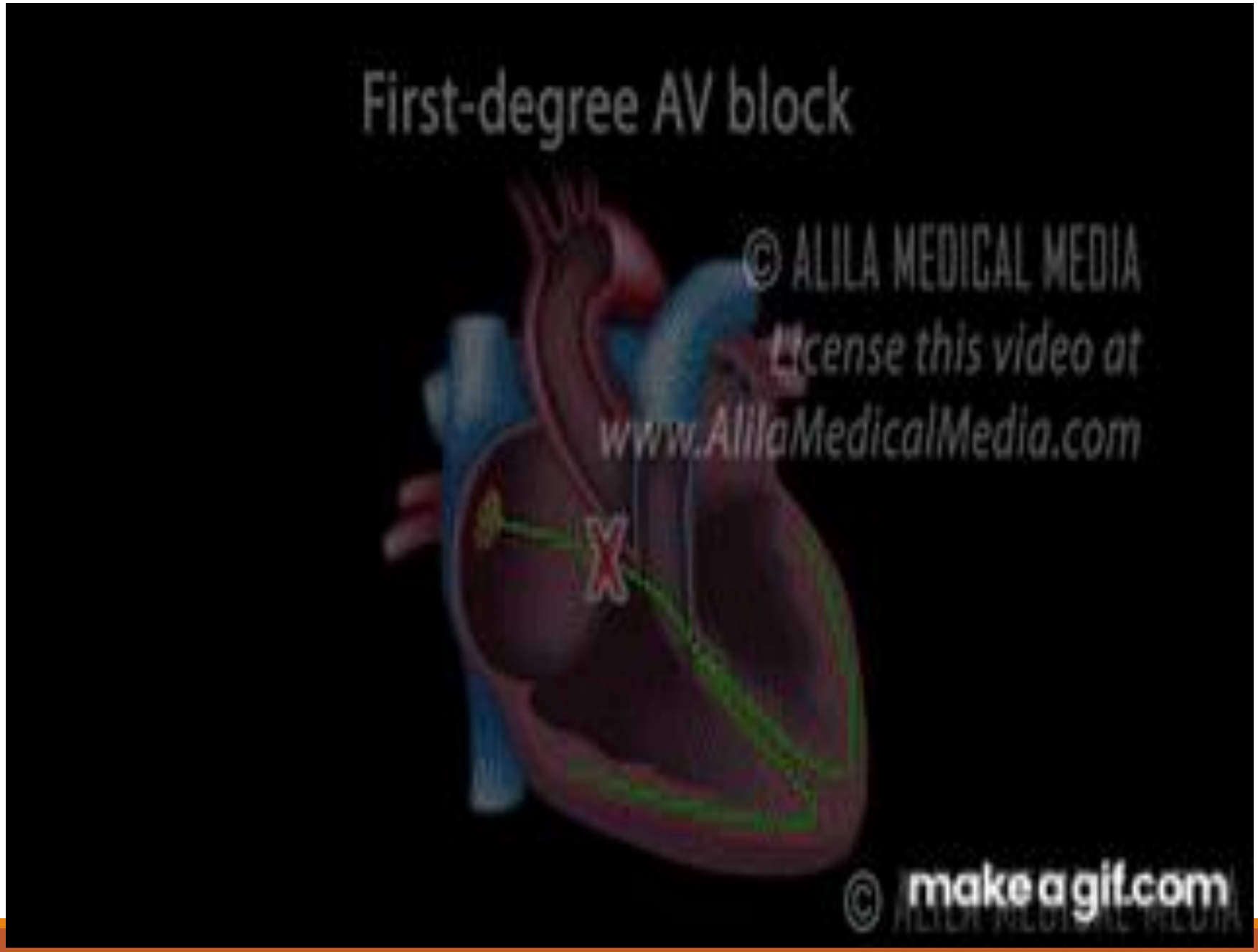
- AV blocks are divided into three categories: first-, second-, and third-degree.

First-Degree AV Block



Rate: Depends on rate of underlying rhythm
Rhythm: Regular
P Waves: Normal (upright and uniform)
PR Interval: Prolonged (>0.20 sec)
QRS: Normal (0.06–0.10 sec)

♥ **Clinical Tip:** Usually AV block is benign, but if associated with an acute MI, it may lead to further AV defects.


First-degree AV block
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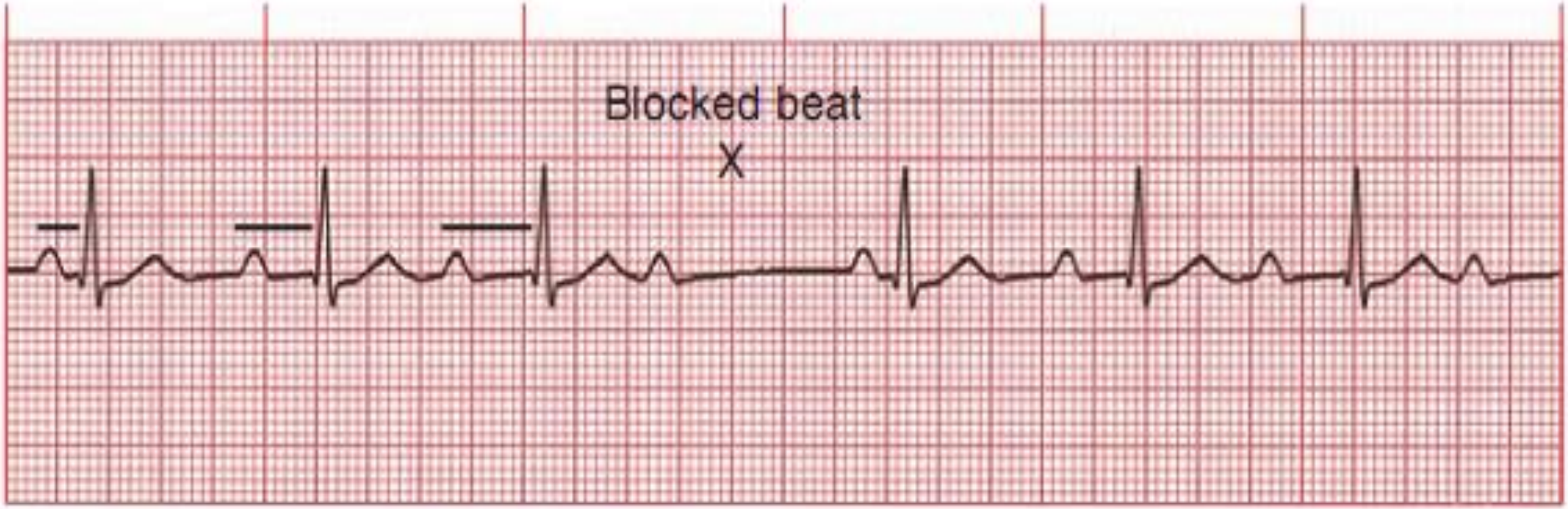
Second-Degree AV Block

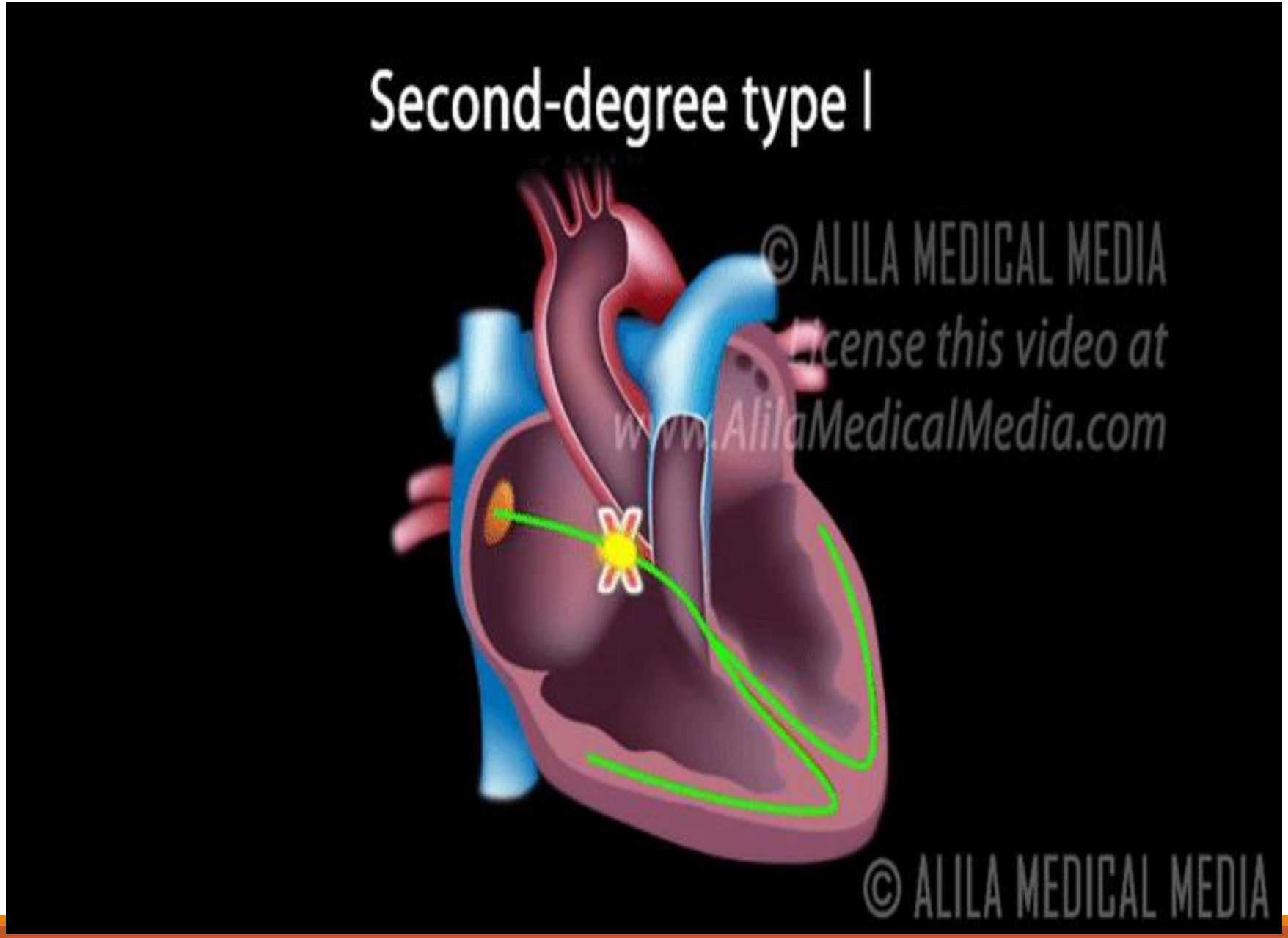
Type I (Mobitz I or Wenckebach)

