



Heart rate disorders

Heart functions

Automatism - the ability of the cells to generate impulses without external stimulation.

Conductivity - the ability of the heart to carry impulses from their place of origin to the contractile myocardium (atria and ventricles).

Excitation - the ability of the cells of the conductive system of the heart and the contractile myocardium to respond to irritation by the generation of PD.

Contractility - The ability of the heart to contract when excited.

SA Node

AV Node

**Right
Bundle
Branch**

**Right
Ventricle**

**Bundle
of His**

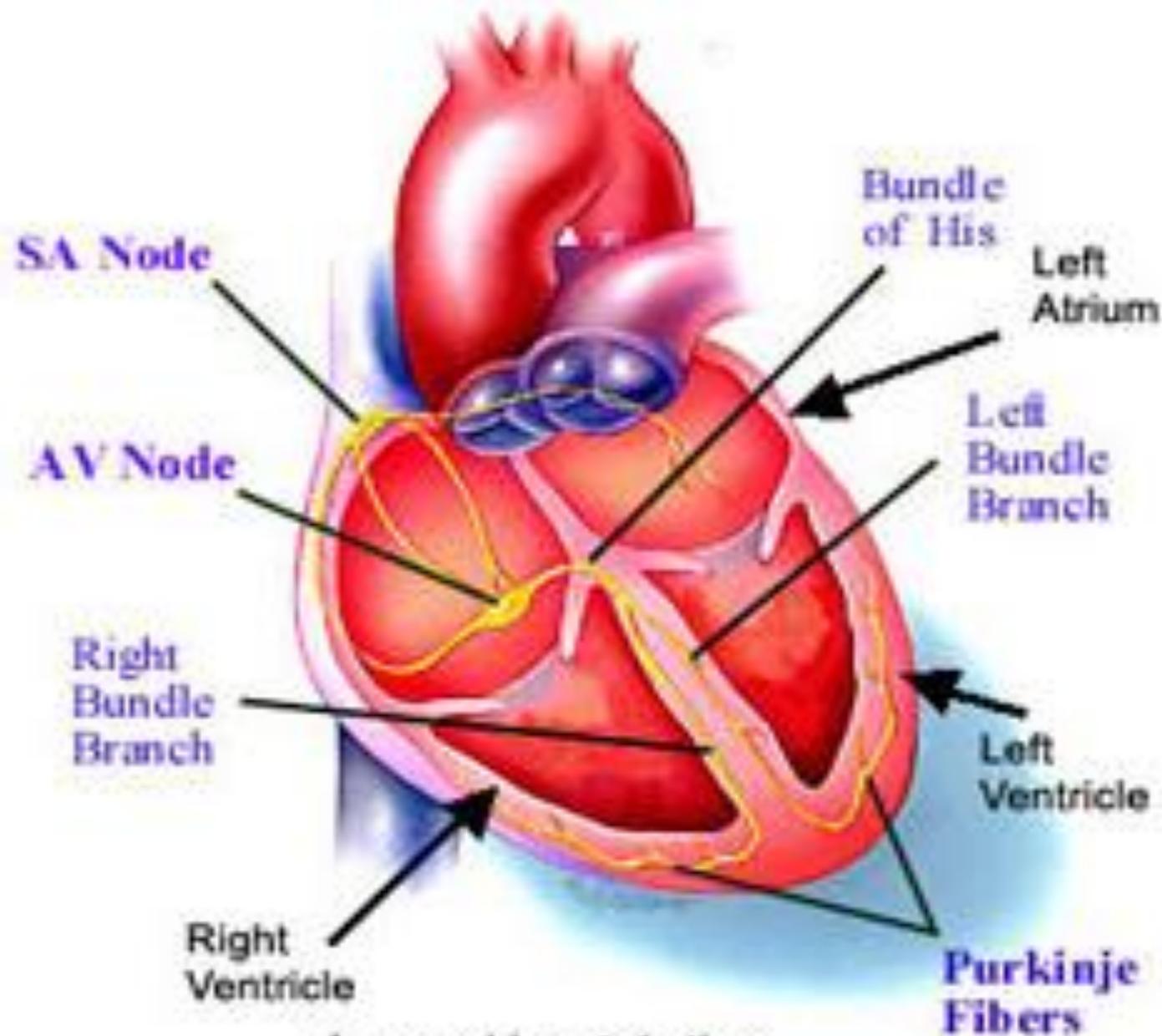
**Left
Atrium**

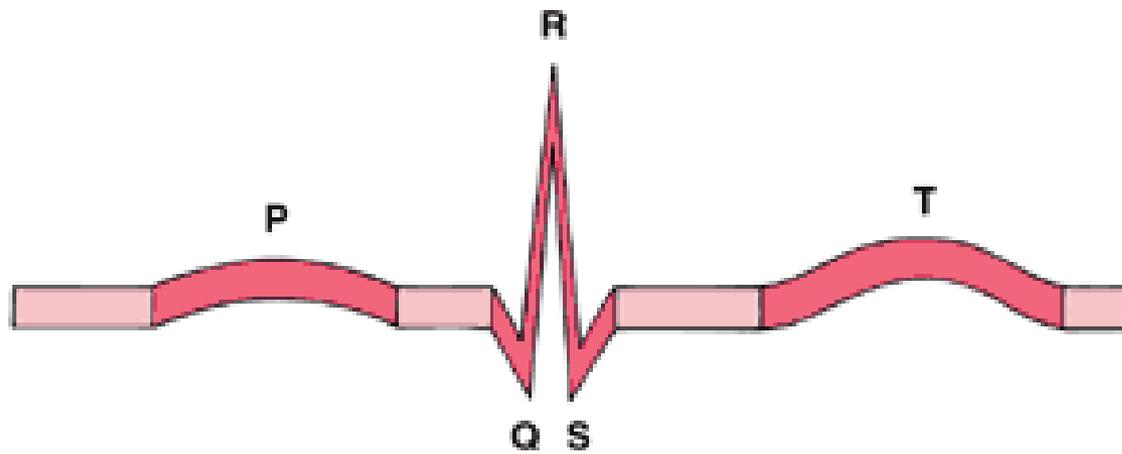
**Left
Bundle
Branch**

**Left
Ventricle**

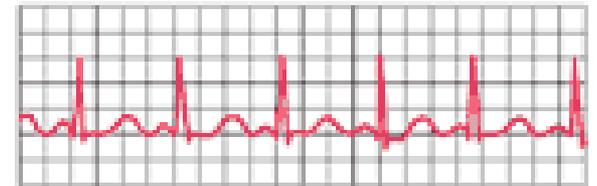
**Purkinje
Fibers**

A normal heart rhythm

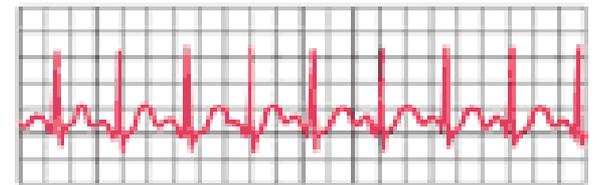




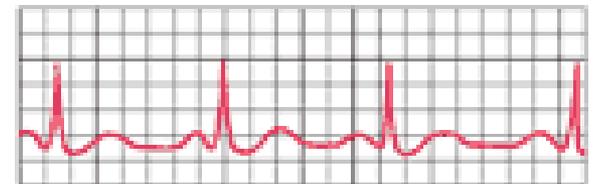
Normal Heartbeat



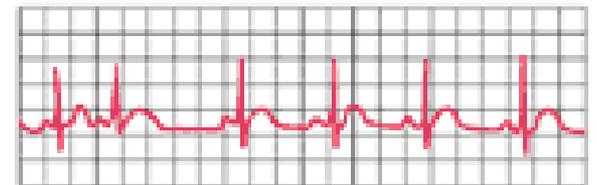
Fast Heartbeat



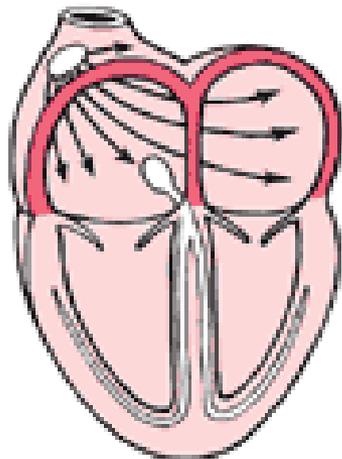
Slow Heartbeat



Irregular Heartbeat

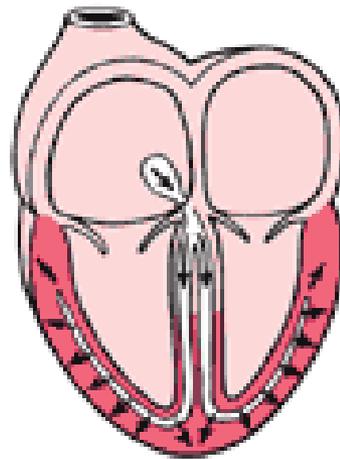


P Wave



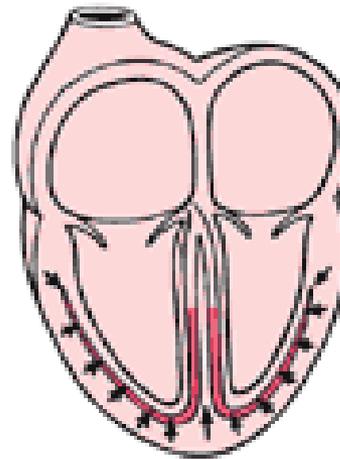
Activation of the atria

QRS Complex



Activation of the ventricles

T Wave



Recovery wave

Characteristics of the normal electrocardiogram

The normal electrocardiogram is composed of a P wave, a QRS complex, and a T wave. The **P wave** is caused by electrical potentials generated when the atria depolarize before atrial contraction begins. The **QRS complex** is caused by potentials generated when the ventricles depolarize before their contraction, that is, as the depolarization wave spreads through the ventricles. Therefore, both the P wave and the components of the QRS complex are depolarization waves. The T wave is caused by potentials generated when the ventricles recover from the state of depolarization. The **T wave** is known as a repolarization wave.

