Conduction disorders

L.V. Bogun, N.I. Yabluchansky, F.M. Abdueva, O.Y. Bichkova, A.N. Fomich, P.A. Garkavyi, A.L. Kulik, N.V. Lysenko, N.V. Makienko, L.A. Martimyanova, I.V. Soldatenko, E.E. Tomina

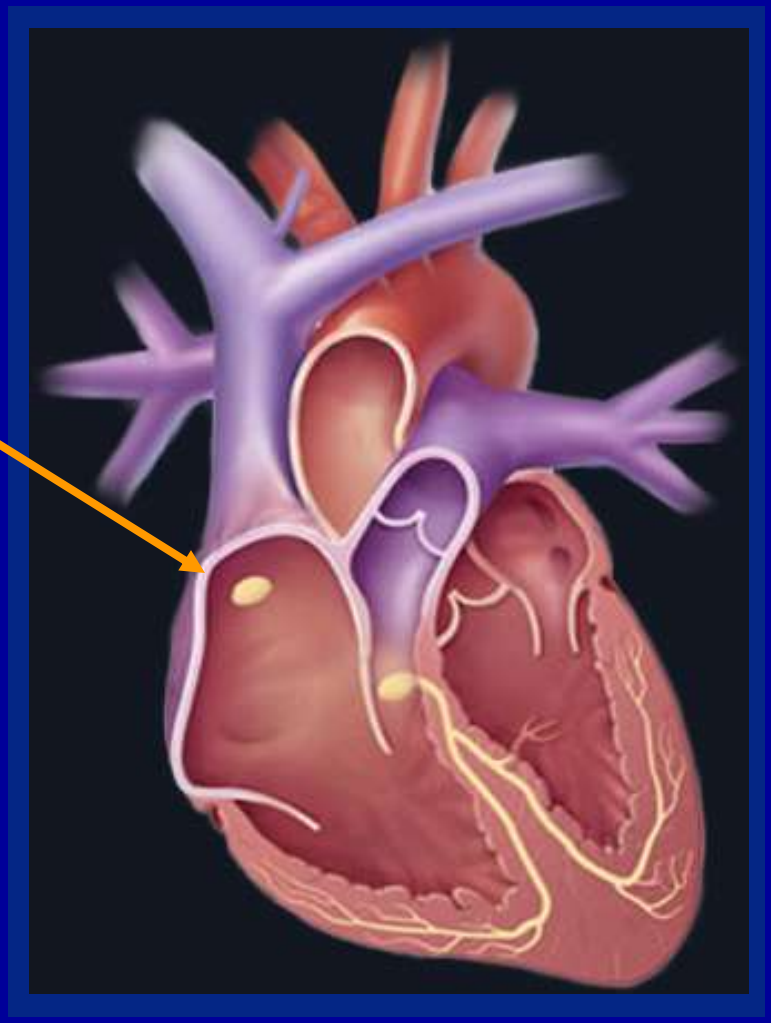
Department of Internal Medicine

Faculty of Medicine

Kharkiv V.N. Karazina National University

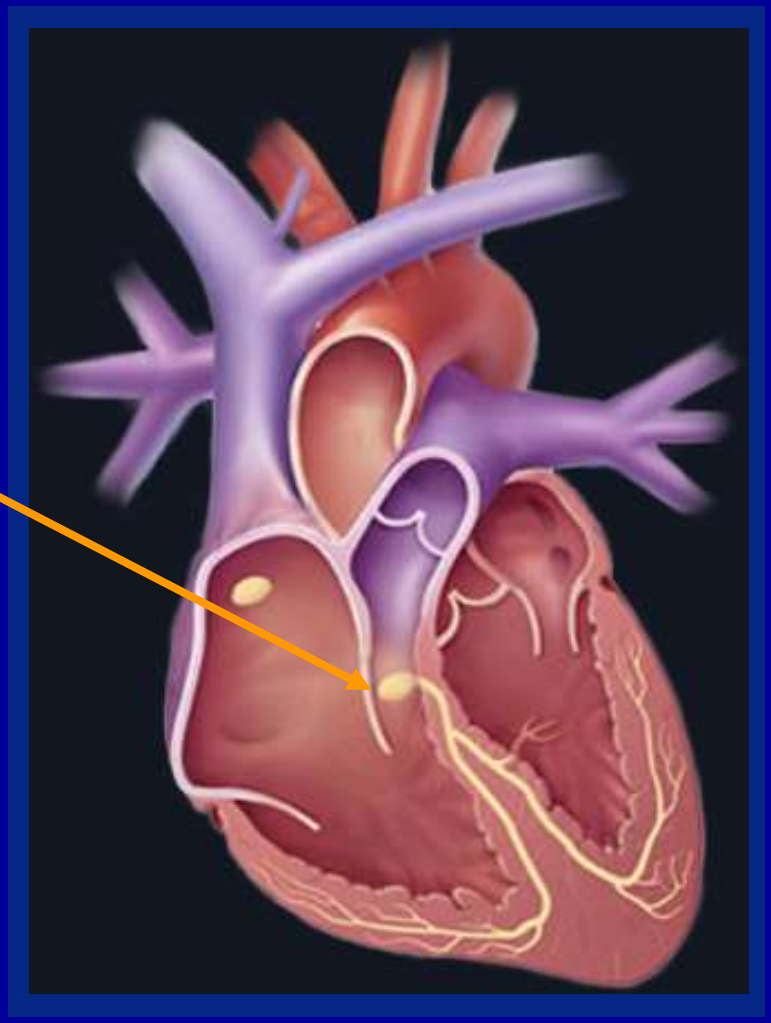
Lecture for 5 course, update 2013

Cardiac Conduction
Sinus Node



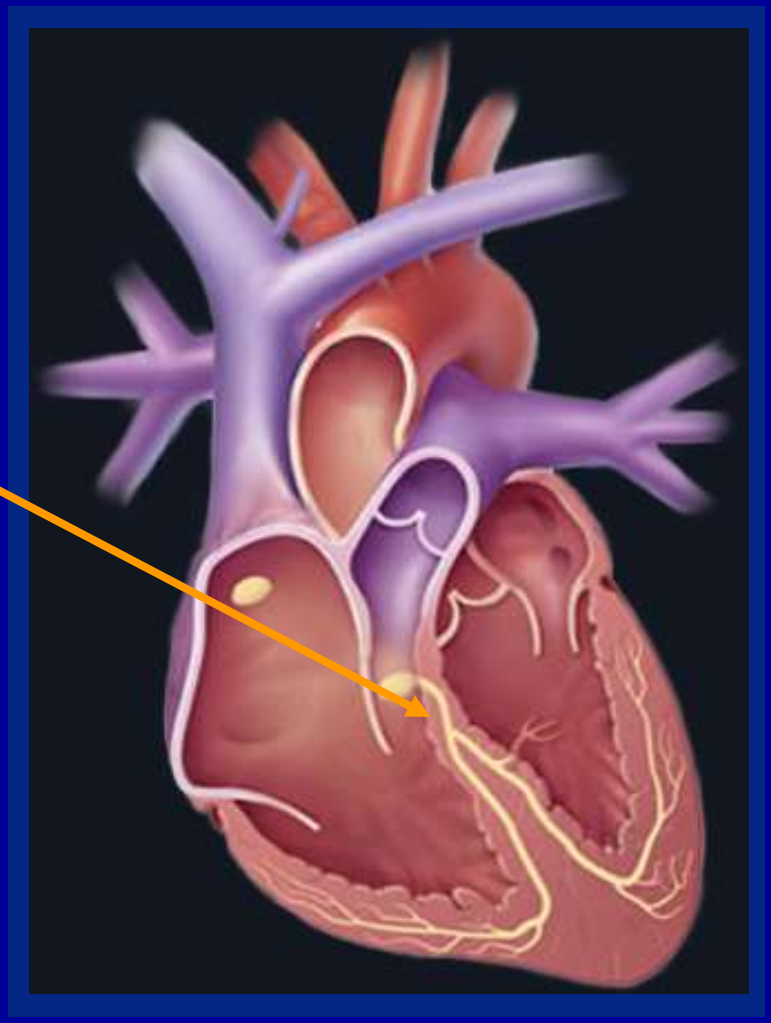
- The Heart's 'Natural Pacemaker'
  - Rate of 60-100 bpm at rest

