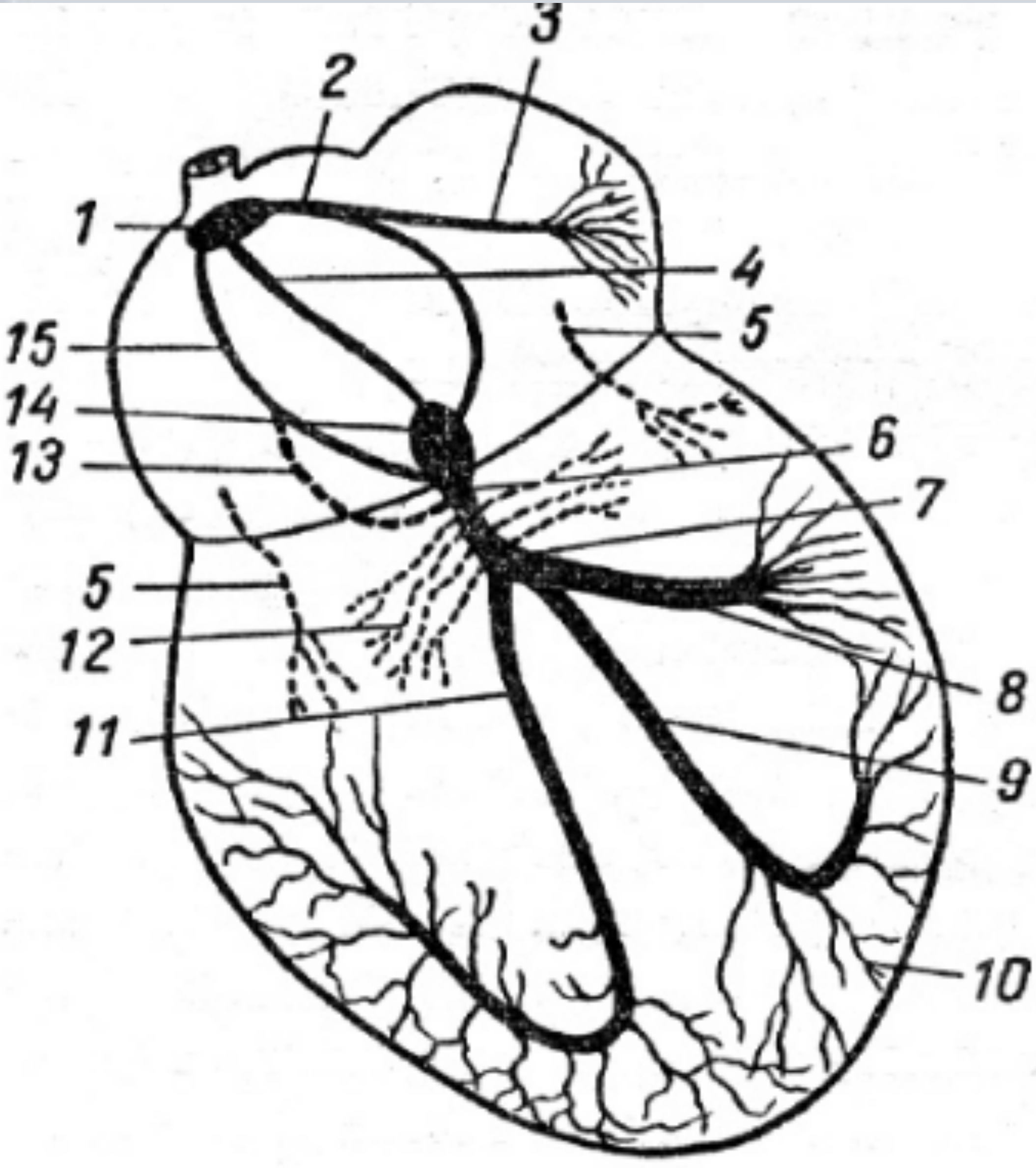
EKG interpretation in conductibility disorders

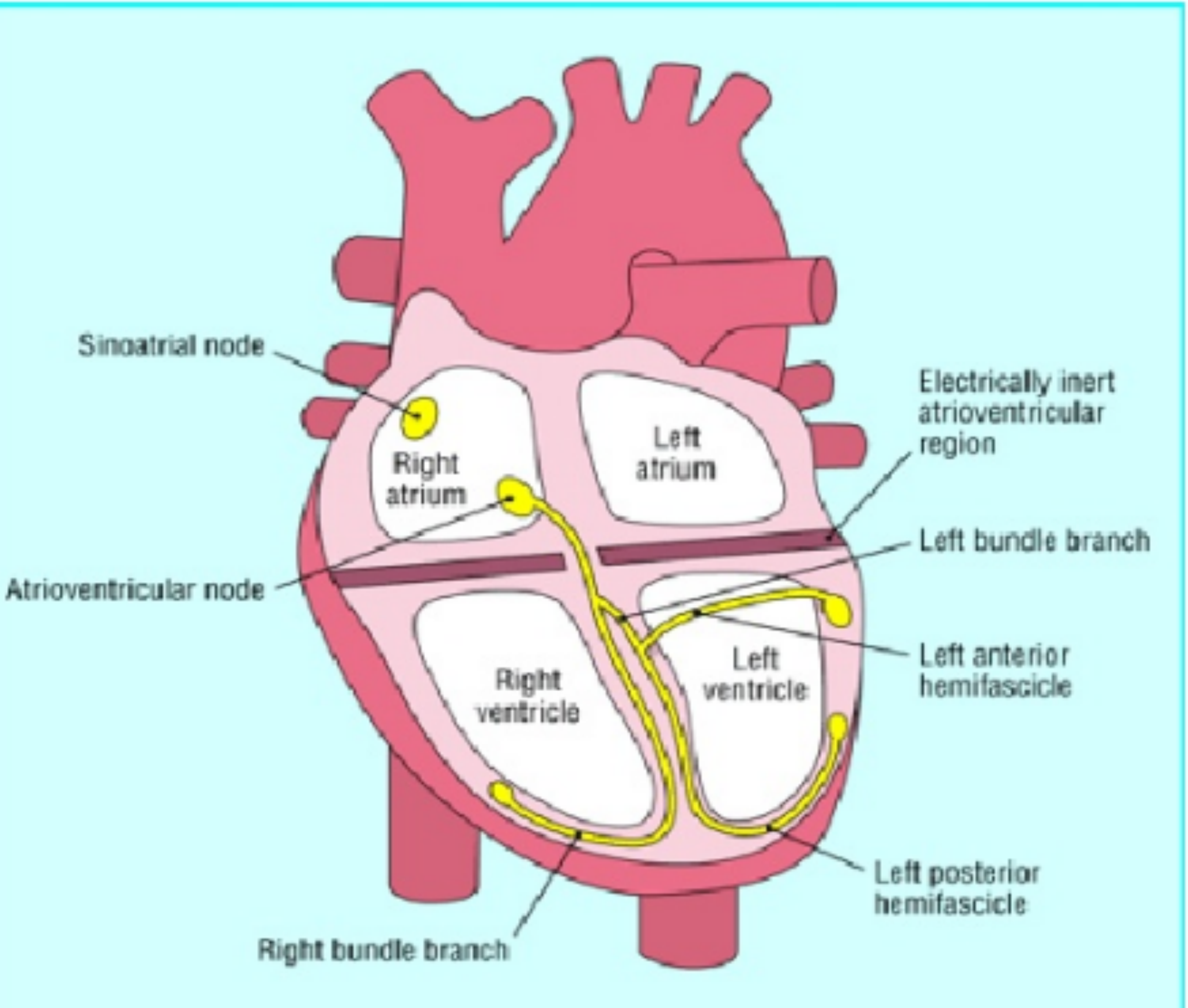
Diana Sasu
Assistant Professor, PhD

The conduction system of the heart



1 – sinoatrial node;
2 – anterior internodal tract;
3 – Bachmann's bundle;
4 – medial internodal tracts;
5 – Kent's bundle;
6 – trunk of His' bundle;
7 – left bundle branch;
8 – posterior hemifascicle;
9 – anterior hemifascicle;
10 – Purkinje fibers;
11 – right bundle branch;
12 – Mahaim fibers;
13 – James tract;
14 – atrioventricular node;
15 – posterior internodal tract.

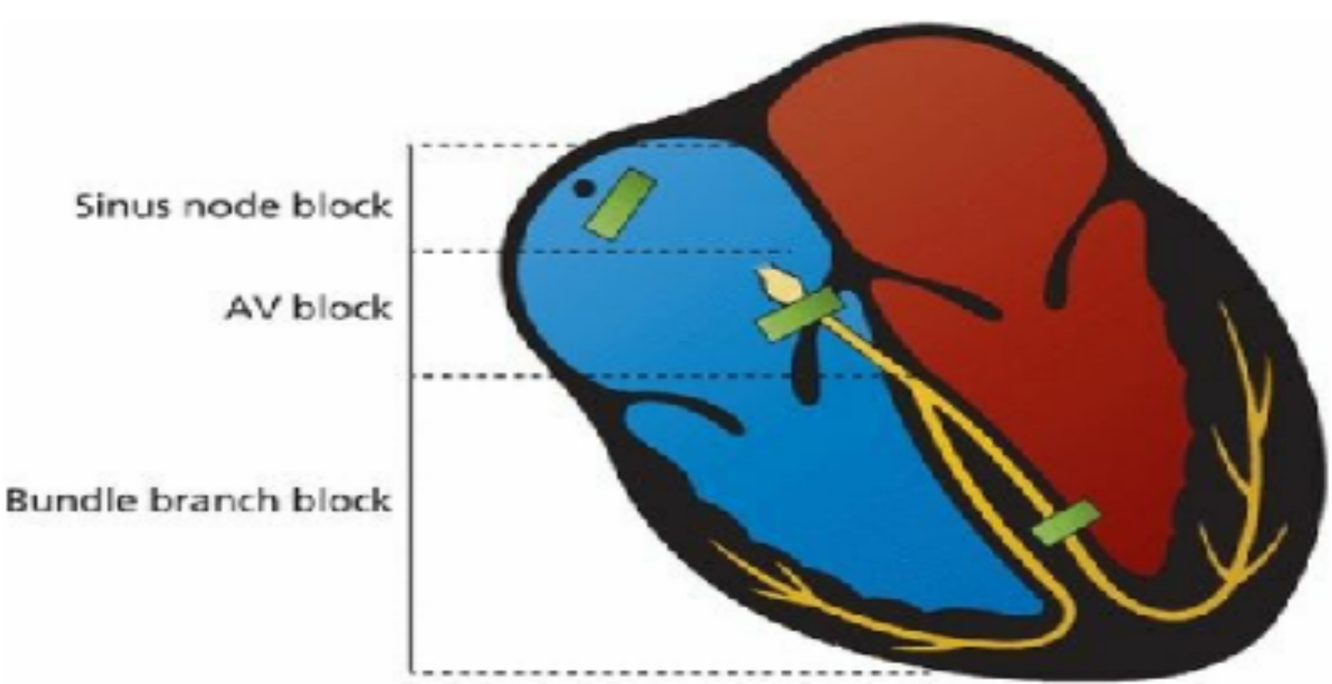
The His-Purkinje conduction system



Atrial activation begins with impulse generation in the sinoatrial (SA) node. Once the impulse leaves this pacemaker site, atrial activation spreads in the right atrium and simultaneously impulse spreads along the atrial internodal tracts toward the left atrium and atrioventricular (AV) node. Upon exiting the AV node, the impulse traverses the bundle of His to enter the bundle branches (right and left) and then Purkinje fibers to finally activate working muscle fibers. Sequence of ventricular activation: interventricular septum, lateral walls of the left and right ventricles (from endocardium to epicardium), the basal areas of the ventricles are the last to be activated.

What is a conduction Block?

- Any obstruction or delay of the flow or electricity along the normal pathways of electrical conduction



Classification of conductibility disorders

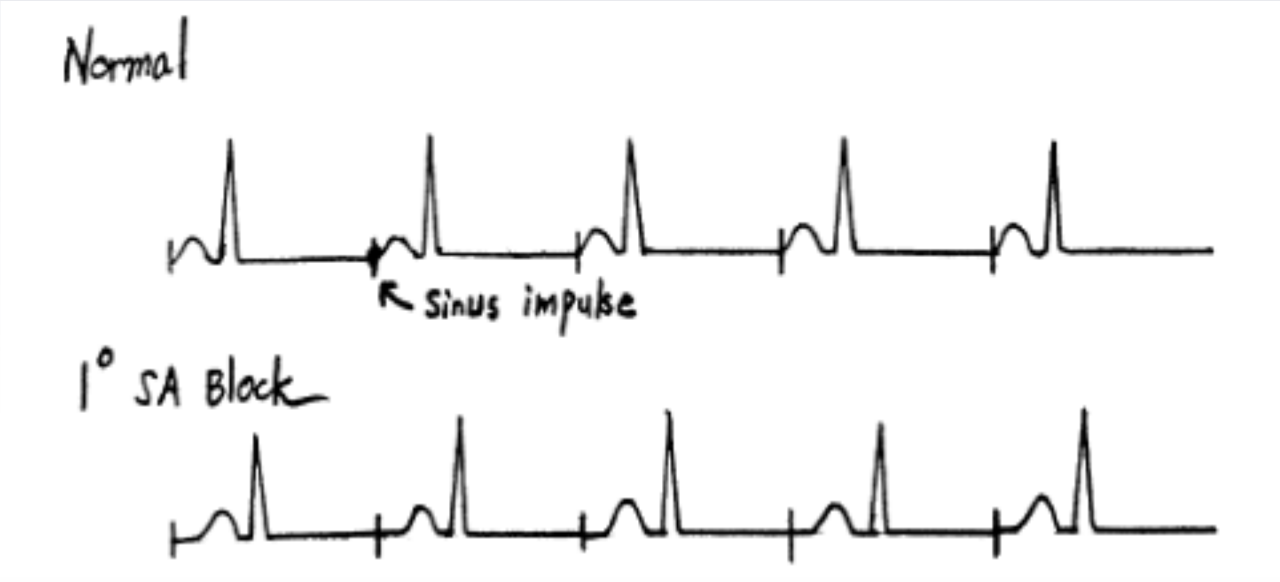
1. **Sino-atrial block (SA block)**
- First degree
- Second degree: type I and type II
- Third degree

2. **Atrioventricular block (AV block)**
- First -Degree AV block
- Second-Degree AV block (Mobitz type I or Wenkebach block, and Mobitz type II)
- Third- Degree AV block (complete AV block)

3. **Intraventricular block** (Right Bundle Branch Block and Left Bundle Branch Block, Hemiblock)

Sino-atrial block (SA block)

- ***In a first-degree* sinoatrial block**, there is a lag between the time that the SA node fires and actual depolarization of the atria.
- It is not recognizable on an ECG strip because an ECG strip does not denote when the SA node fires.
- It can be detected only during an electrophysiology study when a small wire is placed against the SA node from within the heart and the electrical impulses can be recorded as they leave the p-cells in the centre of the node followed by observing a delay in the onset of the p wave on the ECG.



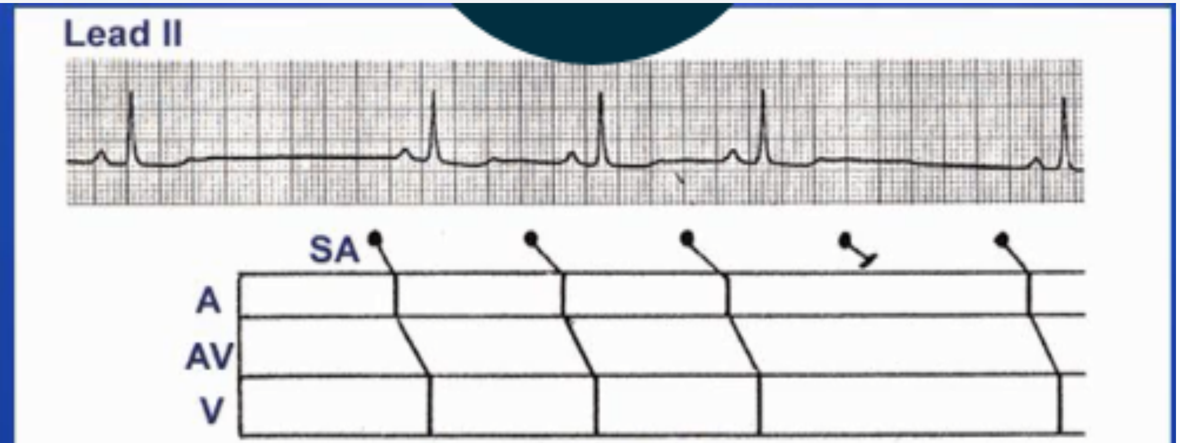
Second-degree SA block

Second -degree SA block, Type I (Wenckebach)=

progressive lengthening of the interval between impulse generation

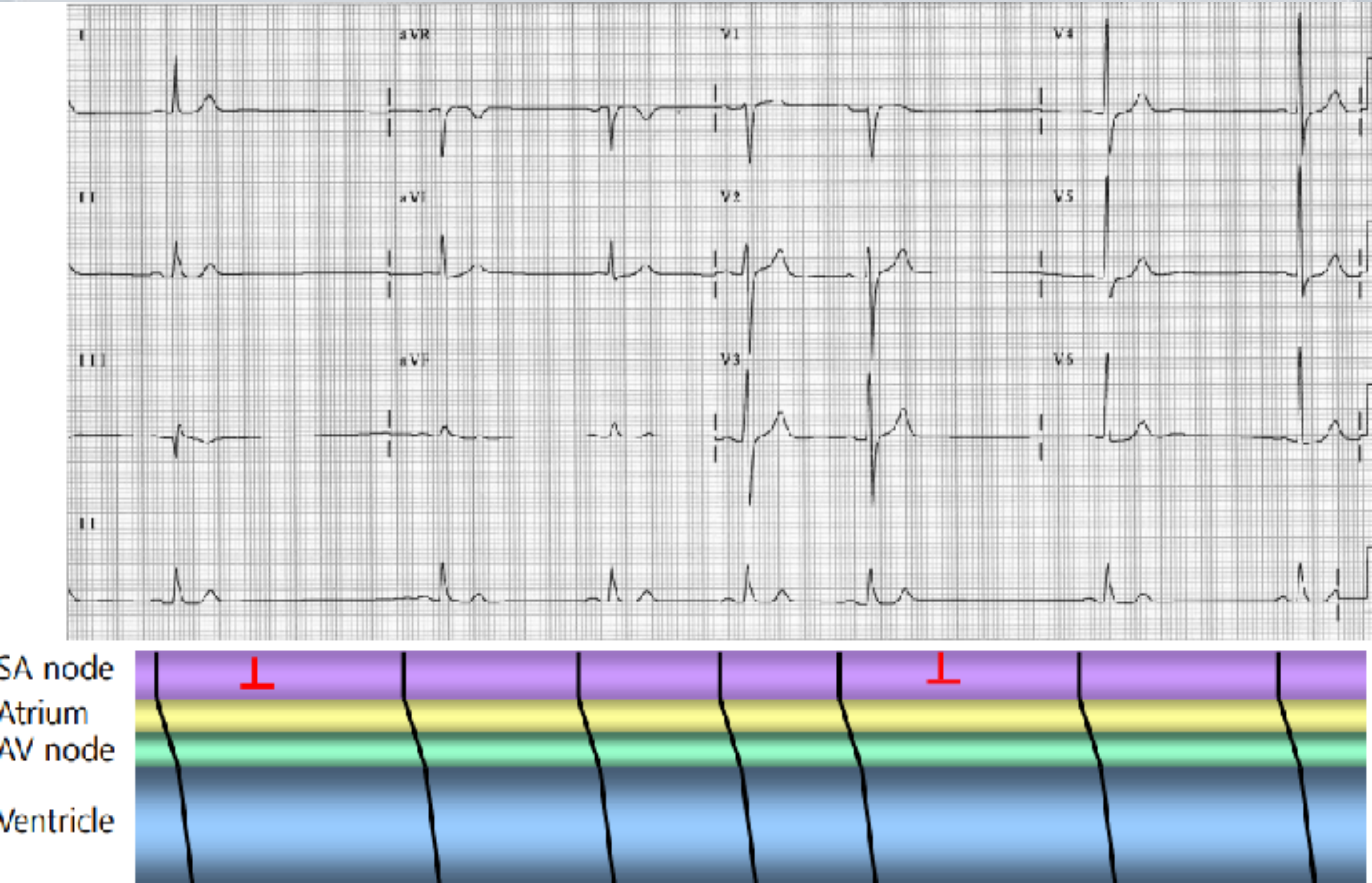
and transmission, culminating in failure of transmission.