- P-R intervals become progressively longer until one P wave is totally blocked and produces no QRS. After a pause, during which the AV node recovers, this cycle is repeated.



Rate: Depends on rate of underlying rhythm
Rhythm: Irregular
P Waves: Normal (upright and uniform)
PR Interval: Progressively longer until one P wave is blocked and a QRS is dropped
QRS: Normal (0.06–0.10 sec)

♥ **Clinical Tip:** This rhythm may be caused by medication such as beta blockers, digoxin, and calcium channel blockers. Ischemia involving the right coronary artery is another cause.


Second-degree type I
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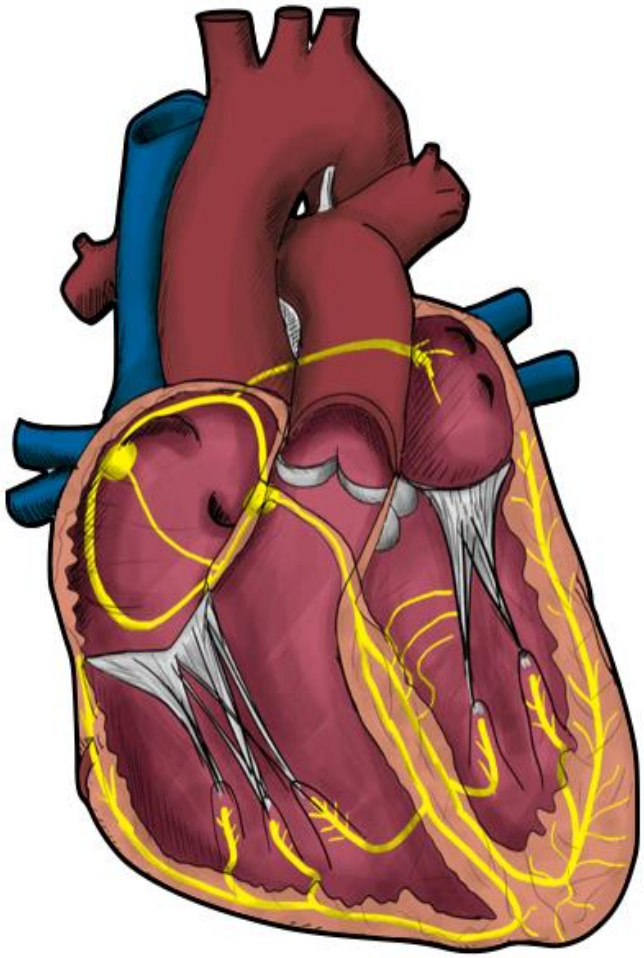
Second-Degree AV Block

Type II (Mobitz II)

- Conduction ratio (P waves to QRS complexes) is commonly 2:1, 3:1, or 4:1.
- QRS complexes are usually wide because this block usually involves both bundle branches.

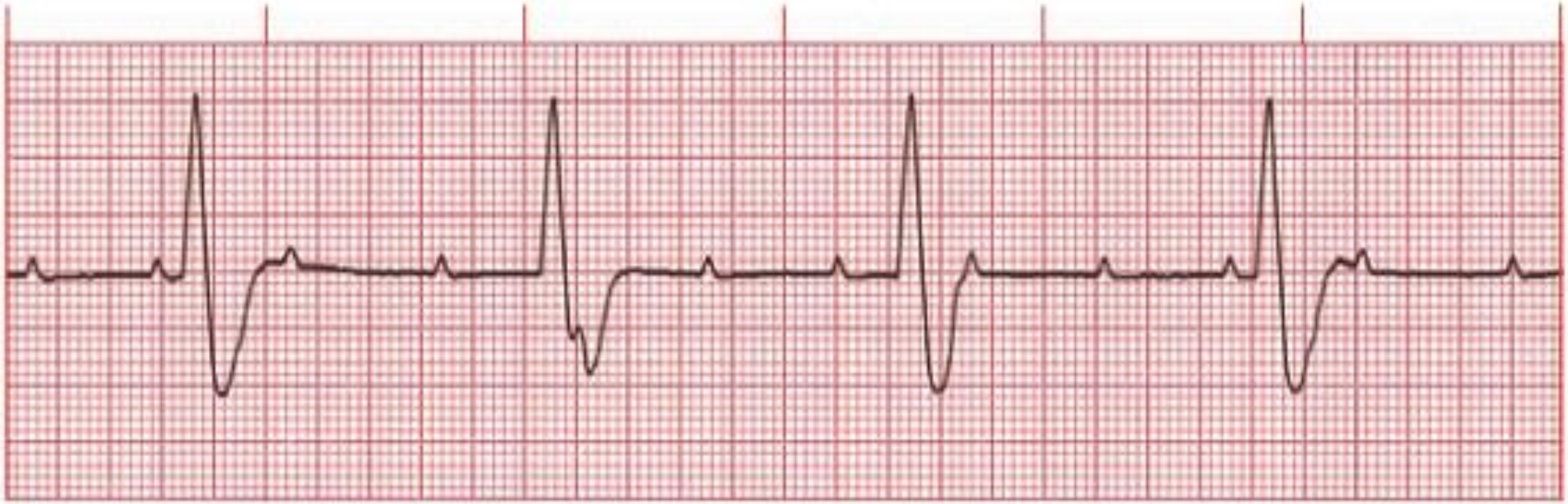
Rate: Atrial rate (usually 60–100 bpm); faster than ventricular rate
Rhythm: Atrial regular and ventricular irregular
P Waves: Normal (upright and uniform); more P waves than QRS complexes
PR Interval: Normal or prolonged but constant
QRS: Usually wide (>0.10 sec)

♥ **Clinical Tip:** Resulting bradycardia can compromise cardiac output and lead to complete AV block. This rhythm often occurs with cardiac ischemia or an MI.



Third-Degree AV Block

- Conduction between atria and ventricles is absent because of electrical block at or below the AV node.
- "Complete heart block" is another name for this rhythm.



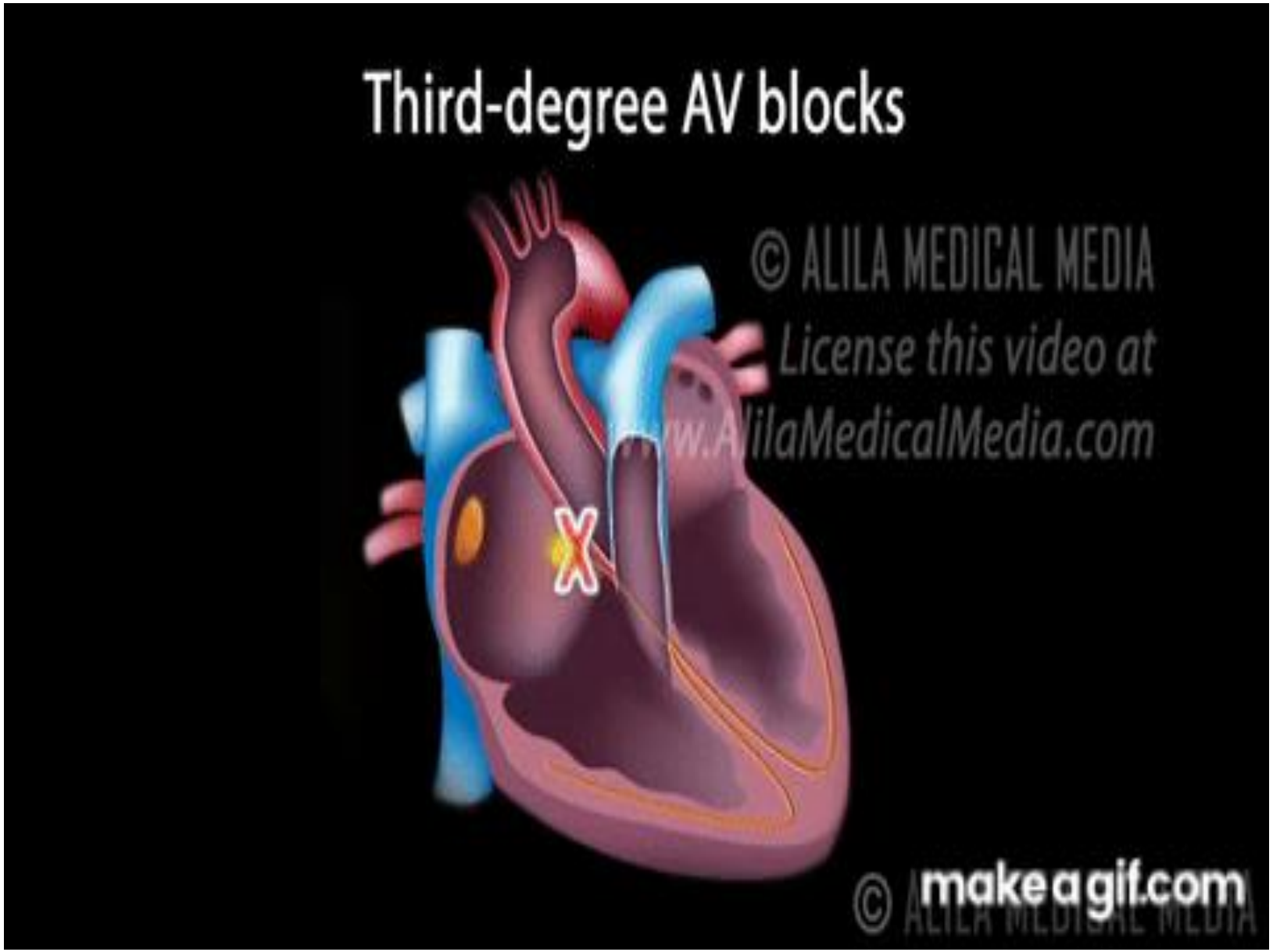
Rate: Atrial: 60–100 bpm; ventricular: 40–60 bpm if escape focus is junctional, <40 bpm if escape focus is ventricular