Cardiac Conduction
AV Node



- Receives impulses from SA node
- Delivers impulses to the His-Purkinje System
- Delivers rates between 40-60 bpm if SA node fails to deliver impulses

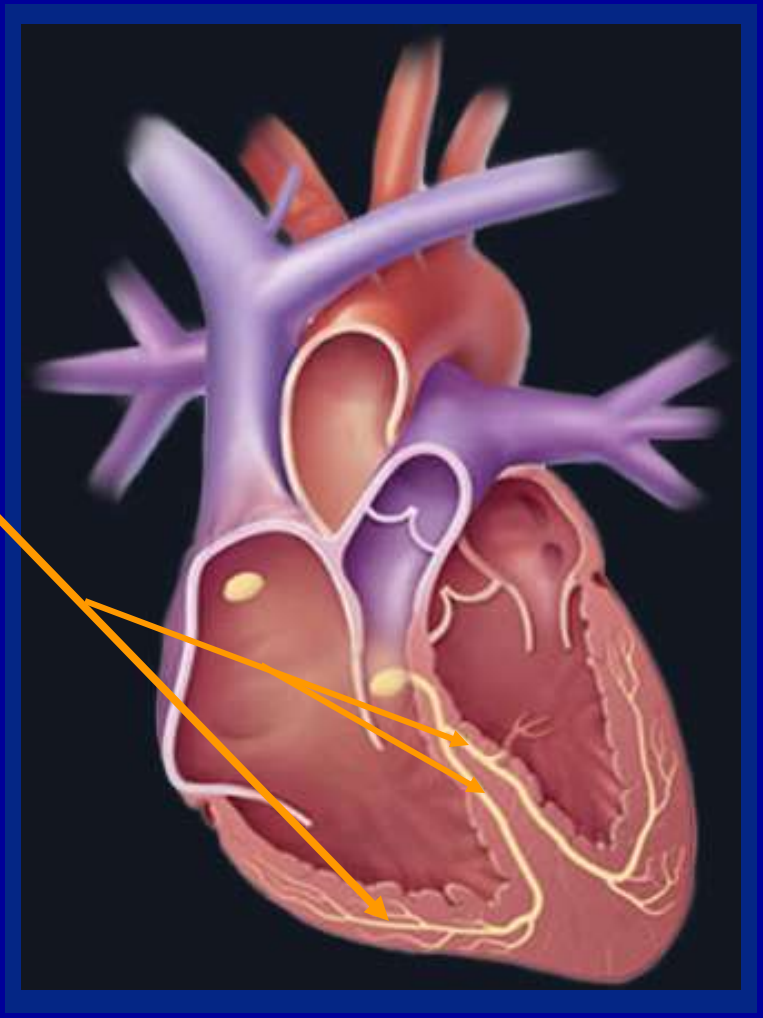
Cardiac Conduction
HIS Bundle



- Begins conduction to the ventricles
- AV Junctional Tissue:
  - Rates between 40-60 bpm

Cardiac Conduction

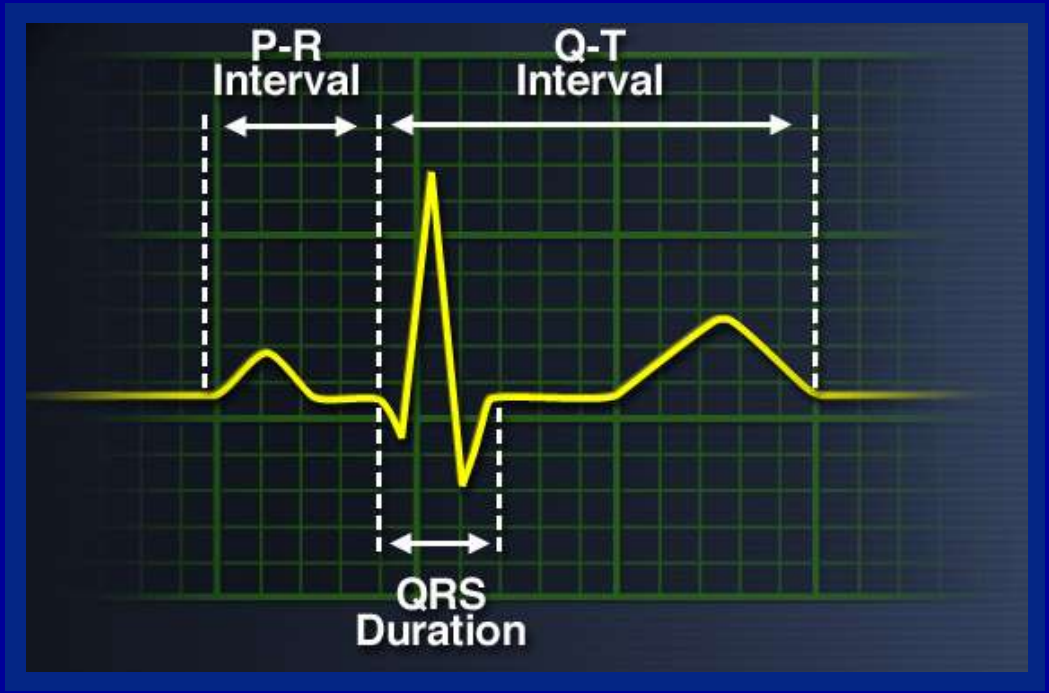
Purkinje Fibers



Bundle Branches and Purkinje Fibers

- Moves the impulse through the ventricles for contraction
- Provides ‘Escape Rhythm’:
  - Rates between 20-40 bpm

ECGs Annotation



Normal Ranges in Milliseconds:

- PR (Q) Interval 120 – 200 ms
- QRS Complex 60 – 100 ms
- QT Interval 360 – 440 ms

