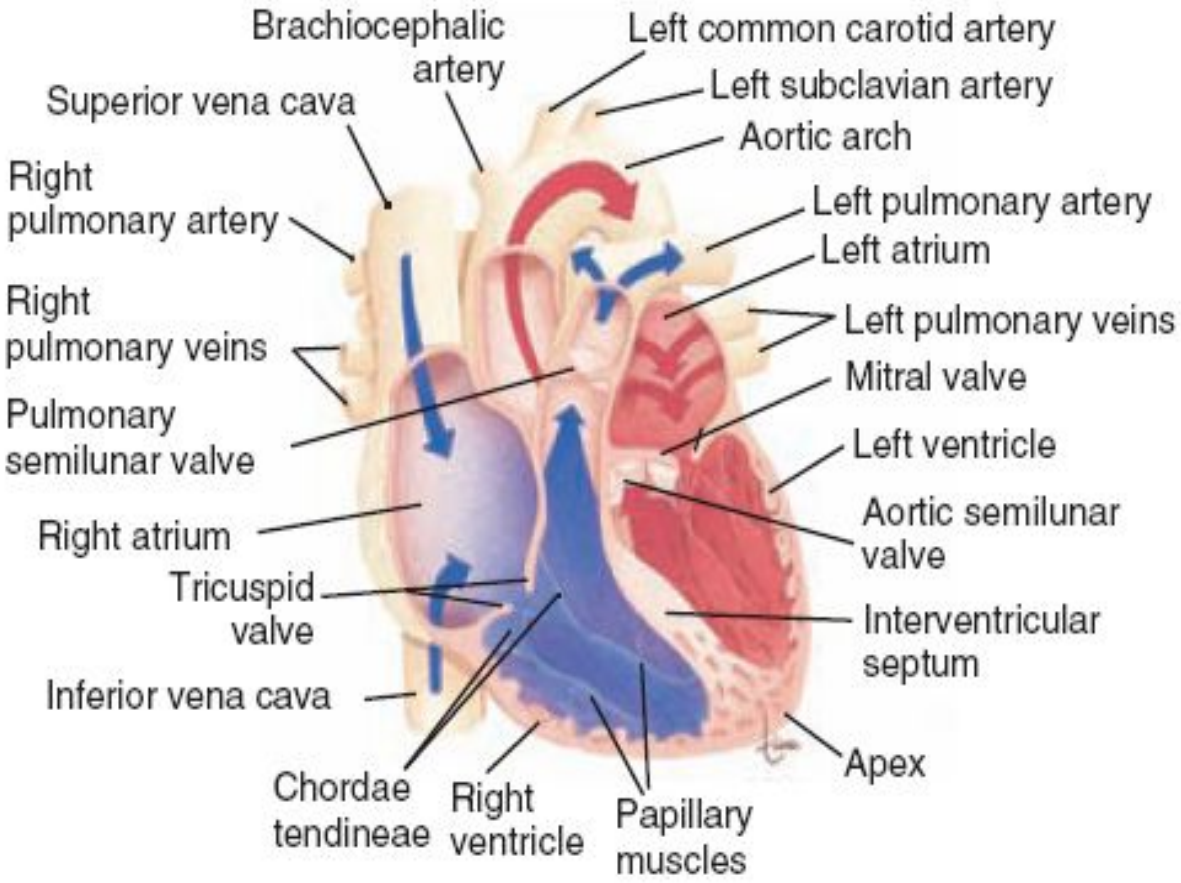
Cardiac rhythm disorders in children

Plan of the lecture

- 1. Definition of cardiac rhythm disorders in children
- 2. Etiologic factors
- 3. Classification
- 4. Clinical presentation of cardiac rhythm disorders in children
- 5. The differential diagnosis of cardiac rhythm disorders in children
- 5. Treatment

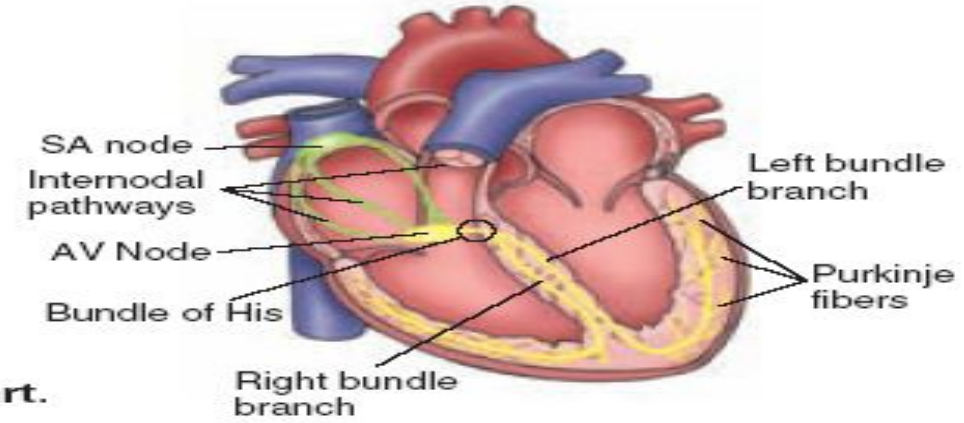
Heart Chambers and Great Vessels



Electrical Conduction System of the Heart

Conduction System Structures and Functions

Structure	Function and Location
Sinoatrial (SA) node	Dominant pacemaker of the heart, located in upper portion of right atrium. Intrinsic rate 60–100 bpm.
Internodal pathways	Direct electrical impulses between SA and AV nodes.
Atrioventricular (AV) node	Part of AV junctional tissue. Slows conduction, creating a slight delay before impulses reach ventricles. Intrinsic rate 40–60 bpm.
Bundle of His	Transmits impulses to bundle branches. Located below AV node.
Left bundle branch	Conducts impulses that lead to left ventricle.
Right bundle branch	Conducts impulses that lead to right ventricle.
Purkinje system	Network of fibers that spreads impulses rapidly throughout ventricular walls. Located at terminals of bundle branches. Intrinsic rate 20–40 bpm.