Rhythm: Usually regular, but atria and ventricles act independently

P Waves: Normal (upright and uniform); may be superimposed on QRS complexes or T waves

PR Interval: Varies greatly

QRS: Normal if ventricles are activated by junctional escape focus; wide if escape focus is ventricular


Third-degree AV blocks
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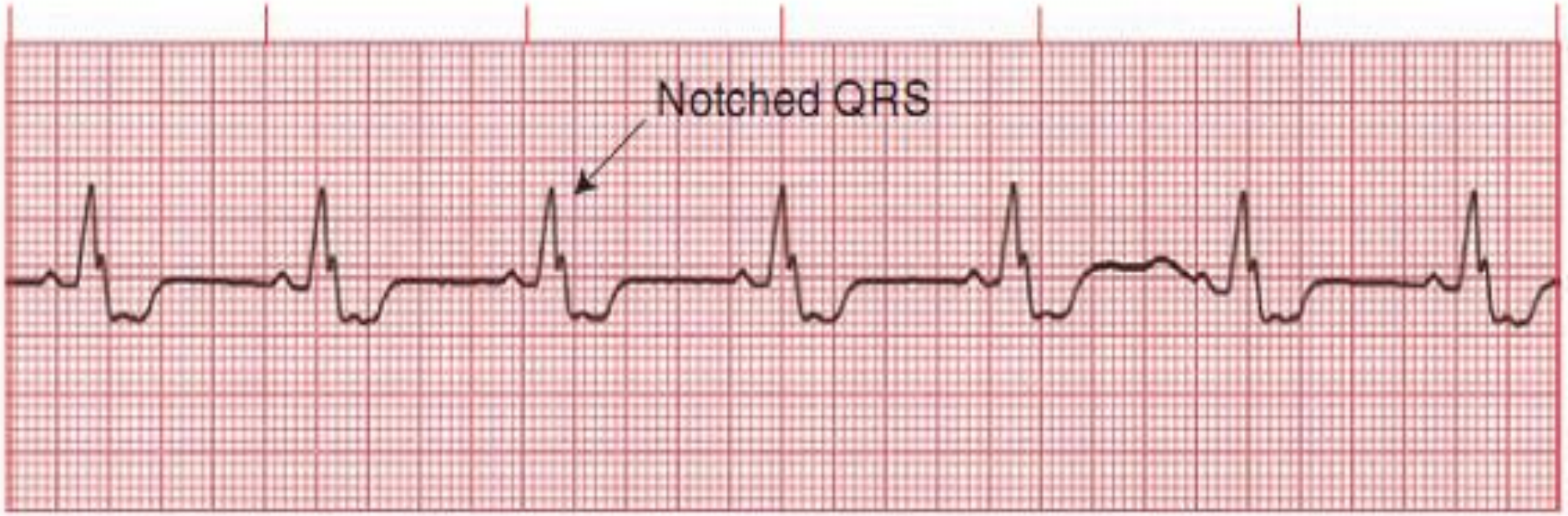
Bundle Branch Block (BBB)

- Either the left or the right ventricle may depolarize late, creating a "notched" QRS complex.

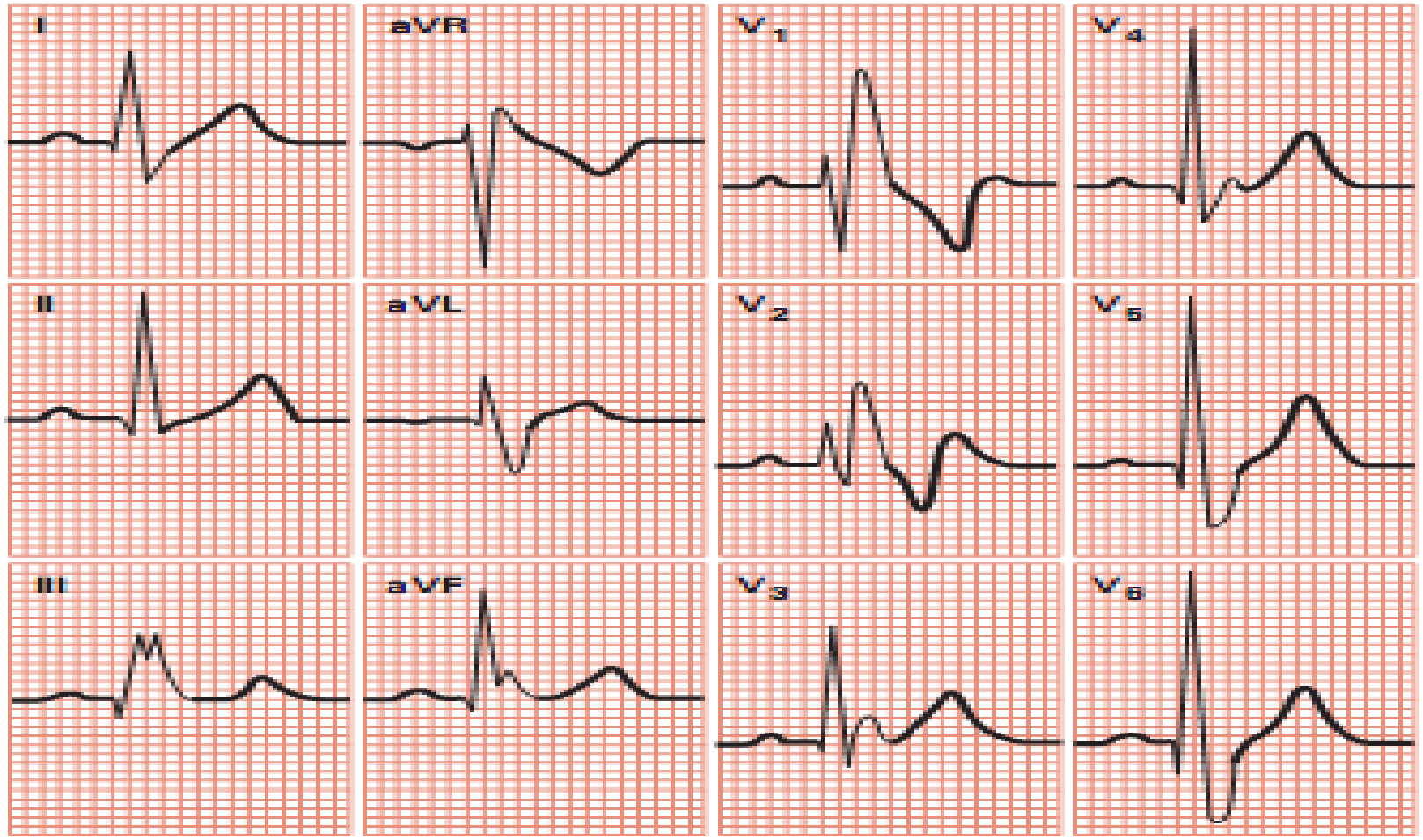


Rate: Depends on rate of underlying rhythm
Rhythm: Regular
P Waves: Normal (upright and uniform)
PR Interval: Normal (0.12–0.20 sec)
QRS: Usually wide (>0.10 sec) with a notched appearance

♥ **Clinical Tip:** Commonly, BBB occurs in coronary artery disease.