- The gradually lengthening transmission interval pushes successive P waves closer together.
- The P-P interval progressively *shortens* prior to the dropped P wave.
- Pauses due to dropped P waves occur at the end of each group
- This pattern is easily mistaken for sinus arrhythmia
-



Sino-Atrial Exit Block (type I)

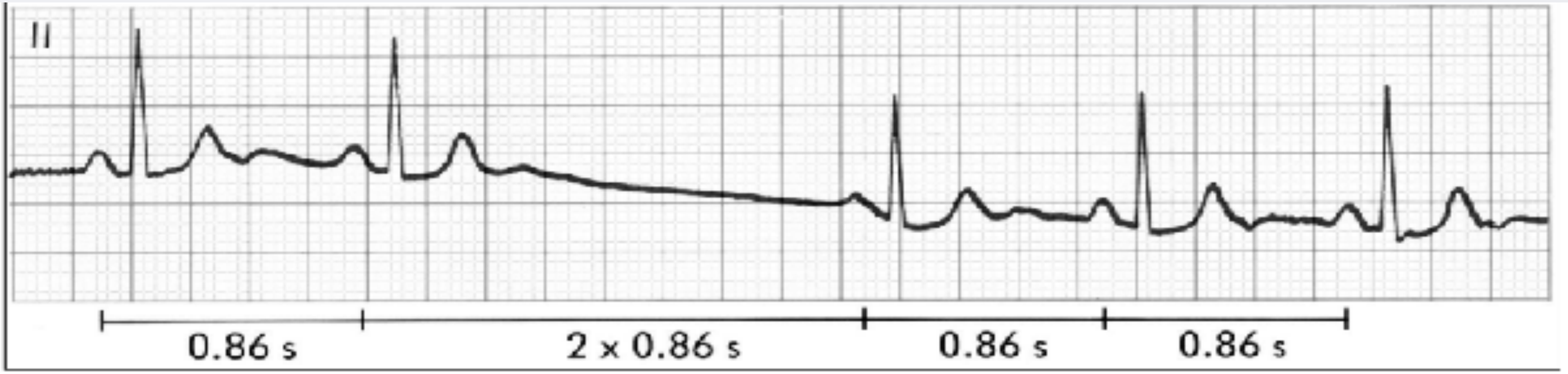
Second -degree SA block, Type I



Second –degree SA block

Second-degree SA block, Type II = Intermittent dropped P waves with a constant interval between impulse generation and atrial depolarisation.

- The impulse are blocked sporadically
- The pause between the visible beats are always multiply of the normal P-P intervals, usually there can be 2 to 4 P-P intervals between the beats
- This pattern is the equivalent of Mobitz II

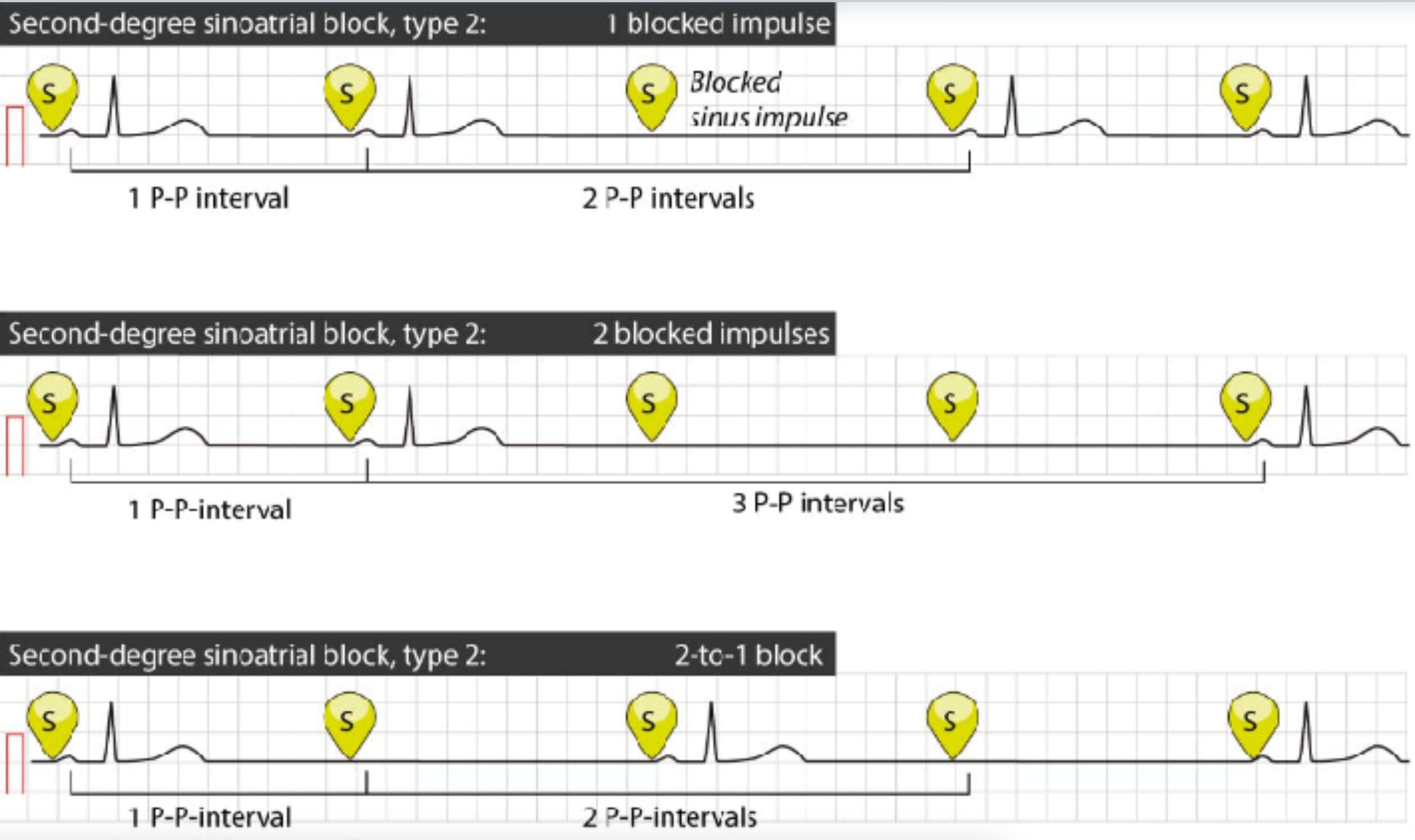


Normal or slow regular rhythm is followed by a pause that is a multiple of the P-P interval usually (2-4)

Second –degree SA block

•Arrows indicate the presumed timing of each sinus impulse.
•The blue arrows represent normally transmitted impulses, i.e. resulting in P waves.
•The black arrows represent blocked sinus impulses (dropped P waves).
•The pauses around the dropped P waves (2.1 seconds) are exactly double the preceding P-P interval (1.05 seconds)

Several cases of type II second-degree SA block

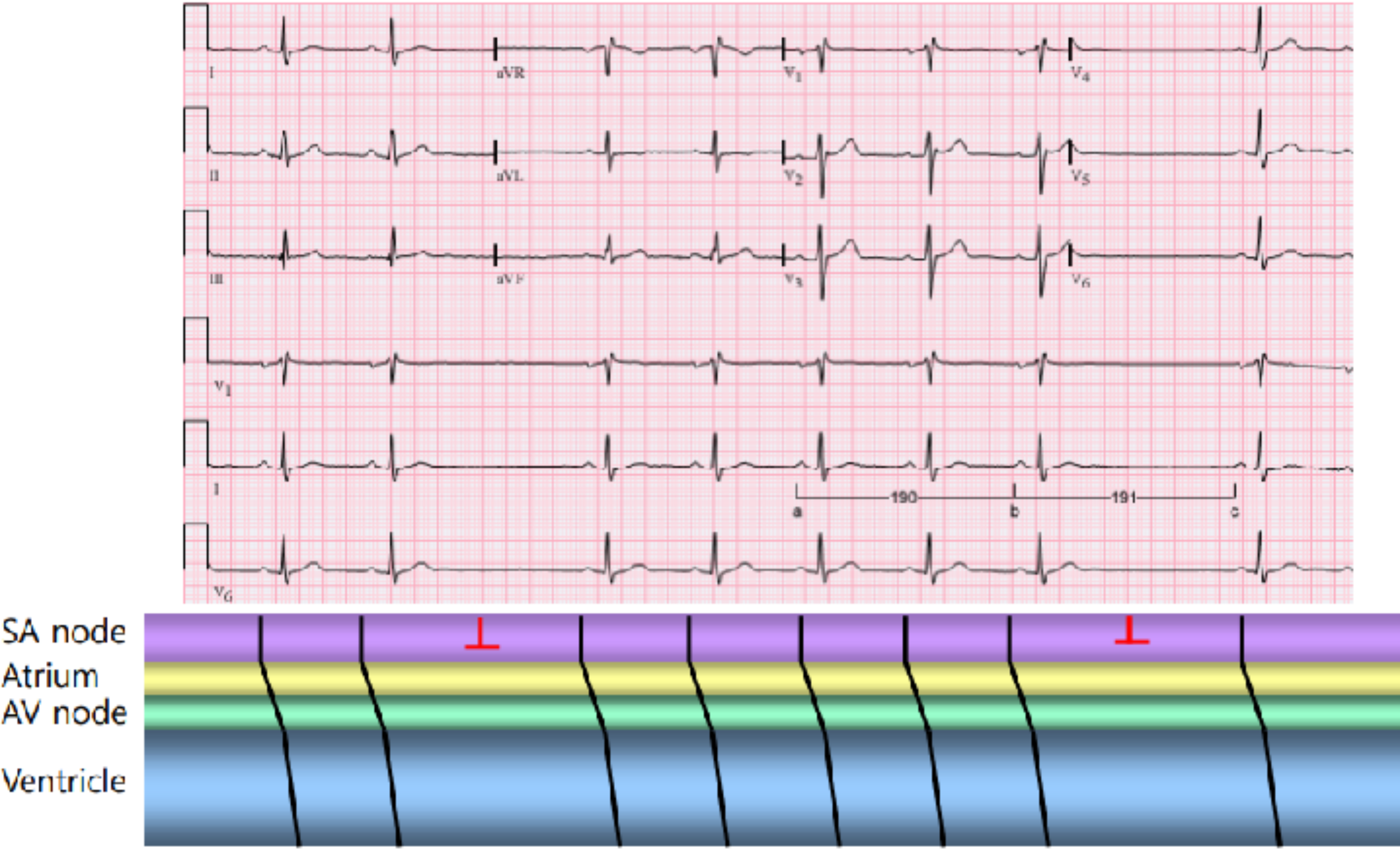


2nd Degree SA Nodal Exit Block, Type 1

Typical Pause Duration < Sum of two previous P-P intervals

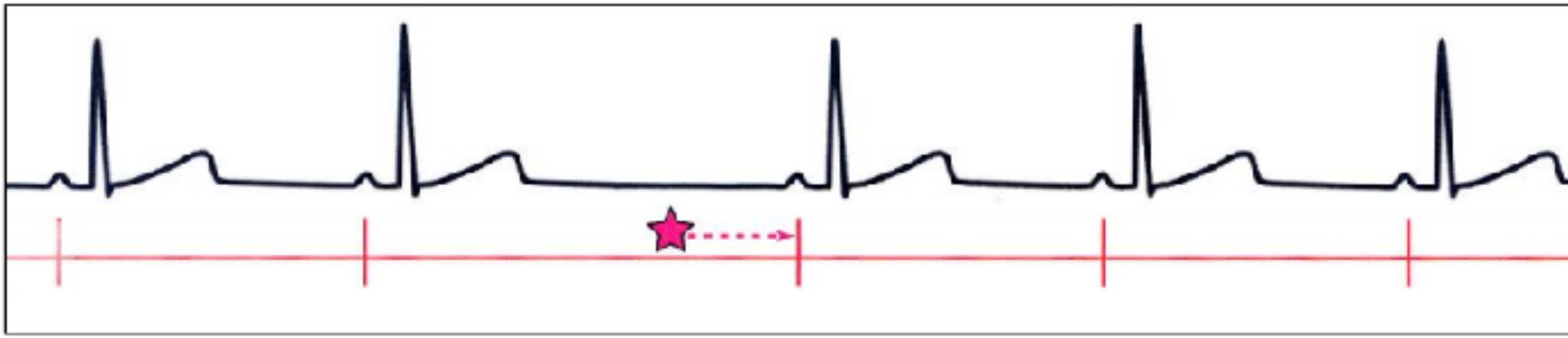
2nd Degree SA Nodal Exit Block, Type 2

Second-degree SA block, Type II



Third-degree SA Block

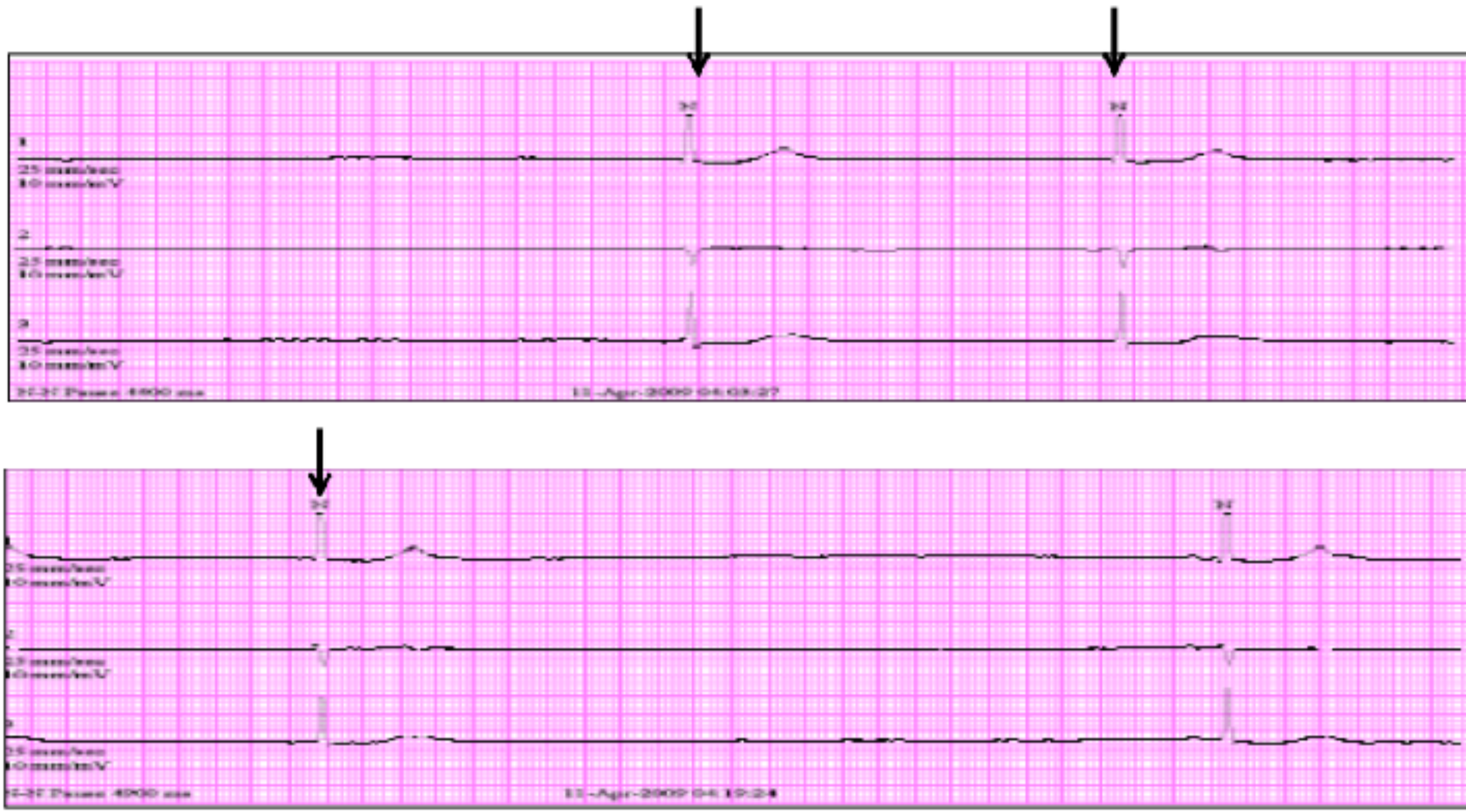
- *None of the sinus impulses are conducted to the right atrium.*
- There is a complete absence of P waves.
- The onset of 3rd degree SA block may produce long sinus pauses or sinus arrest (may lead to fatal asystole).
- Rhythm may be maintained by a jonctional escape rhythm.



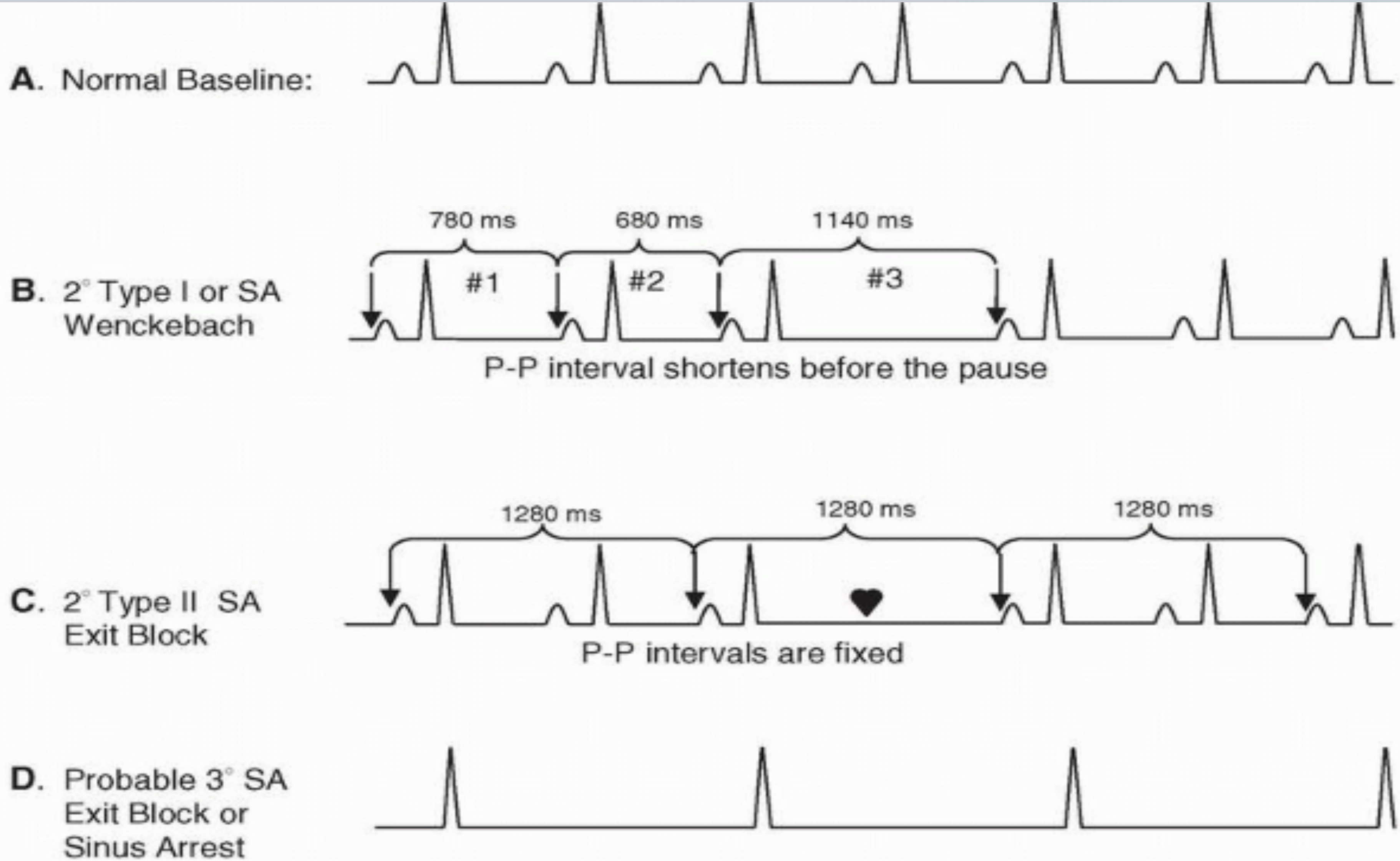
Sinus pause is not a multiple of the PP interval