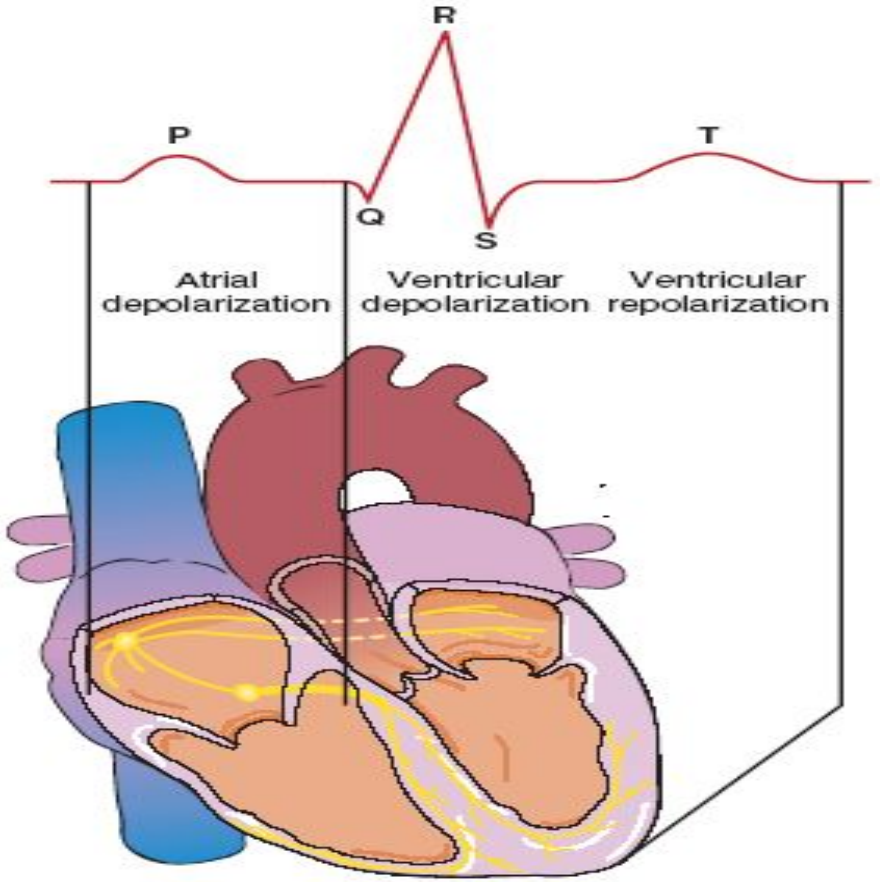


Conduction system of the heart.

Electrical Conduction System of the Heart

Electrophysiology

Action	Effect
Depolarization	The electrical charge of a cell is altered by a shift of electrolytes on either side of the cell membrane. This change stimulates muscle fiber to contract.
Repolarization	Chemical pumps re-establish an internal negative charge as the cells return to their resting state.



Depolarization and repolarization of the heart.

♥ **Clinical Tip:** Mechanical and electrical functions of the heart are influenced by proper electrolyte balance. Important components of this balance are sodium, calcium, potassium, and magnesium.

Arrhythmia reasons

- **Cardial**
- **CHD**
- **Acquired chronic HD**
- **Carditis**
- **Cardiomyopathies**
- **Mitral valve prolapse**
- **Cardiac neoplasms**

- **Combined**

- **Extracardial**
- **Vegetative nervous system dysregulation**
- **Endocrine disorders**
- **CNS diseases**
- **Intoxications**
- **Any somatic disease**

Rhythm and conductivity disorders classification (Belokon N.A. 1987)

1 **Impulse formation disturbance**

А. **Nomotope disturbance (sinus tachycardia, bradycardia, pacemaker migration)**

Б. Heterotopic rhythm disturbance (extrasystole, paroxysmal tachycardia, atrium and ventricular flutter or fibrillation)

2 **Conductivity abnormalities**

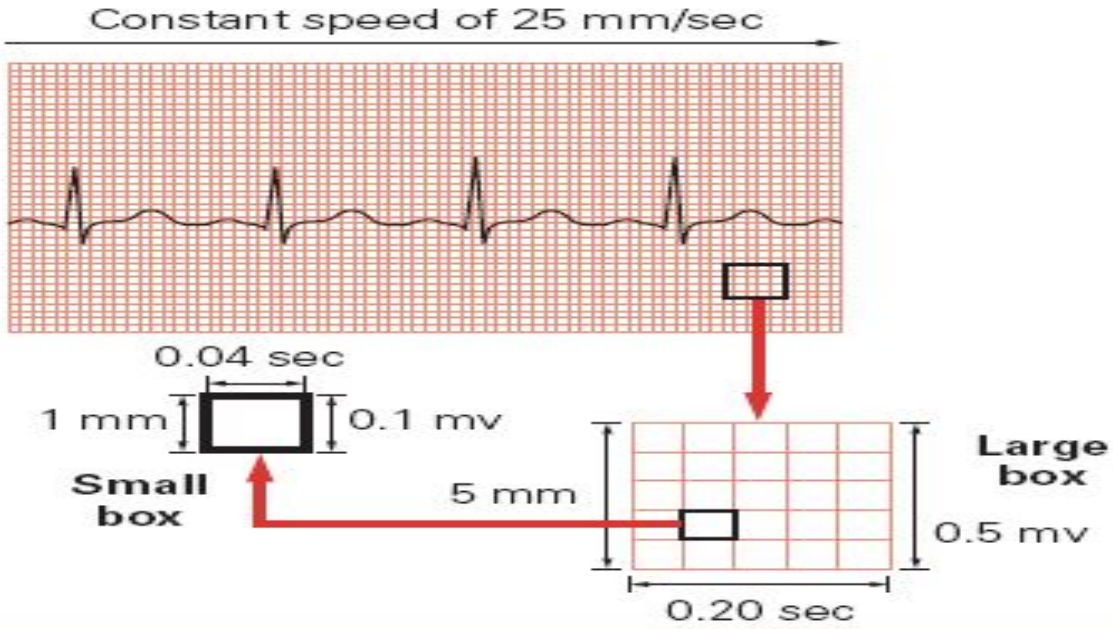
(sinoauricularis, ventricular, atrium, AV-blockades of 1,2, 3 grade)

3 **Combined arrhythmias (sick sinus syndrome, sinus node arrest, pre-excitation syndromes, AV- dissociation)**

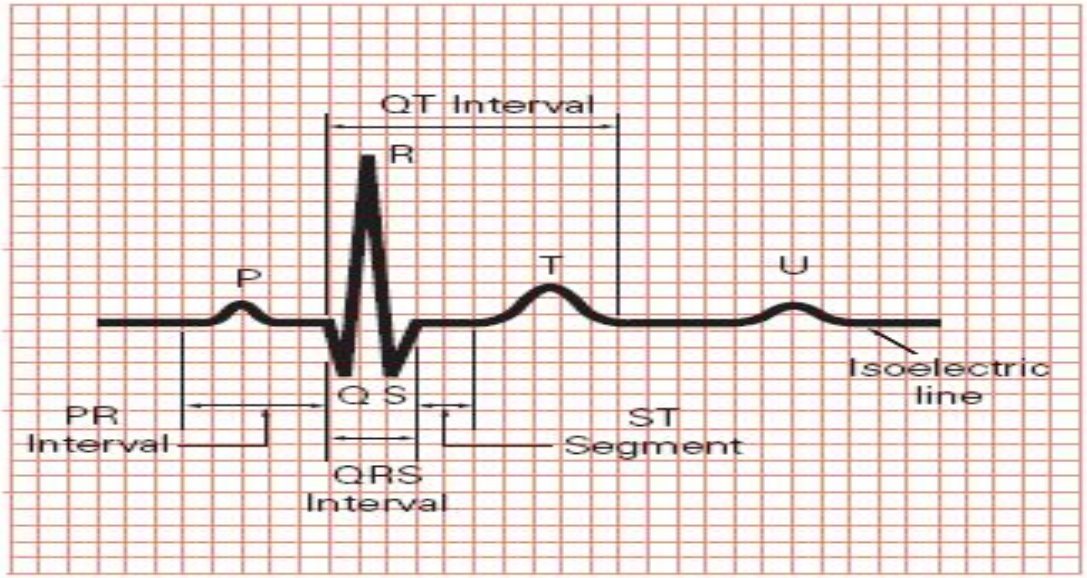
Diagnostic approach

- Superficial ECG (12 traditional leads)
- Electrophysiologic examining methods (EPM)-intracardiac or transesophageal electrodes
- HR and BP Cholter monitoring

Recording of the ECG



Components of an ECG Tracing



ECG Interpretation

Analyzing a Rhythm

Component	Characteristic
Rate	The bpm is commonly the ventricular rate. If atrial and ventricular rates differ, as in a 3rd-degree block, measure both rates. Normal: 60–100 bpm Slow (bradycardia): <60 bpm Fast (tachycardia): >100 bpm
Regularity	Measure R-R intervals and P-P intervals. Regular: Intervals consistent Regularly irregular: Repeating pattern Irregular: No pattern
P Waves	If present: Same in size, shape, position? Does each QRS have a P wave? Normal: Upright (positive) and uniform Inverted: Negative Notched: P′ None: Rhythm is junctional or ventricular.
PR Interval	Constant: Intervals are the same. Variable: Intervals differ. Normal: 0.12–0.20 sec and constant
QRS Interval	Normal: 0.06–0.10 sec Wide: >0.10 sec None: Absent
QT Interval	Beginning of R wave to end of T wave Varies with HR. Normal: Less than half the R-R interval
Dropped beats	Occur in AV blocks. Occur in sinus arrest.