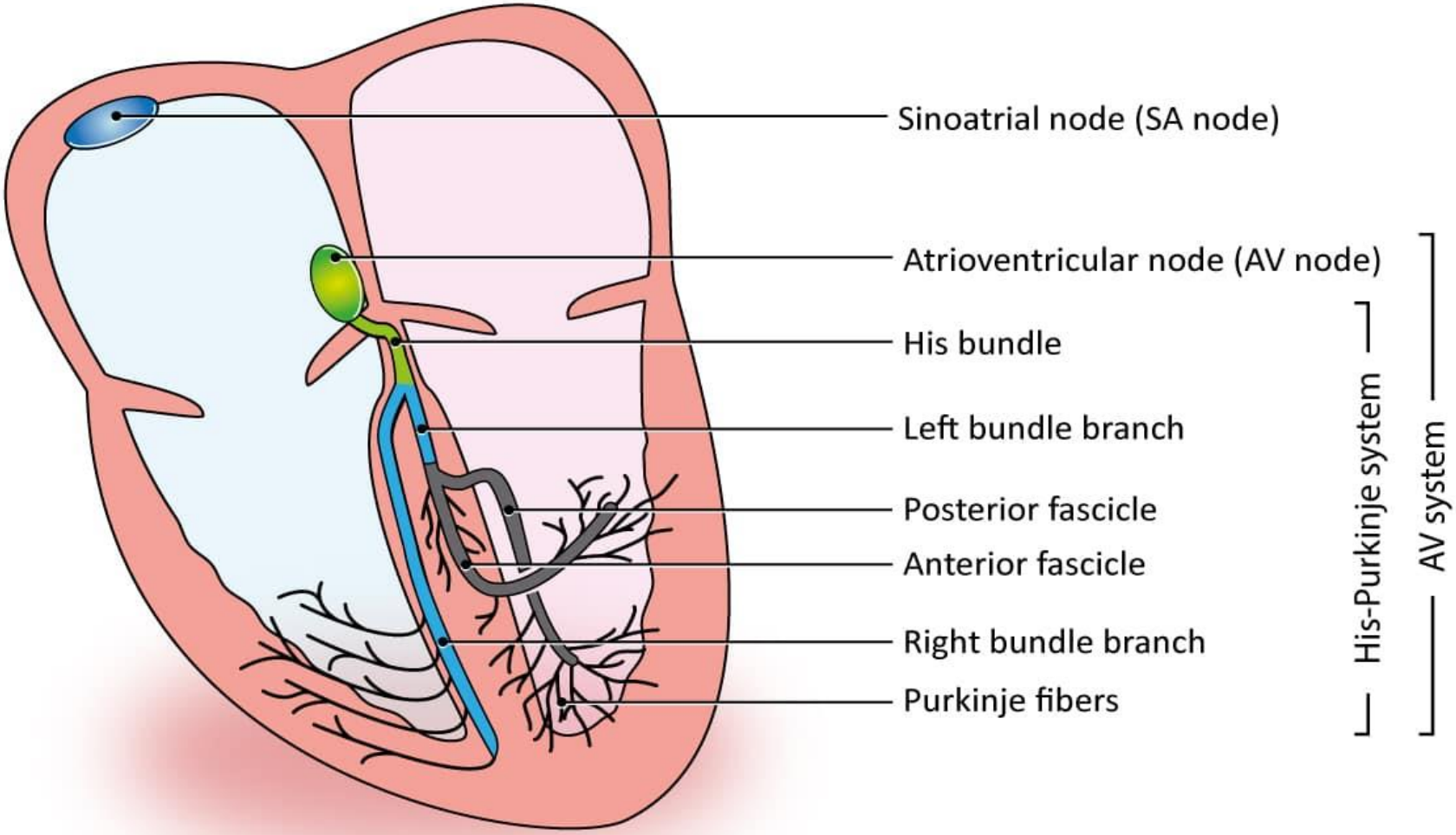
Right Bundle Branch Block

- QRS >0.10 sec
- QRS normal or deviated to the right
- Slurred S wave in leads I and V_6
- RSR′ pattern in lead V_1 with R′ taller than R



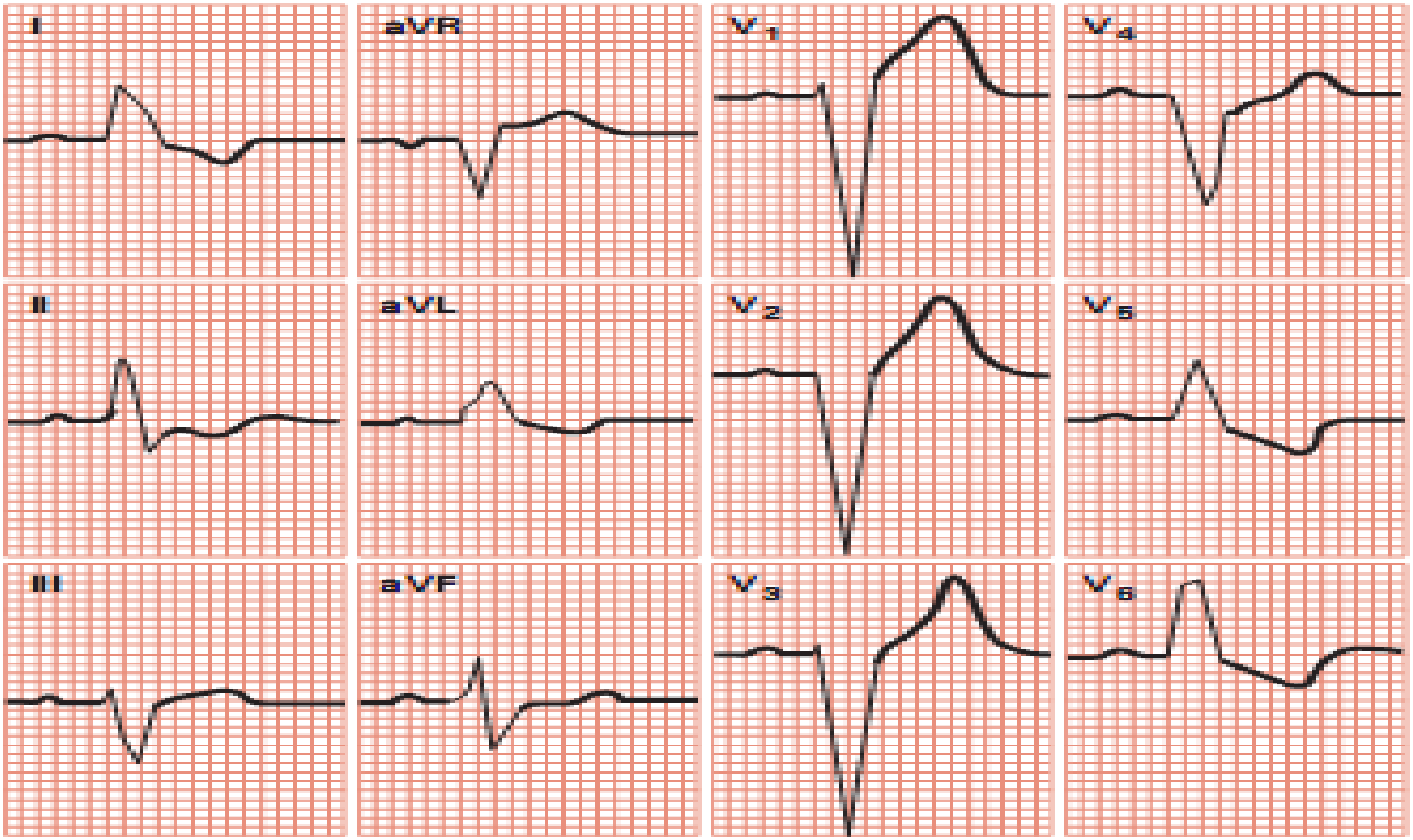
Clinical Tip: Patients may have underlying right ventricular hypertrophy, pulmonary edema, cardiomyopathy, congenital heart disease, or rheumatic heart disease.