Sinus arrest is longer than a sinus pause
and is not a multiple of the PP interval

Sinus arrest with junctional escape beat

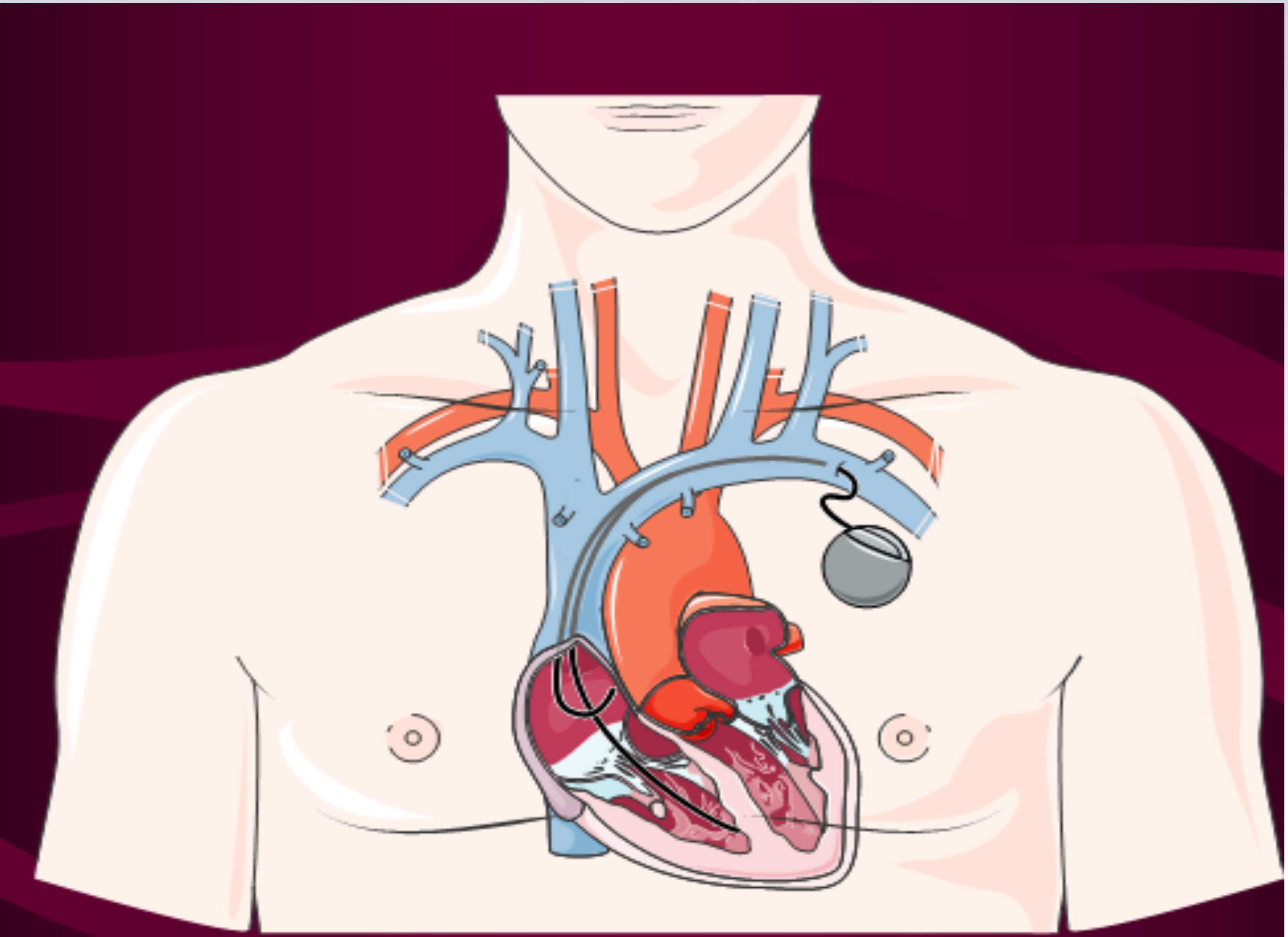


Sino-atrial block (SA block)



TREATMENT

- Permanent pacemakers are the mainstay of therapy for patients with symptomatic SA node dysfunction.



Atrioventricular (AV) block

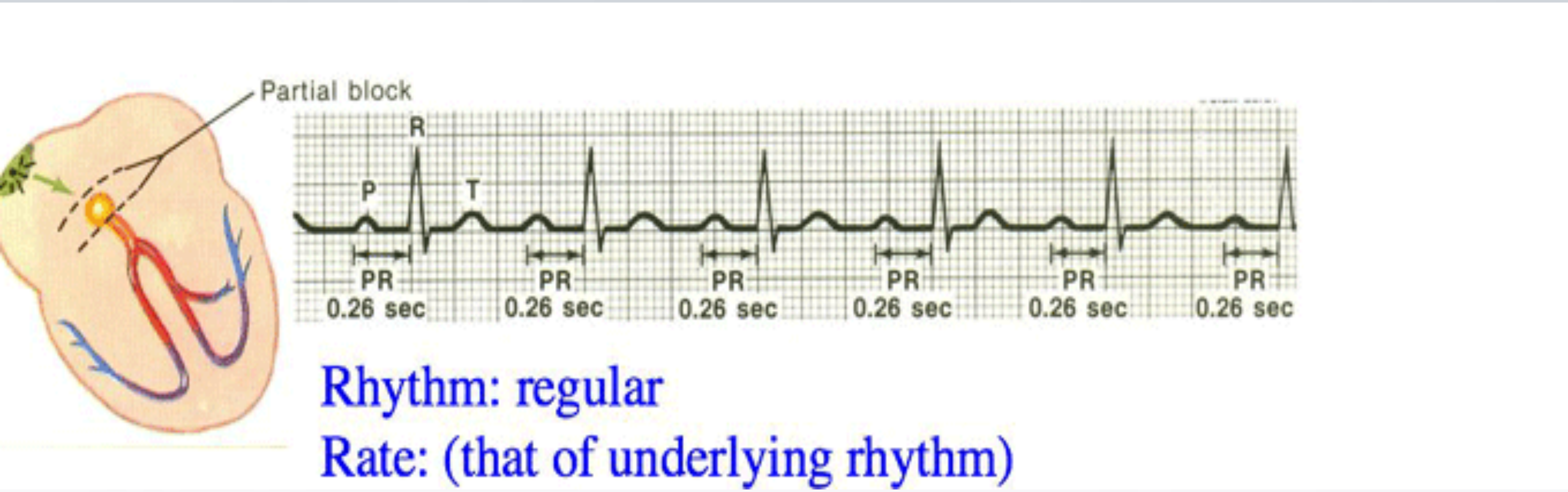
- **Atrioventricular (AV) block –** any conduction block between the sinus node and the terminal Purkinje fibers.

The **most common causes of AV block** are:

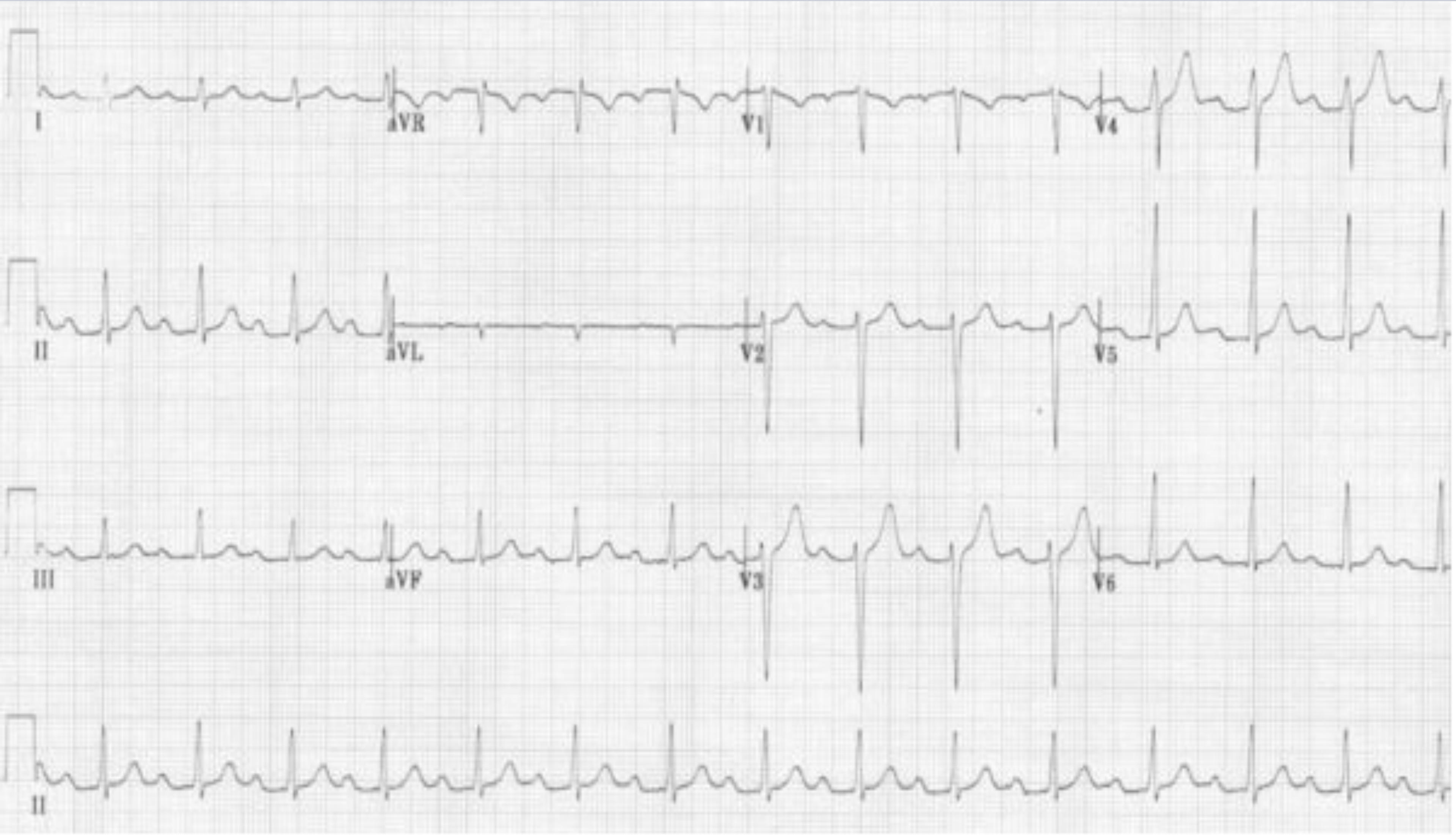
- Idiopathic fibrosis and sclerosis of the conduction system (about 50% of patients)
- Ischemic heart disease (40%)
- Drugs (beta-blockers, calcium channel blockers, digoxin, amiodarone)
- Increased vagal tone
- Valvulopathy
- Congenital heart, genetic, or other disorders

First-degree AV block

- All normal P waves are followed by QRS complexes, but the PR interval is longer than normal (> 0.2 sec).

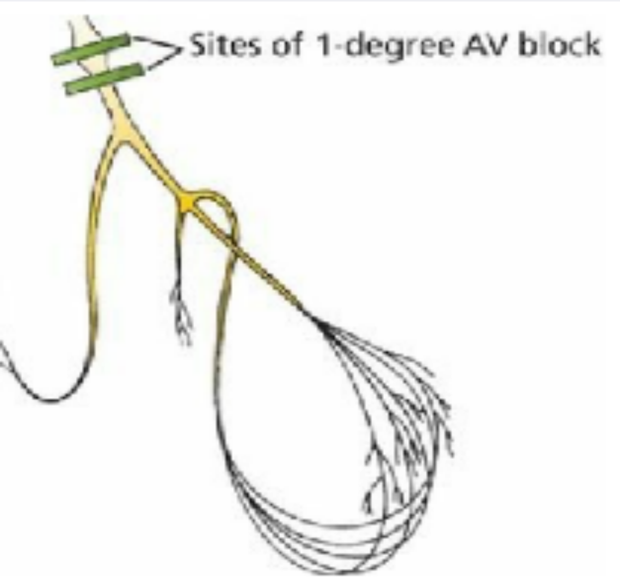


First-degree AV block



First-degree AV block may be:

- physiologic in younger patients with high vagal tone and in well-trained athletes.
- an early sign of degenerative disease of the conduction system or a transient manifestation of myocarditis
- rarely symptomatic and no treatment is required, but further investigation may be indicated



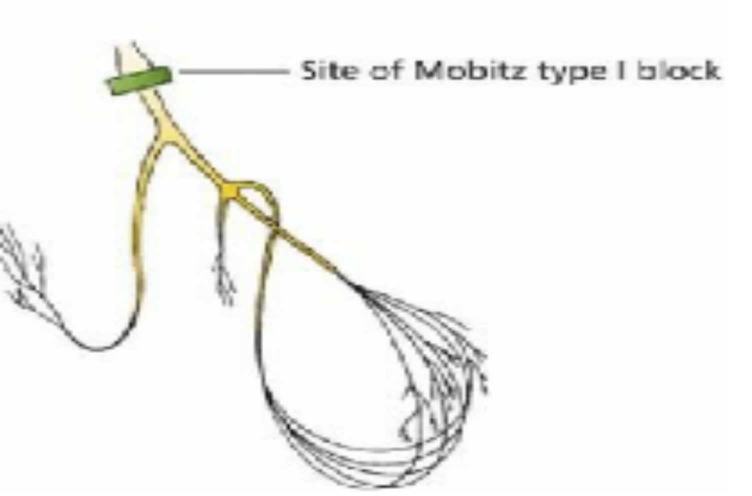
Second-Degree AV block

- Not every atrial impulse is able to pass through the AV node into ventricles

Two types exist:

- Mobitz type I, more common called Wenckebach block
- Mobitz type II

Wenckebach block is almost due to a block within the AV node. Each succesive atrial impulse encounters a longer and longer delay in the AV node until one impulse (usully every third or fourth) fails to make it through.



Mobitz type I second-degree AV block

ECG signs:

- The PR interval progressively lengthens with each beat and then suddenly a P wave is not followed by a QRS complex ("a dropped beat "-Wenckebach phenomenon);
- AV nodal conduction resumes with the next beat, and the sequence is repeated.

Mobitz type I second-degree AV block

Progressive prolonging of PR interval

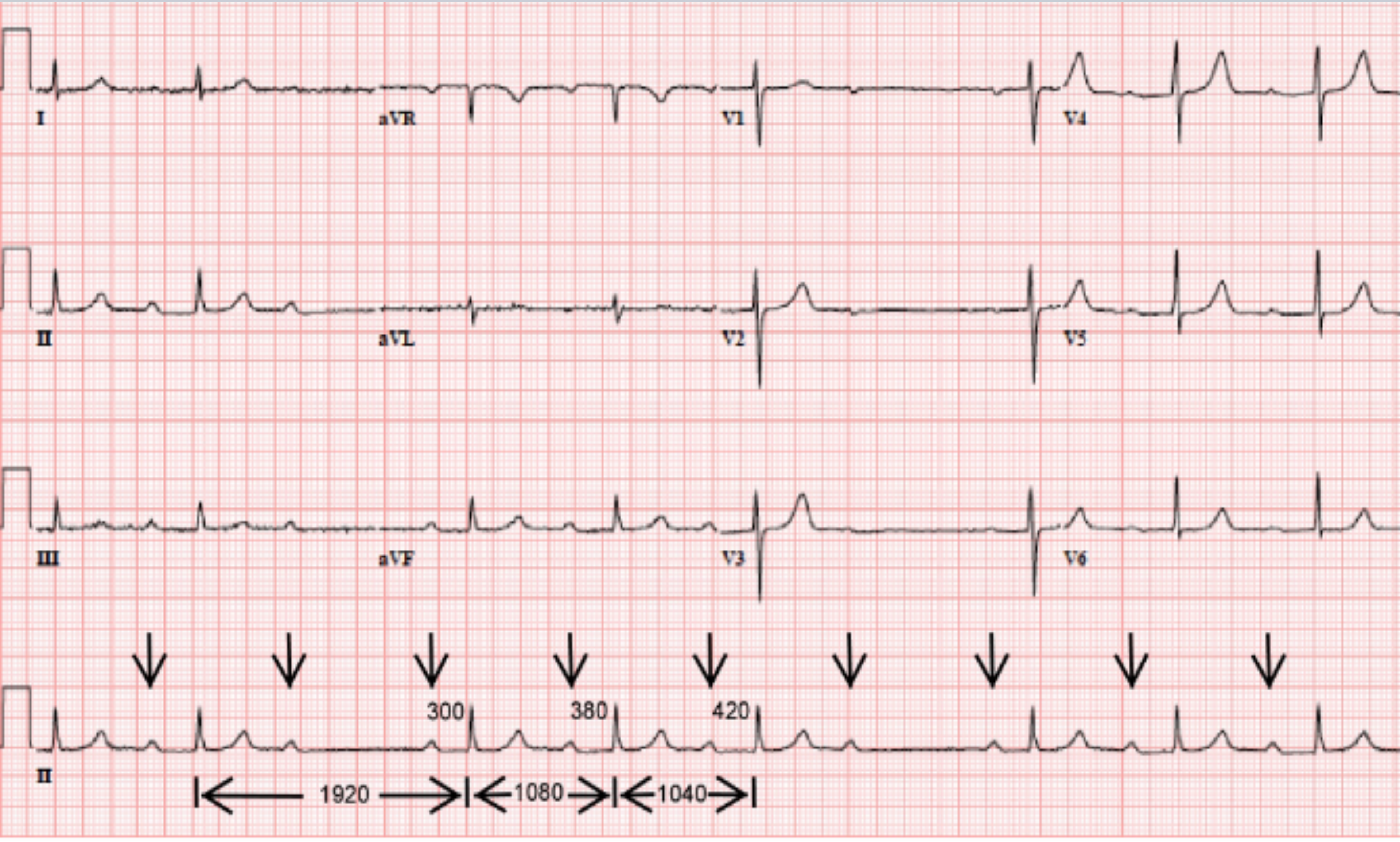
P waves and QRS complexes are normal but…

- PR interval progressively lengthens
- Dropped beats (non-conducted P wave)
- Leads to “grouped beating”
- The block is almost always within the AV node

Other Features of AV Block: second degree, Mobitz I

- The P-P interval remains relatively constant
- The *greatest increase* in PR interval duration is typically *between the first and second beats of the cycle*.
- The RR interval progressively shortens with each beat of the cycle. The Wenckebach pattern tends to repeat in P:QRS groups with ratios of 3:2, 4:3 or 5:4.

4:3 Mobitz Type I 2nd-degree AV Block



Causes of Mobitz type II AV block

- Anterior MI (due to septal infarction with necrosis of the bundle branches).
- Idiopathic fibrosis of the conducting system
- Cardiac surgery (especially surgery occurring close to the septum, e.g. mitral valve repair)
- Inflammatory conditions (rheumatic fever, myocarditis, Lyme disease).
- Autoimmune (SLE, systemic sclerosis).
- Infiltrative myocardial disease (amyloidosis, haemochromatosis, sarcoidosis).
- Hyperkalaemia.
- Drugs: beta-blockers, calcium channel blockers, digoxin, amiodarone.

Mobitz type II AV block

Clinical Significance

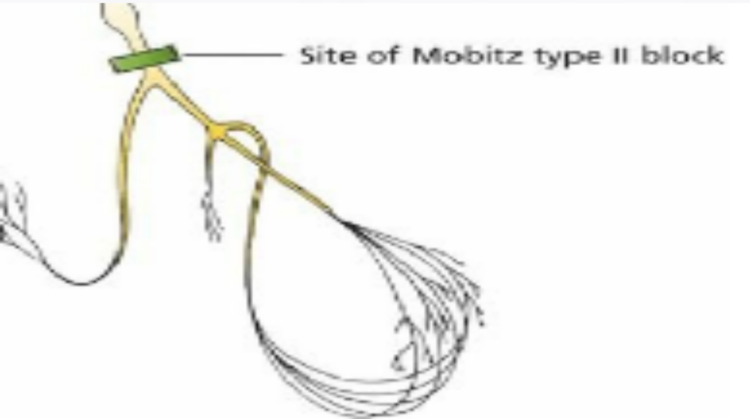
- Mobitz II is much more likely than Mobitz I to be associated with haemodynamic compromise, severe bradycardia and progression to 3rd degree heart block.
- Onset of haemodynamic instability may be sudden and unexpected, causing syncope (Stokes-Adams attacks) or sudden cardiac death.
- The risk of asystole is around 35% per year.
- Mobitz II mandates immediate admission for cardiac monitoring, backup temporary pacing and ultimately insertion of a permanent pacemaker.