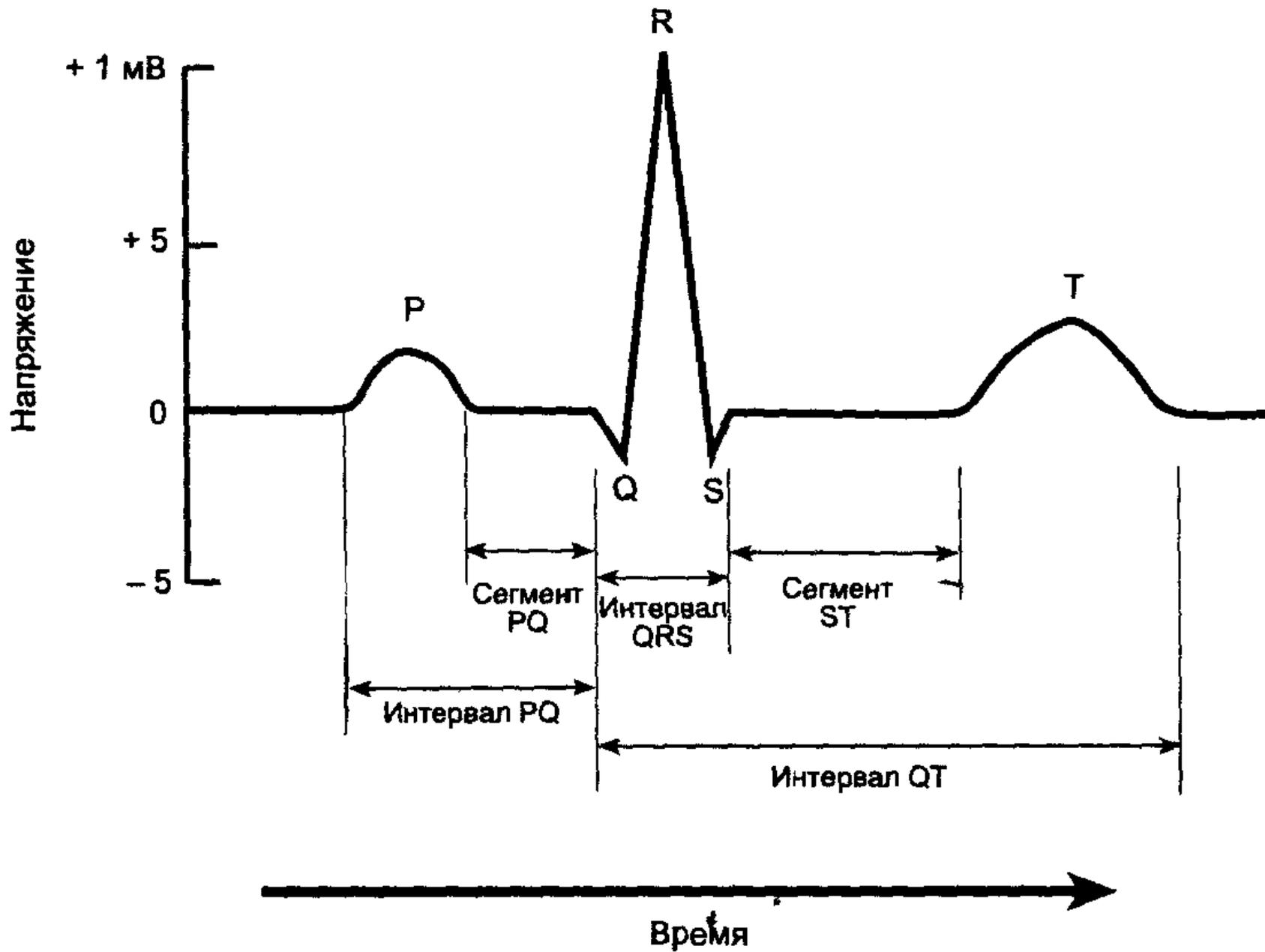
Characteristics of normal sinus rhythm include:

P wave 0,06-0,10s

Interval P-Q 0,12-0,2s

QRS complex – 0,12s

T wave – 0,16-0,24s



ECG evaluation

1. Determine the source of excitation.
2. Evaluation of the regularity of the heart rate.
3. Evaluation of heart rate

If the rhythm is regular,

$$HR = 60 / R-R(s)$$

$$50 \text{ mm/s} - 1\text{mm} = 0,02\text{s}$$

$$25 \text{ mm/s} - 1\text{mm} = 0,04\text{s}$$



Arrhythmia is the condition, which is characterized by the violation of such heart physiological properties, as **automatism, conduction of impulses through conductive ways, contractive myocardium properties** by the violation of frequency, rhythm or coordination of heart beats.

Etiology of heart rhythm disorder

- 1) Functional violations and influences: violation of autonomous nerves system condition (sympathetic or parasympathetic link hyperactivity), physical work, body temperature changes;
- 2) Organic injury of myocardium: inflammation of myocardium, necrosis of myocardium;
- 3) Influences of toxic substances on the myocardium (alcohol, drugs, big dose adrenalin and noradrenalin, glucocorticoids, bacterial toxins);
- 4) Hormone balance disorder (hyperthyroidism, hypothyroidism, hyperfunction of supranephral glands);
- 5) Violation of intracellular or extracellular ions balance (changes of sodium, potassium, calcium, magnesium and chlorine concentration)

ARRHYTHMIAS CLASSIFICATION

- **Automatism violations**
- **Excitability violations**
- **Conduction violations**

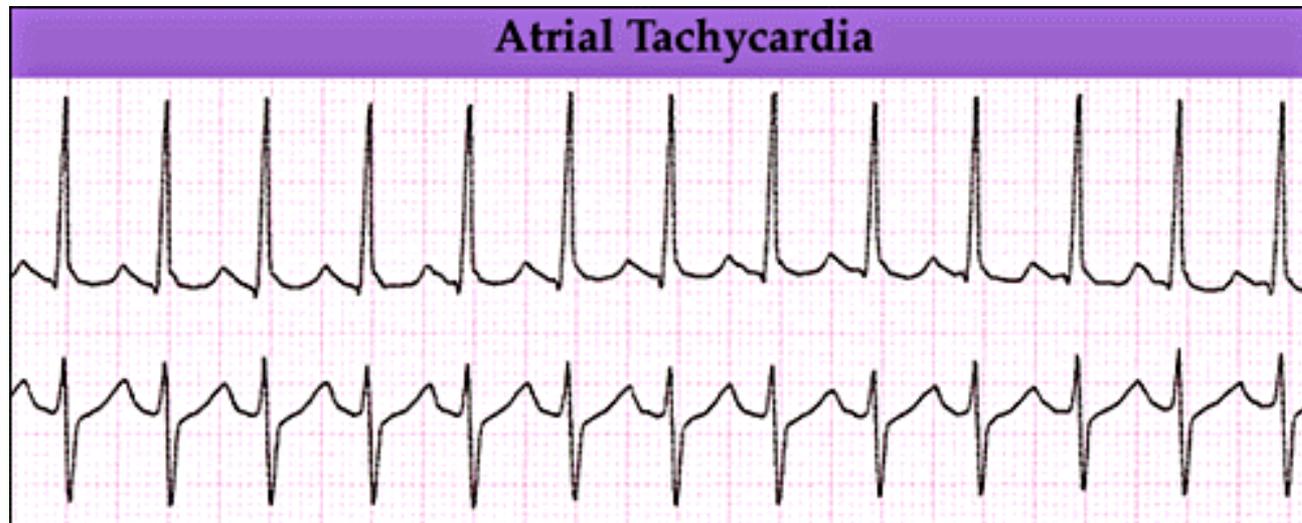
- **Combined violations (conduction and excitability)**

Nomotopic Automatism violation

Sinus tachycardia

Reasons: physical load, emotional stress, heart failure, myocardium ischemia or infarction, fever

ECG: rapid sinus rhythm, HR 90-180 /min, all waves have normal configuration, P wave precedes each QRS complex (sinus rhythm), all R-R are shortened.

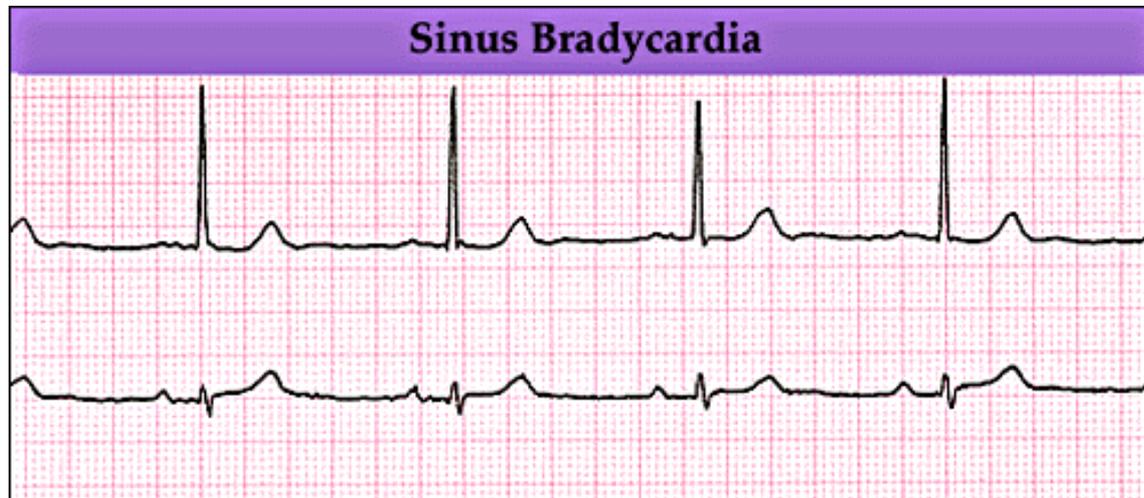


Nomotopic Automatism violation

Sinus bradycardia

Reasons: n. Vagus high activity (sportsmen), during sleep). This arrhythmia may cause heart output decrease and leads to cerebral or coronary blood flow insufficiency.

ECG: slow sinus rhythm, HR 59-40 /min, all waves have normal configuration, normal P wave and PQ interval precedes each QRS complex (sinus rhythm), all R-R are lengthened.



Nomotopic Automatism violation

Sinus (respiratory) arrhythmia

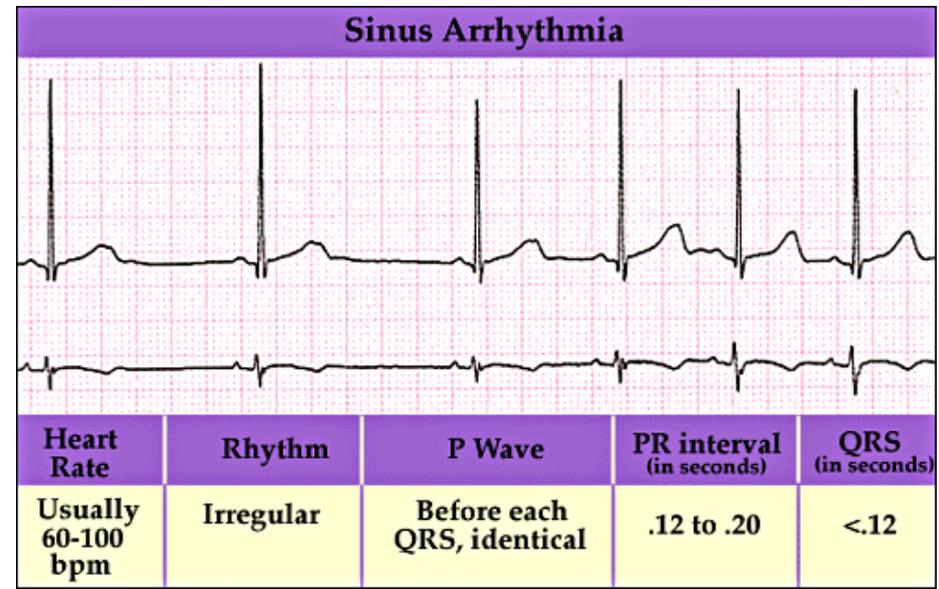
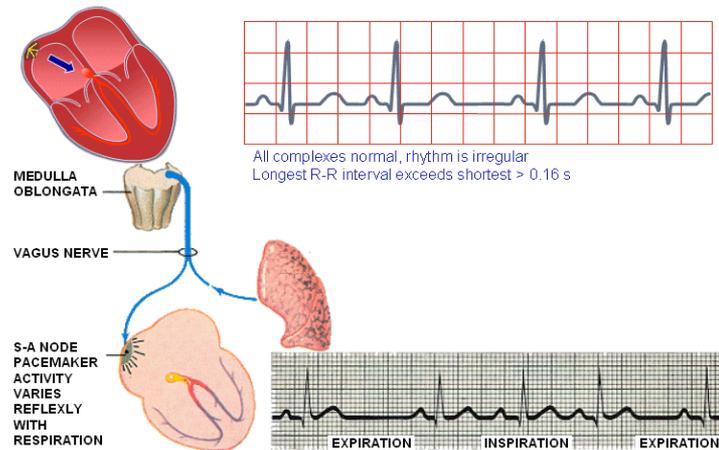
Reasons: breathing (in children), after viruses infections, neurocirculative dystonia

Characterized by gradually lengthening (at expiration) and shortening (at inspiration) R-R intervals and is the result of intrathoracic pressure changes during respiration.