The ventricular conduction system

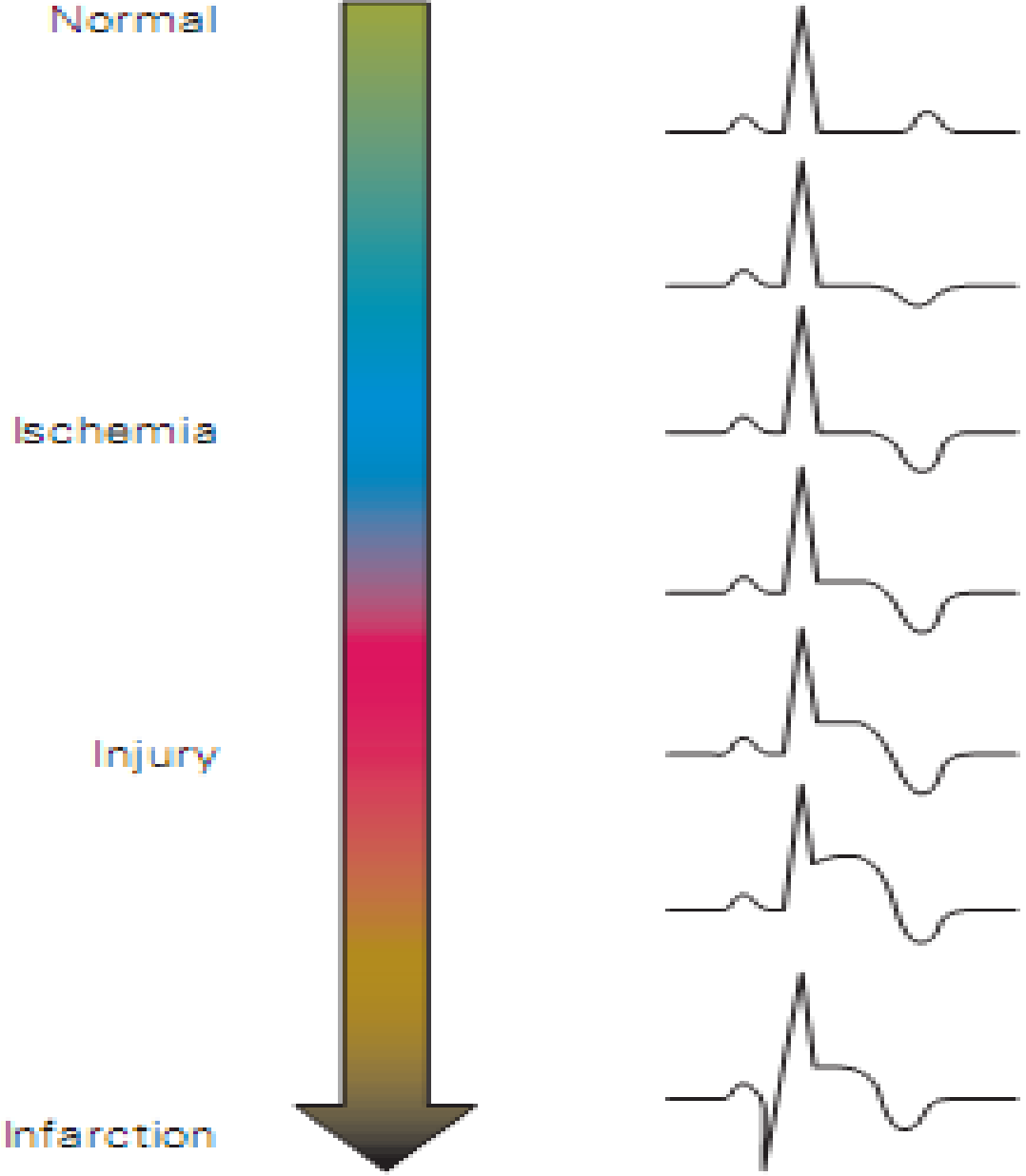


Left Bundle Branch Block

- QRS >0.10 sec
- QRS predominantly negative in leads V_1 and V_2
- QRS predominantly positive in V_5 and V_6 and often notched
- Absence of small, normal Q waves in I, aVL, V_5, and V_6
- Wide monophasic R waves in I, aVL, V_1, V_5, and V_6



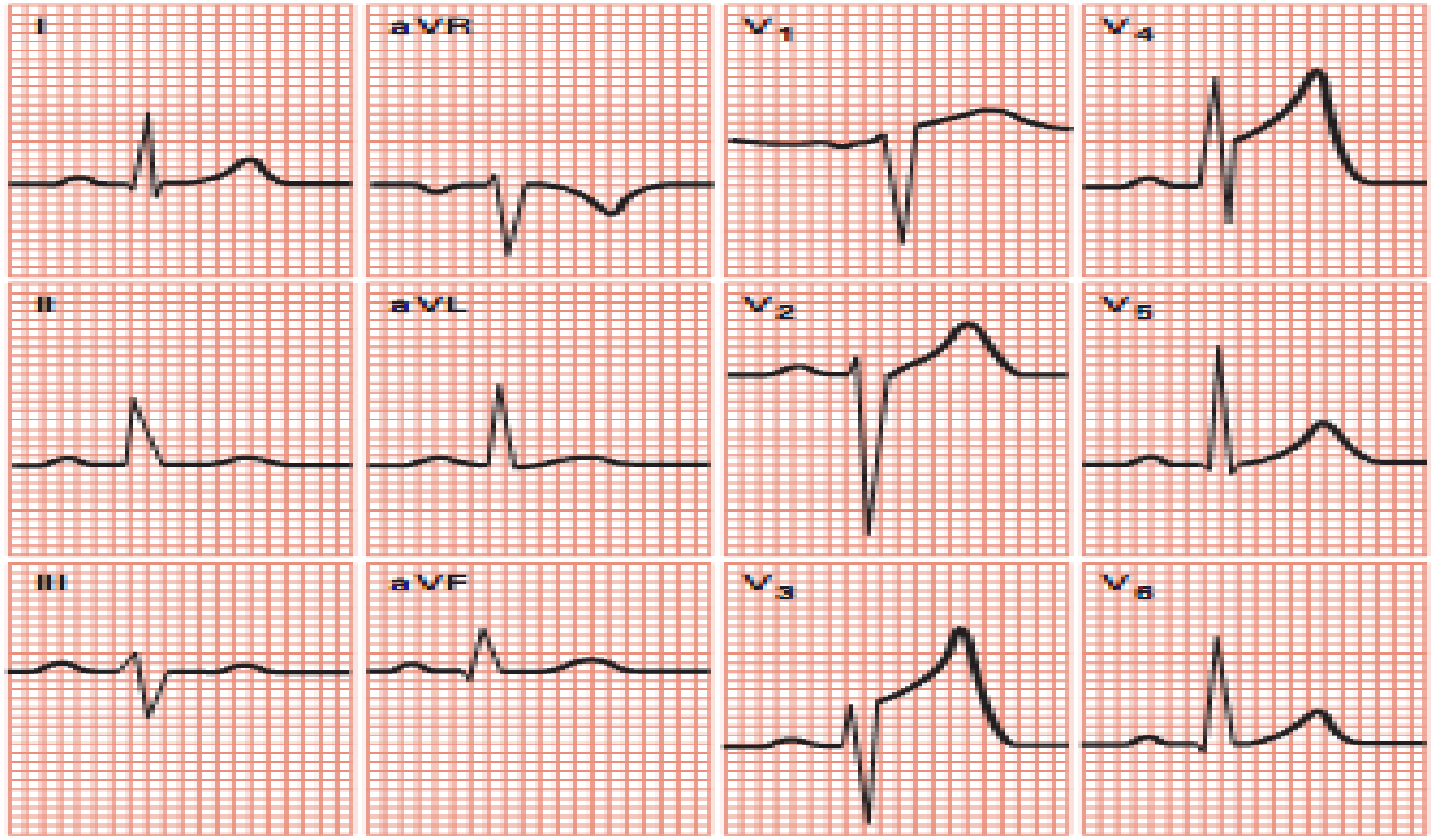
Clinical Tip: Patients may have underlying heart disease, including coronary artery disease, hypertension, cardiomyopathy, and ischemia.



♥ **Clinical Tip:** Once the acute MI has ended, the ST segment returns to baseline and theT wave becomes upright, but the Q wave remains abnormal because of scar formation.

Anterior Myocardial Infarction

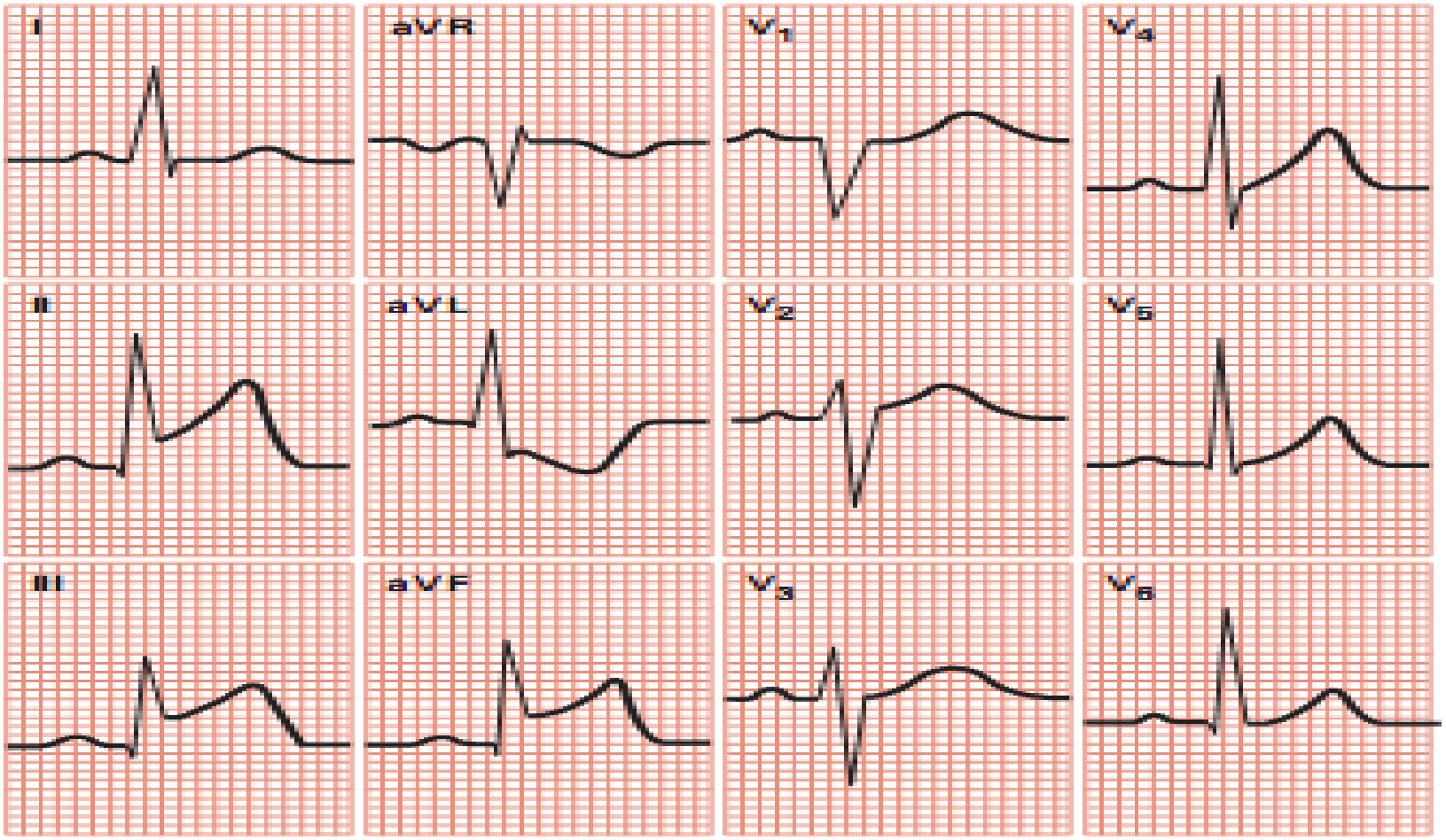
- Occlusion of the left coronary artery—left anterior descending branch
- ECG changes: ST segment elevation with tall T waves and taller-than-normal R waves in leads V_3 and V_4



♥ **Clinical Tip:** Anterior MI frequently involves a large area of the myocardium and can present with cardiogenic shock, second-degree AV block type II, or third-degree AV block.