Mobitz type II second-degree AV Block

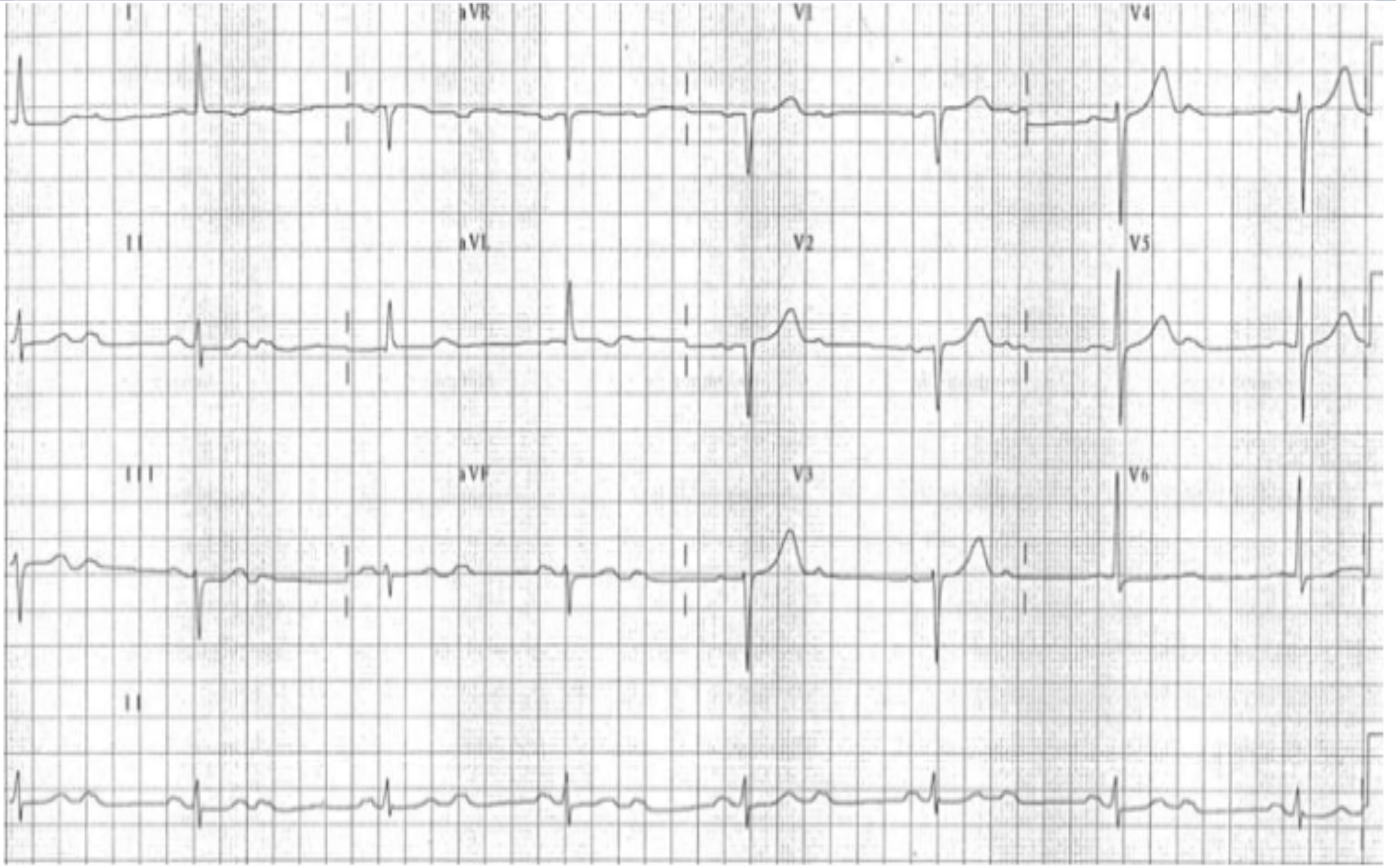
- Is due to a block below the AV node in the His bundle
- It resembles Wenchebach block in that some, but not all, of the atrial impulses are transmitted to ventricles

EKG criteria:

- Progressive lenghtening of the PR interval does not occur
- Two ore more normal beats with normal PR intervals and then a P wave that is not followed by a QRS complex (a dropped beat), the cycle is the repeated
- The ratio of conducted beats to nonconducted beats is rarely constant, with the ratio of P waves to QRS complex, varying from 2:1 to 3:2 and so on.



Mobitz type II second-degree AV Block



Mobitz type II second-degree AV Block

3:1 block

- The atrial rate (purple arrows) is approximately 90 bpm.
- The ventricular rate rate is approximately 30 bpm.
- Note how every third P wave is almost entirely concealed within the T wave.

Second
degree, “high-grade” AV block

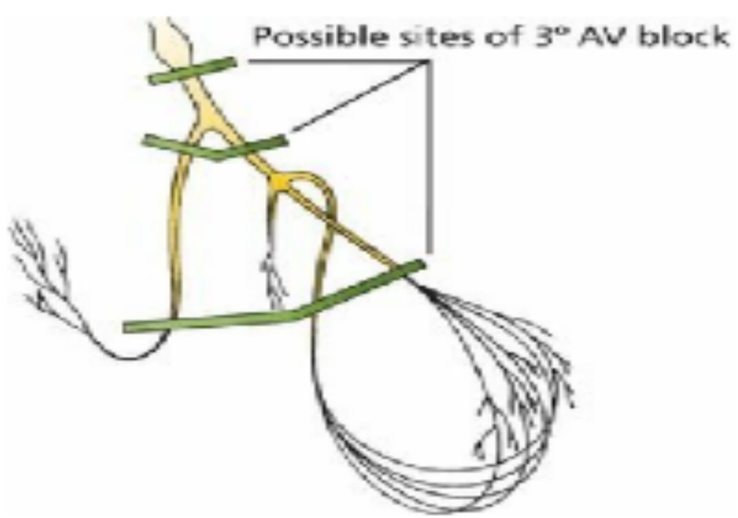
Is it a Wenckebach Block or a Mobitz Type II Block?

A

B

Third- degree AV Block (complete heart block)

- No atrial impulses at all make it through to activate the ventricles
- The site of the block can be either at the AV node or lower
- The ventricles respond by generating an escape rhythm, 30-45 beats/min (idioventricular escape)
- Atria are contracting in their own rhythm and the ventricles are working in their own rhythm – no relationship between their activity. The atria and ventricles have nothing to do with each other, separated by the absolute barrier of the complete conduction block (AV dissociation), the atria and the ventricles are being driven by independent pacemaker.



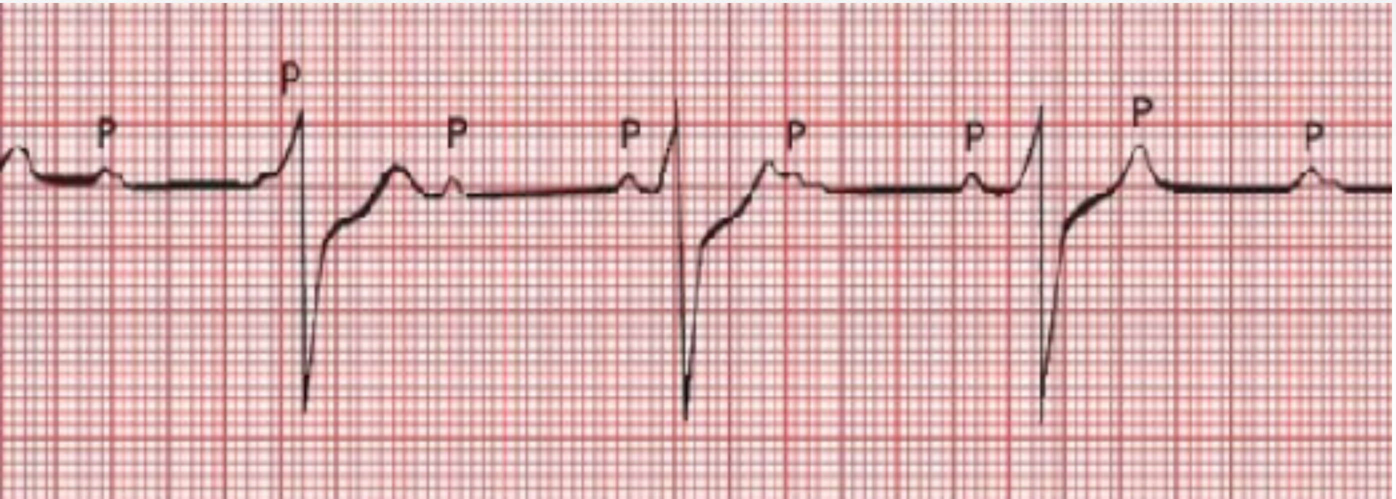
Third-degree heart block has important hemodynamic consequences :

- Syncope, dizziness, and acute heart failure are common.
- When the escape pacemaker rate is > 40 beats/min, symptoms are less acute and include lethargy, hypotension, and dyspnea.

Third- degree AV Block (complete heart block)

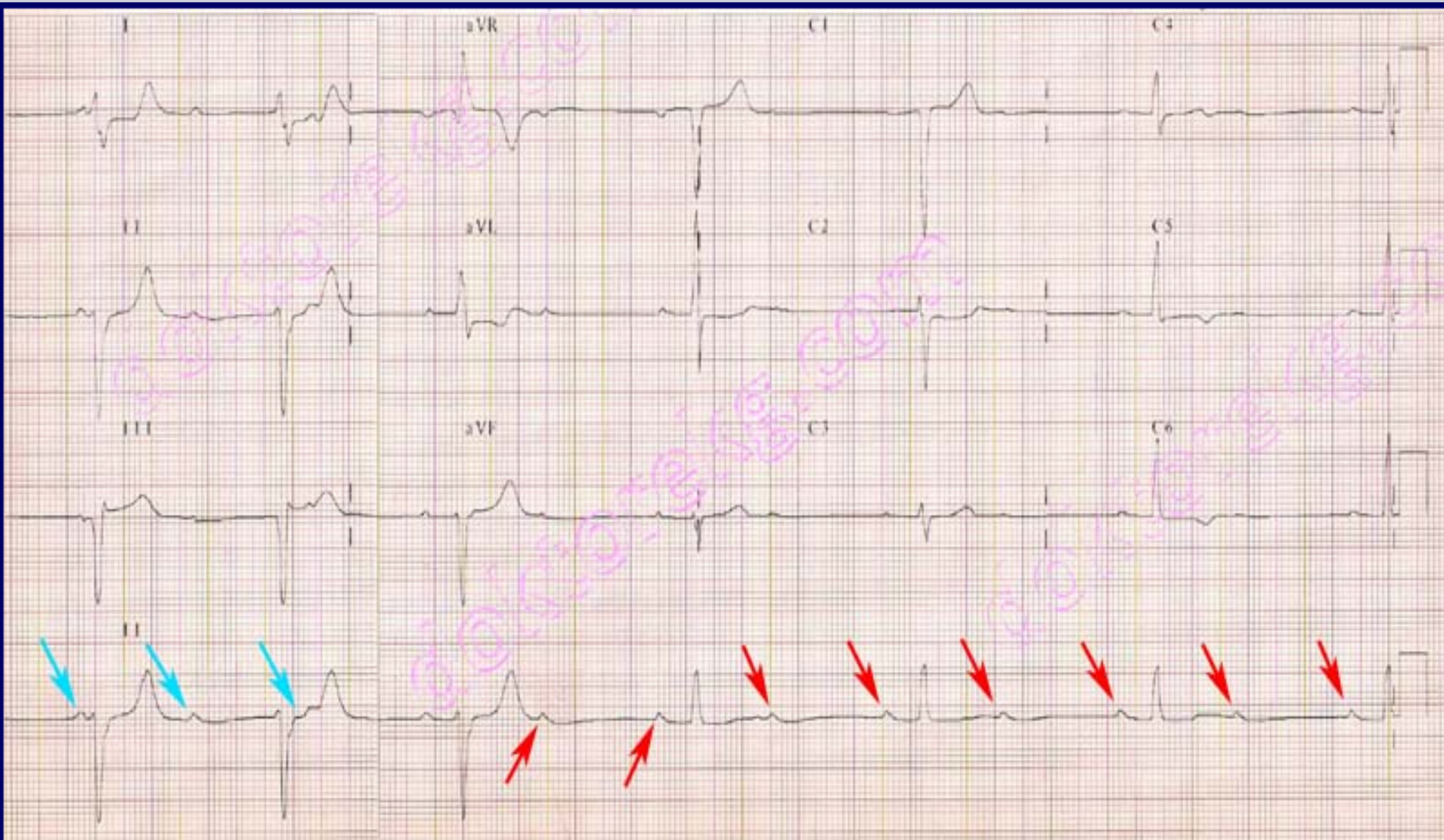
EKG criteria:

- P waves marching across the rhythm strip at the rate 60-100 waves/min, but bearing no relationship to the ORS complexes that apeapear at a much slower escape rate
- QRS complexes are wide and bizzarre, just a premature ventricular contractions, implying a ventricular origin.

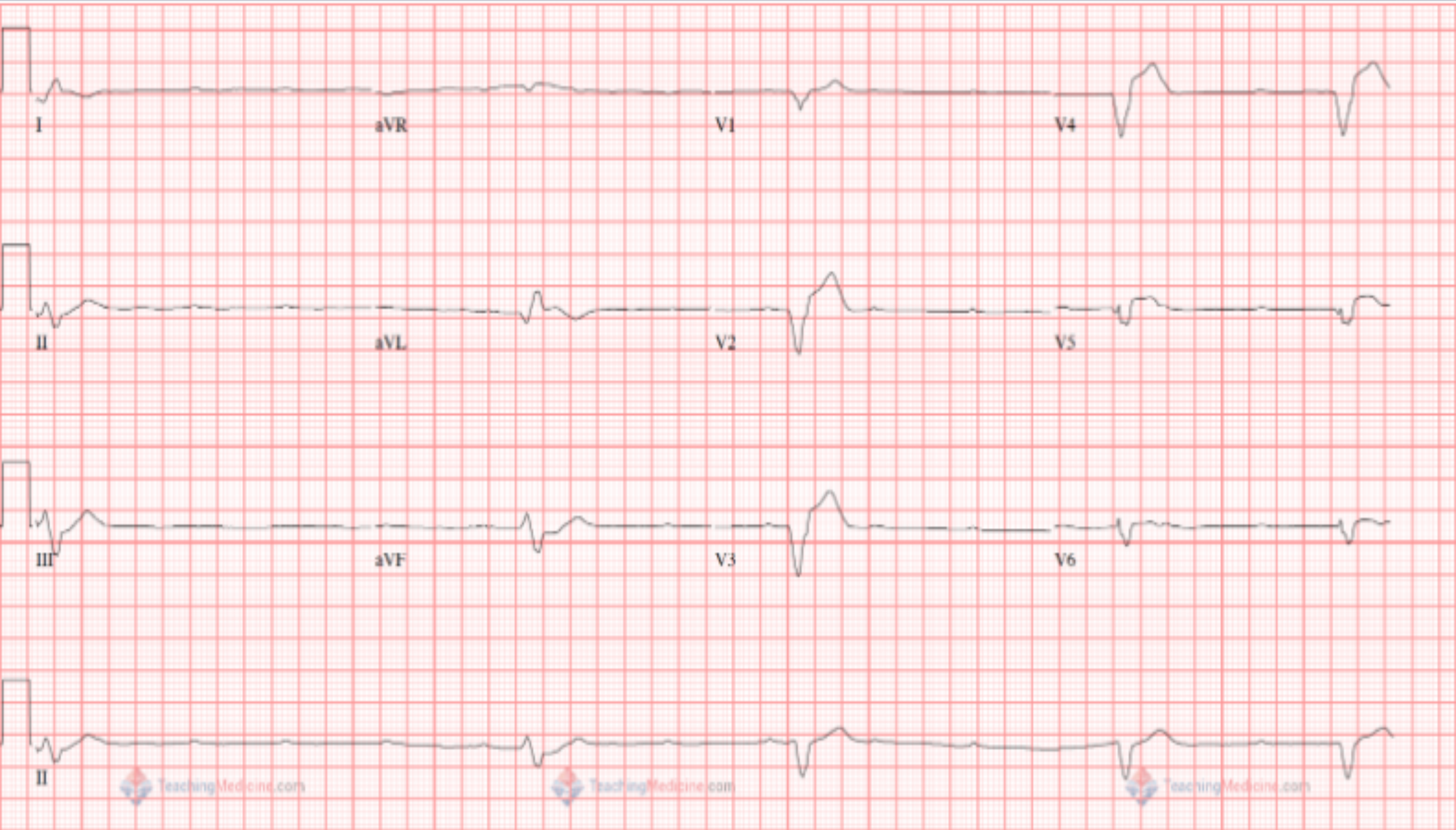


Third- degree AV Block (complete heart block)

AV Block



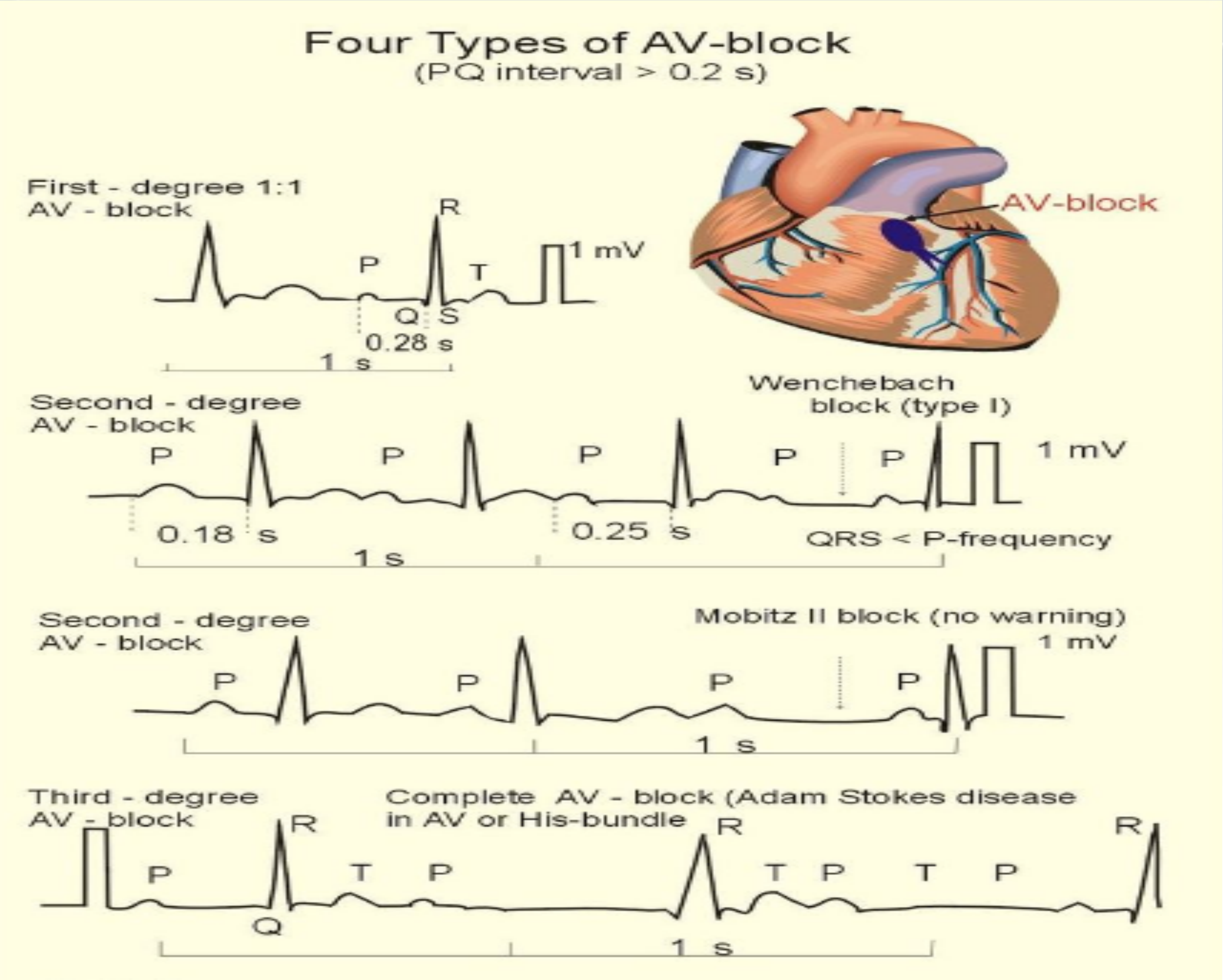
Third- degree AV Block (complete heart block)



Clinical significance

- Patients with third degree heart block are at high risk of ventricular standstill and sudden cardiac death.
- They require urgent admission for cardiac monitoring, backup temporary pacing and usually insertion of a permanent pacemaker.