ECG: sinus rhythm, difference between the shortest R-R and longest R-R $>0,15$ sec

SINUS ARRHYTHMIA

Impulses originate at S-A node at varying rate



Heterotopic rhythms. They are the result of ectopic automaticism driver activation that is localized **out SA node** (for example, in atrium, in AV-node or in ventricle) because SA node failure (reasons - digitalis toxicity, myocardial infarction, hyper- or hypokalemia).

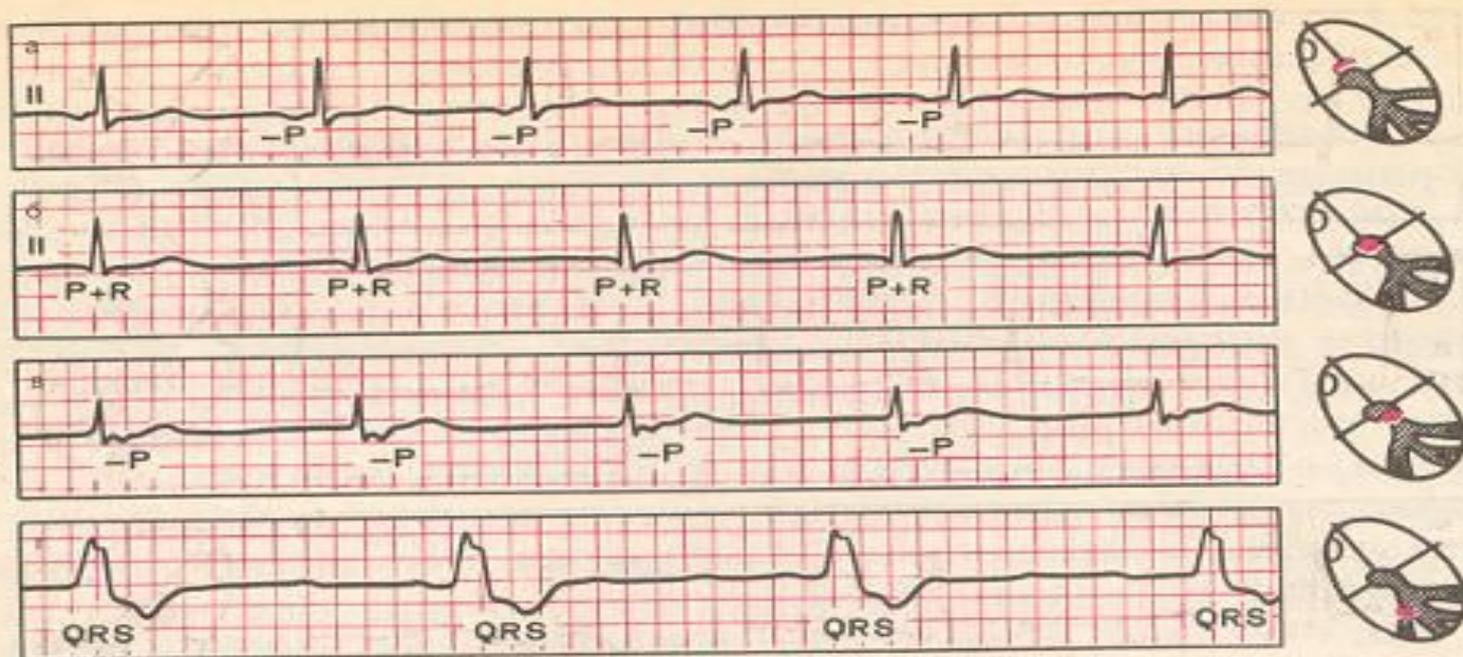


Рис. 5.2. ЭКГ больных с медленными (замещающими) выскальзывающими ритмами.

а — предсердный ритм; б — ритм из АВ-соединения с одновременным возбуждением желудочков и предсердий; в — ритм из АВ-соединения с возбуждением желудочков, предшествующим возбуждению предсердий; г — желудочковый (идиовентрикулярный ритм).

Conduction violations - block

Conduction violations are the results from abnormality impulse conduction.

Conduction block can arise:

- between SA node and atrium
- inside atrium
- In the AV nodal fibers,
- in bundle of His,

Conduction violations

Sinus atrial block

Violation of impulses transmission from SA-node to atriums

ECG : PQRST complex is absent

compensatory pause is equal 2 (R-R)

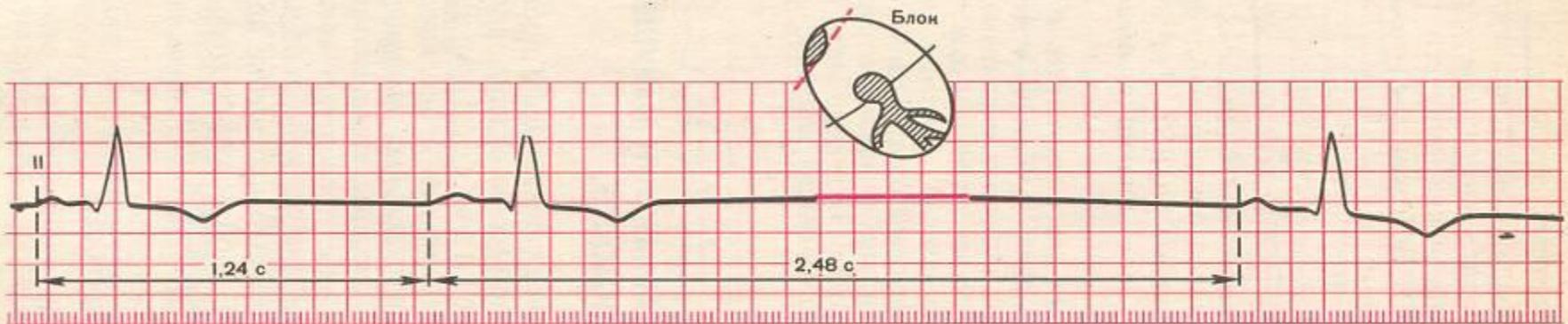


Рис. 6.1. ЭКГ при синоатриальной блокаде.

Conduction violations

Atrial block

Violation of impulses transmission through the atrium conductive system

ECG : P duration $> 0,11$ sec, P - deformed (two waved)

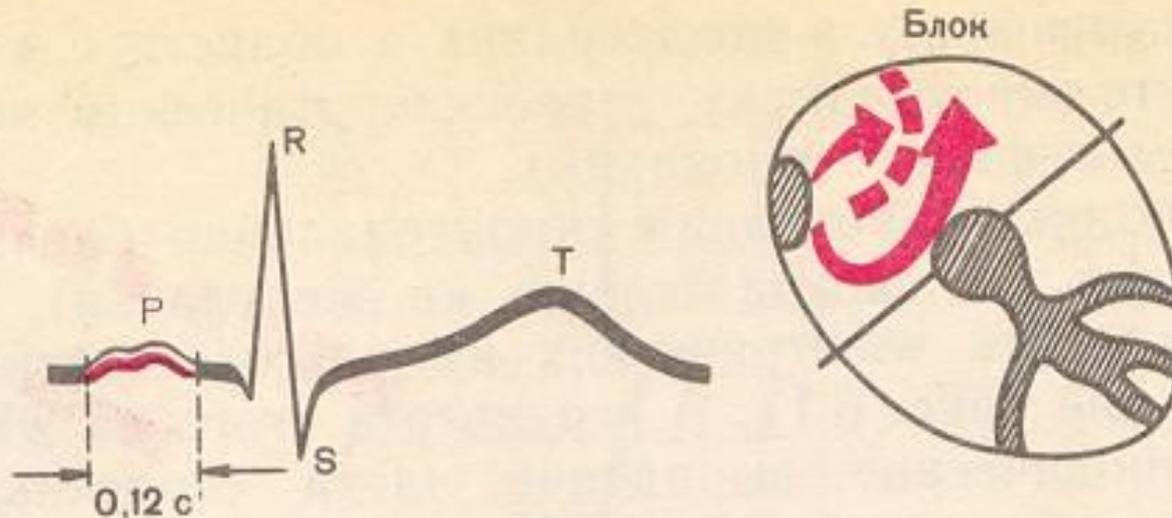


Рис. 6.2. ЭКГ при внутрисердечной блокаде.

Conduction violations

AV-block

Violation of impulses transmission through the AV node

1 degree

2 degree: Mobitz type I, Mobitz type II, type III (**high degree AV block**)

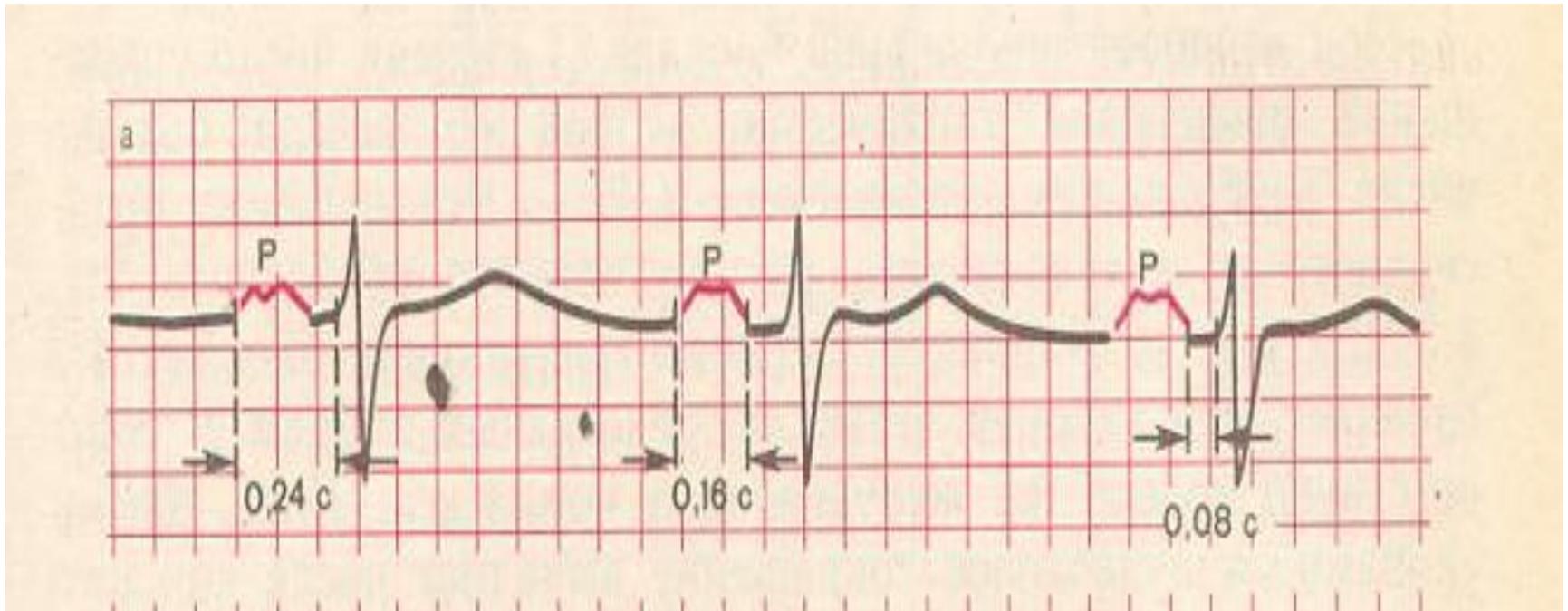
3 degree (**complete AV block**)

Conduction violations

AV-block

1 degree

ECG : prolonged P-Q interval (**>0,2 sec**)
in the result of retardation impulses
conduction from atria to ventricles
through AV node.