Inferior Myocardial Infarction

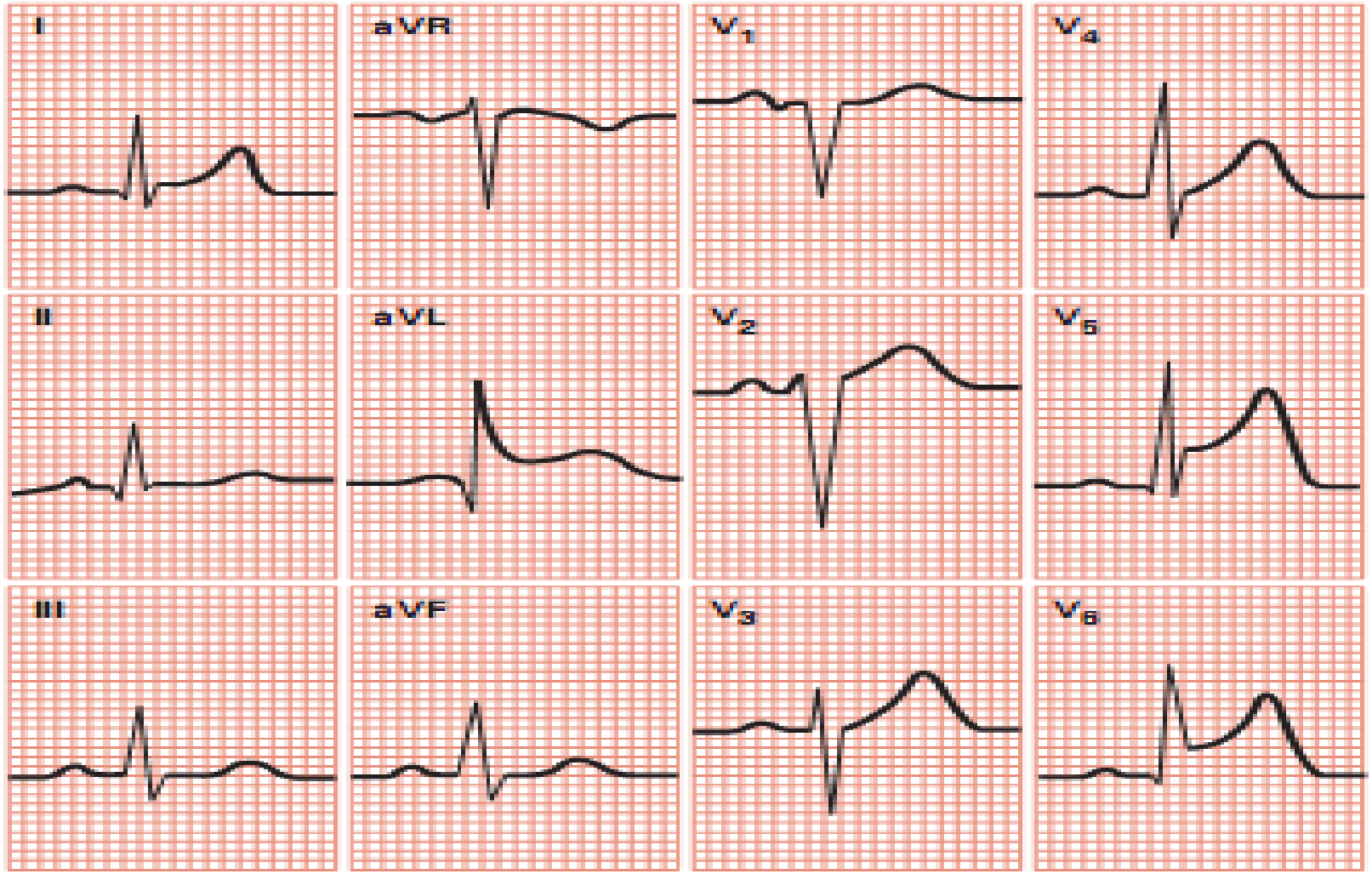
- Occlusion of the right coronary artery—posterior descending branch
- ECG changes: ST segment elevation in leads II, III, and aVF



Clinical Tip: Be alert for symptomatic sinus bradycardia, AV blocks, hypotension, and hypoperfusion.

Lateral Myocardial Infarction

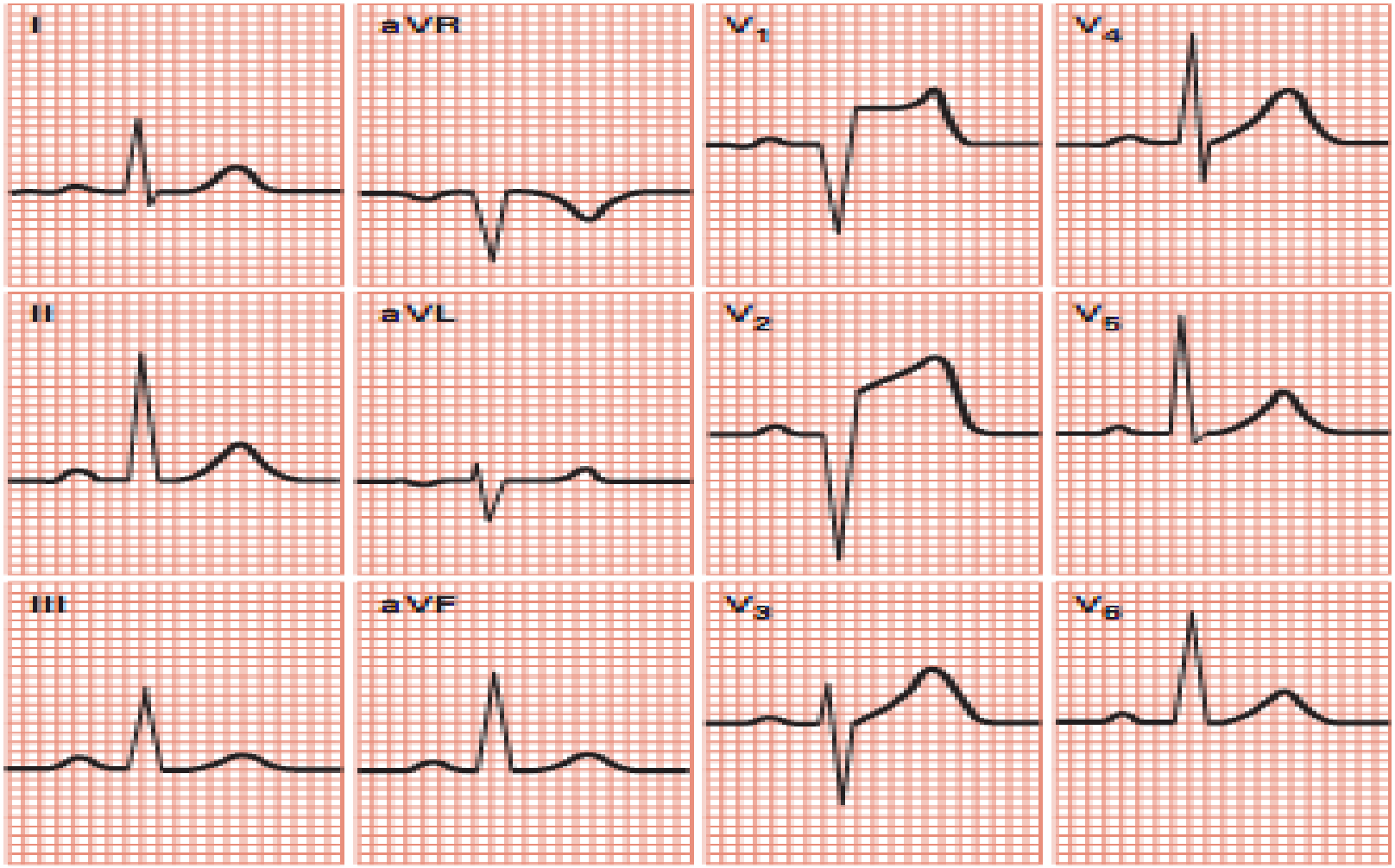
- Occlusion of the left coronary artery—circumflex branch
- ECG changes: ST segment elevation in leads I, aVL, V_5, and V_6



Clinical Tip: Lateral MI is often associated with anterior or inferior wall MI. Be alert for changes that may indicate cardiogenic shock or congestive heart failure.