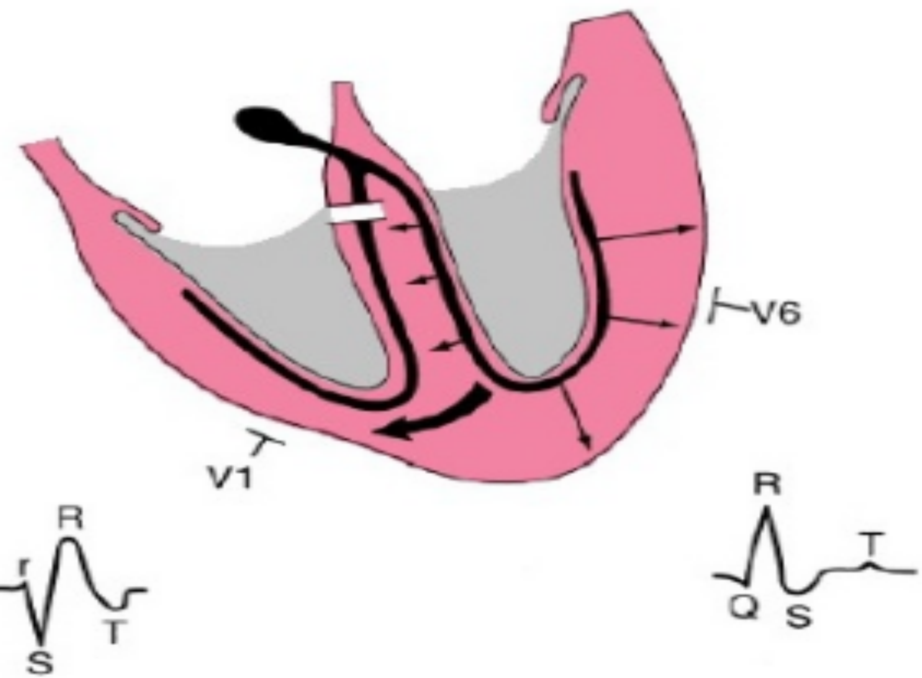
Atrioventricular (AV) block



Bundle Branch Block

- Refers to a conduction block (or slowing) of current flow in either the left or right bundle branches

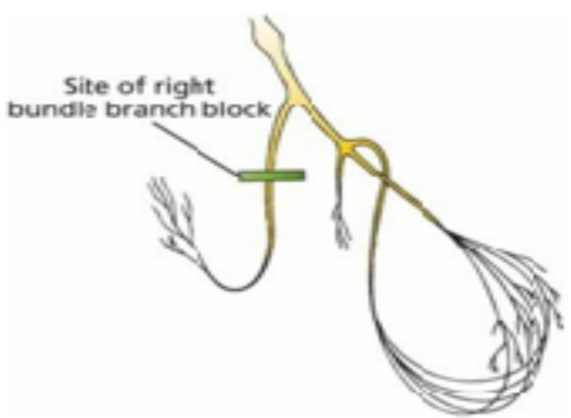
RIGHT BUNDLE BRANCH BLOCK (RBBB)



In this disorder, the right branch of the bundle is blocked, but the septum is activated from left to right, as in the normal heart. The left ventricular *q* wave is preserved, as is the initial *r* wave over right chest leads. The left ventricle is then depolarized, producing an *S* wave in right chest leads and an *R* wave in left chest leads. Finally, depolarization reaches the right ventricle, and so produces an *R* in the right chest leads and a deep broad *S* wave in the left chest leads. An M pattern is thus seen in the right chest leads, such as V1. It is also common to see *T* wave abnormalities in leads V2 and V3.

Causes of Right Bundle Branch Block

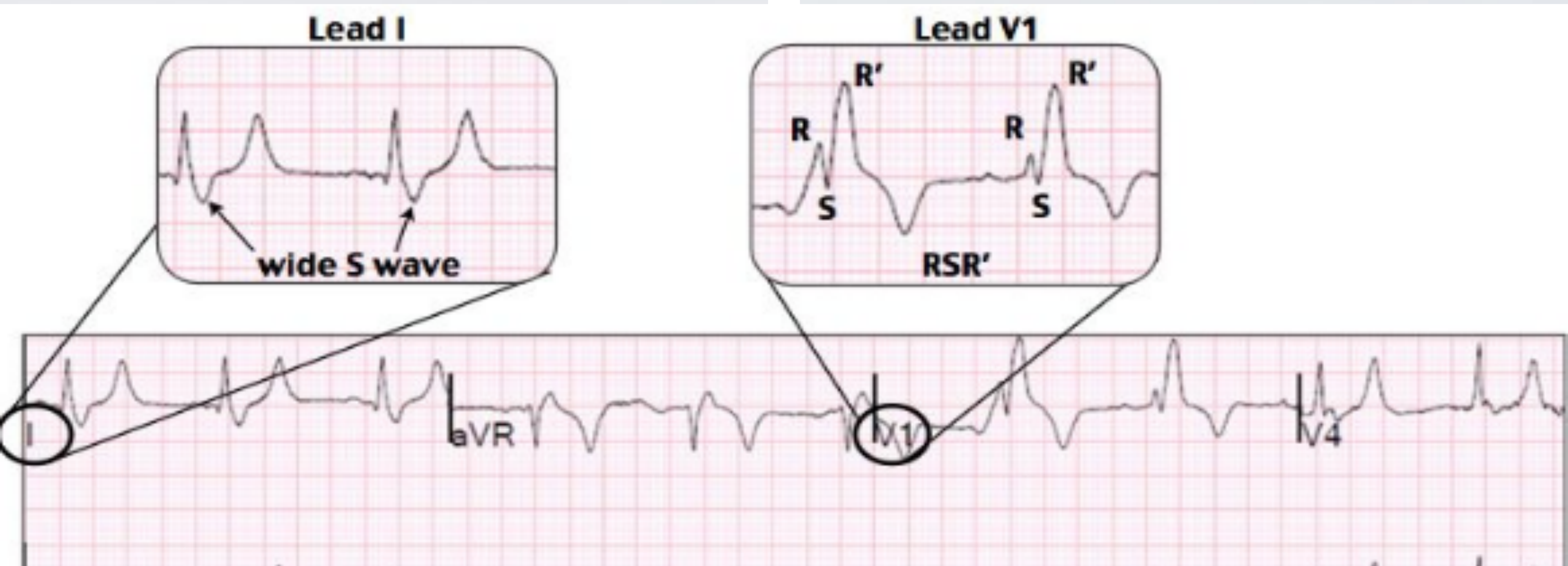
- Right ventricular hypertrophy / cor pulmonale
- Pulmonary embolus
- Ischaemic heart disease
- Rheumatic heart disease
- Myocarditis or cardiomyopathy
- Degenerative disease of the conduction system
- Congenital heart disease (e.g. atrial septal defect)



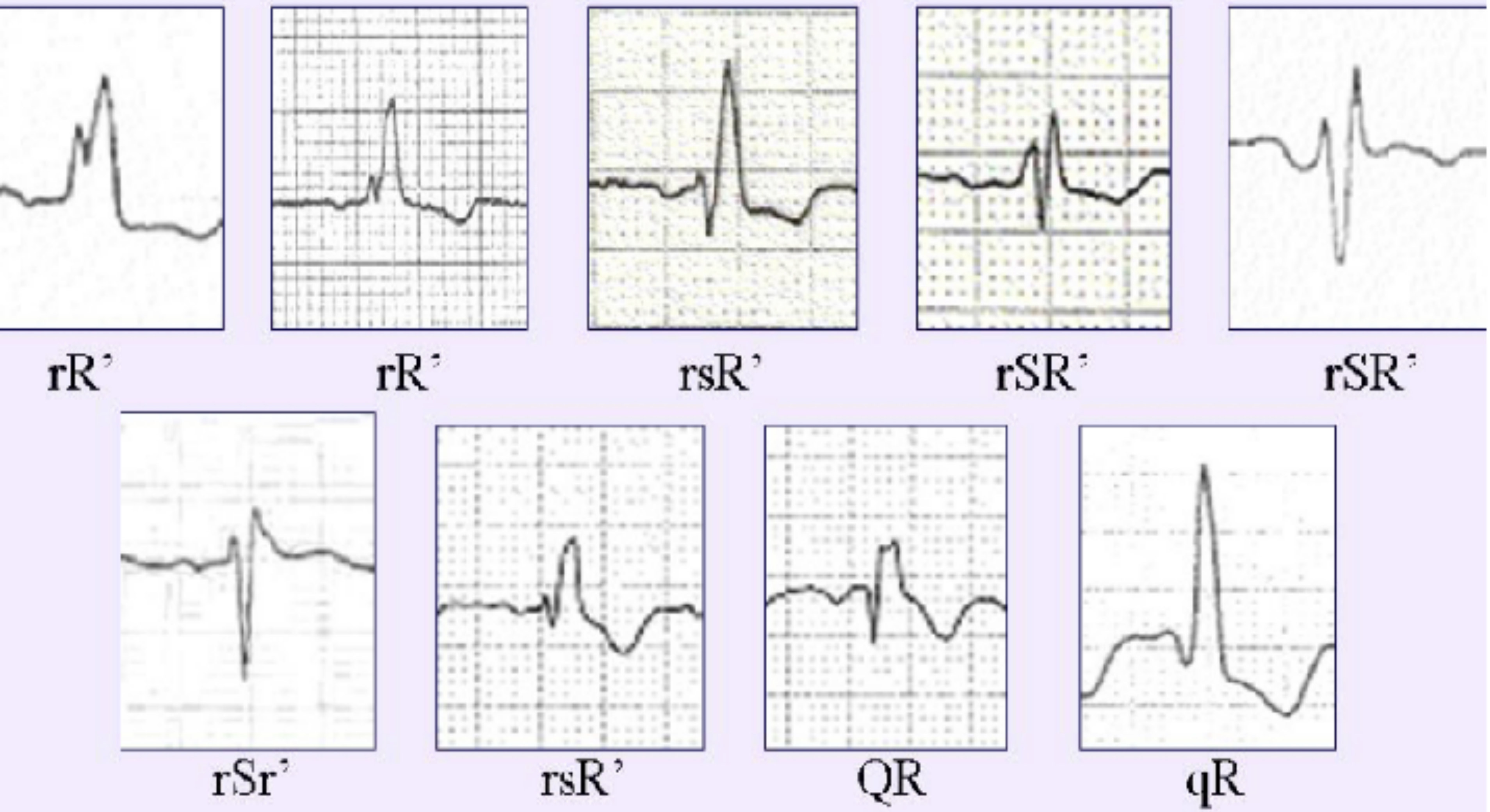
Right Bundle Branch Block (RBBB)

The ECG criteria include the following:

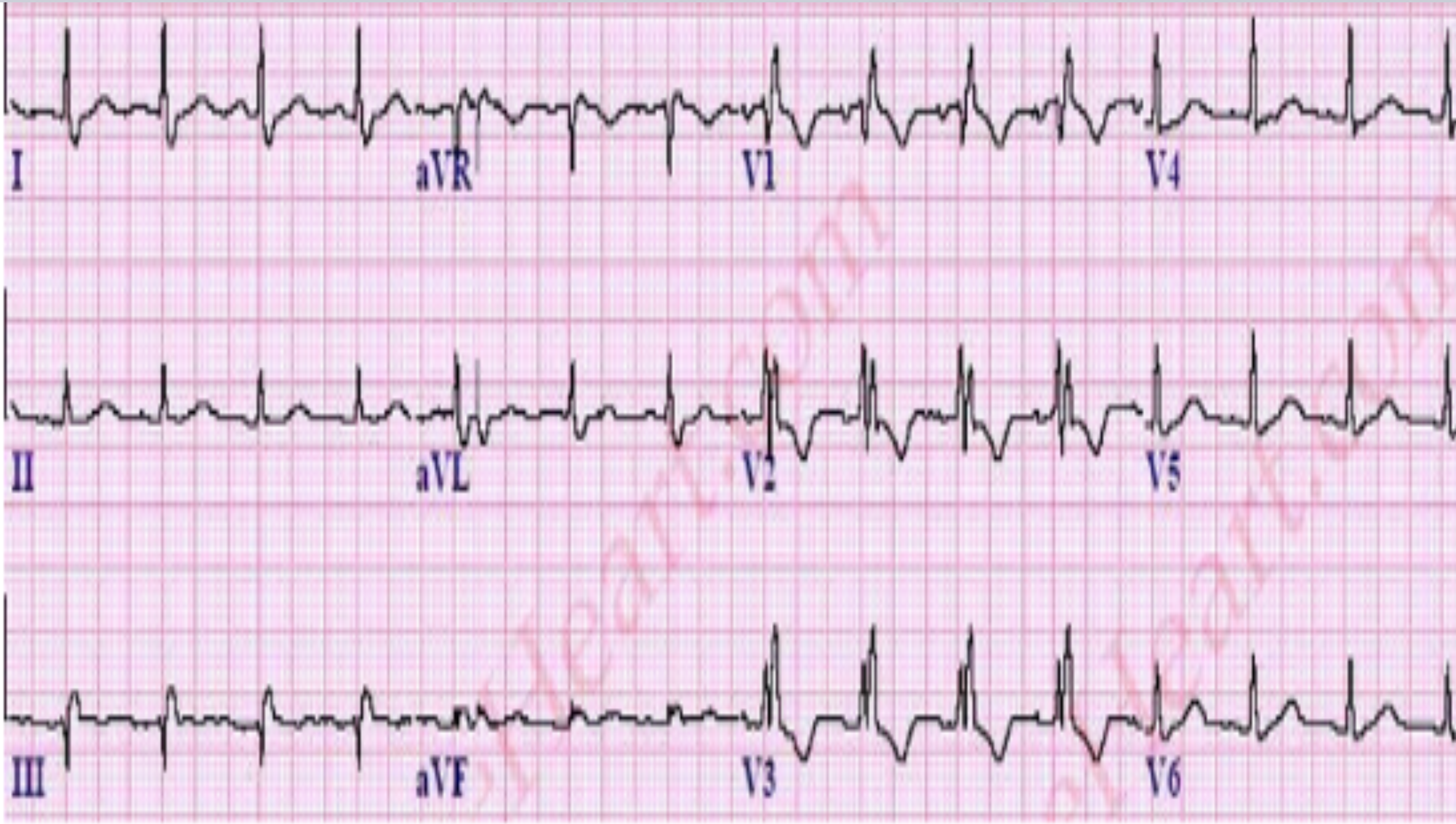
- QRS duration greater than 0.12 seconds
- RsR' "rabit ears" or a tall R wave in leads V1 and V2 with ST-segment depression and T-wave inversion
- Reciprocal changes in V5, V6, I and aVL.