Component	Characteristic
Pause	Compensatory: Complete pause following a premature atrial contraction (PAC), premature junctional contraction (PJC), or premature ventricular contraction (PVC) Noncompensatory: Incomplete pause following a PAC, PJC, or PVC
QRS Complex grouping	Bigeminy: Repeating pattern of normal complex followed by a premature complex Trigeminy: Repeating pattern of 2 normal complexes followed by a premature complex Quadrigeminy: Repeating pattern of 3 normal complexes followed by a premature complex Couplets: 2 Consecutive premature complexes Triplets: 3 Consecutive premature complexes

Normal sinus rhythm criteria

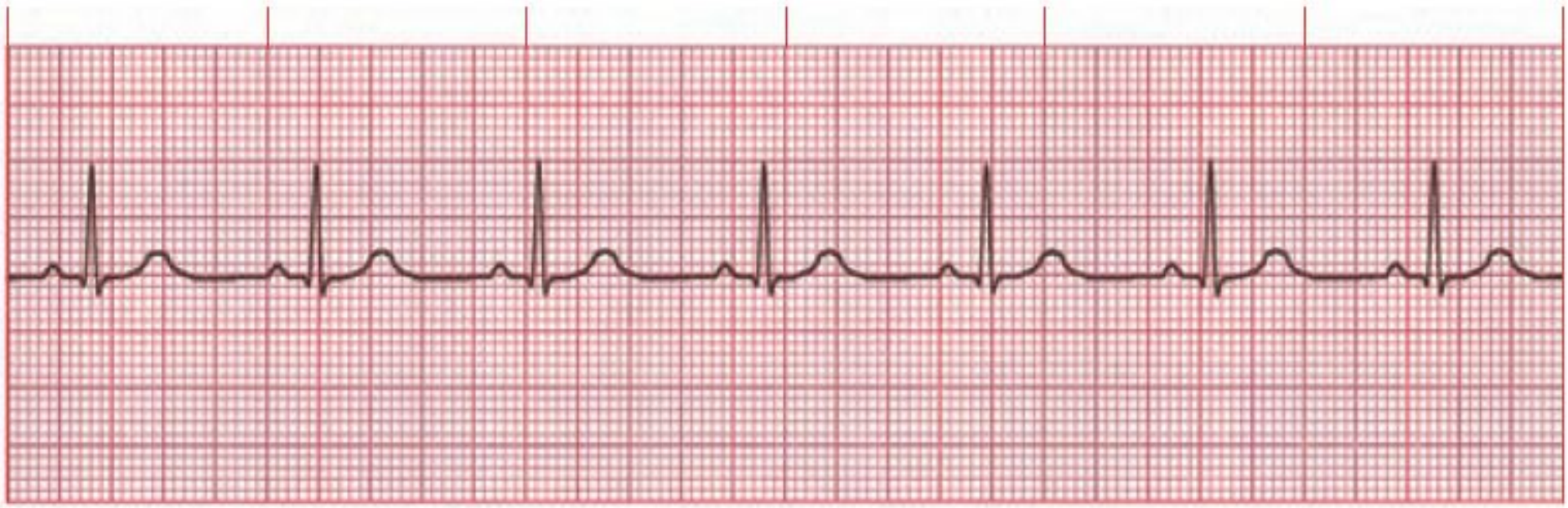
- Regular consecutive P-P row
- Constant wave P morphology
- Wave P precedes QRS complex
- Normal QRS complex

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.

ECG criteria of sinus arrhythmia

- R-R interval irregular (decreases during inspiration)
- P-P interval irregular
- Wave P constantly precedes QRS complex
- PR interval ranges 0,02 sec

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)

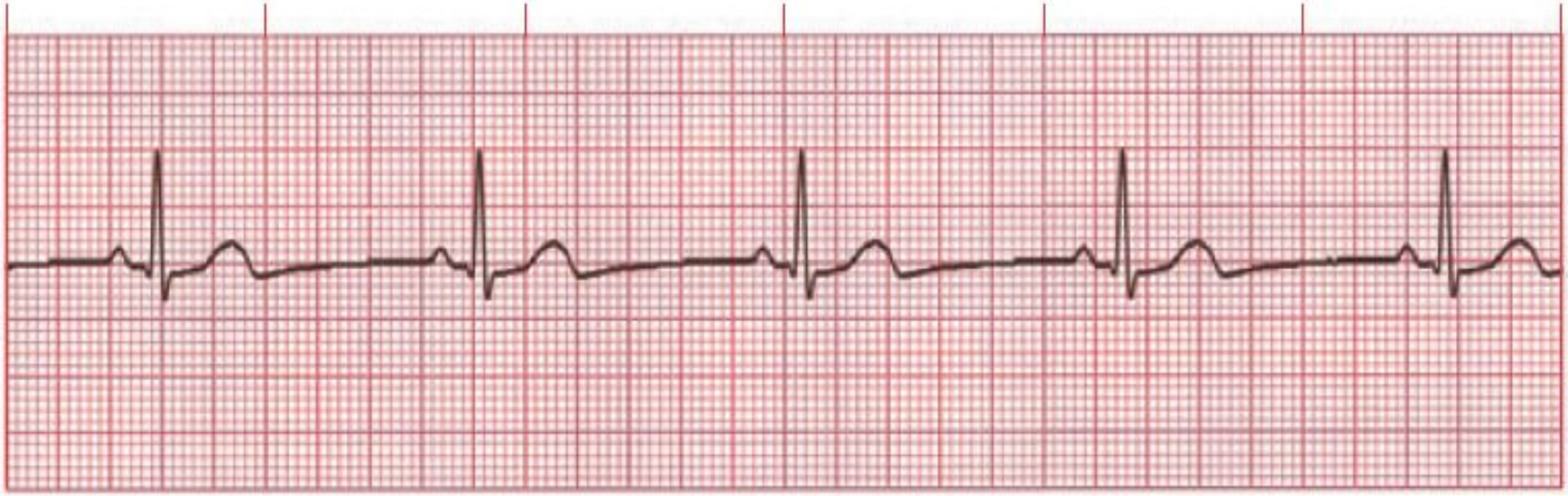
♥ **Clinical Tip:** The pacing rate of the SA node varies with respiration, especially in children and elderly people.

ECG criteria of sinus bradycardia

- QRS complexes frequency less than100/min in neonates and infants; less than 60/min in 6-9 years old children and less than 50/min. in 9-16 years old
- R-R interval is constant
- Wave P precedes every QRS complex
- Interval P-R is constant not more than 0,18 sec.