Conduction violations

AV-block

2 degree

* **Mobitz type I (period of Wenckebach)** - **Progressive increase of PQ duration** (Wenckebach's periods) until an impulse is blocked with after fall out QRST and then the cycle repeats again. R-R are different, rhythm is irregular and there are more P waves than QRS complexes.

Mobitz type II - **PQ are prolonged but their length is constant**
QRST fall out (periodicity is 3:1, some time 4:1)

Symptoms: dizziness, unconsciousness

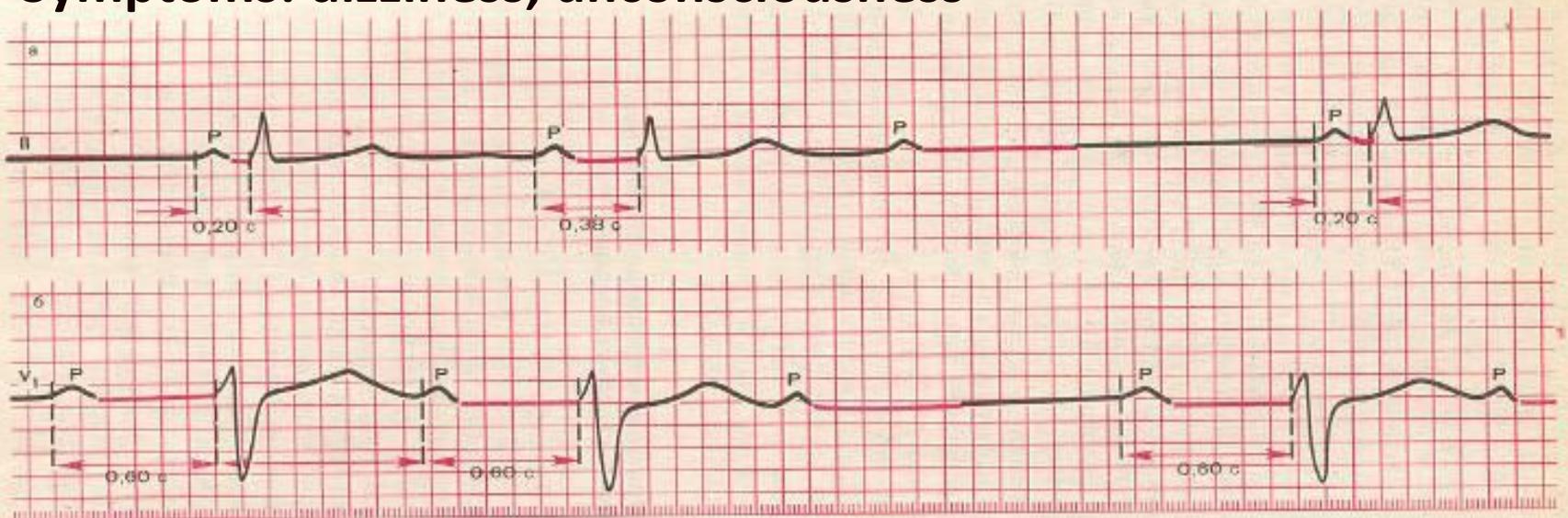


Рис. 6.5. ЭКГ при атриовентрикулярной блокаде II степени (3:2).
а — I тип (с периодами Самойлова — Венкебаха); б — II тип.

Conduction violations

AV-block

2 degree

Mobitz type III

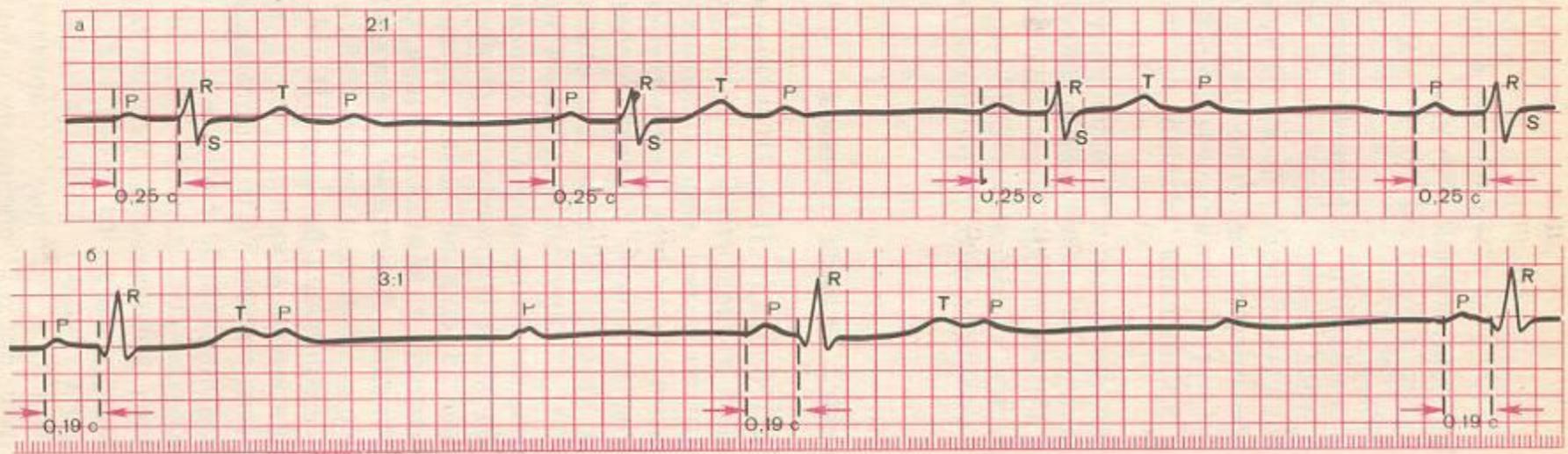


Рис. 6.6. ЭКГ при атриовентрикулярной блокаде II степени (III тип, или неполная атриовентрикулярная блокада высокой степени).

а — 2:1; б — 3:1.

Conduction violations

AV-block

3 degree (complete)

- The conduction link between the atria and ventricles is lost.
- Independent excitation and contraction of the atriums and ventricles
- The atria continue to beat at a normal rate and the ventricles develop their own rate, which normally is slow (30-40/min, idioventricular rhythm)

ECG : P amount > QRS amount, P waves and QRS complexes appear **independently**.

It causes periods of syncope, known as a Stokes-Adams attack (sings: asystole more than 10-20 sec, a decrease of cardiac output, insensibility, convulsions, possible death).

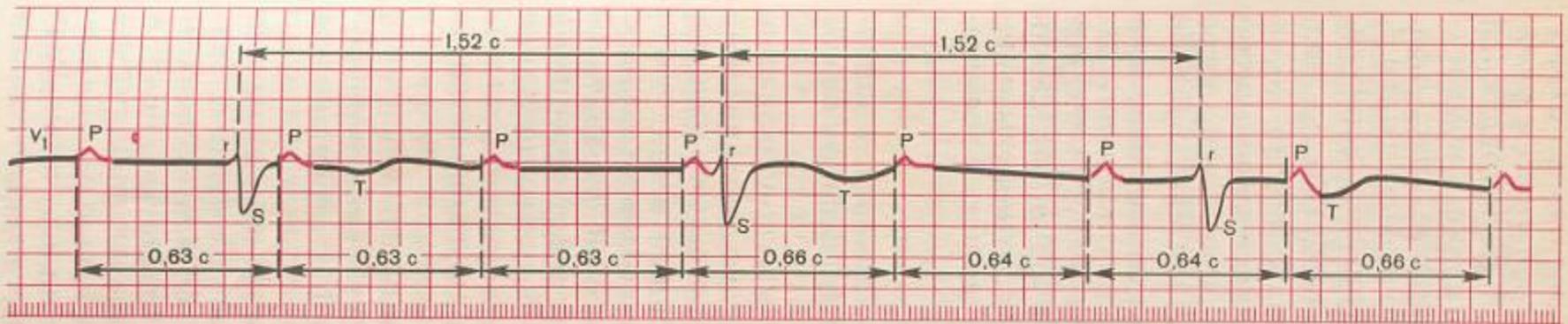


Рис. 6.7. ЭКГ при полной атриовентрикулярной блокаде (III степень). Полное разобщение ритма предсердий и желудочков. Описание в тексте.

Conduction violations

ventricle block

- **Violation of impulses conduction in ventricle conductive system**

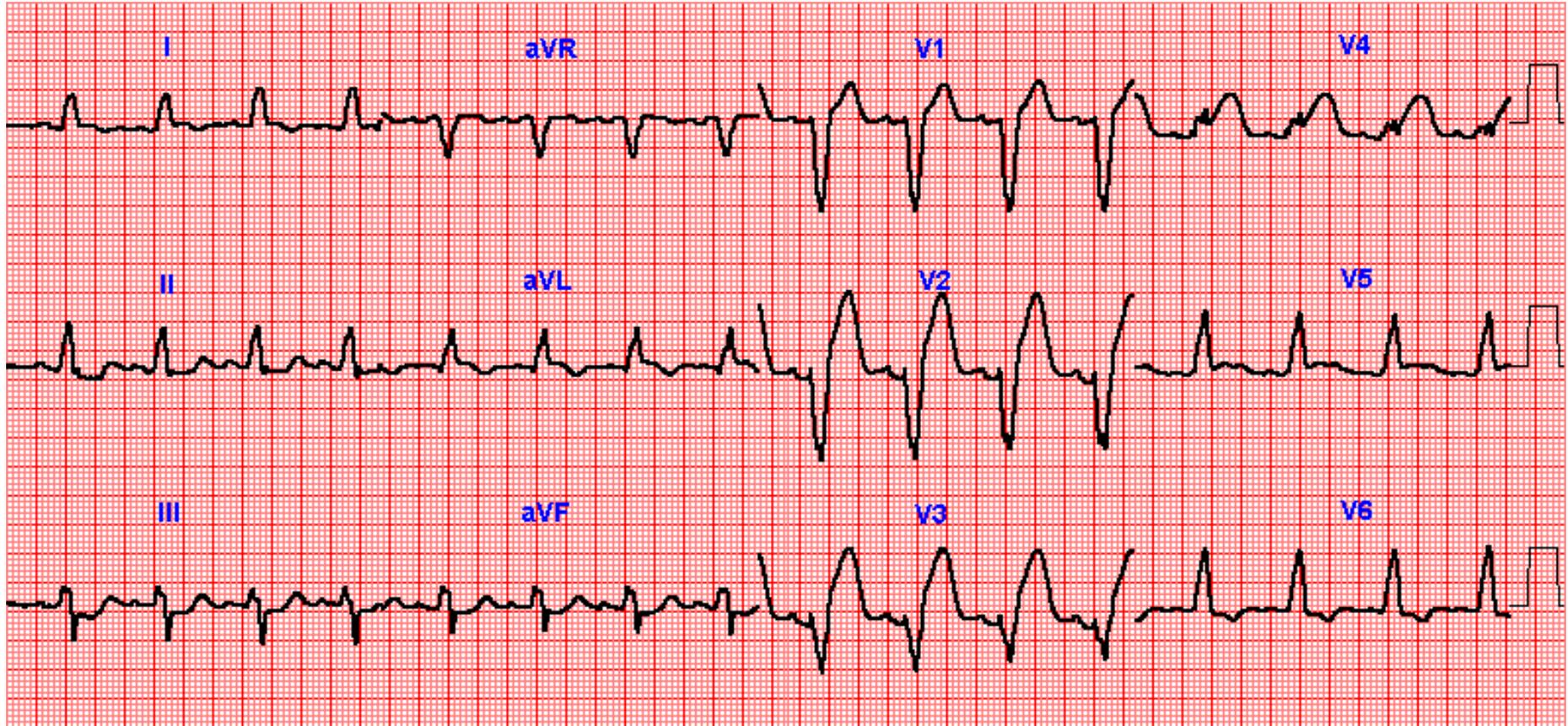
Interruption of impulse conduction through the bundle branches is called bundle branch block. These blocks usually do not cause alterations in the rhythm of the heartbeat. Bundle branch block interrupts the normal progression of depolarization, causing the ventricles to depolarize one after the other because the impulses must travel through muscle tissue rather than through the specialized conductive tissue. It cause the QRS deformation, it is wide (normal is 0.08 to 0.12 second) and distorted.