Septal Myocardial Infarction

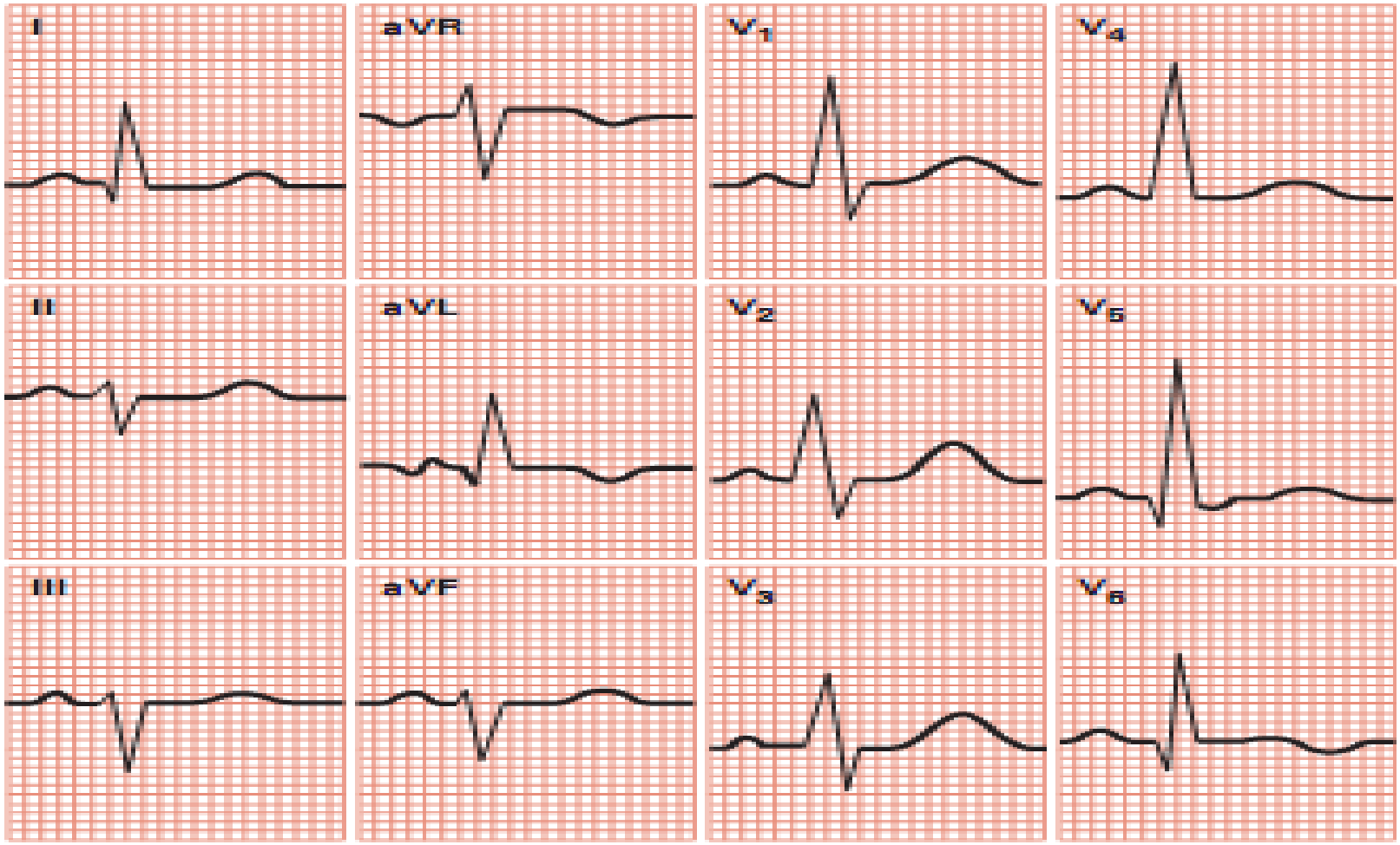
- Occlusion of the left coronary artery—left anterior descending branch
- ECG changes: pathological Q waves; absence of normal R waves in leads V_1 and V_2



Clinical Tip: Septal MI is often associated with an anterior wall MI.

Posterior Myocardial Infarction

- Occlusion of the right coronary artery (posterior descending branch) or the left circumflex artery
- Tall R waves and ST segment depression possible in leads V_1, V_2, V_3, and V_4
- ST segment elevation in true posterior leads, V_8 and V_9



Clinical Tip: Diagnosis may require a 15-lead ECG because a standard 12-lead does not look directly at the posterior wall.

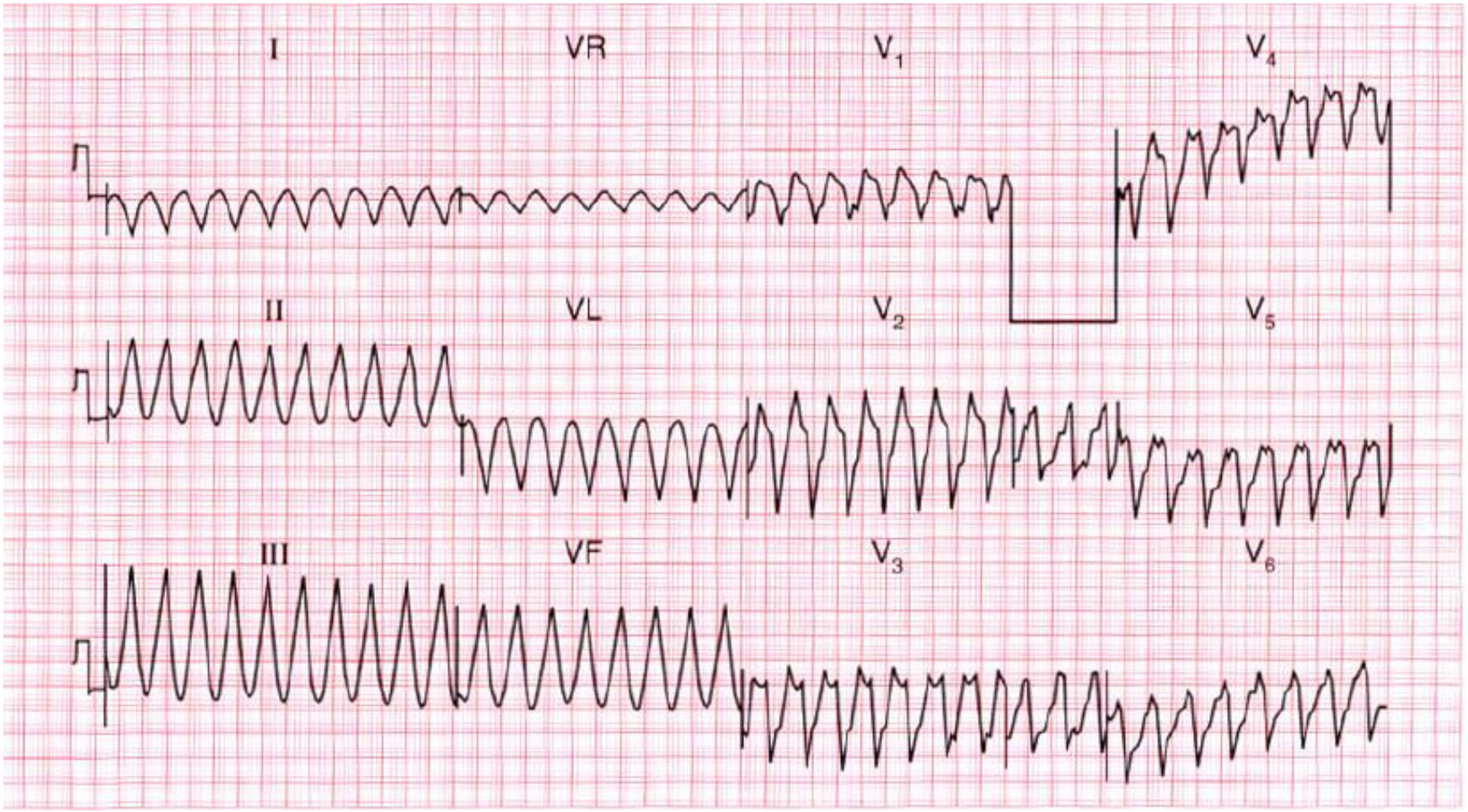
Table 2.1: Region of left ventricle represented on ECG

ECG leads	*Region of left ventricle*
V_1, V_2	Septal
V_3, V_4	Anterior
V_5, V_6	Lateral
V_1 to V_4	Antero-septal
V_3 to V_6	Antero-lateral
L_I, aVL	High lateral
L_{II}, L_{III}, aVF	Inferior