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)

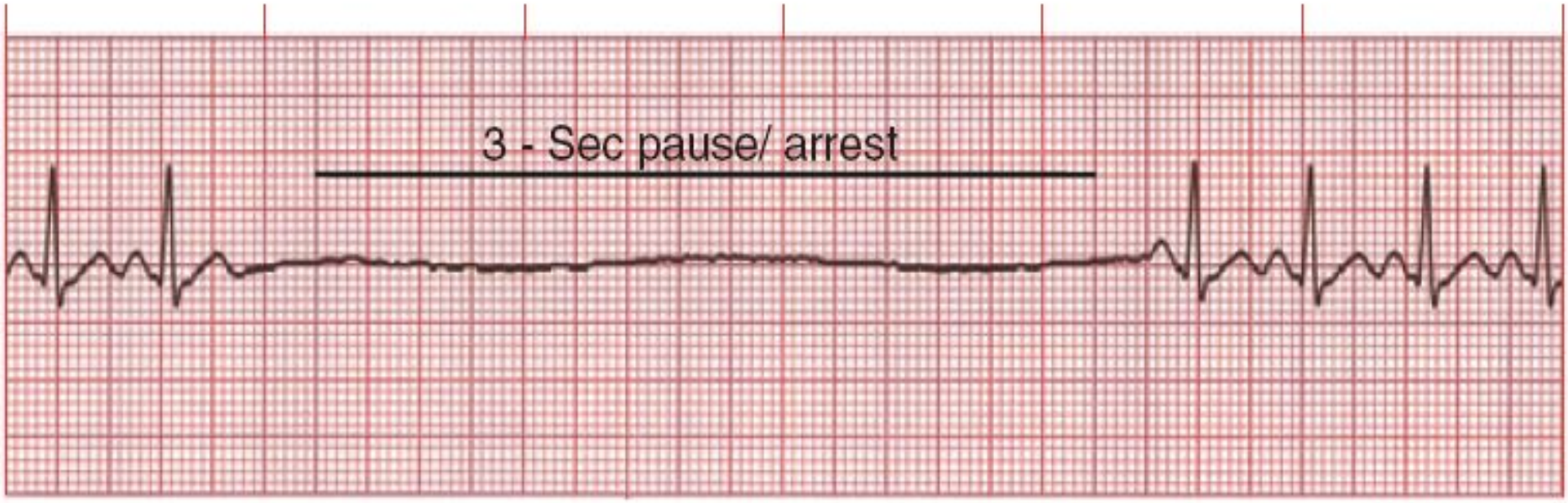
♥ **Clinical Tip:** Sinus bradycardia is normal in athletes and during sleep. In acute MI, it may be protective and beneficial or the slow rate may compromise cardiac output. Certain medications, such as beta blockers, may also cause sinus bradycardia.

ECG criteria of sick sinus node syndrome

- Evident tachy-brady-arrhythmia
- Sinus-auricularis blockage
- Atrium or/and cardiac asystolia
- When rhythm retarded less than 40/min. weakness, dizziness syncope amnesia can occur

Sinus Pause (Sinus Arrest)

- The SA node fails to discharge and then resumes.
- Electrical activity resumes either when the SA node resets itself or when a lower latent pacemaker begins to discharge.
- The pause (arrest) time interval is not a multiple of the normal P-P interval.



Rate: Normal to slow; determined by duration and frequency of sinus pause (arrest)
Rhythm: Irregular whenever a pause (arrest) occurs
P Waves: Normal (upright and uniform) except in areas of pause (arrest)
PR Interval: Normal (0.12–0.20 sec)
QRS: Normal (0.06–0.10 sec)

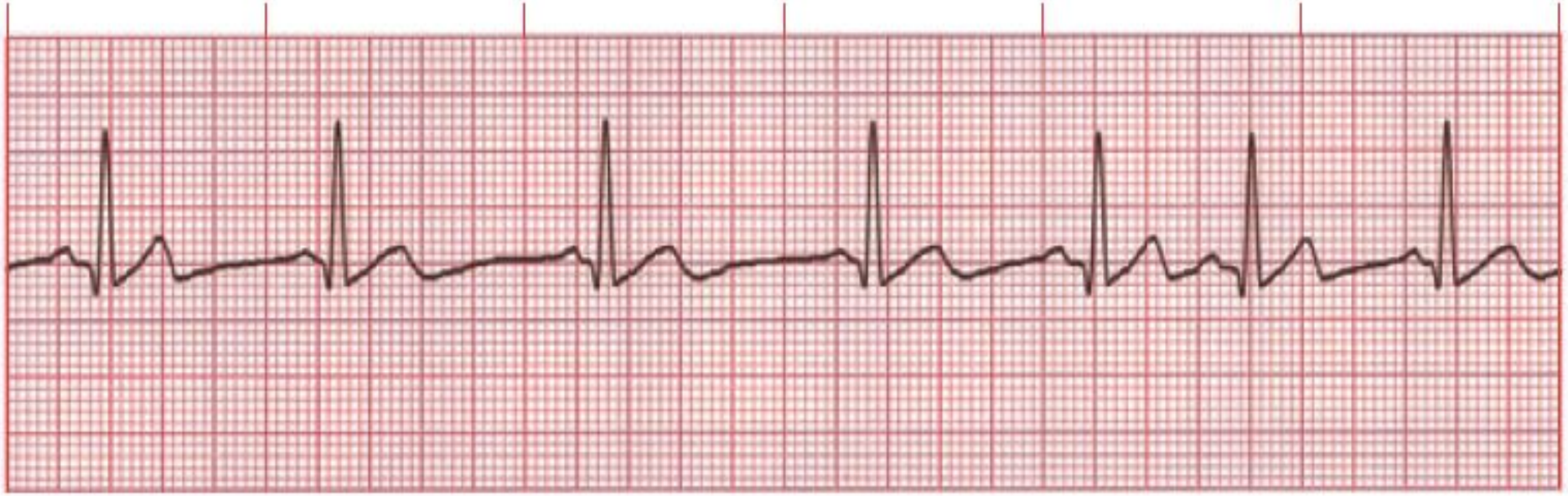
♥ **Clinical Tip:** Cardiac output may decrease, causing syncope or dizziness.

Atrial Arrhythmias

- P Waves differ in appearance from sinus P waves.
- QRS Complexes are of normal duration.

Wandering Atrial Pacemaker (WAP)

- Pacemaker site transfers from the SA node to other latent pacemaker sites in the atria and the AV junction and then moves back to the SA node.