Giss's bundle branches block

- * **block of 1 branche**
- * **block of 2 branches**

ECG : QRS deformation

Giss's bundle left branche block



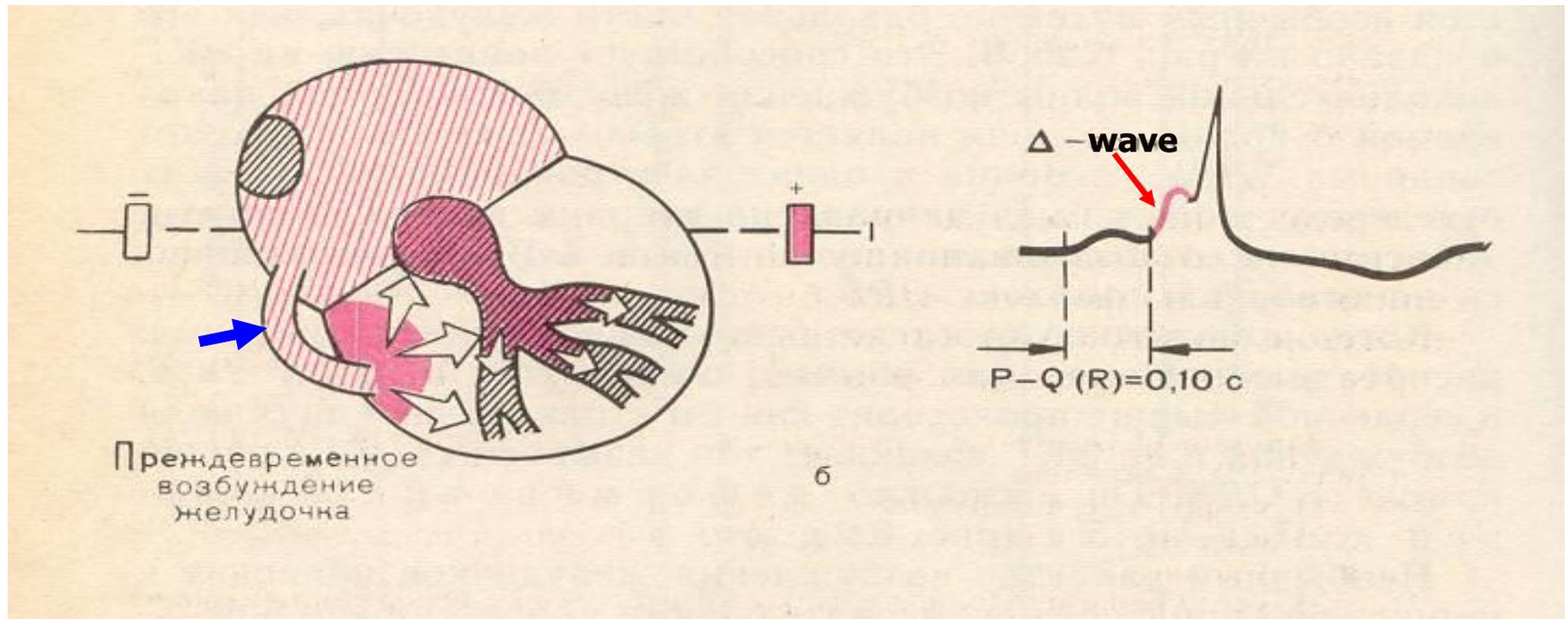
Conduction violations

WPW (Wolff-Parkinson-White) syndrome

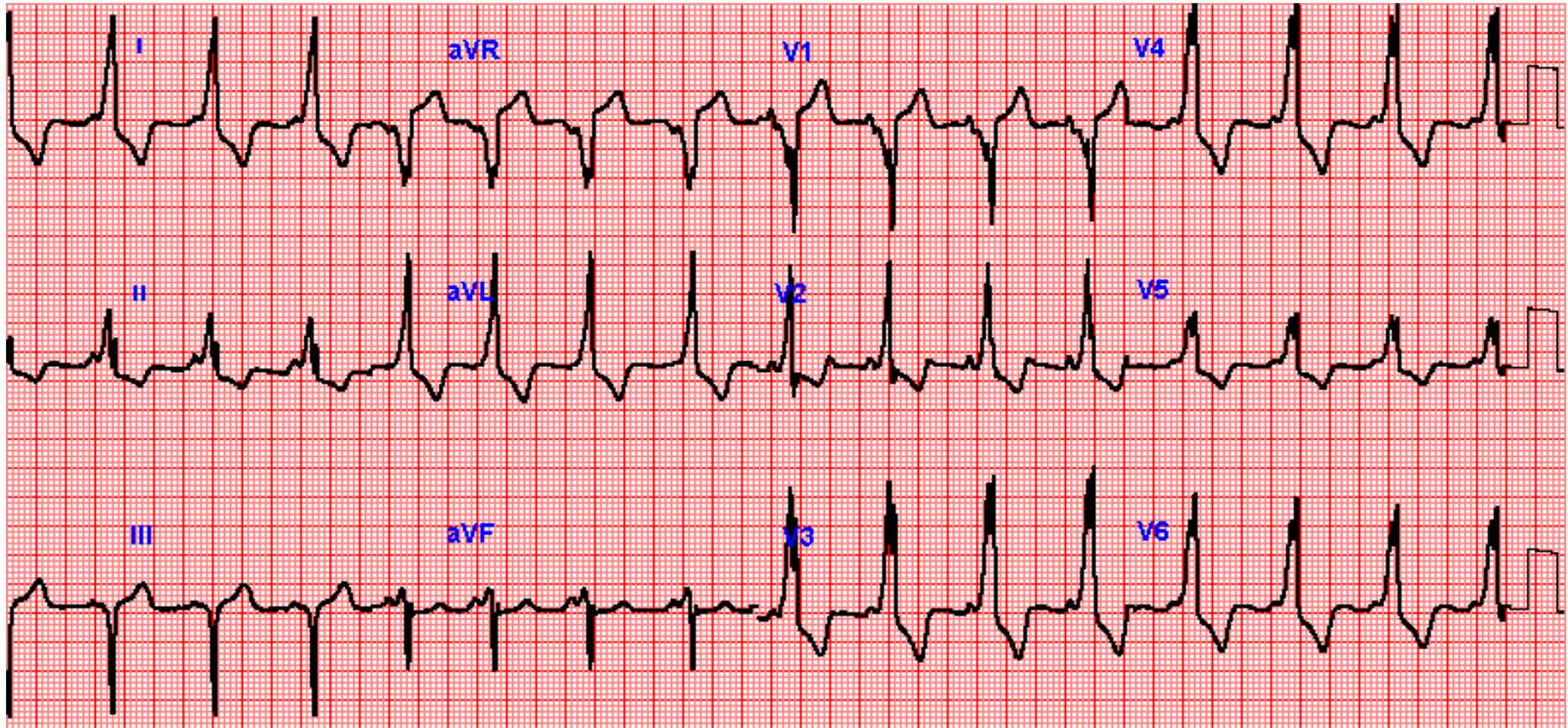
syndrome exists when atrial impulses are transmitted directly to the ventricles through shortcut conduction pathways.

Reason: additional Kent's bungle (impulses don't transmit through the AV node but through Kent's brunch)

ECG : $PQ < 0,12$ sec, QRS is deformed and wide because Δ -wave, ST and T are localized dyscordly, pre-excitation of the ventricles



WPW (Wolff-Parkinson-White) syndrome



Arrhythmias in the result of combined violations

(automatism, conduction and excitability)

- **Extrasistole**
- **Paroxysmal tachycardia**
- **Atrium flutter**
- **Atrium fibrillation**
- **Ventricle flutter (ventricular tachycardia)**
- **Ventricle fibrillation**

Extrasistole

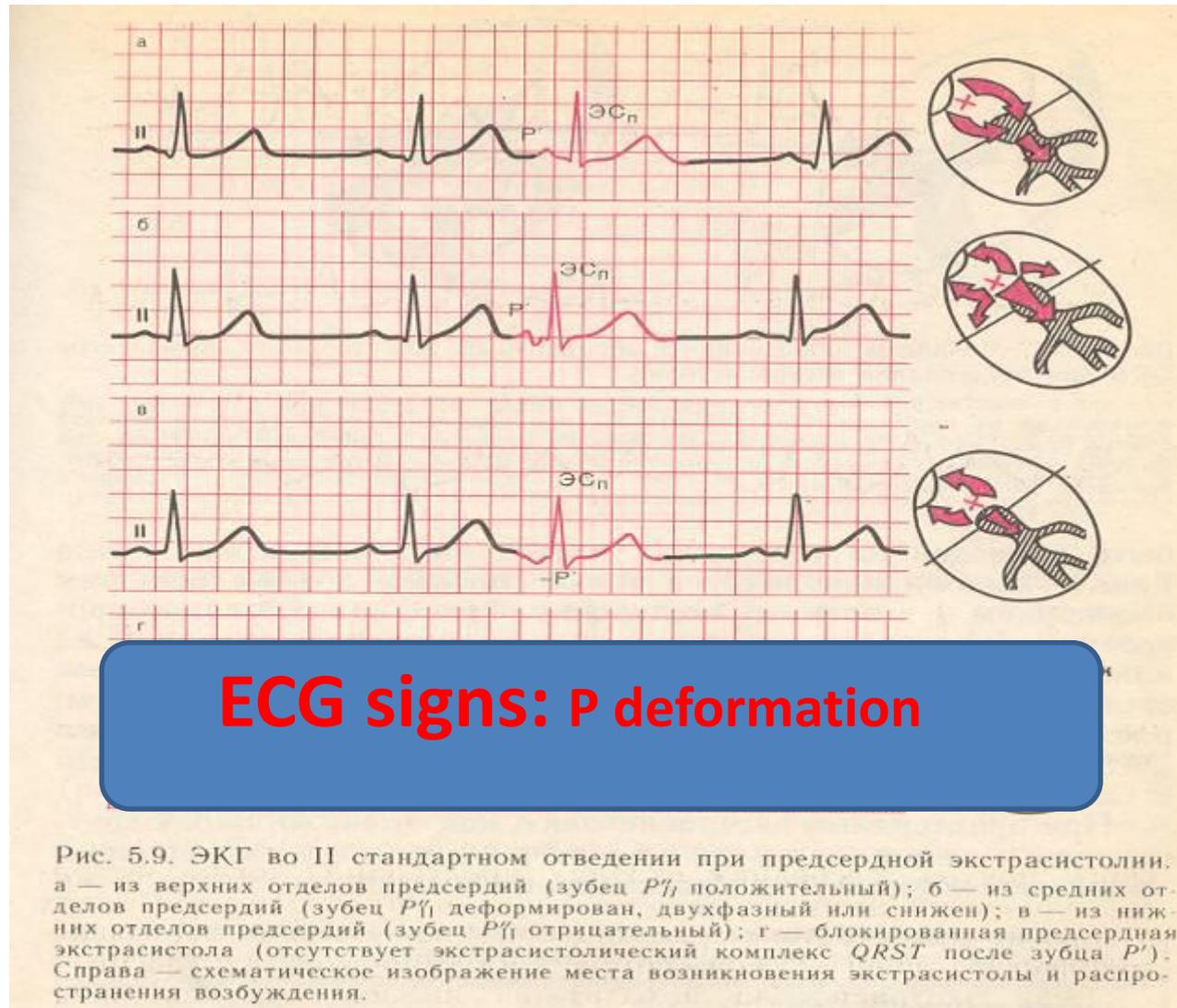
extraordinary systole in the result of ectopic pacemaker activation

New pacemaker (out sinus node) causes beginning excitation wave, which spreads in altered direction.