Status Check

Match the term on the left with the description on the right

Click for Answer

- P-R Interval
- AV Node
- Purkinje Network
- Bundle Branches

Escape rate is 40-60 bpm

Connect His bundle to Purkinje network

Normally 120-200 ms

Depolarizes the Ventricles

Bradycardia Classifications

Disorders of

- Impulse Formation
- Impulse Conduction

Bradycardia Classifications

Impulse Formation

- **Sinus Arrest**
- **Sinus Bradycardia**
- **Brady/Tachy Syndrome**

Impulse Conduction

- **Slow or Blocked Conduction**

Sinus Arrest

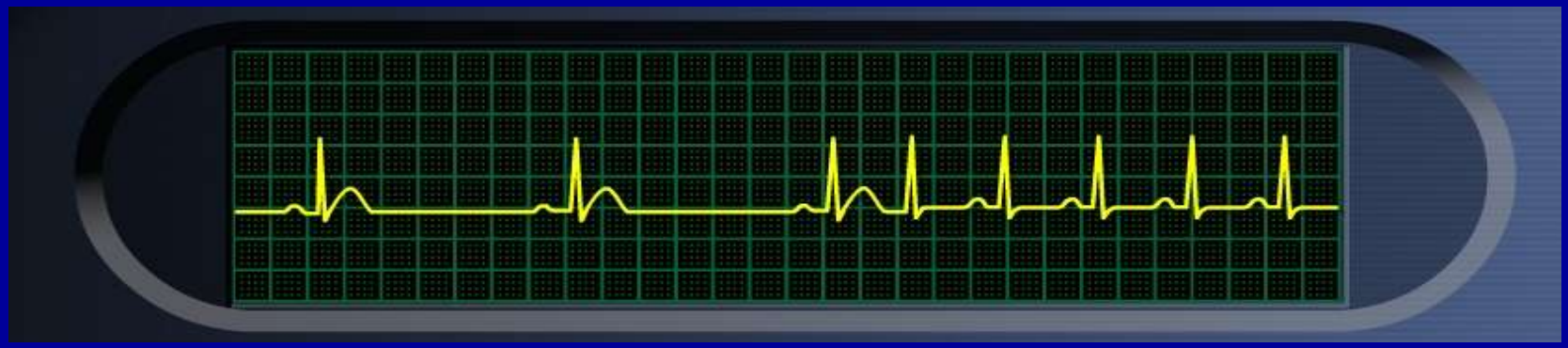
- Failure of sinus node discharge
- Absence of atrial depolarization
- Periods of ventricular asystole
- May be episodic as in vaso-vagal syncope, or carotid sinus hypersensitivity
  - May require a pacemaker

Sinus Bradycardia

- Sinus Node depolarizes very slowly
- If the patient is symptomatic and the rhythm is persistent and irreversible, may require a pacemaker

Brady/Tachy Syndrome

- Intermittent episodes of slow and fast rates from the SA node or atria
- Brady < 60 bpm
- Tachy > 100 bpm
- AKA: Sinus Node Disease
  - Patient may also have periods of AF and chronotropic incompetence
  - 75-80% of pacemakers implanted for this diagnosis



Bradycardia Classifications

Impulse Formation

- **Sinus Arrest**
- **Sinus Bradycardia**
- **Brady/Tachy Syndrome**

Impulse Conduction

- **Slow or Blocked Conduction**

Mechanisms of Rhythm Disorders

Slowed or Blocked Conduction

- Impulse generated normally
- Impulse slowed or blocked as it makes its way through the conduction system

Cardiac conduction block

Block position:

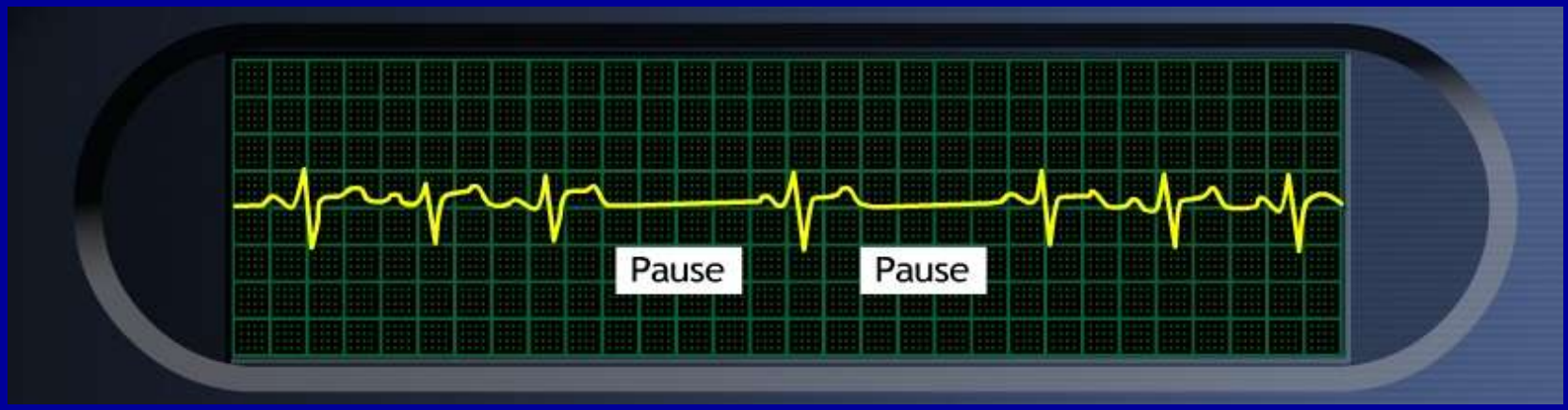
Sinoatrial; intra-atrial; atrioventricular; intra-ventricular

Block degree

1. Type I: prolong the conductive time
2. Type II: partial block
3. Type III: complete block

Exit Block (Sinoatrial block)

- Transient block of impulses from the SA node
- Pacing is rare unless symptomatic, irreversible, and persistent



Atrioventricular (AV) Block

- **AV block is a delay or failure in transmission of the cardiac impulse from atrium to ventricle.**
- **Etiology:**

  Atherosclerotic heart disease; myocarditis; rheumatic fever; cardiomyopathy; drug toxicity; electrolyte disturbance, collagen disease

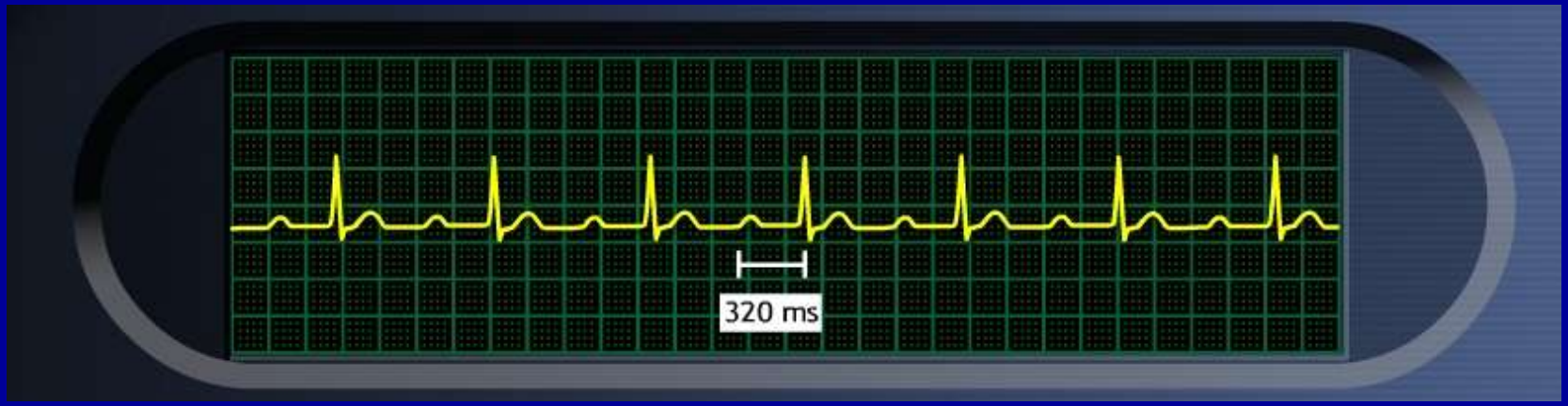
AV Block

AV block is divided into three categories:

1. First-degree AV block
2. Second-degree AV block: further subdivided into Mobitz type I and Mobitz type II, or a “high grade” block (2:1, 3:1)
3. Third-degree AV block: complete block

First-Degree AV Block

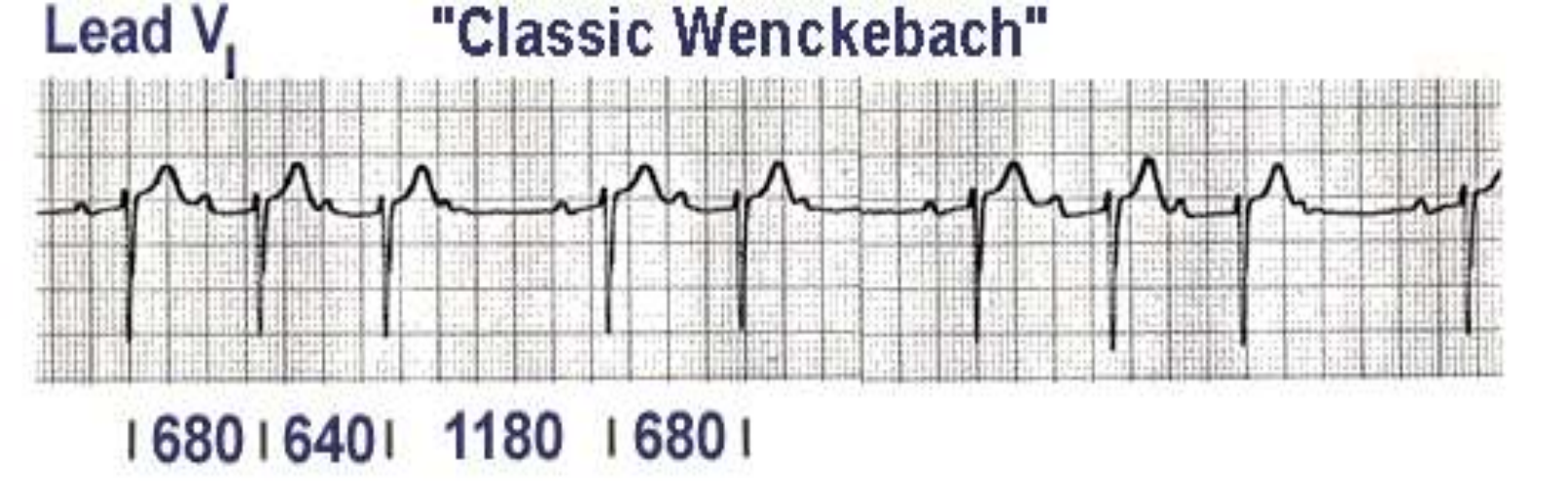
- PR interval > 200 ms
- Delayed conduction through the AV Node
  - Not an indication for pacing *Leave it alone!*



Second-Degree AV Block – Mobitz I

- Progressive prolongation of the PR interval until there is failure to conduct and a ventricular beat is dropped
- AKA: Wenckebach block
  - Usually not an indication for pacing

Second Degree AV Block Type 1 (Wenckebach)



- Increasing delay at AV node until a p wave is not conducted.
- Often comes post inferior MI with AV node ischemia
- Gradual prolongation of the PR interval before a skipped QRS. QRS are normal!
- No pacing as long as no bradycardia.

Second-Degree AV Block – 2:1 block

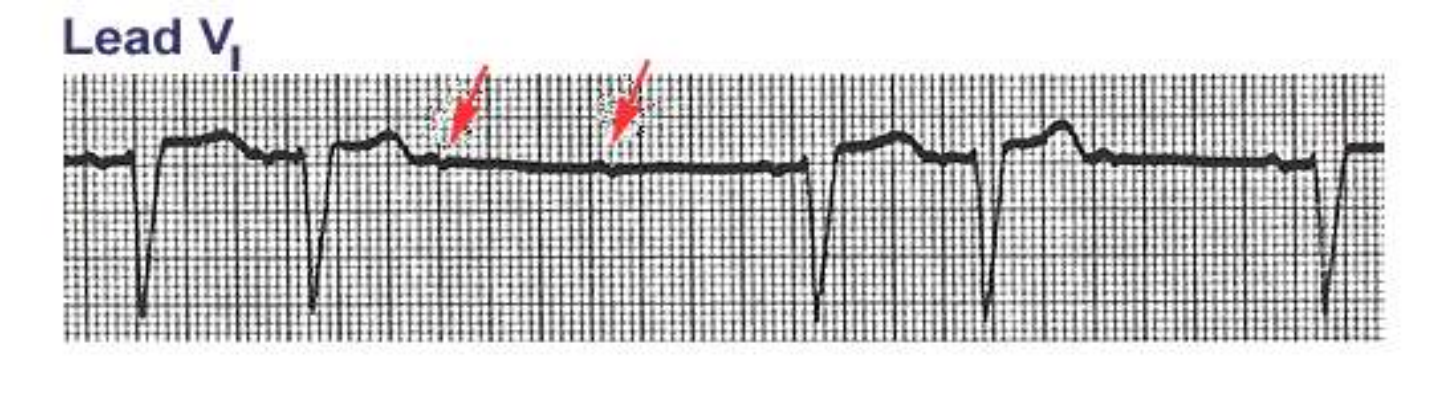
- Regularly dropped ventricular beats
- A “high grade” block,
- Usually an indication for pacing
- May progress to third-degree, or Complete Heart block (CHB)