Rate: Normal (60–100 bpm)
Rhythm: Irregular
P Waves: At least three different forms, determined by the focus in the atria
PR Interval: Variable; determined by focus
QRS: Normal (0.06–0.10 sec)

Premature Contractions (PC) can be

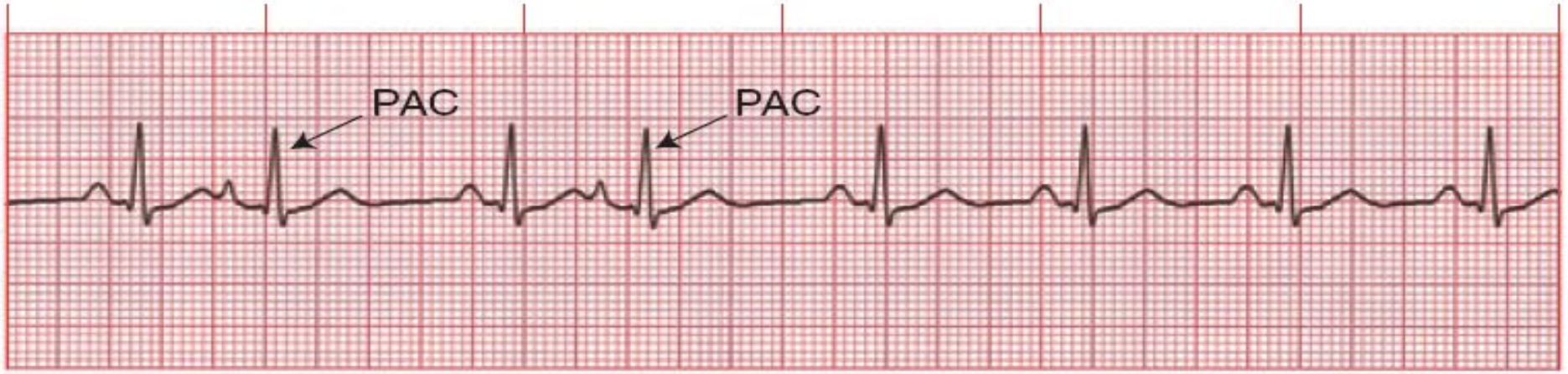
1. Supraventricular or ventricular
2. Monotopic or polytopic
3. Aberrant
4. Ultraearly, early, late
5. Rare, moderate, frequent
6. Single, double, group
7. Allorhythmia

ECG signs of premature atrium contractions (PAC)

- Short-cut preectopic interval
- Wave P is present before complex QRS
- Stable shortened PQ(R)-interval
- Normal narrow QRS complex, similar to previous one
- Incomplete compensated pause

Premature Atrial Contraction (PAC)

- A single complex occurs earlier than the next expected sinus complex.
- After the PAC, sinus rhythm usually resumes.



Rate: Depends on rate of underlying rhythm
Rhythm: Irregular whenever a PAC occurs
P Waves: Present; in the PAC, may have a different shape
PR Interval: Varies in the PAC; otherwise normal (0.12–0.20 sec)
QRS: Normal (0.06–0.10 sec)

♥ **Clinical Tip:** In patients with heart disease, frequent PACs may precede paroxysmal supraventricular tachycardia (PSVT), A-fib, or A-flutter.

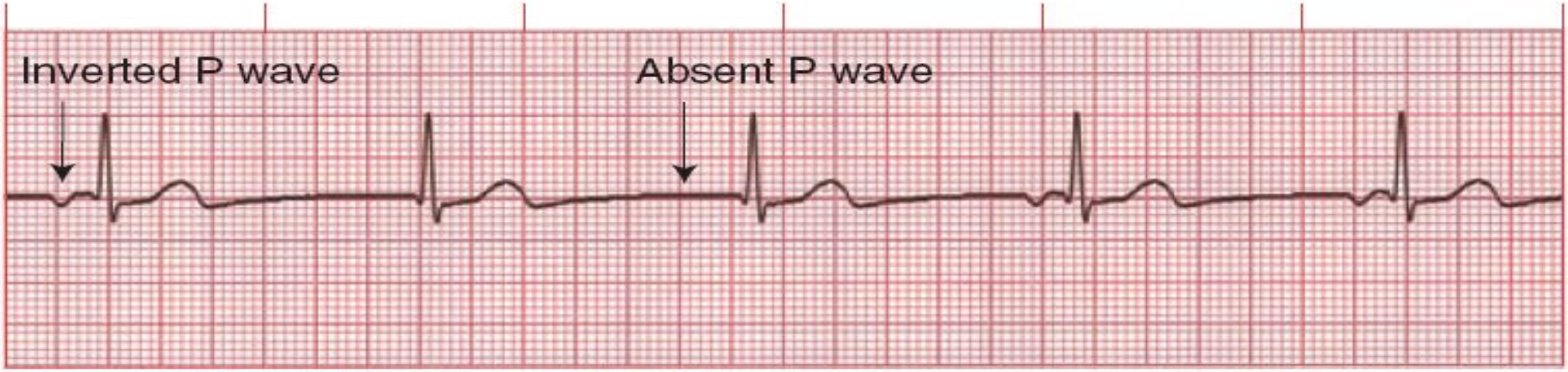
ECG criteria of PC originated from AV-node

- Premature unstrained complex QRS
- P wave is absent before QRS
- Incomplete compensated pause

Junctional Arrhythmias

- The atria and SA node do not perform their normal pacemaking functions.
- A junctional escape rhythm begins.

Junctional Rhythm



Rate: 40–60 bpm
Rhythm: Regular
P Waves: Absent, inverted, buried, or retrograde
PR Interval: None, short, or retrograde
QRS: Normal (0.06–0.10 sec)

Premature Junctional Contraction (PJC)

- Enhanced automaticity in the AV junction produces PJCs.

Rate: Depends on rate of underlying rhythm
Rhythm: Irregular whenever a PJC occurs
P Waves: Absent, inverted, buried, or retrograde in the PJC
PR Interval: None, short, or retrograde
QRS: Normal (0.06–0.10 sec)

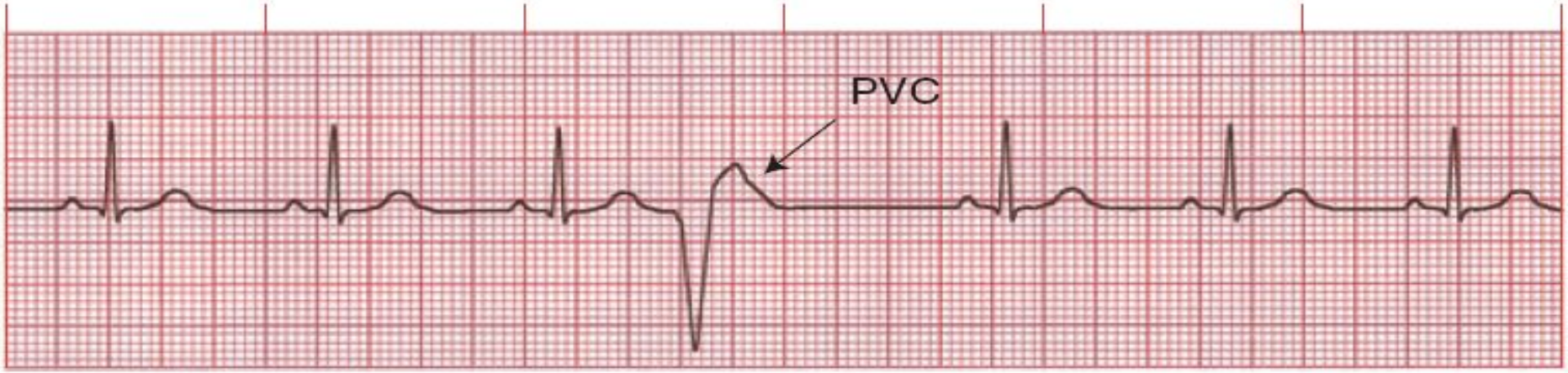
♥ **Clinical Tip:** Before deciding that isolated PJCs may be insignificant, consider the cause.