Dependency on cell localization, where the extraordinary impulse is formed, there are such types of extrasystole: sinus, atrial, atria-ventricular and ventricular.

Extrasistole (atrial)

Atrial extrasystole is the result of ectopic pacemaker activation in different parts of atria. It is characterized by P wave distortion (depressed, dysphasic, and negative) because excitation wave goes retrograde.



Extrasistole (from AV node)

Atrial-ventricular extrasystole is observed at ectopic pacemaker in AV node. Excitation wave spreads in two directions: in ventricles – in normal, in atria – in retrograde. So, P wave is negative or after normal QRS complex or can be coincide with QRS.

ECG signs: P appears after QRS

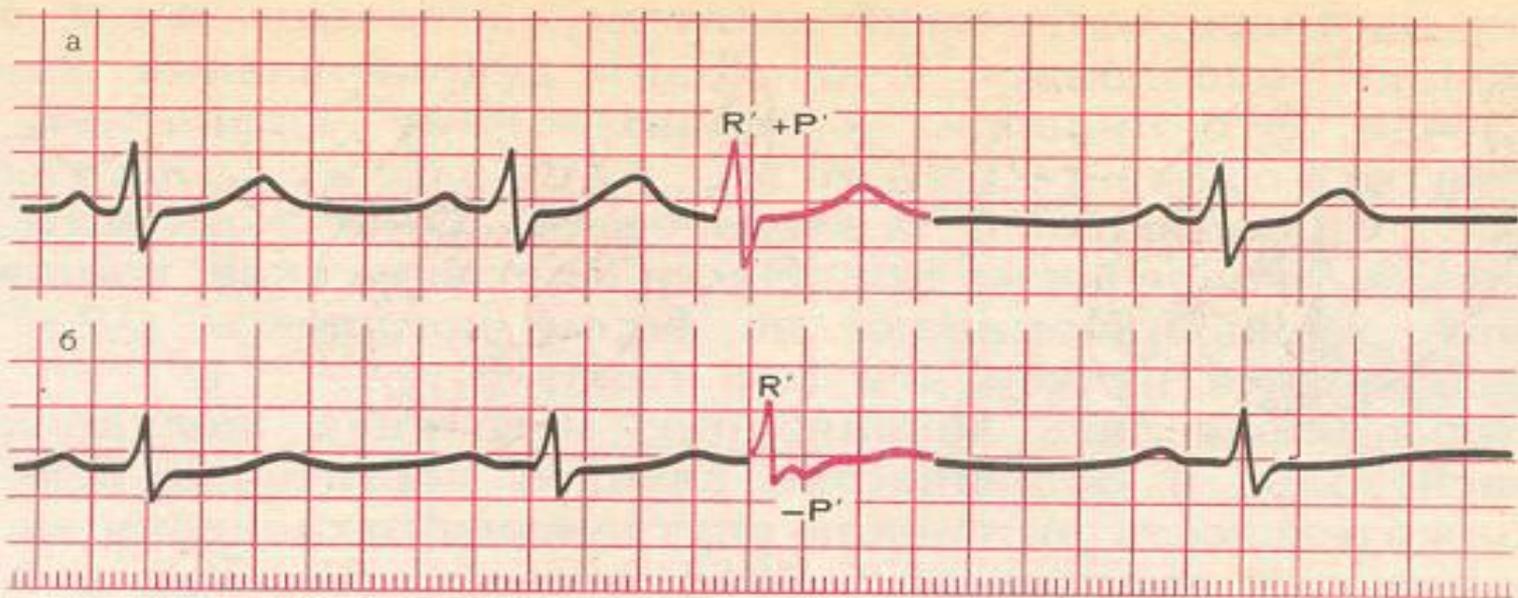


Рис: 5.11. ЭКГ при экстрасистолии из АВ-соединения.

а — экстрасистолический импульс одновременно достигает предсердий и желудочков, комплекс QRS и зубцы P' сливаются друг с другом (зубца P' экстрасистолы не видно); б — экстрасистолический импульс вначале достигает желудочков, а затем предсердий, отрицательный зубец P' расположен после желудочкового комплекса QRS'.

Extrasistole (ventricular)

Ventricular extrasystole is caused by a ventricular ectopic pacemaker

ECG signs: no P before QRS, deformation of QRS, large looping ST segment opposite in direction to that of the QRS, full **complete compensatory pause** (interval between the R waves before and after the extrasystole complex is twice that of the normal R-R).

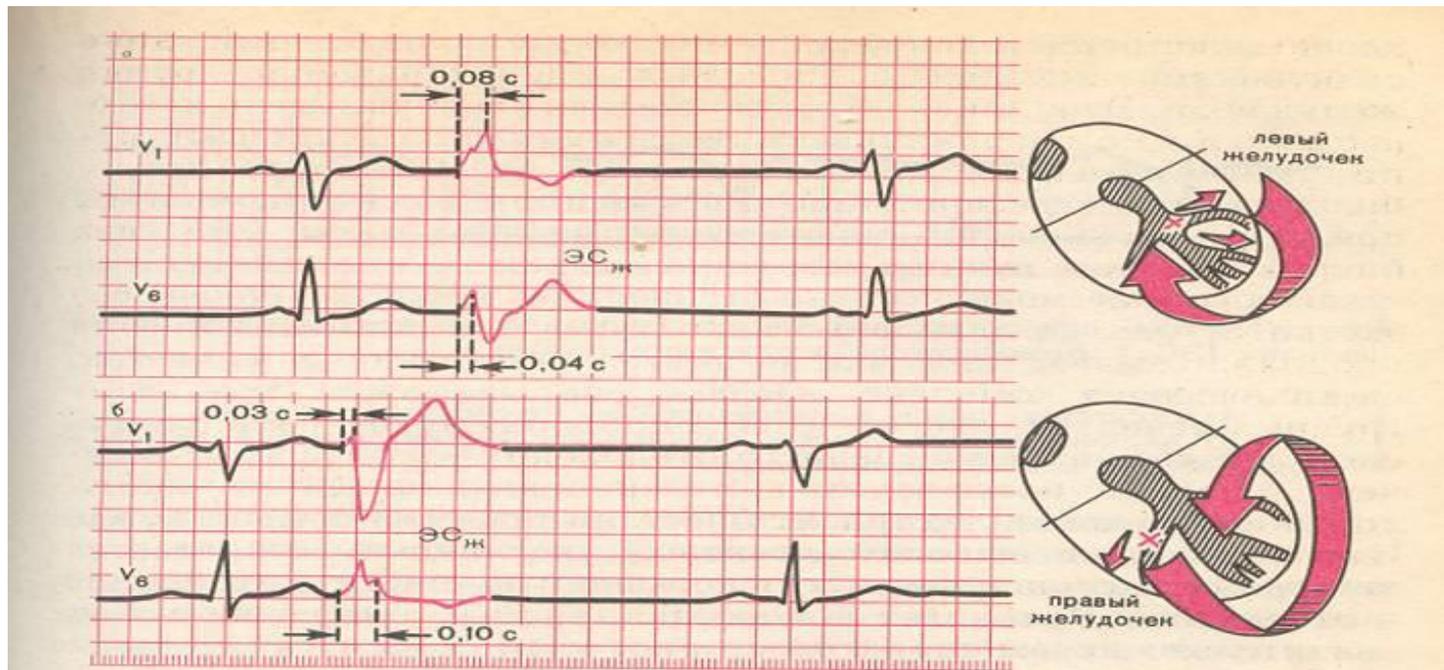


Рис. 5.12. ЭКГ при левожелудочковой (а) и правожелудочковой (б) экстрасистолах. При левожелудочковой экстрасистоле интервал внутреннего отклонения QRS увеличен в отведении V₁, при правожелудочковой — в отведении V₆.

Справа — схематическое изображение распространения возбуждения при желудочковой экстрасистоле.

Paroxysmal tachycardia

Paroxysmal tachycardia develops in case of numerous extrasystoles, with a rapid heart rate (**180-250/min**), which sudden onset and offset at regular rhythm

Duration – from some seconds to some minutes

The heart is beating so rapidly that the ventricle doesn't have time to fill completely, each beat pumps out less blood. If this tachycardia persists, the usual treatment is stimulation of the n.Vagus by carotid sinus or eyes massage, which slows the heart rate.