Second-degree AV block type II

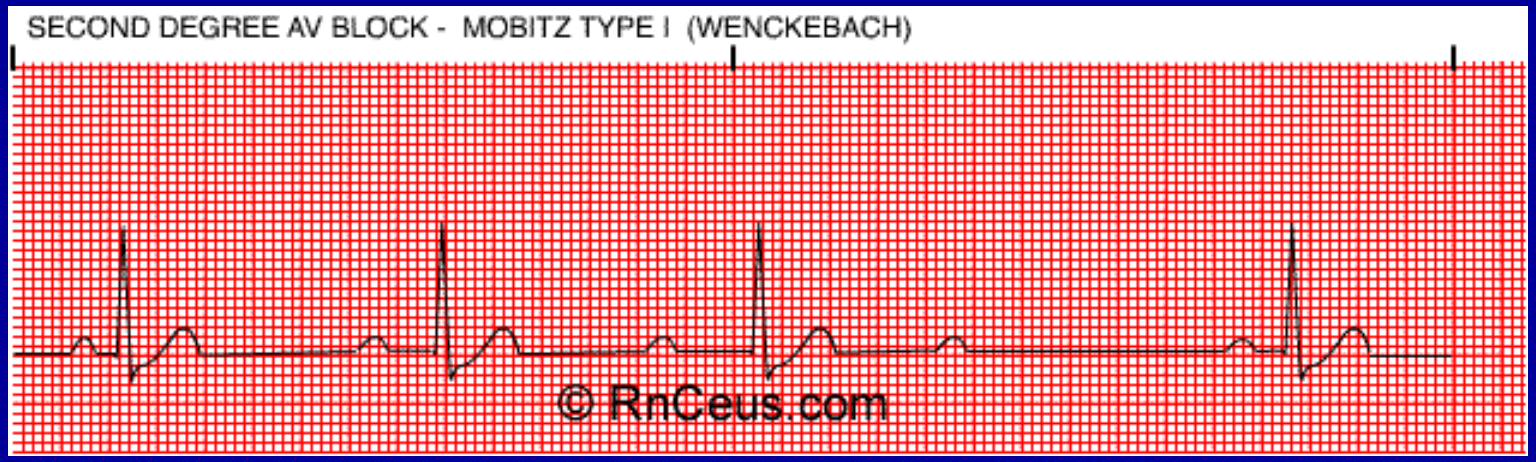
Sudden loss of a QRS wave because p wave was not transmitted beyond AV node.

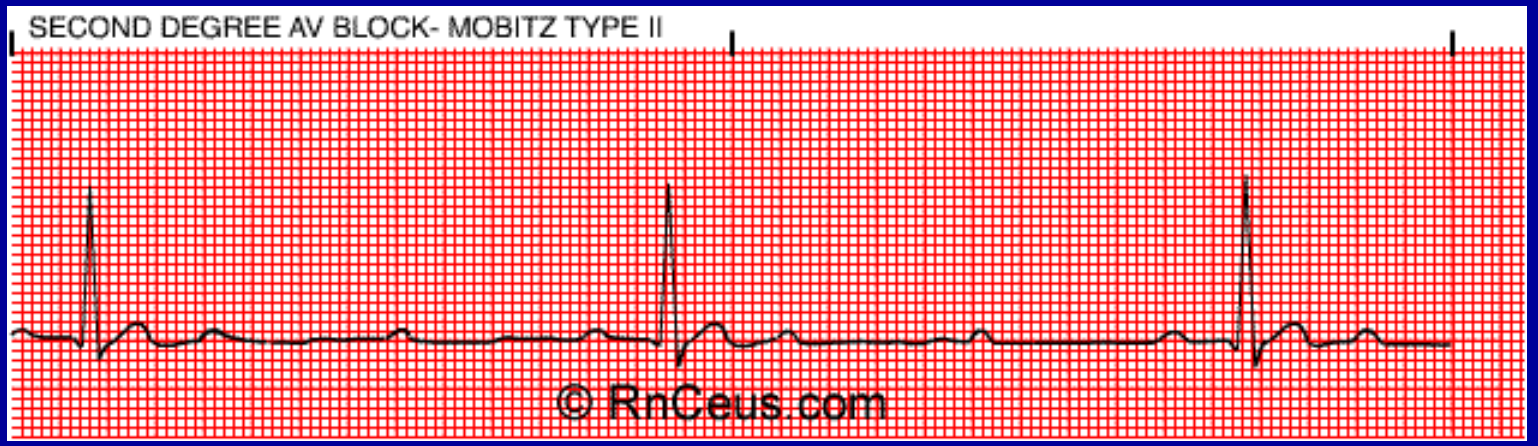
2nd degree heart block (2:1)

Second Degree AV Block 3:1 block



- Sudden loss of a QRS wave because p wave was not transmitted beyond AV node. May be precursor to complete heart block and needs pacing.

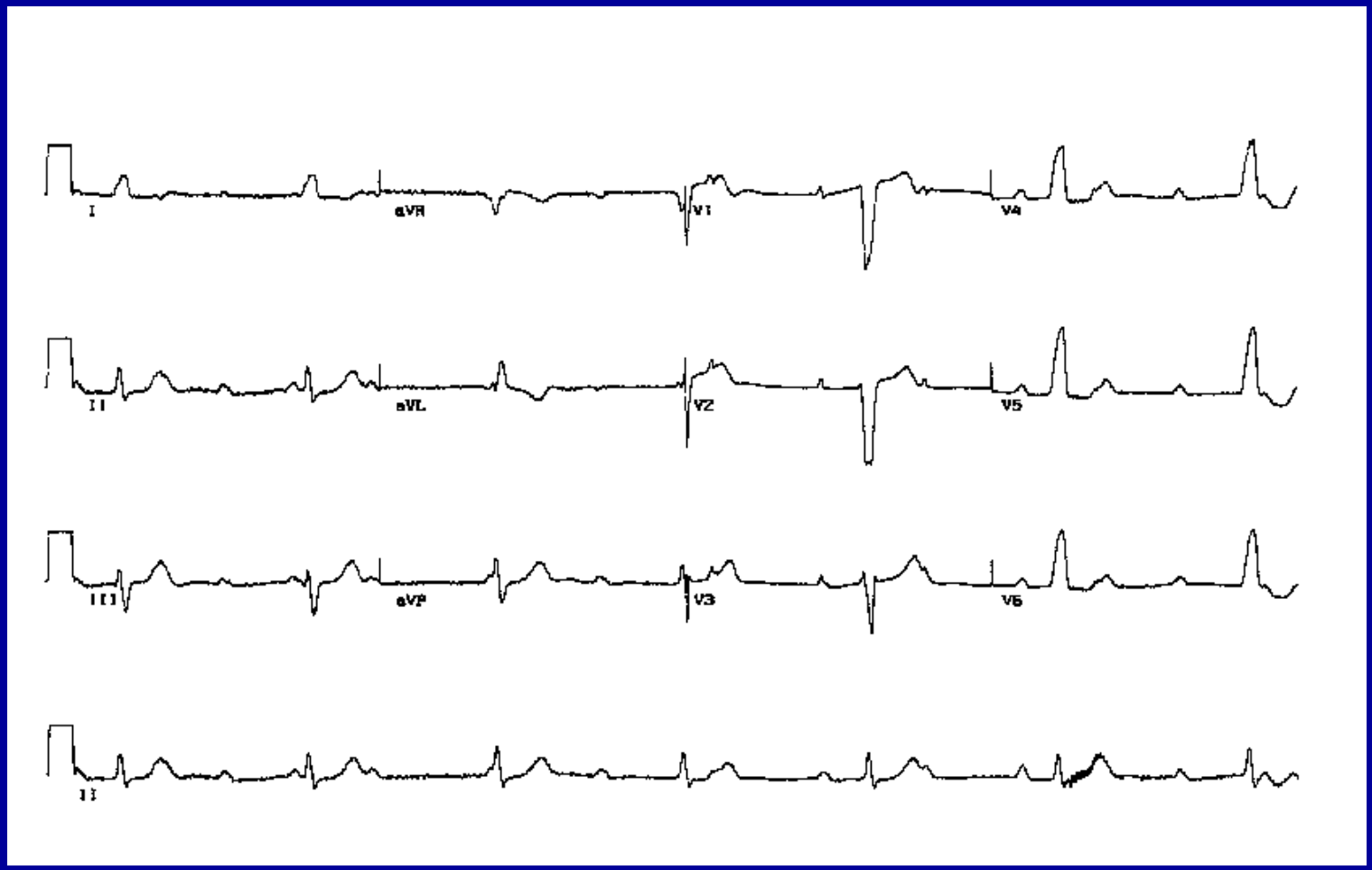

SECOND DEGREE AV BLOCK - MOBITZ TYPE I (WENCKEBACH)
© RnCeus.com


SECOND DEGREE AV BLOCK- MOBITZ TYPE II
© RnCeus.com

Third-Degree (Complete) AV Block

- **No impulse conduction from the atria to the ventricles - atria and ventricles beat independently AND atria beat faster than ventricles:**
  - **Complete A – V disassociation**
  - **Atrial rate is faster than Ventricular rate**
  - **Usually a wide QRS as ventricular rate is idioventricular (distal block) or narrow QRS if AV is pacemaker (proximal block)**