ECG criteria of premature ventricular contraction (PVC)

- Wave is absent before QRS
- QRS is premature aberrant, wide
- ST segment is dislocated and wave T is discordant to QRS
- Complete compensated pause

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

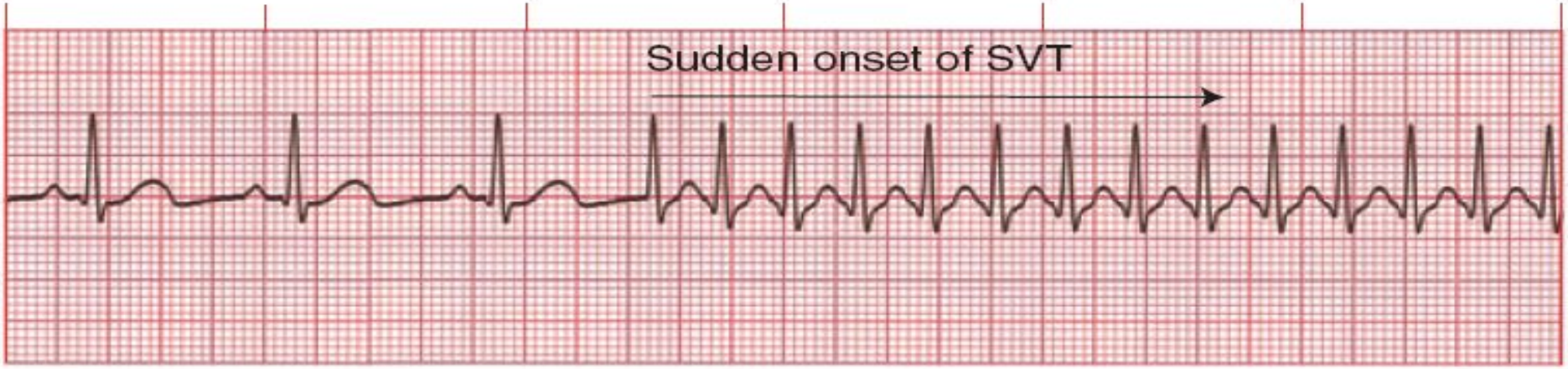
♥ **Clinical Tip:** Patients may sense the occurrence of PVCs as skipped beats. Because the ventricles are only partially filled, the PVC frequently does not generate a pulse.

Signs of atrium paroxysmal tachycardia (PT)

- Wave P is present before QRS
- QRS is unstrained
- HR in schoolchildren 150-160/min, in infants and toddlers– more than 200/min.
- Interval PQ is relatively elongated
- Segment ST is lowered, sometimes wave T is inverted

Paroxysmal Supraventricular Tachycardia (PSVT)

- PSVT is a rapid rhythm that starts and stops suddenly.
- For accurate interpretation, the beginning or end of the PSVT must be seen.
- PSVT is sometimes called paroxysmal atrial tachycardia (PAT).



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:** The patient may feel palpitations, dizziness, lightheadedness, or anxiety.

ECG signs of AV PT

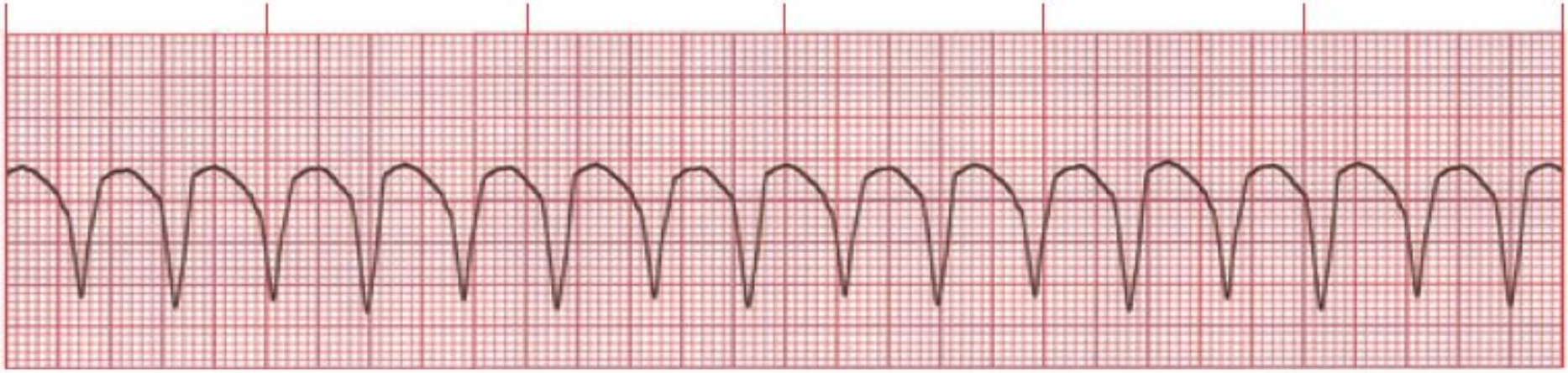
- Wave P is absent before QRS
- QRS is unstrained
- HR is more than150-200/min
- PQ interval is normal or elongated
- Secondary changes of ST and T

ECG signs of ventricular PT

- Aberrant wide regular QRS
- HR 150-200/min
- Constant R-R interval
- Secondary discordant segment ST and wave T changes
- AV-dissociation
- Reflectory maneuvres are inefficiant

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

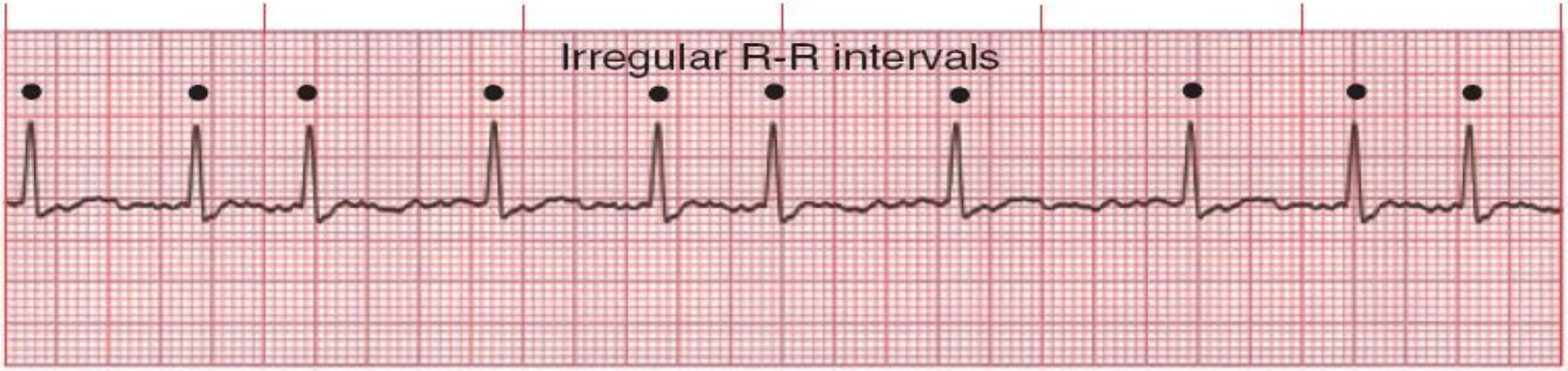
- **Clinical Tip:** It is important to confirm the presence or absence of pulses because monomorphic VT may be perfusing or nonperfusing.
- **Clinical Tip:** Monomorphic VT will probably deteriorate into VF or unstable VT if sustained and not treated.