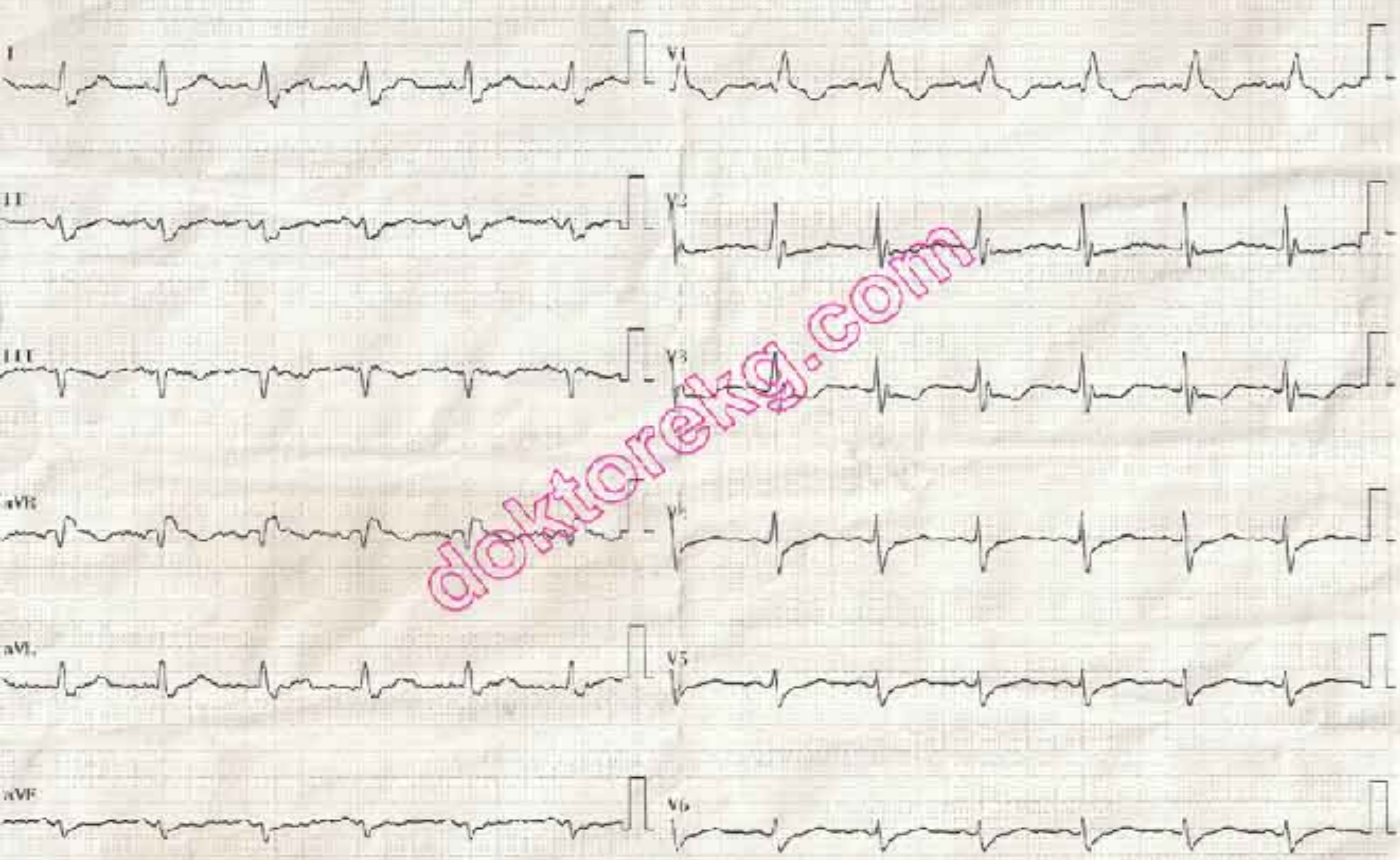
Various RBBB Morphologies Lead V1

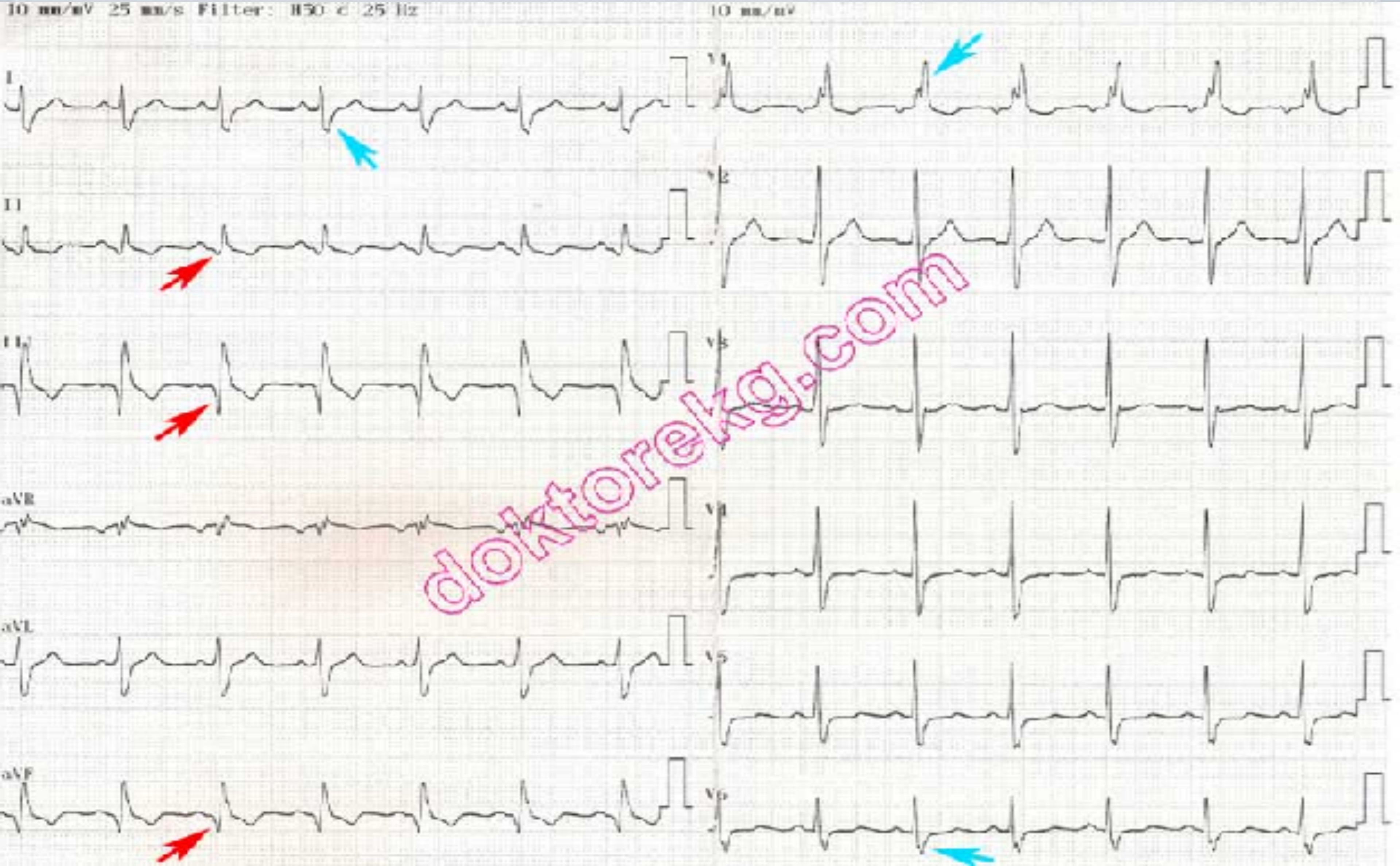


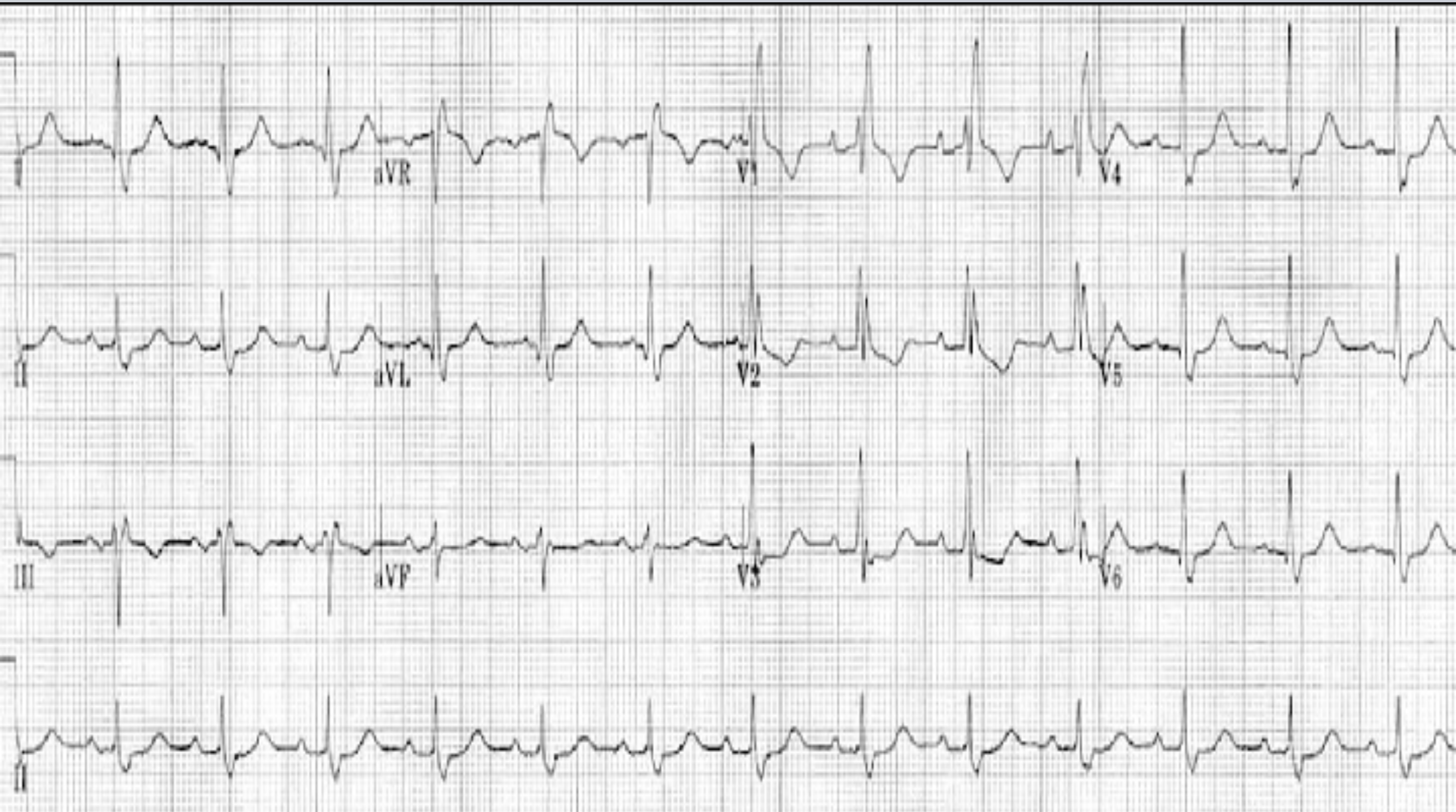
Right Bundle Branch Block



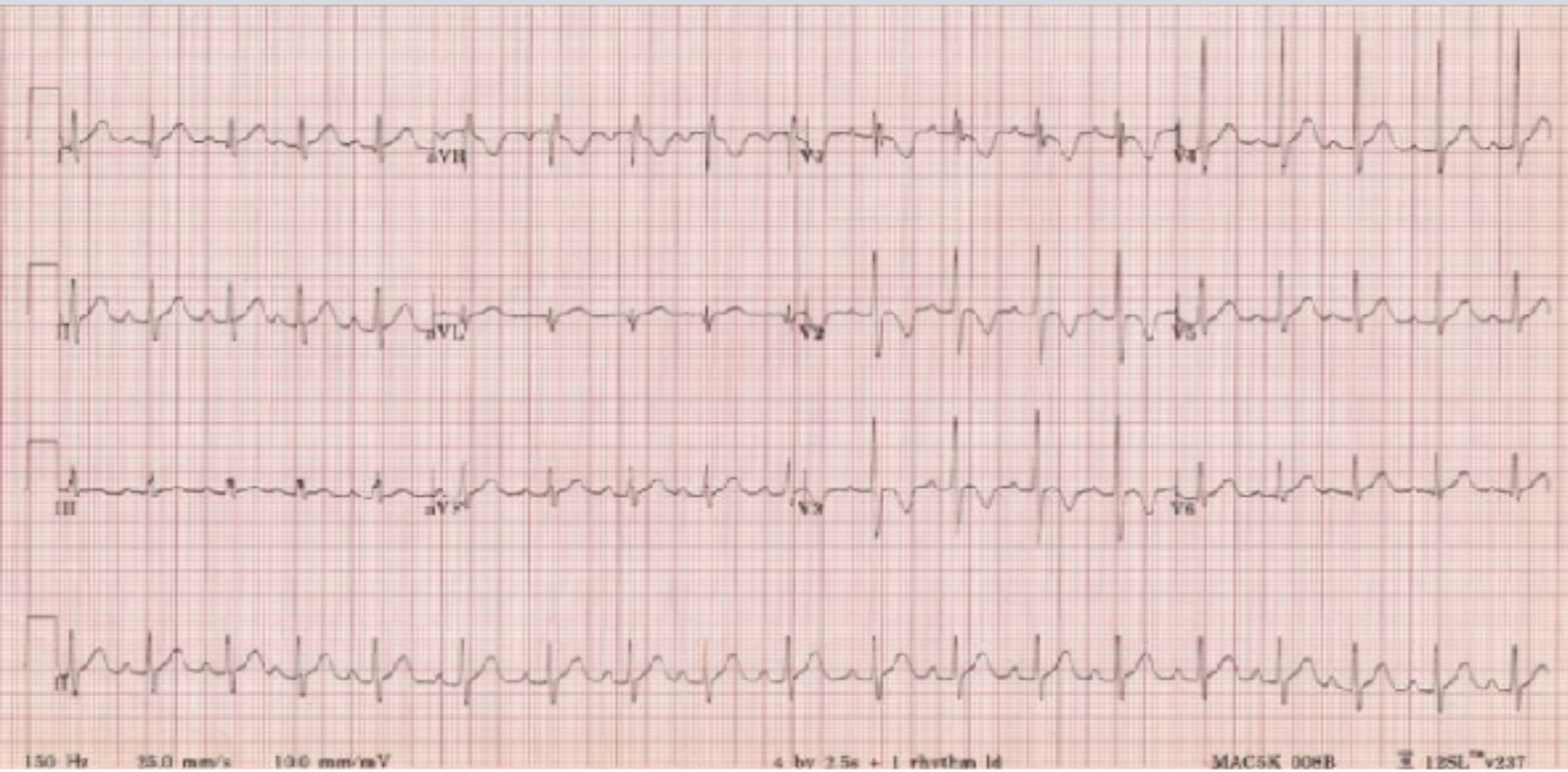
Right Bundle Branch Block



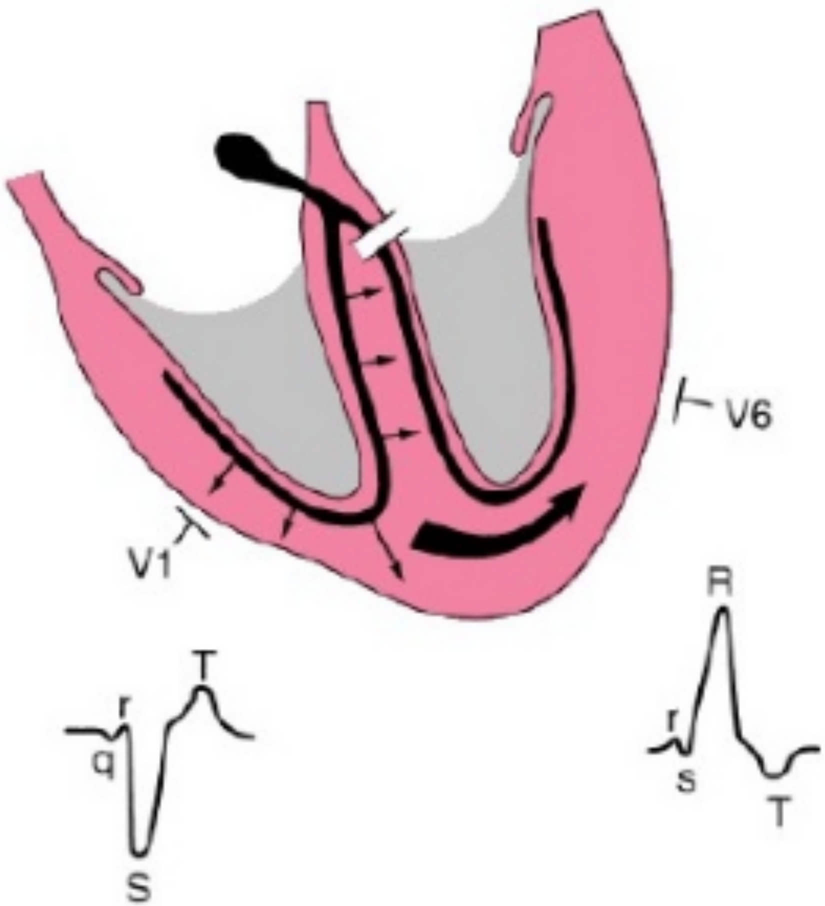

10 mm/mV 25 mm/s Filter: H50 d 25 Hz
10 mm/mV
I
II
aVR
aVL
aVF
doktorekg.com


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II

- Incomplete RBBB is defined as an RSR’ pattern in V1-3 with QRS duration < 120ms.
- It is a normal variant, commonly seen in children (of no clinical significance)



Left Bundle Branch Block



When the left branch of the bundle is blocked, the interventricular septum is activated from the right instead of from the left side and the initial vector (phase 1) is directed to the left. Because of this, the normal initial *q* wave in the left ventricular leads is lost, being replaced by a small *r* wave. Right ventricular depolarization, which follows, produces an *r* in V1 and an *s* in V6. The left ventricle is finally depolarized resulting in an *R* in V6 and a broad *S* in V1. The *QRS* duration is increased to 0.12 s or more. The abnormal left ventricular depolarization sequence in left bundle branch block causes secondary repolarization changes. Consequently, the *ST* segment and *T* wave are abnormal.

Clinical implications of left Bundle Branch Block

Is always pathological and is associated with:

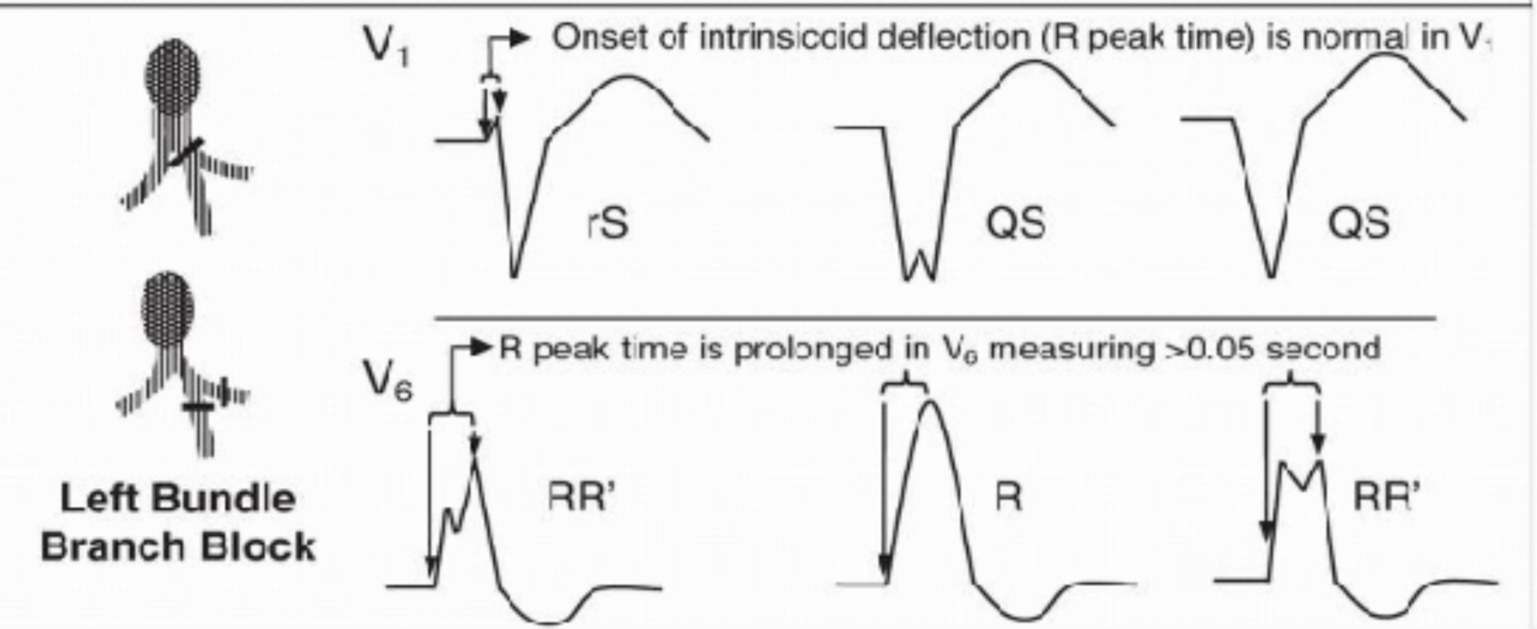
- Hypertension, ventricular hypertrophy
- Valvular heart disease, myocarditis
- Ischemic heart disease
- Heart failure and cardiomyopathies

Framingham Heart Study that acquired left bundle branch block was associated with seven times as great a risk of heart failure, two times as great a risk of coronary artery disease.

Left Bundle Branch Block

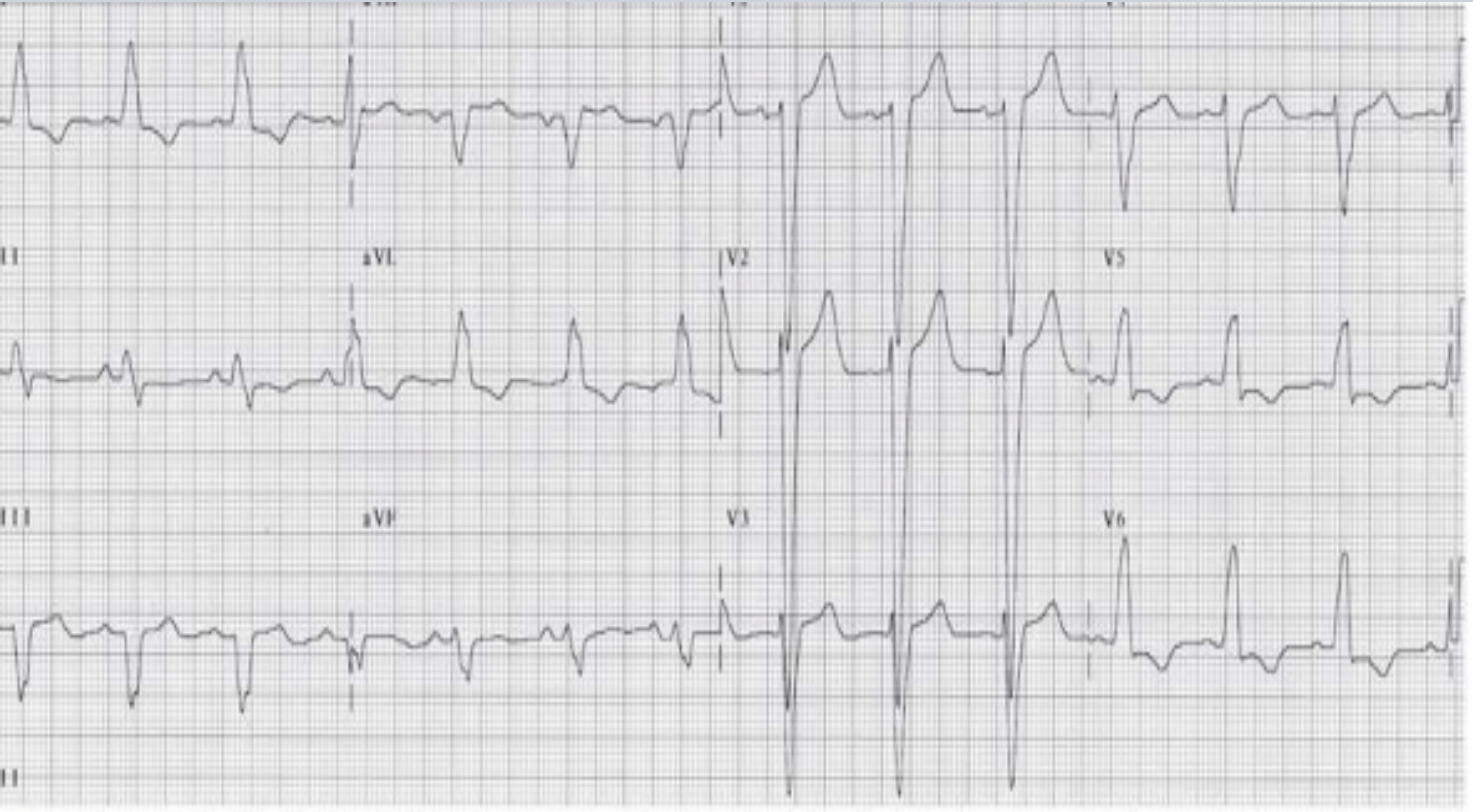
EKG criteria:

- Wide QRS complexes measuring ≥0.12 second
  - **V_1:**
    - QS or rS complexes
  - **V_6 and leads on left side of ventricular septum (I and aVL):**
    - Septal q waves are absent
    - Monophasic R, RR', slurred R or M-shaped R
    - Onset of intrinsicoid deflection or R peak time is prolonged (>0.05 sec)

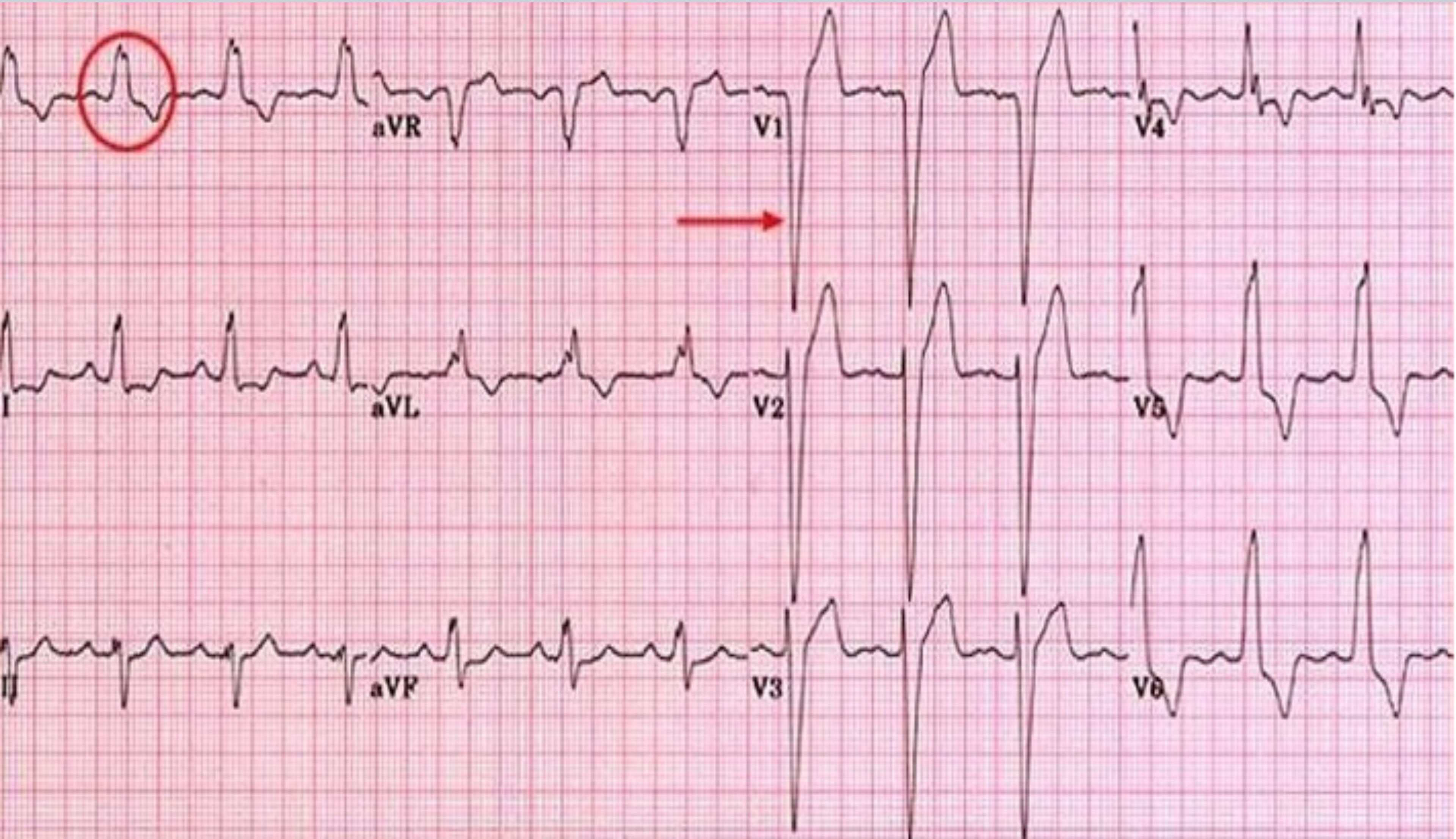


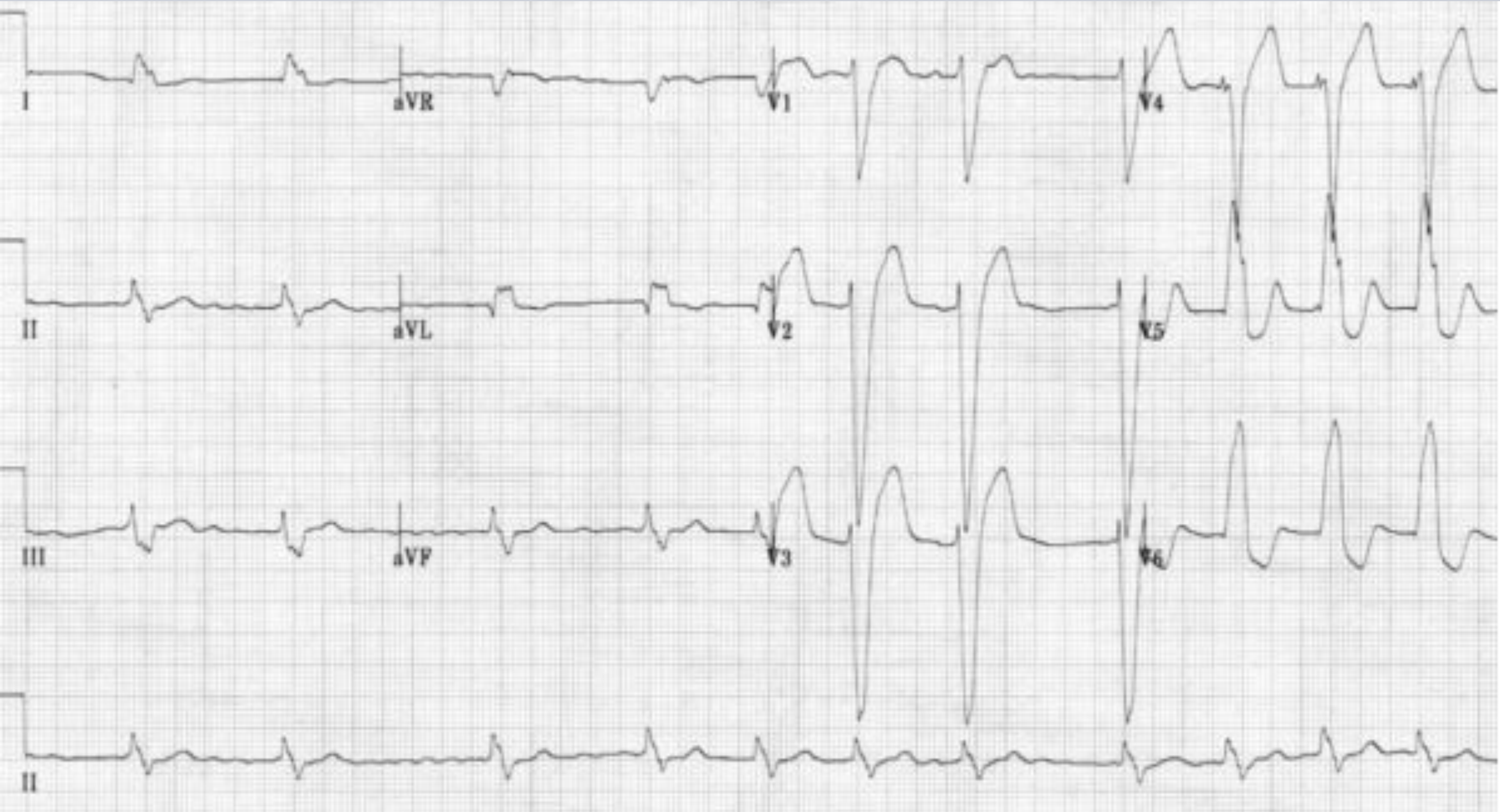
In left bundle branch block, the QRS complexes are wide with a QS or rS complex in V1 and tall monophasic R wave in V6 without septal q wave

The ST segment and T waves are normally discordant.

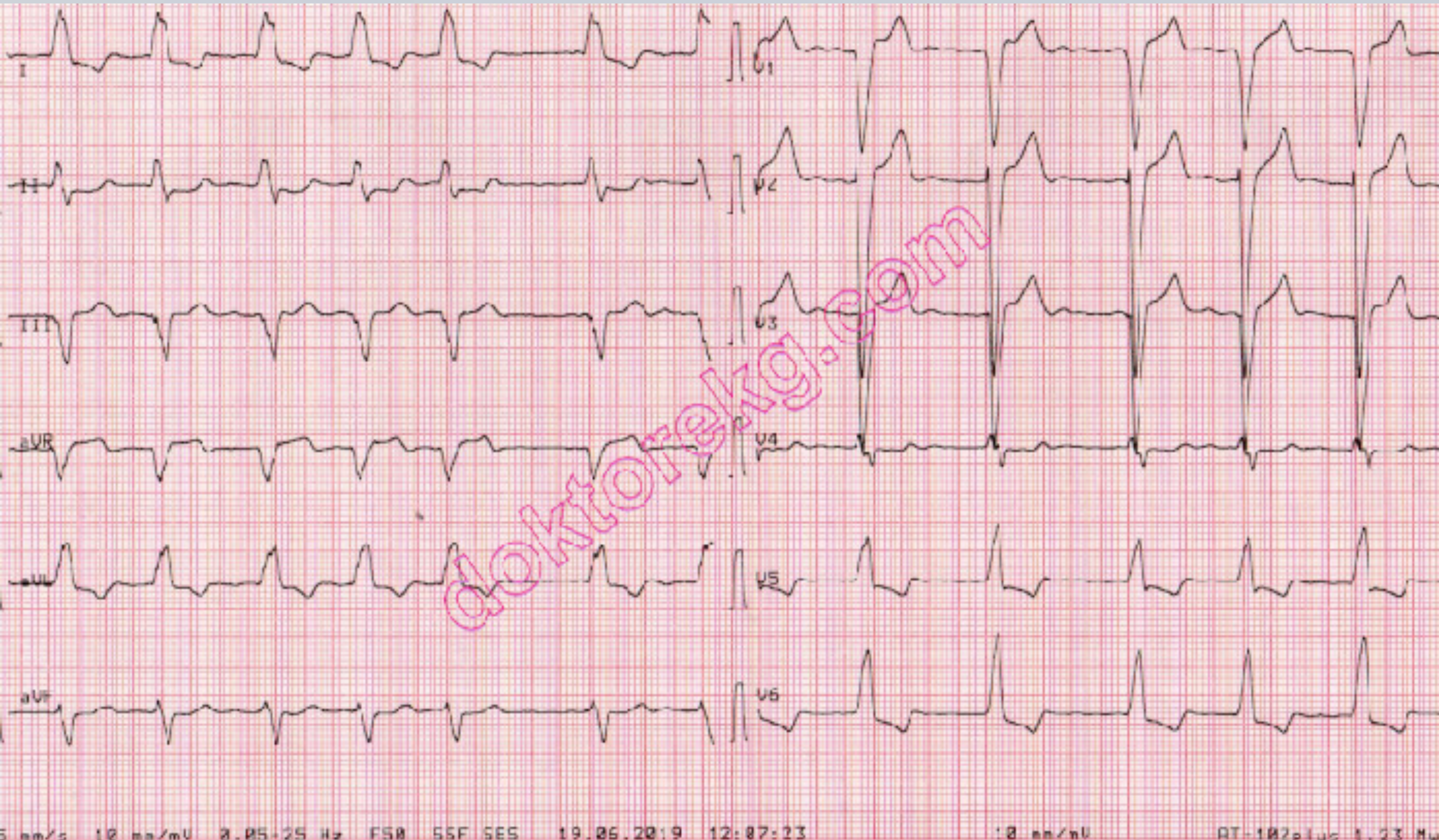


Left Bundle Branch Block



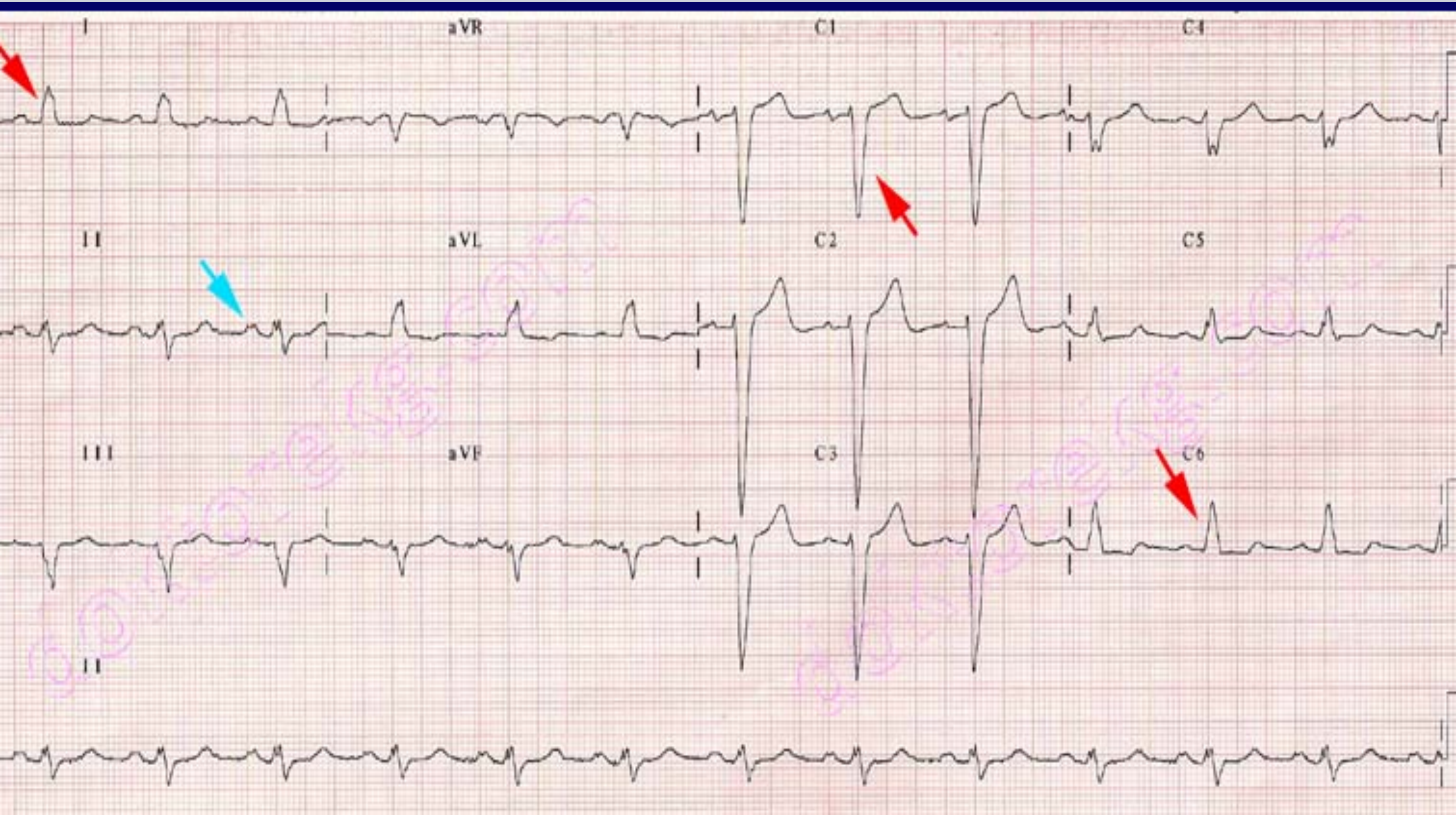

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II

The ECG above is from a 77 years-old woman with left ventricular systolic dysfunction and mild mitral valve stenosis.
The rhythm is atrial fibrillation. Left bundle branch block is also seen.



Left bundle branch block in another patient. This subject also has mitral stenosis.

The notched P wave in lead II suggests left atria abnormality.



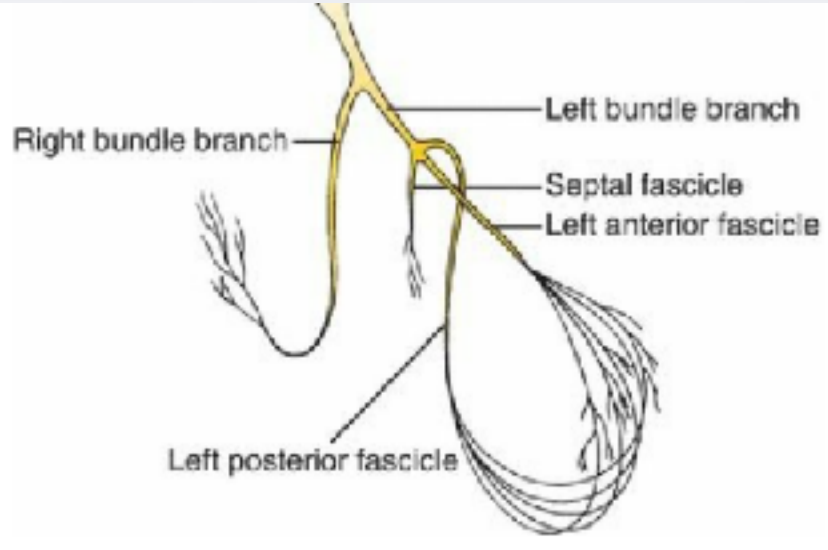

I
aVR
C1
C4
II
aVL
C2
C5
III
aVF
C3
C6
III

Hemiblock (fascicular block)

- The left bundle branch is composed of three separate fascicles.
- Hemiblock- refers to a conduction block of just of the fascicles.
- The right bundle branch does not divide into separate fascicles, only applies to the left ventricular conducting system.

Left anterior hemiblock is more common than left posterior hemiblock, because the anterior fascicle is longer and thinner.

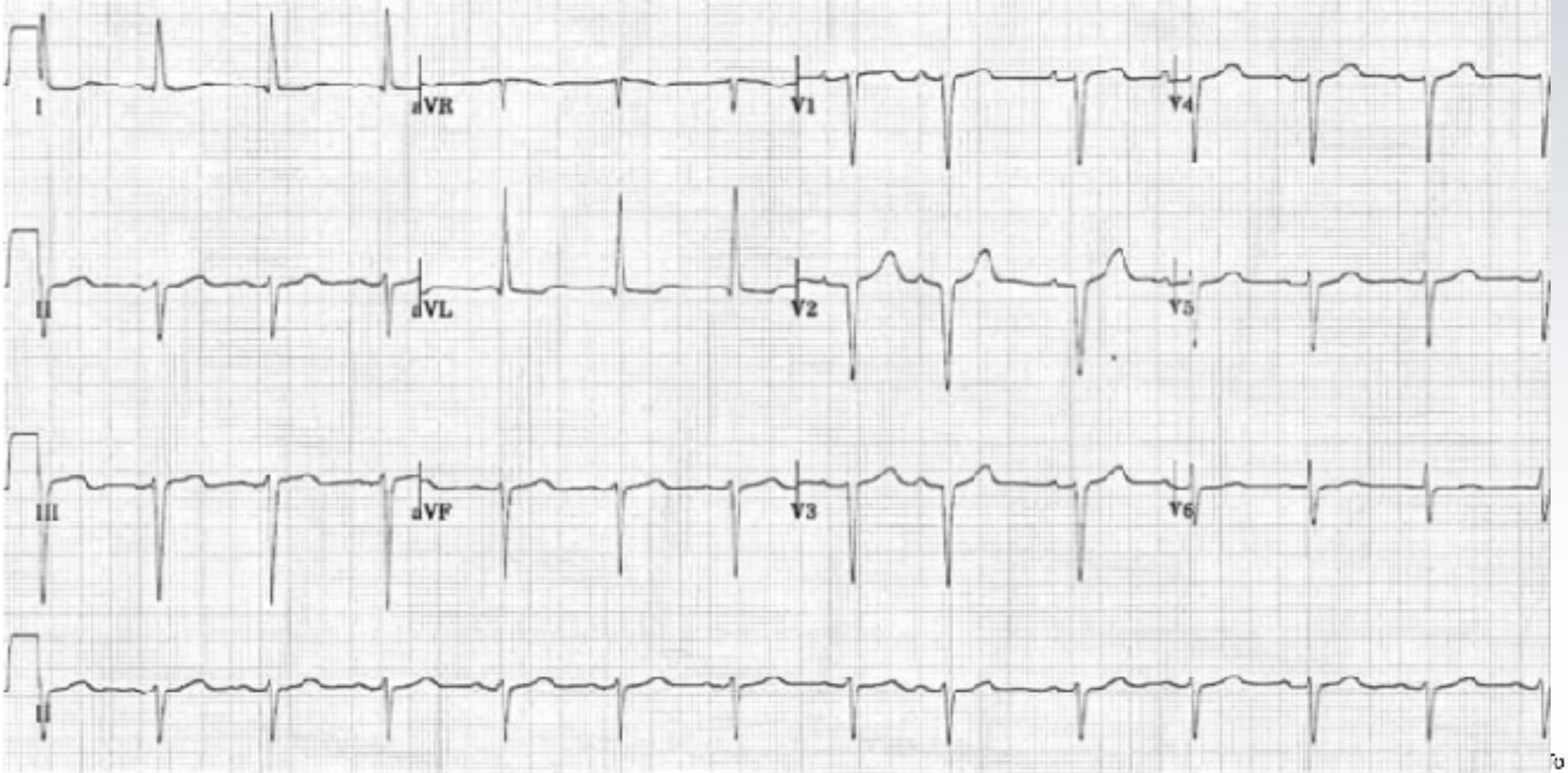
Left anterior hemiblock can be seen in both normal and diseased hearts, whereas left posterior is exclusive of sick hearts.