Paroxysmal tachycardia (ventricle)

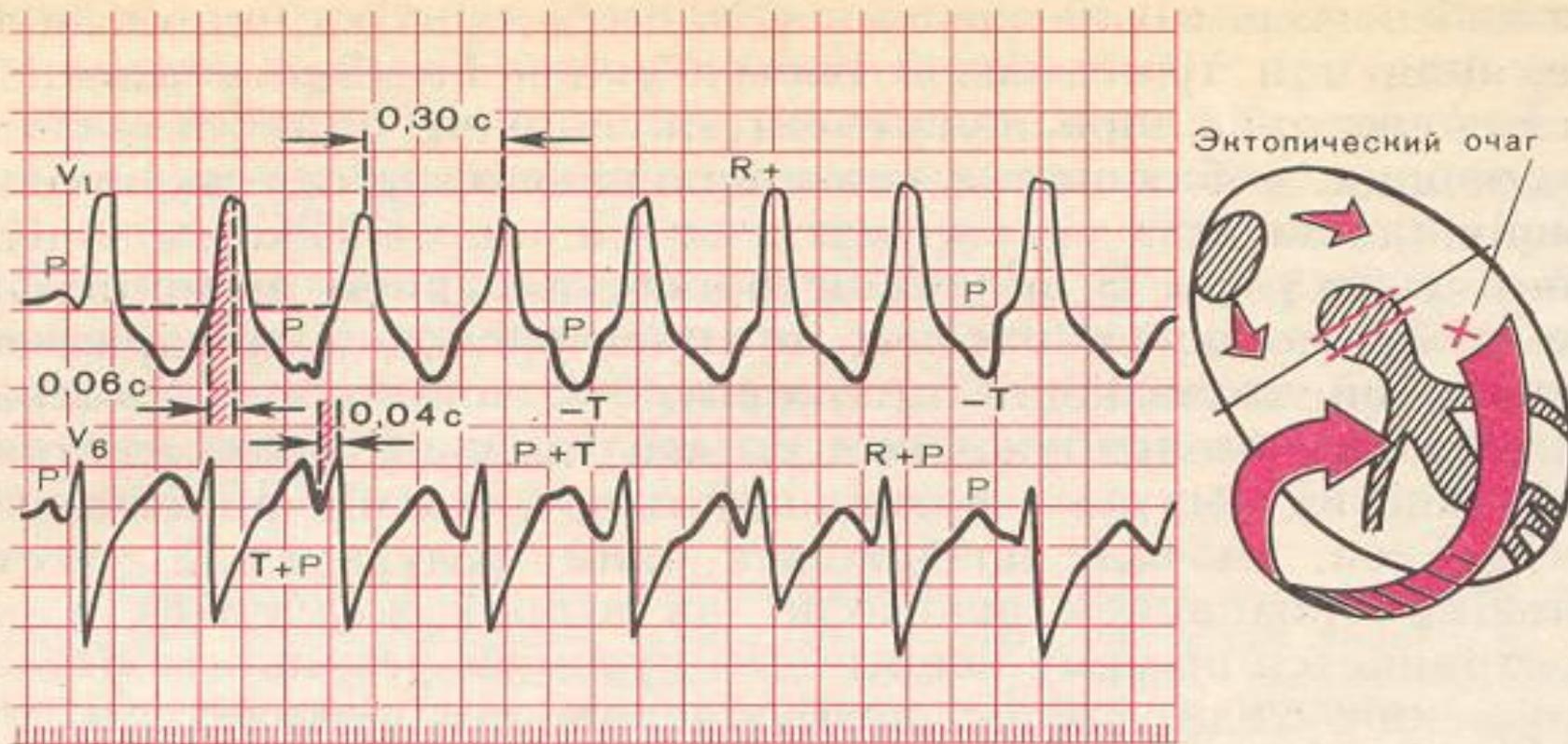
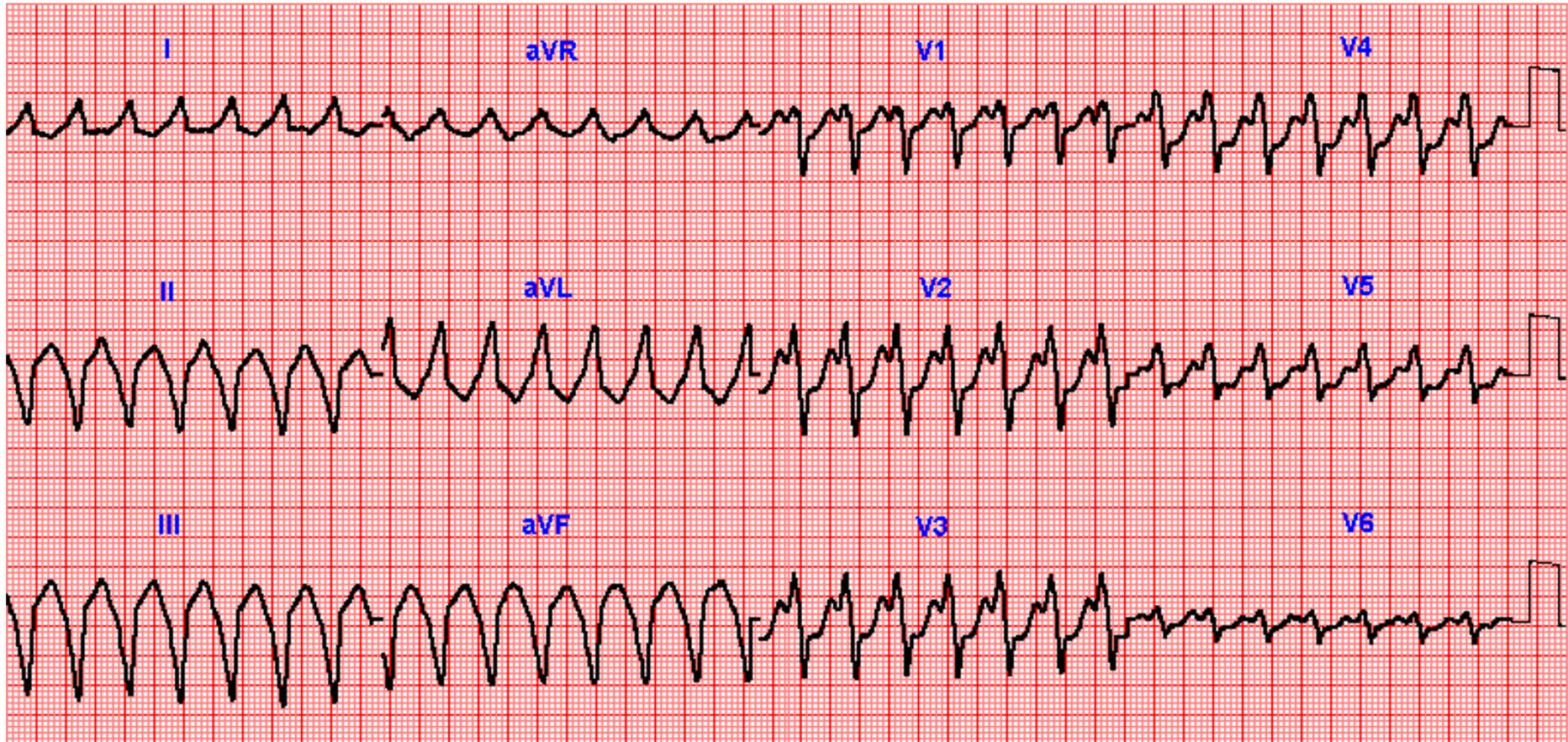


Рис. 5.15. ЭКГ при пароксизмальной желудочковой тахикардии.

Эктопический очаг расположен в левом желудочке, поэтому форма комплекса QRS напоминает таковую при левожелудочковой экстрасистолии или блокаде правой ножки пучка Гиса. Предсердия возбуждаются в своем ритме, а желудочки — в своем; имеется атриовентрикулярная диссоциация. Объяснение в тексте.

Paroxysmal tachycardia (ventricle)



Atrium flutter

A condition caused by a rapid discharge of abnormal electrical impulses from the right atrium. Typically, the right atrium fires at a rate of 300 beats per minute, but only every other beat is conducted through the AV node, meaning that the ventricular rate is classically 150 beats per minute.

rapid and regular atrial contractions with a rate from 240 to 450/min

Mechanisms: ectopic driver activation

ECG : regular and rapid F-waves, QRS unchanged

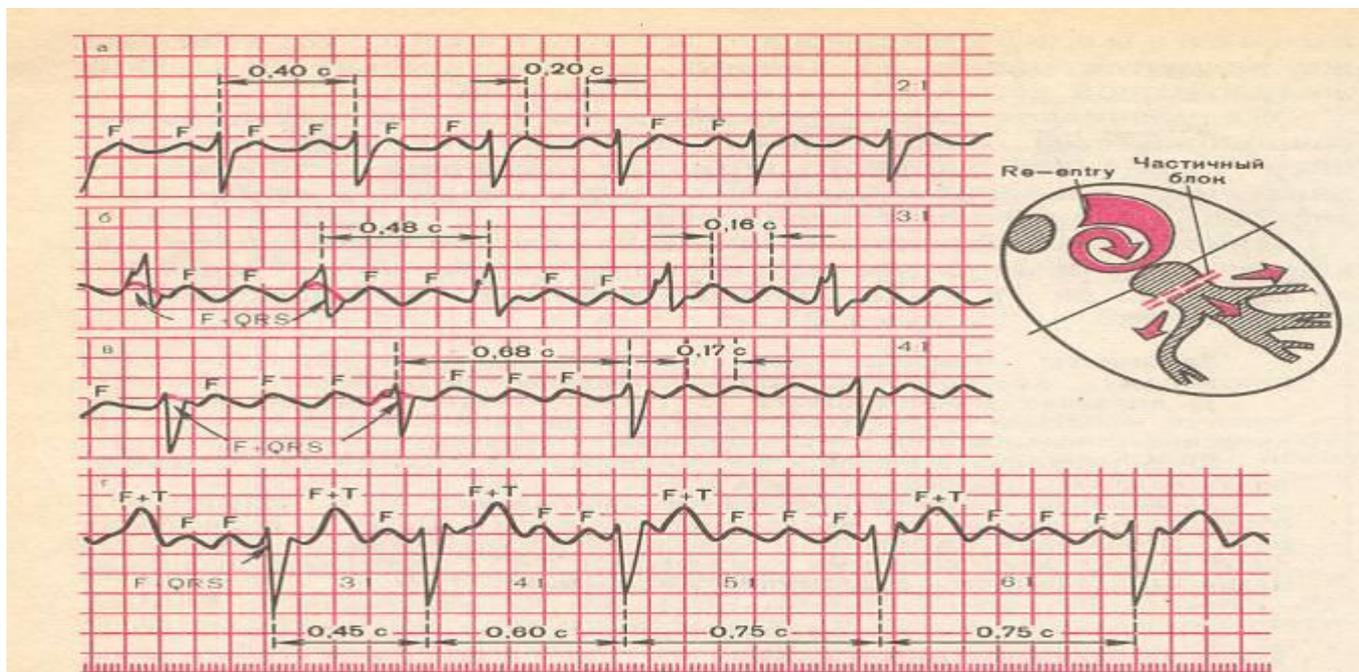


Рис. 5.16. ЭКГ при трепетании предсердий.

а — правильная форма с функциональной атриовентрикулярной блокадой (2:1); б — правильная форма (3:1); в — правильная форма (4:1); г — неправильная форма трепетания предсердий (изменение степени атриовентрикулярной блокады) (3:1, 4:1, 5:1). Красным пунктиром показаны волны F, сливающиеся с комплексом QRS. Справа — схема возникновения re-entry при трепетании предсердий.

Atrium fibrillation

Caused by electrical impulses discharged at a rapid rate from many different areas of the atria.

rapid and unregular atrial contractions with frequency 350-700/min

Mechanisms ectopic driver activation

ECG : unregular and rapid f-waves, complexes **QRS** appear irregular

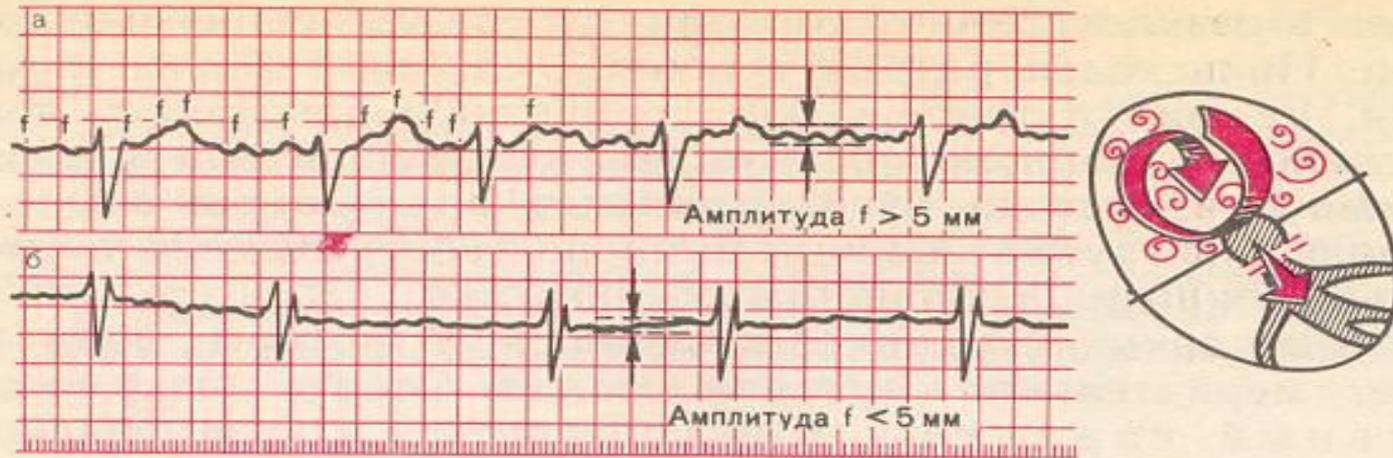


Рис. 5.17. ЭКГ при мерцании (фибрилляции) предсердий.