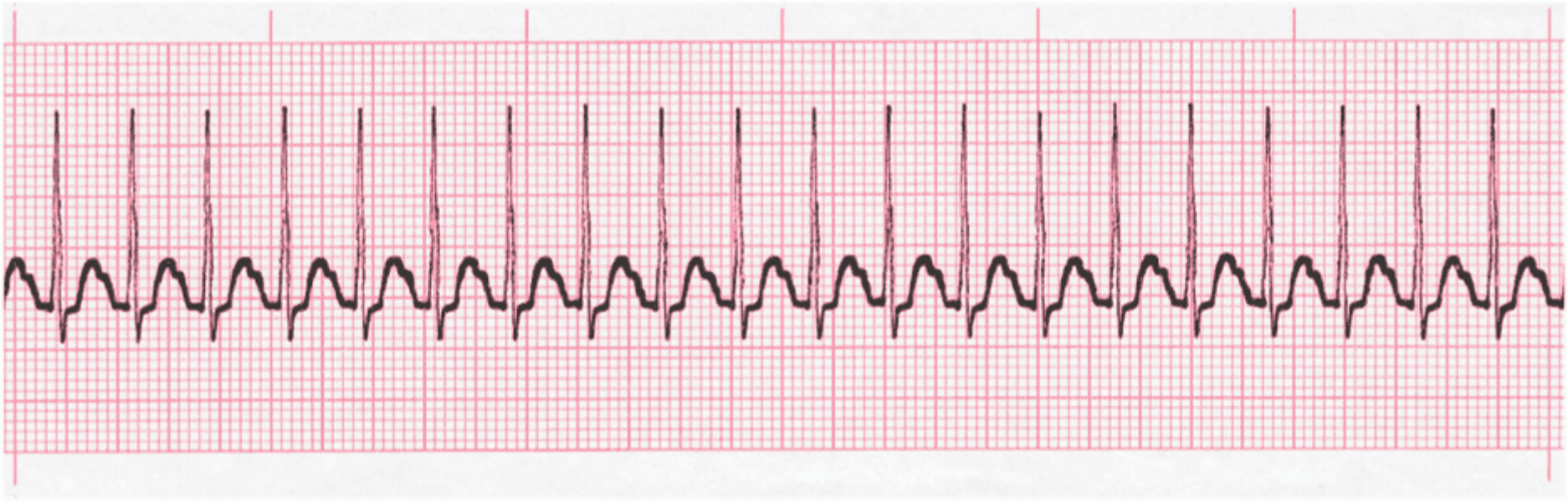
A

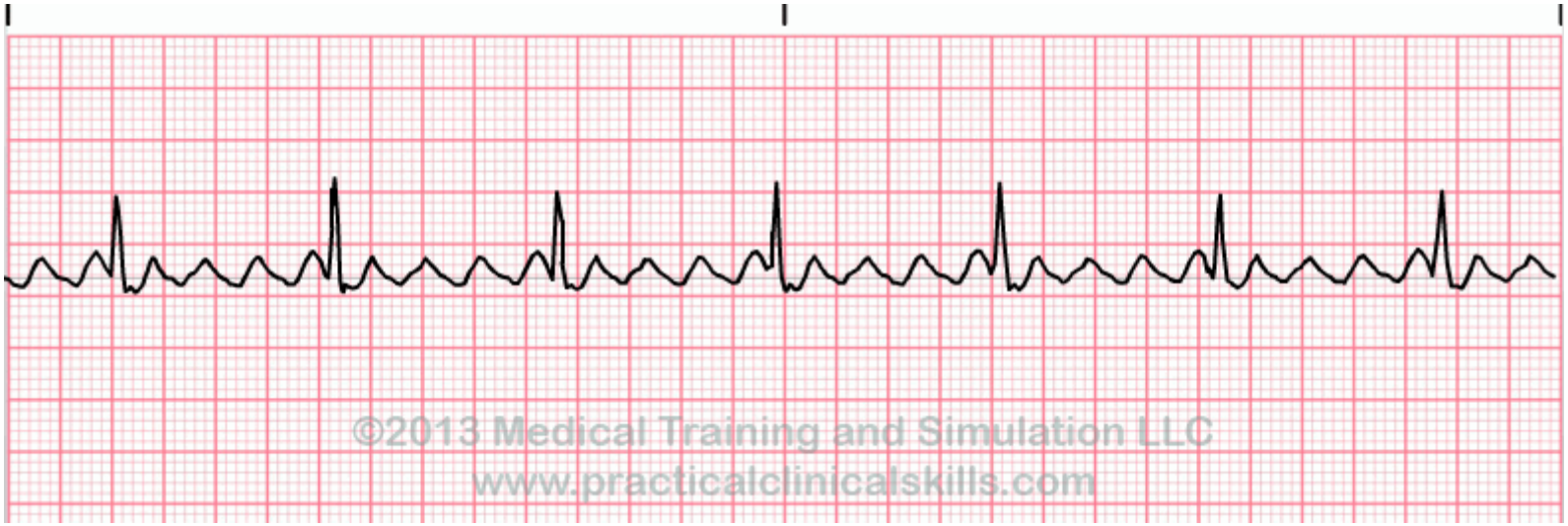
B

C


I
VR
V1
V4
II
VL
V2
V5
III
VF
V3
V6

3.

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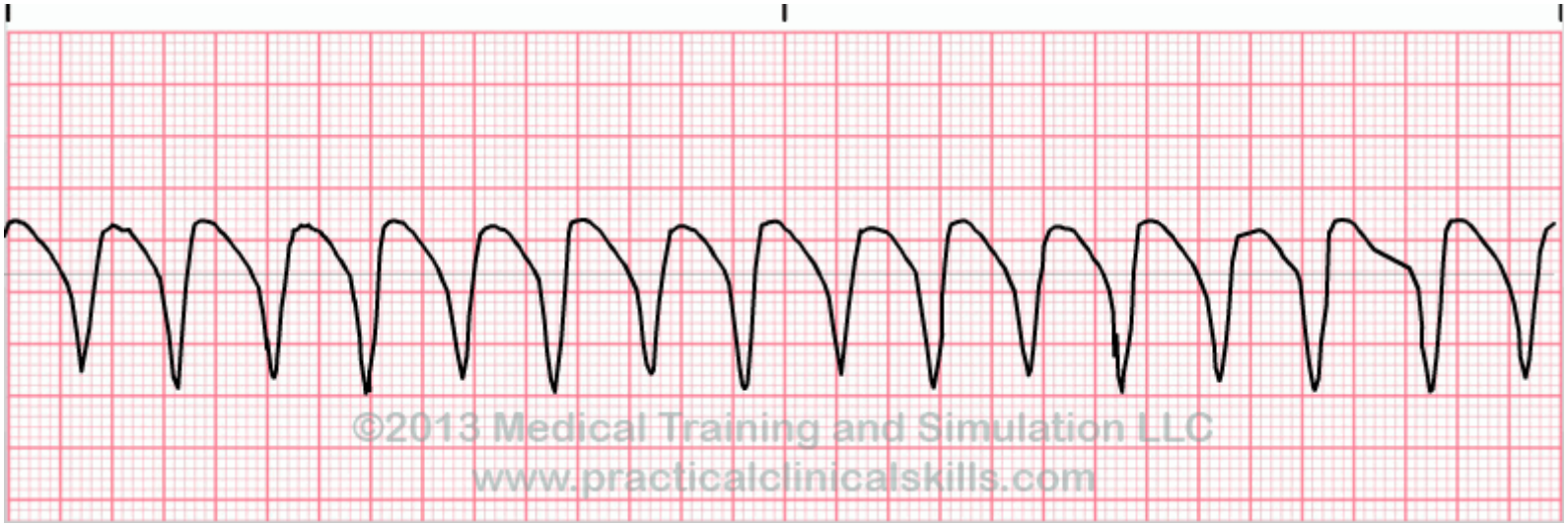
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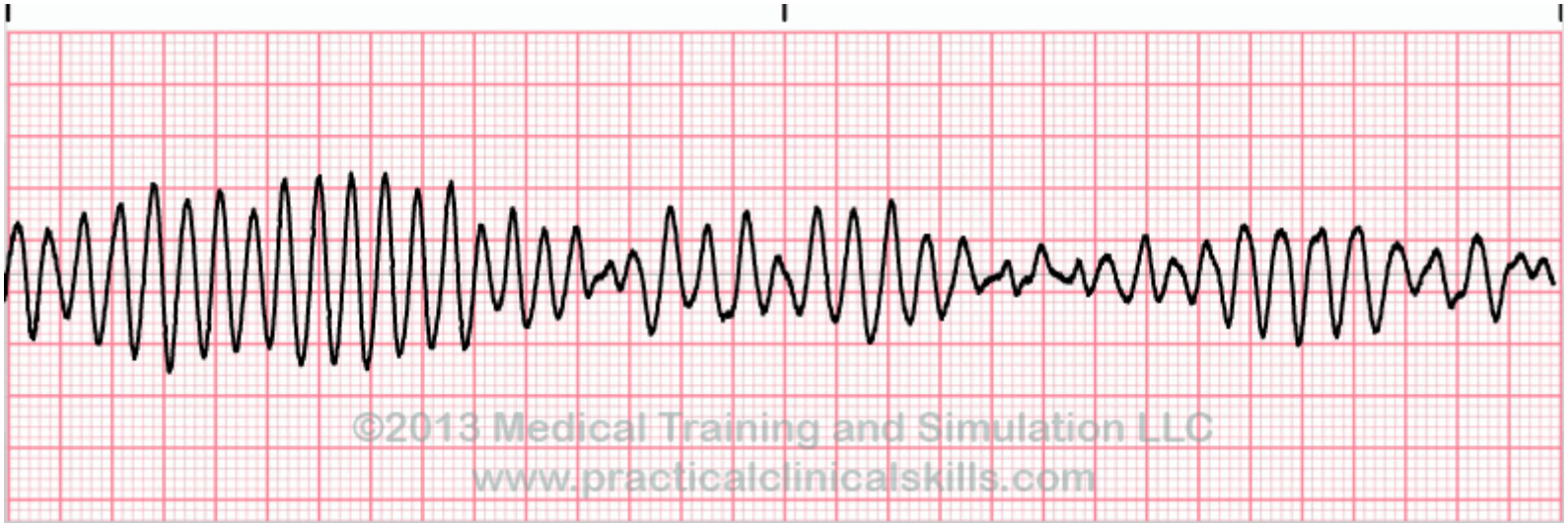
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