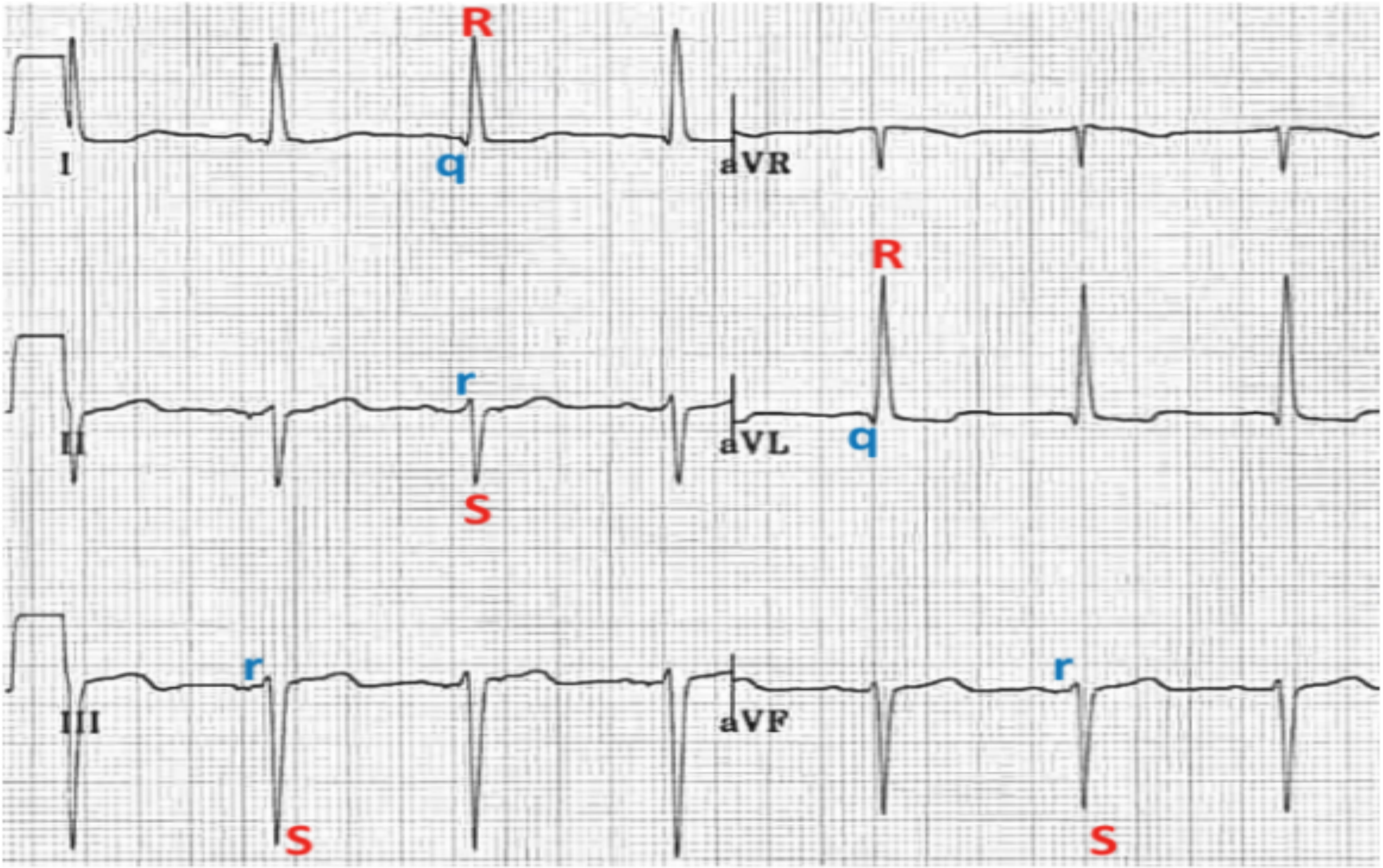
The anatomy of the ventricular bundle branches

Left Anterior Fascicular Block

- Left axis deviation (usually between -45 and -90 degrees)
- Small Q waves with tall R waves (= ‘qR complexes’) in leads I and aVL
- Small R waves with deep S waves (= ‘rS complexes’) in leads II, III, aVF
- QRS duration normal or slightly prolonged (80-110 ms)

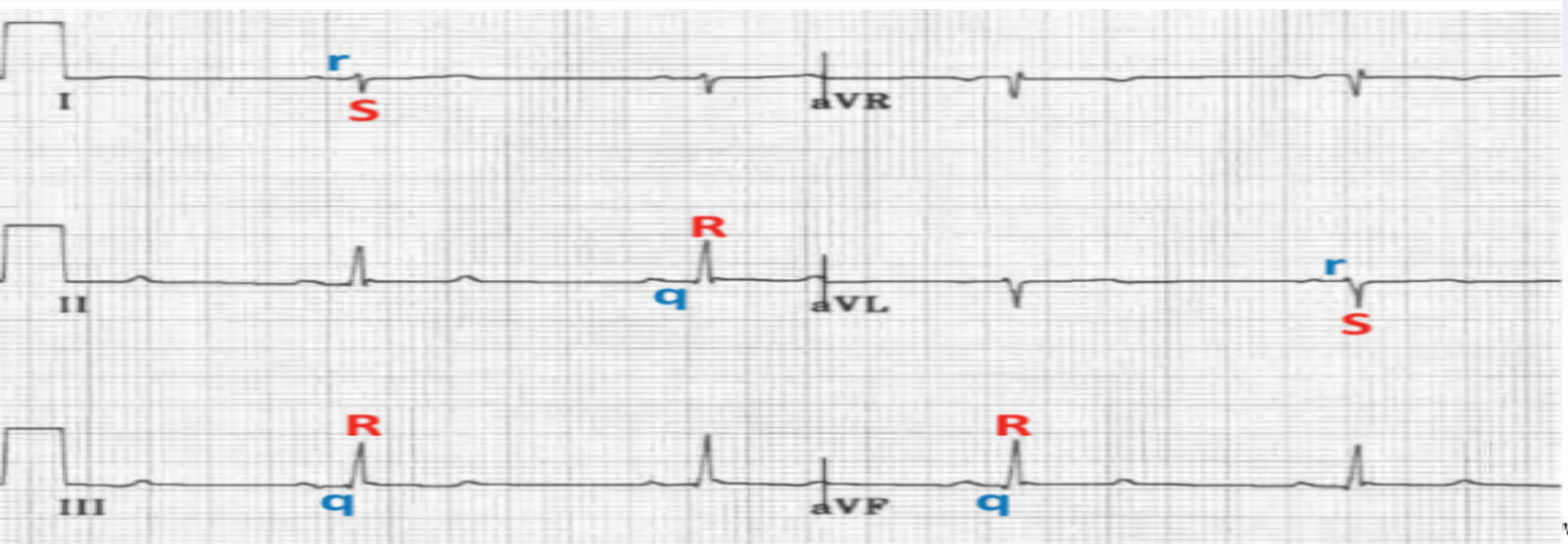


Left Anterior Hemiblock

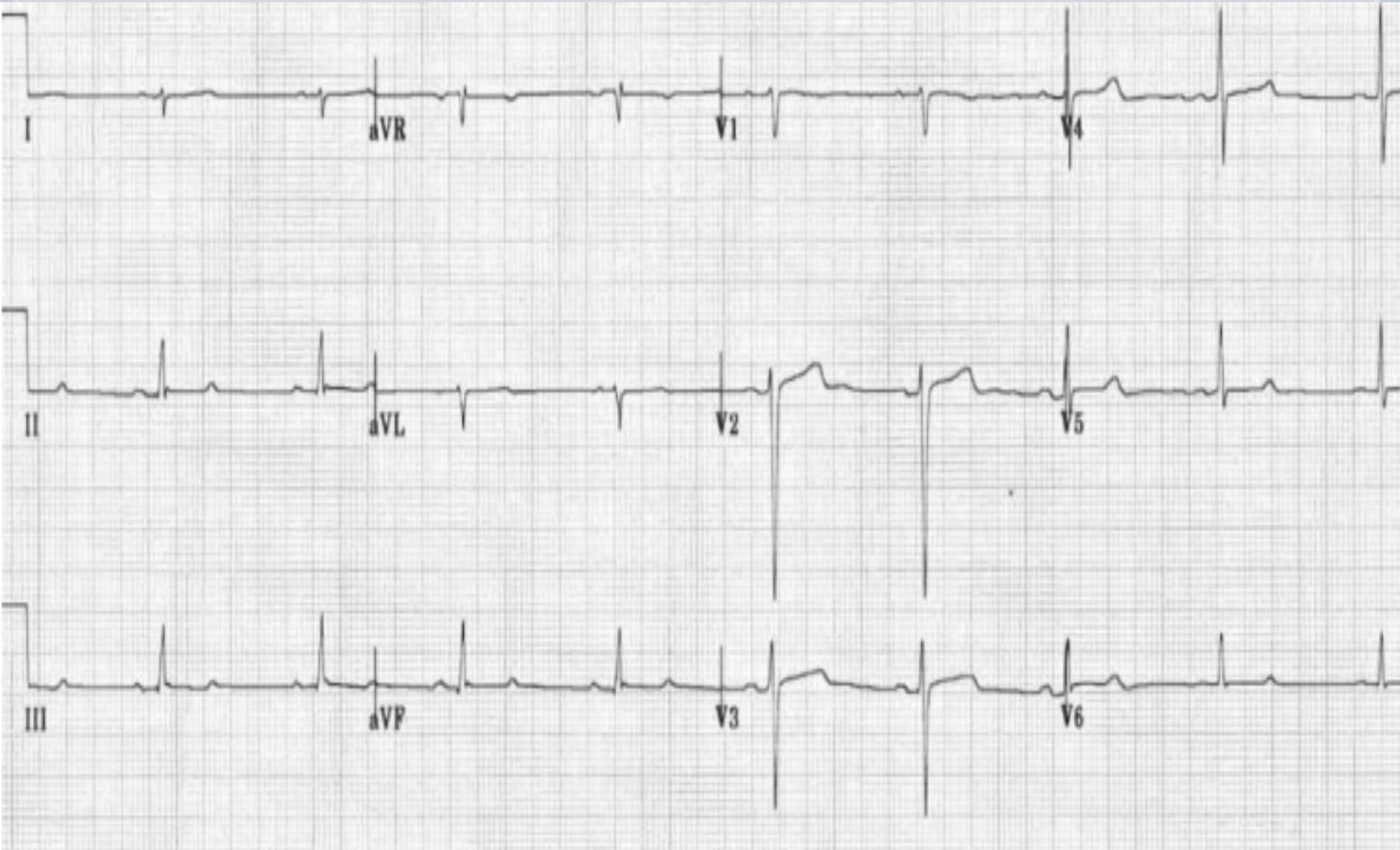


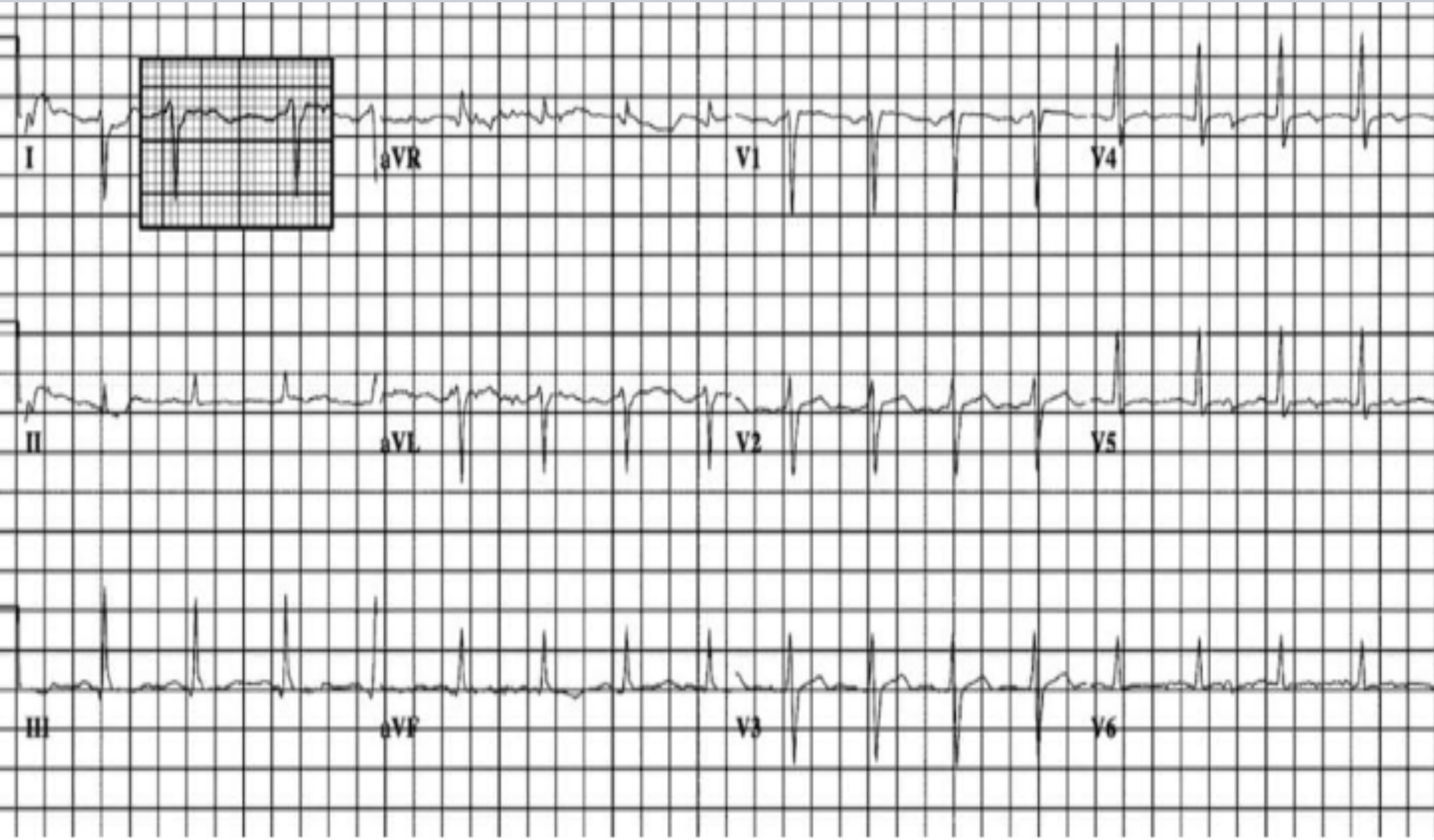
Left Posterior Fascicular Block (LPFB)

- Right axis deviation (RAD) (> +90 degrees)
- Small R waves with deep S waves (= ‘rS complexes‘) in leads I and aVL
- Small Q waves with tall R waves (= ‘qR complexes‘) in leads II, III and aVF
- QRS duration normal or slightly prolonged (80-110ms)
- Prolonged R wave peak time in aVF
- Increased QRS voltage in the limb leads
- No evidence of right ventricular hypertrophy
- No evidence of any other cause for right axis deviation



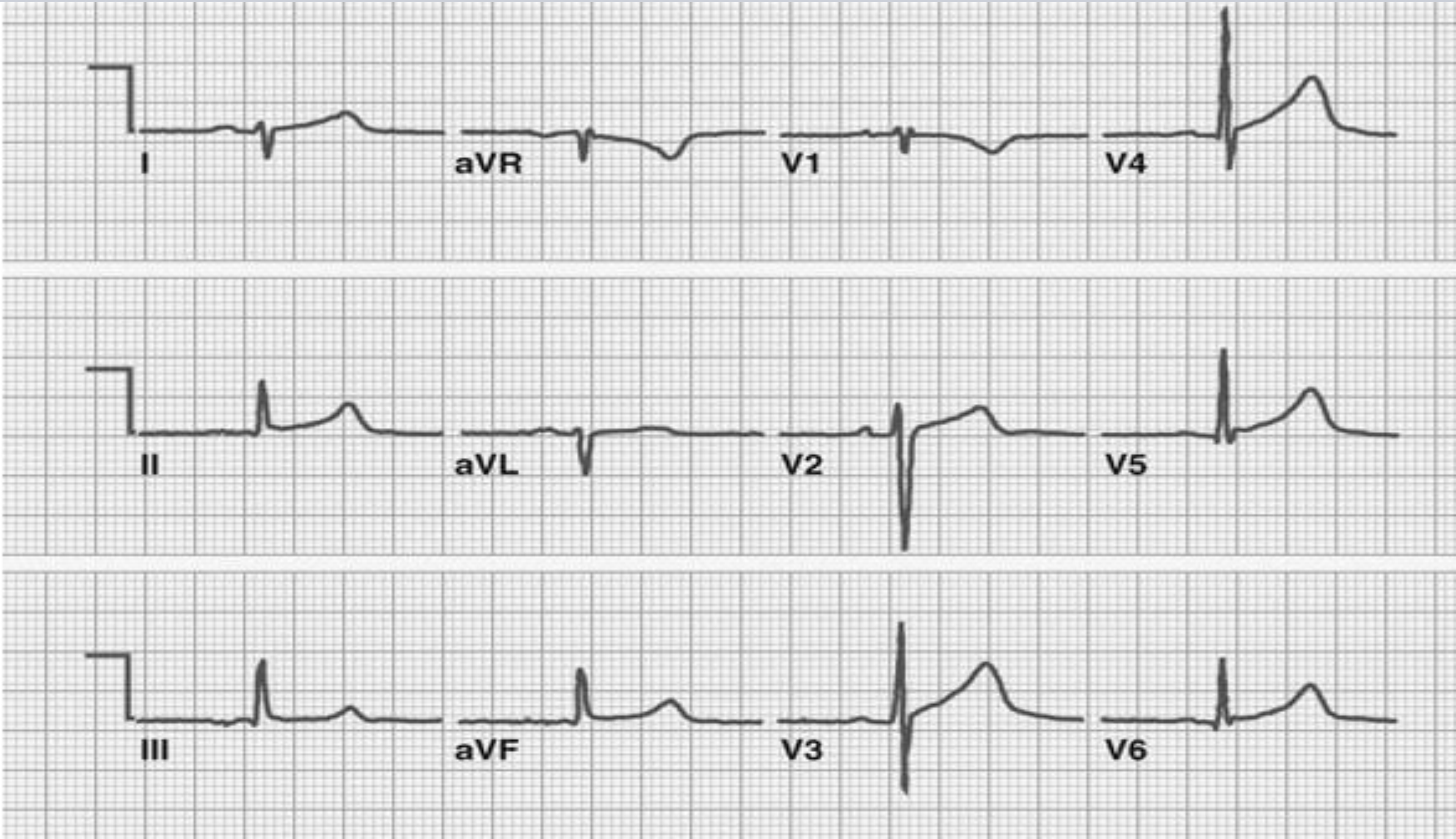
Left Posterior Fascicular Block (LPFB)




I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6

Left Posterior Fascicular Block (LPFB)

- It is extremely rare to see LPFB in isolation. It usually occurs along with RBBB in the context of a bifascicular block.
- Do not be tempted to diagnose LPFB until you have ruled out more significant causes of right axis deviation (acute pulmonary embolus; lateral STEMI; and right ventricular hypertrophy).


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6