ECG signs of atrium fibrillation

- **P-wave is displaced by F-waves of different shape and amplitude**
- **QRS is normal but rhythm is irregular, chaotic**
- **R-R interval changes in duration**

Atrial Fibrillation (A-fib)

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



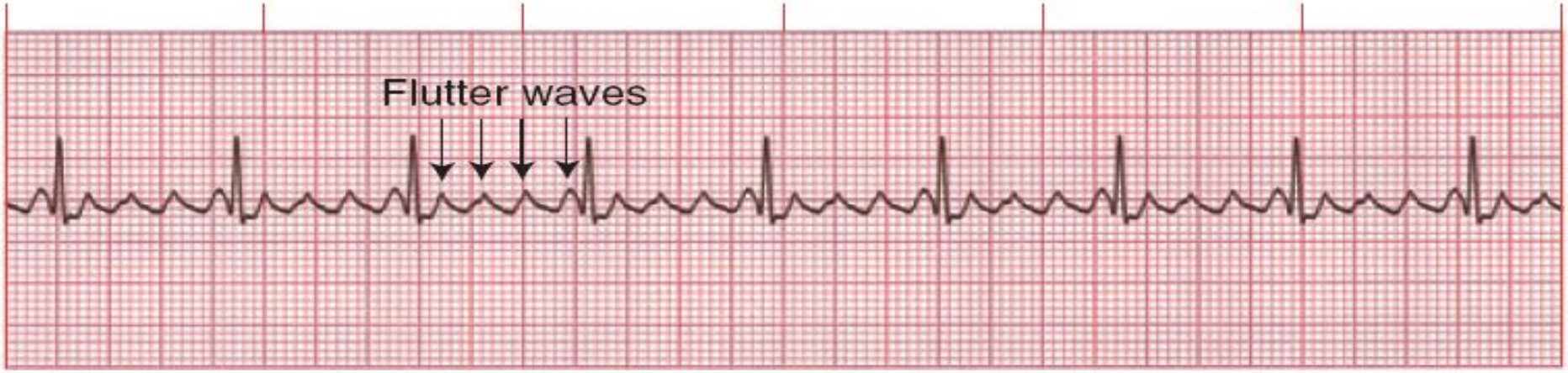
Rate: Atrial: 350 bpm or greater; ventricular: slow or fast
Rhythm: Irregular
P Waves: No true P waves; chaotic atrial activity
PR Interval: None
QRS: Normal (0.06–0.10 sec)

♥ **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 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.

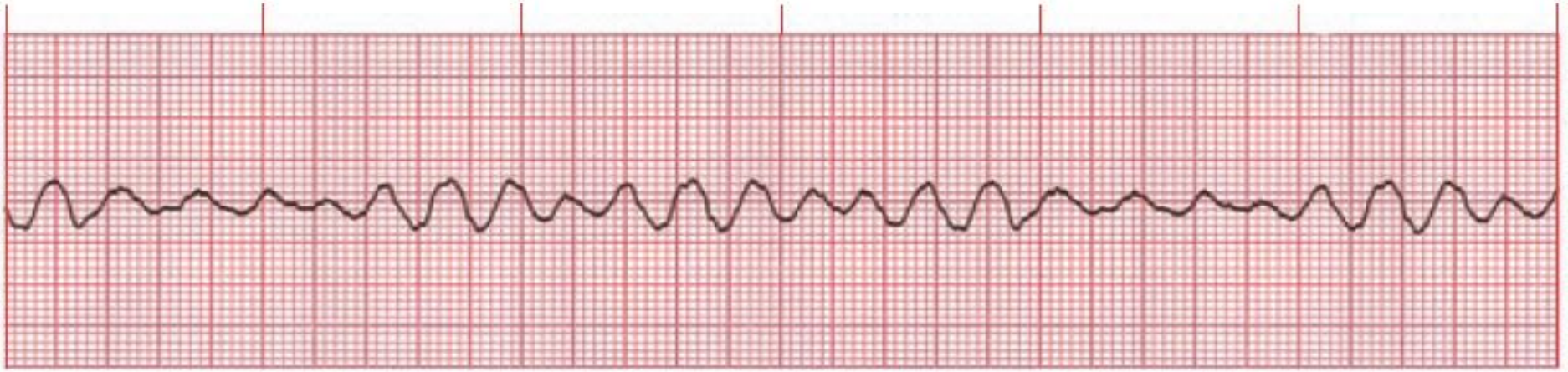
♥ **Clinical Tip:** Signs and symptoms depend on ventricular response rate.

ECG signs of ventricular fibrillation

- QRS are wide of the same shape and amplitude
- End part of QRST complex isn't differentiated (ST and T are absent)
- Diastolic pause is absent (isoline isn't visualized)
- Frequency of ventricular complexes is 250-300/min.

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

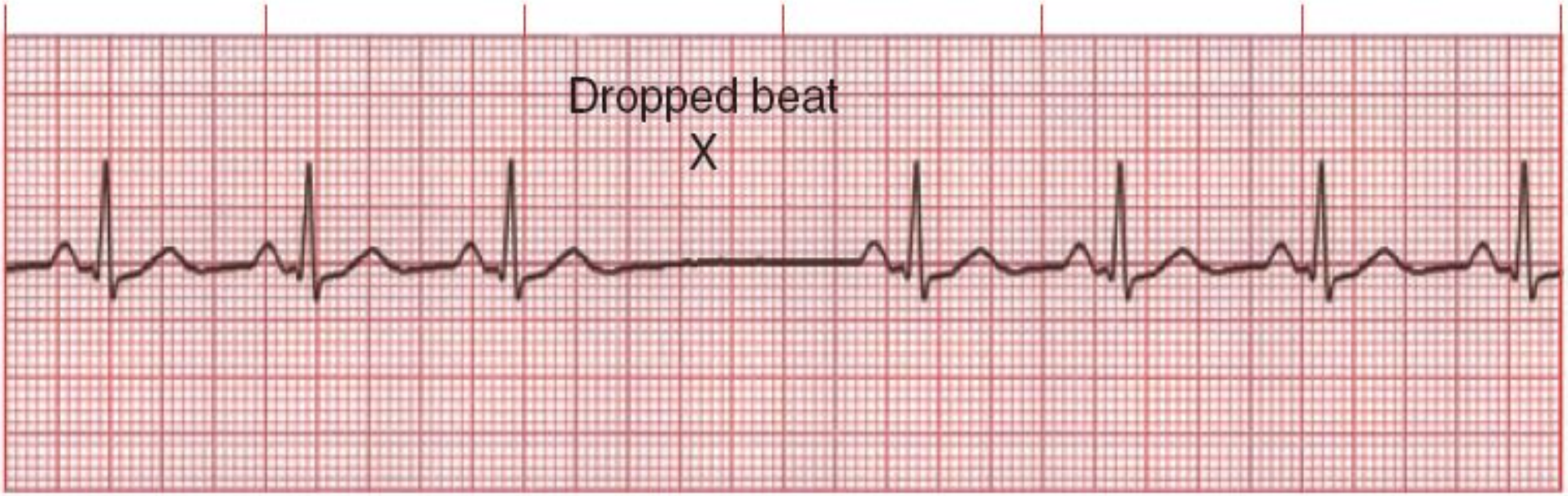
❤ **Clinical Tip:** There is no pulse or cardiac output. Rapid intervention is critical. The longer the delay, the less the chance of conversion.