Complete (3rd degree) heart block



AV Block

Manifestations:

- **First-degree AV block: almost no symptoms;**
- **Second degree AV block: palpitation, fatigue**
- **Third degree AV block: Dizziness, agina, heart failure, lightheadedness, and syncope may cause by slow heart rate, Adams-Stokes Syndrome may occurs in sever case.**
- **First heart sound varies in intensity, will appear booming first sound**

AV Block

Treatment:

1. **I or II degree I type AV block needn't antibradycardia agent therapy**
2. **II degree II type and III degree AV block need antibradycardia agent therapy**
3. **Implant Pace Maker**

Intraventricular Block

Intraventricular conduction system:

1. **Right bundle branch**
2. **Left bundle branch**
3. **Left anterior fascicular**
4. **Left posterior fascicular**

Intraventricular Block

Etiology:

- **Myocarditis, valve disease, cardiomyopathy, CAD, hypertension, pulmonary heart disease, drug toxicity, Lenegre disease, Lev's disease et al.**

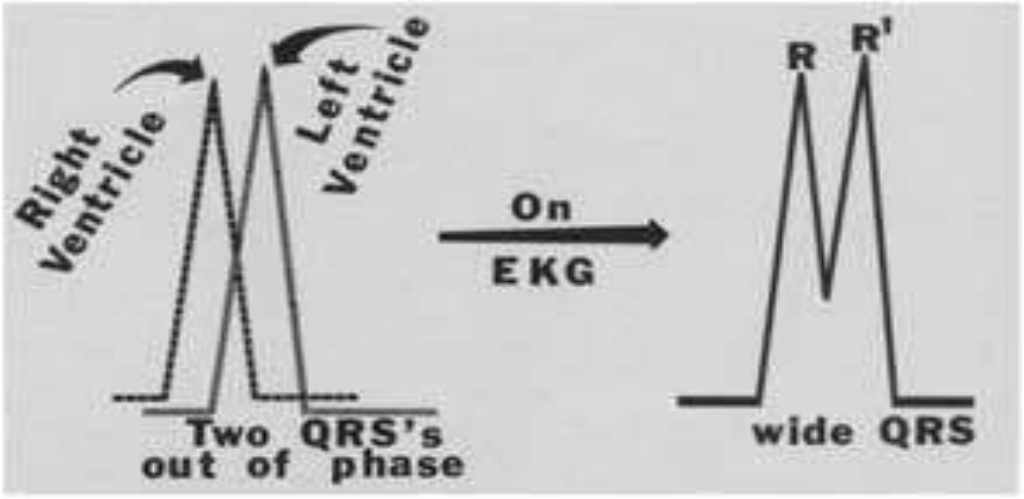
Manifestation:

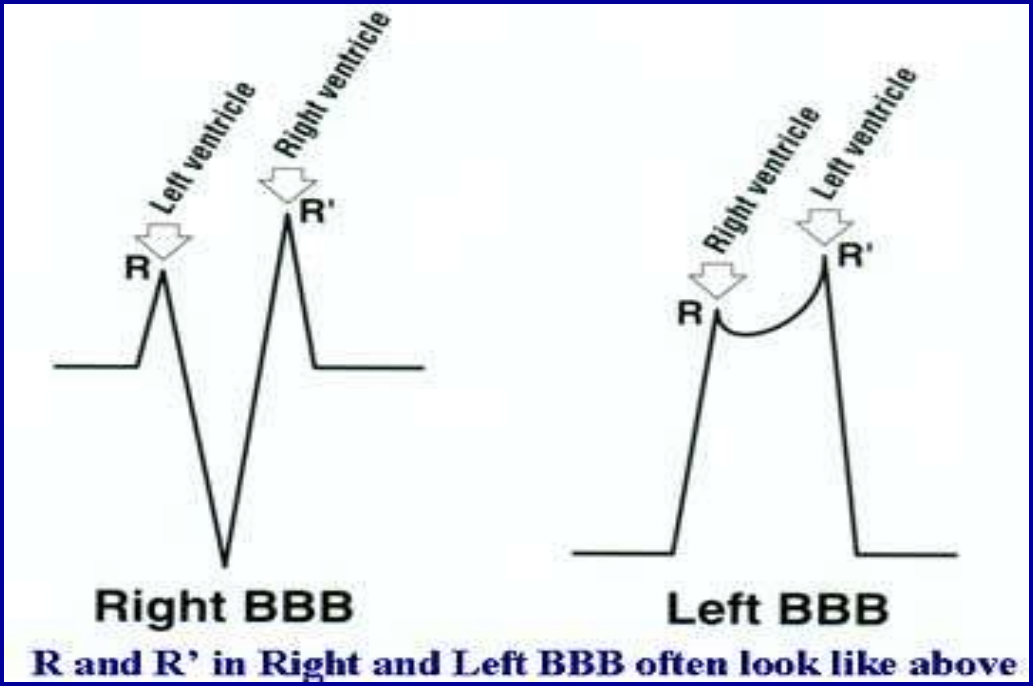
- **Single fascicular or bifascicular block is asymptom; tri-fascicular block may have dizziness; palpitation, syncope and Adams-stokes syndrome**

Intraventricular Block

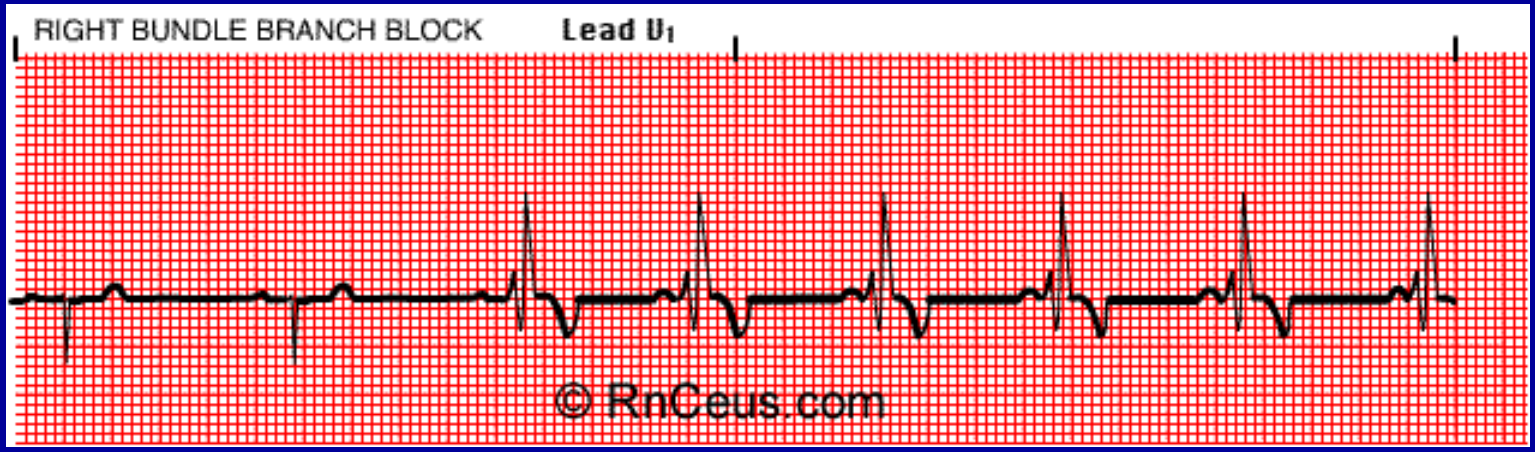
What happens to Right and Left ventricular depolarization if one bundle branch is blocked?