а — крупноволнистая форма; б — мелковолнистая форма. Справа — схематическое изображение вихревого движения волны возбуждения по предсердиям.

Ventricle flutter and fibrillation

Flutter – frequent (200-300/min) regular excitation and contraction of the ventricles because impulses from ectopic driver circulates constantly (“re-entry”)

ECG : no P, QRS is wide

Fibrillation – frequent (200-500/min), irregular and chaotic excitation and contraction of cardiomyocyte’s separated groups in ventricles

(finally ventricles don’t contract)

ECG : changed shape and amplitude of the waves without any intervals

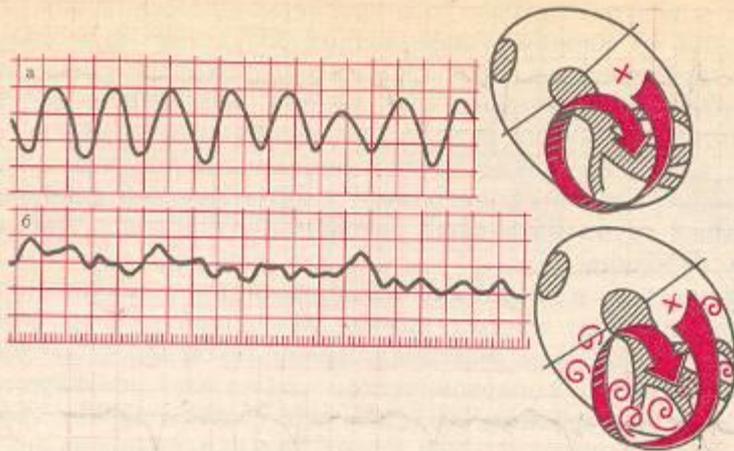
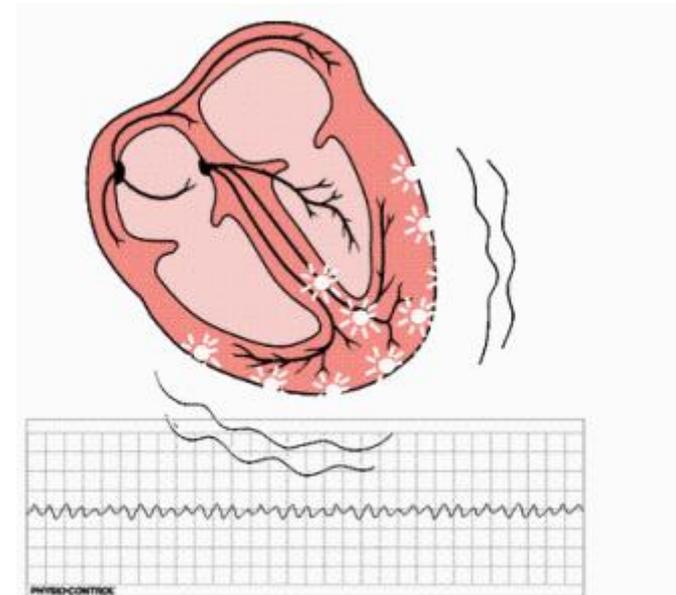


Рис. 5.18. ЭКГ при трепетании (а) и мерцании (фибриляции) желудочков (б). Трепетание вызвано правильным круговым движением, мерцание — неправильным вихревым движением волны возбуждения по желудочкам.



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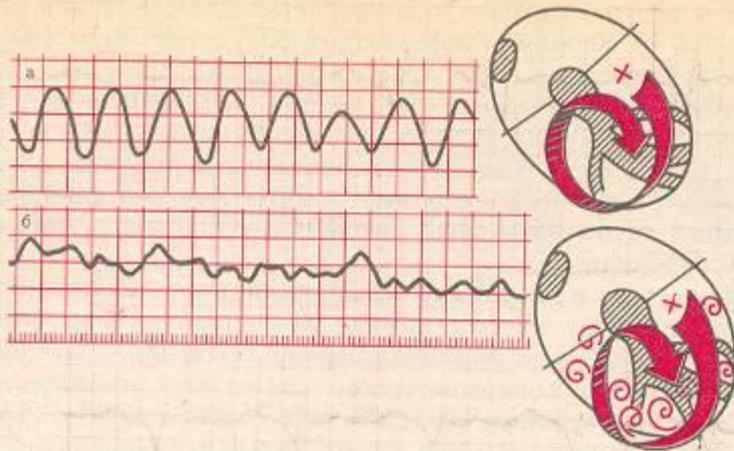
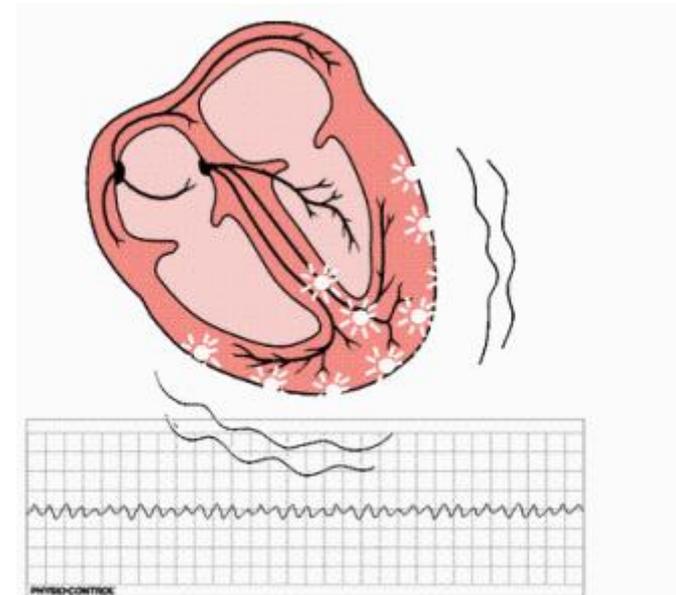
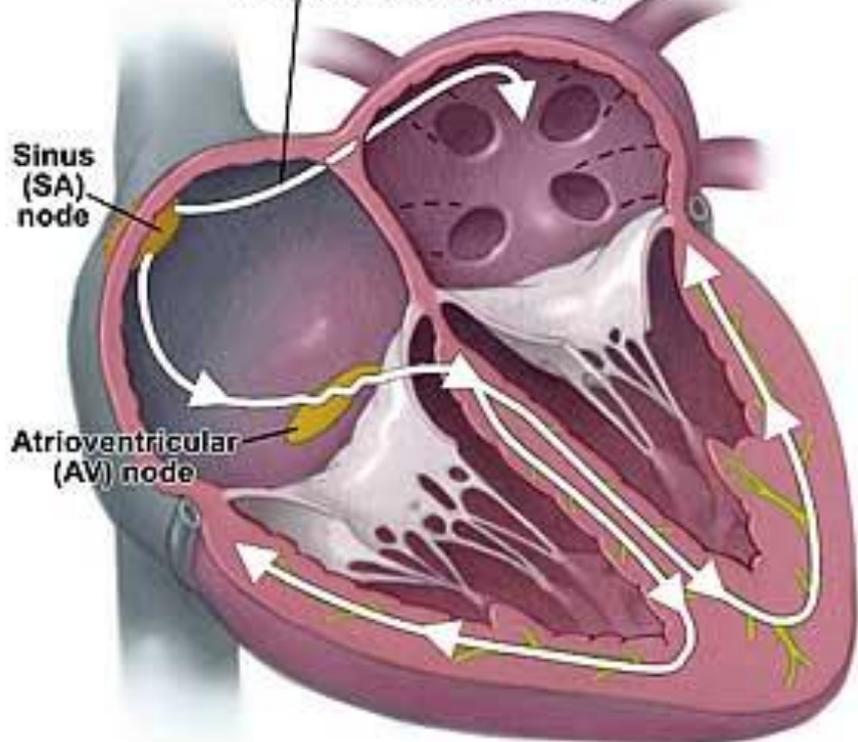


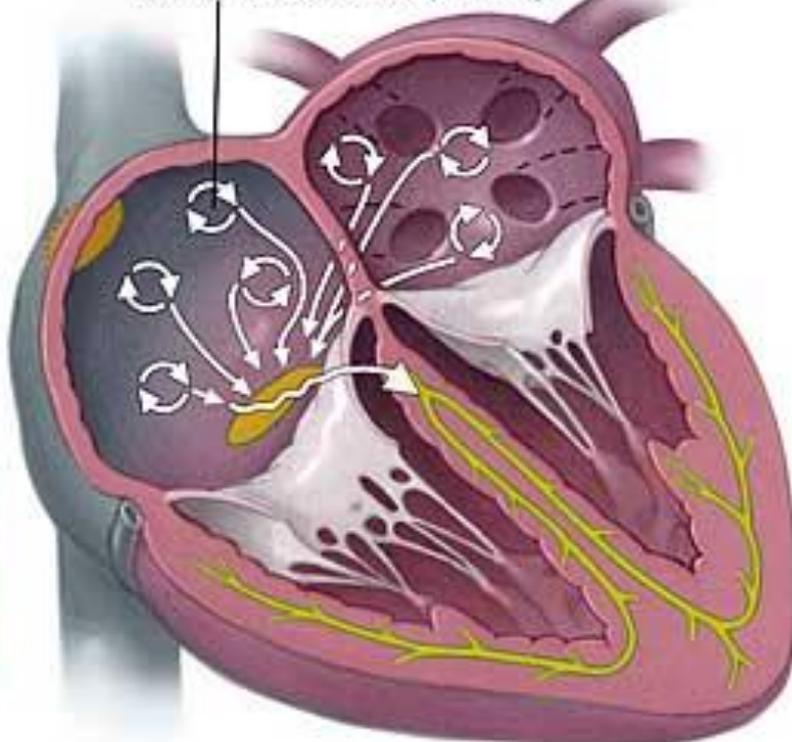
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Normal electrical pathways



Abnormal electrical pathways



Normal sinus rhythm



Atrial fibrillation



Symptoms of a Heart Rhythm Disorders

Many arrhythmias cause no or minimal symptoms.

Other people, however, can actually feel the arrhythmia when it happens.

Common symptoms include the following:

- Palpitations, feeling "skipped beats"
- Thumping or fluttering in the chest
- Sensation of the heart racing

In addition, some can experience the following:

- Feeling faint or tired
- Light-headedness or passing out (syncope)
- Shortness of breath
- Chest pain or discomfort