ECG signs of atrium blockage

- Wave P is wide (elongation to 120msec (normal one isn't more than 95 msec)
- Normal P wave amplitude
- Splitting of P wave and appearance of negative wave
- PQ segment becomes shorter or disappear PR interval is normal

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.

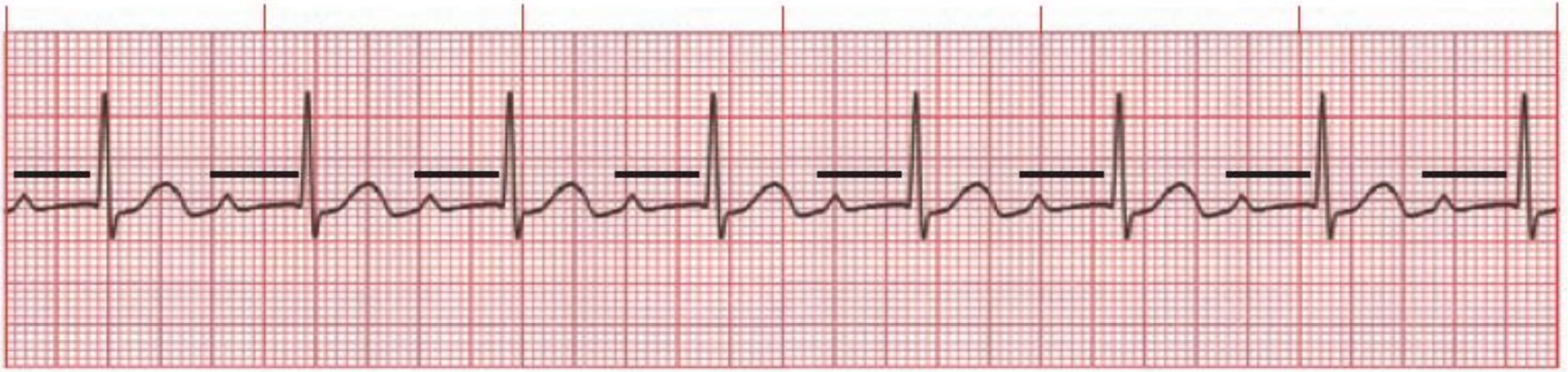
ECG signs of I grade AV blockage

- Interval PQ elongation more than 170 ms for younger children and 200 ms for adolescents
- Wave P is present after every QRS
- Stable PQ interval
- All QRS complexes are present

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.

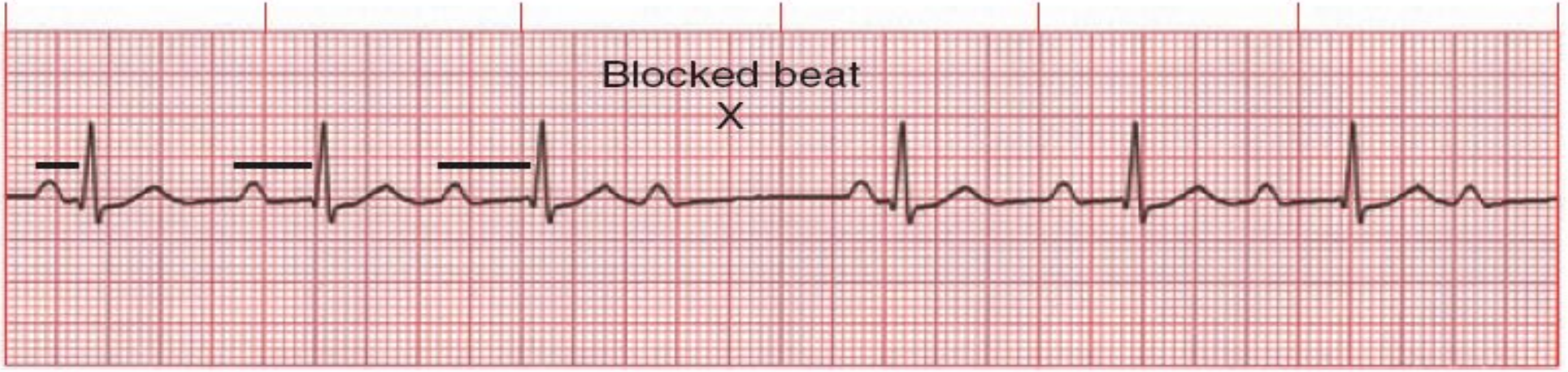
Ecg signs of Mobitz-I type AV block

- Consecutive AV-conductivity retardation from cycle to cycle and elongation of PQ until QRS fallout
- Invariability of QRS
- R-R interval before QRS missing is longer than after it.
- After complex missing PQ interval restitutes again

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.

ECG signs of Mobitz-II AV blockage

- Periodic conductivity atrium impulse to ventricular blockage and QRS fallout.
- Stable PQ interval in all cycles
- Unchangeable QRS
- Regular or irregular QRS fallout with ratio of P waves to QRS as 2:1, 3:2, 4:3 etc.

ECG signs of III grade AV -blockage

- Complete dissociation of atrium and ventricular contractility
- P waves originate from sinus node or atrium heterotopic pacemakers
- Atrium contractility frequency is according to age
- Ventricular complexes are of normal morphology (if rhythm originates from AV node) or aberrant if rhythm is ideoventricular
- Ventricular rhythm is1,5-2 times less than atrium one (40-65/min)
- Different rhythm rate and dissociation of atrium and ventricular contractility lead to chaotic P wave location as for QRS.

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

Arrhythmias treatment

- **Treatment of arrhythmia in children differs from therapy in adults. Main approach is to treat reasons that cause development of rhythm disorders (i.e. inflammatory processes, endocrine diseases, vegetative or metabolic disorders). Only in cases of threatening to life arrhythmias anti-arrhythmic drugs can be used**

Arrhythmias treatment

- Antiarrhythmic drugs are classified according E. Vaughan-Williams (1984) for IV classes
- Class I membrane stabilizers (lidocain)
- Class II Beta-blockers (propranolol)
- Class III medications that prolong repolarization phase (amiodaron)
- Class IV –Ca-channels blockers (verapamil, diltiazem)

Arrhythmias treatment

- **Beta-blockers (propranolol-0,5 mg/kg increasing dosage to 3-5 mg/kg/day steadily, atenolol 1-2 mg/kg bid, nadolol 1-3 mg/kg/day)- in supraventricular tachycardias or premature beats, sometimes in ventricular ones**
- **Amiodaron or cordaron (5-15 mg/kg/day bid 2 weks, then steadily dosage must be decreased)-is effective in both supraventricular and ventricular rhythm disorders**
- **Lidocain (0,5-1 mg/kg for first 2 hours, then 1-2 mg/min IV slowly) – only for ventricular tachycardia, premature beats**

Arrhythmias treatment

Some medications that improve metabolism of cardiomyocytes has also indirect anti-arrhythmic activity

- mildronat,
- L-carnitin,
- preductal,
- Magne-B6, magnerot
- Riboxyn,
- panangyn or asparcam,
- vitamins - antioxydants like triovit, vitamax

Questions

- Prevention of cardiac rhythm disorders in children
- Frequency and prognosis
- Common clinical symptoms of cardiac rhythm disorders in children
- Additional (instrumental) methods of invastigations
- Prevention of complications.
- Principles of treatment of cardiac rhythm disorders in children
-