What do you suspect the QRS complex may look like?





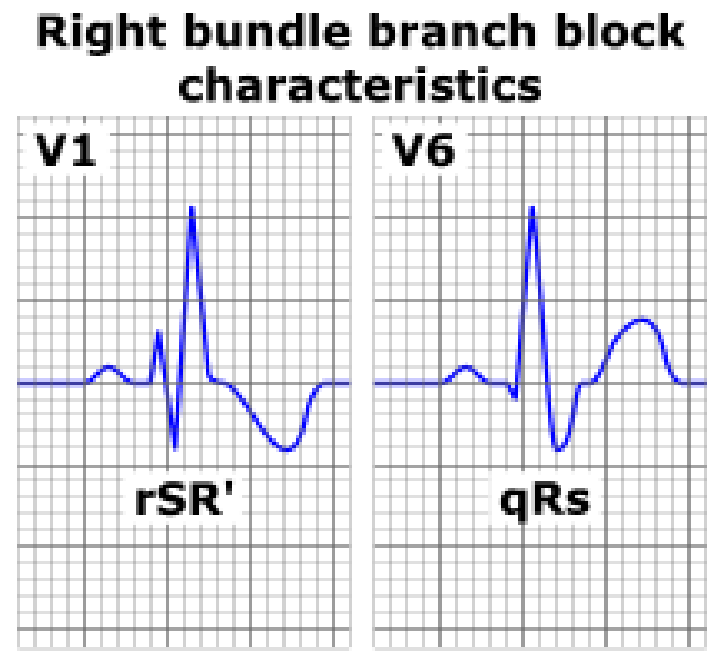
R and R' in Right and Left BBB often look like above



Right Bundle Branch Block (RBBB)

Right ventricle gets a delayed impulse

1. Depolarization spreads from the left ventricle to the right ventricle.
2. This creates a second R-wave (R') in V1, and a slurred S-wave in V5 - V6.
3. The T wave should be deflected opposite the terminal deflection of the QRS complex. This is known as appropriate T wave discordance with bundle branch block. **A concordant T wave may suggest ischemia or myocardial infarction.**
4. Pacemaker if syncope occurs.

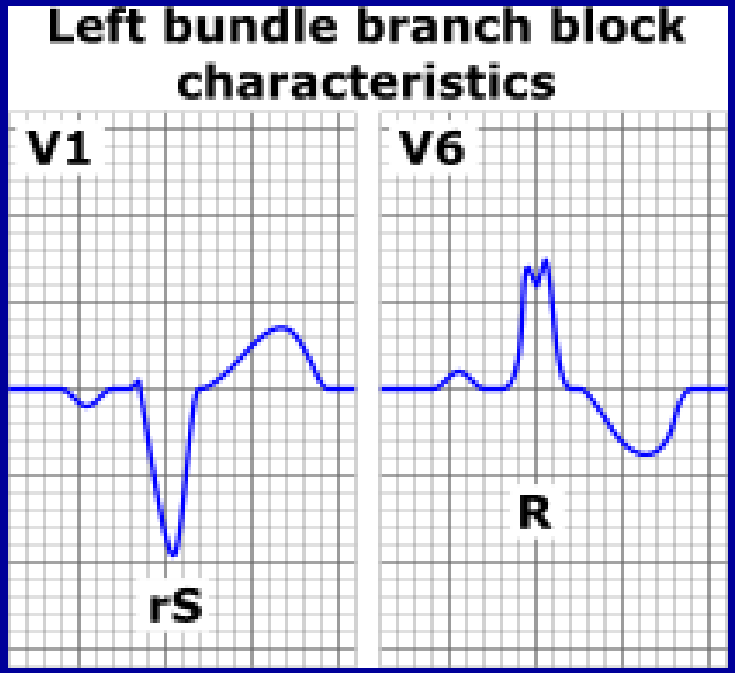


QRS is widened
V1 and V2 have rSR'

Left Bundle Branch Block (LBBB)

Left ventricle gets a delayed impulse

1. **Depolarization enters the right side of the right ventricle first and simultaneously depolarizes the septum from right to left. This creates a QS or rS complex in lead V1 and a monophasic or notched R wave in lead V6.**
2. **The T wave should be deflected opposite the terminal deflection of the QRS complex. This is known as appropriate T wave discordance with bundle branch block. A concordant T wave may suggest ischemia or myocardial infarction.**
3. **Pacemaker if syncope occurs**



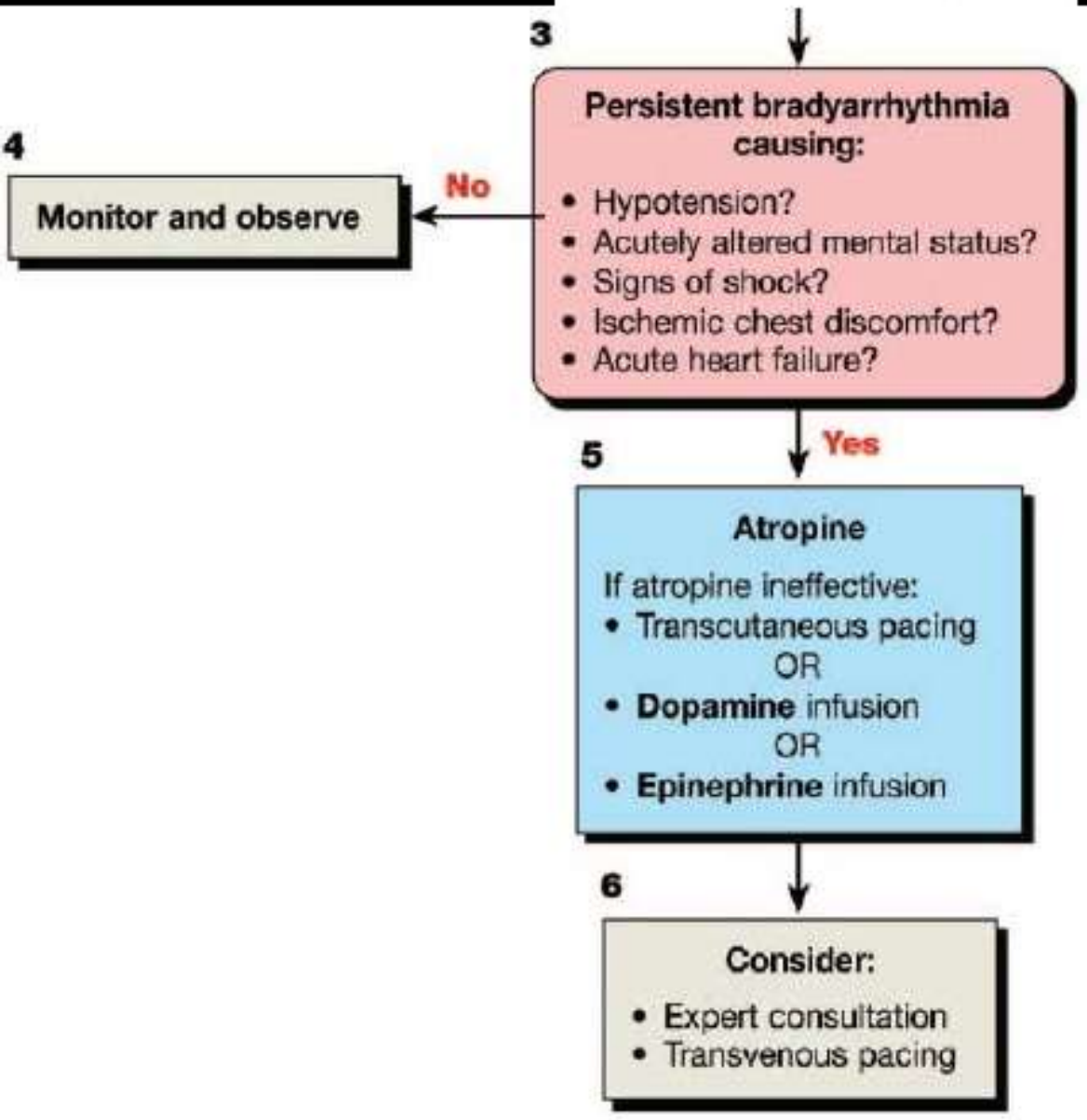
QRS is widened
V5 and V6 have RR' (rabbit ears)

Intraventricular Block

Therapy:

1. **Treat underlying disease**
2. **If the patient is asymptom; no treat,**
3. **If progress to complete block, may need implant pace maker if the patient with syncope**

Adult Bradycardia (With Pulse)



Doses/Details

Atropine IV Dose:
First dose: 0.5 mg bolus
Repeat every 3-5 minutes
Maximum: 3 mg

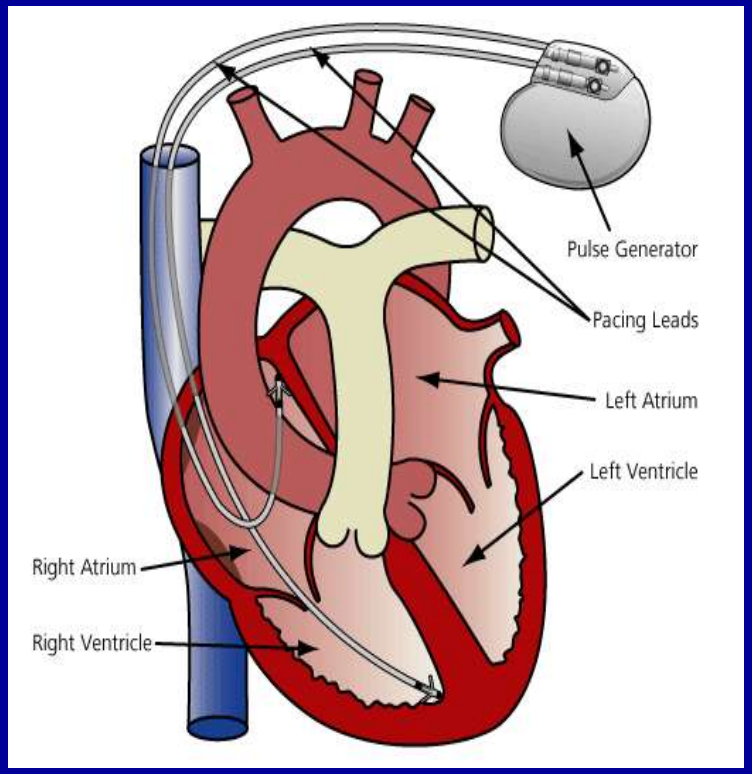
Dopamine IV Infusion:
2-10 mcg/kg per minute

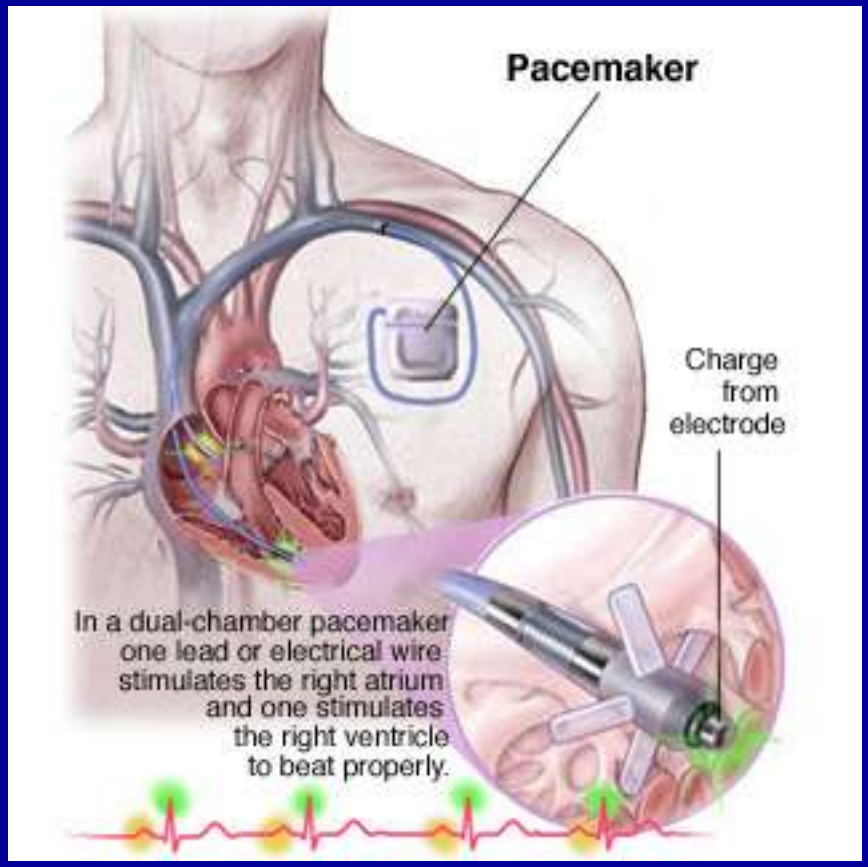
Epinephrine IV Infusion:
2-10 mcg per minute

Pacemaker

- Permanent- battery under skin
- Temporary- battery outside body
- Types
  - Transvenous
  - Epicardial- bypass surgery
  - Transcutaneous- emergency
- Modes
  - Asynchronous- at preset time without fail
  - Synchronous or demand- when HR goes below set rate

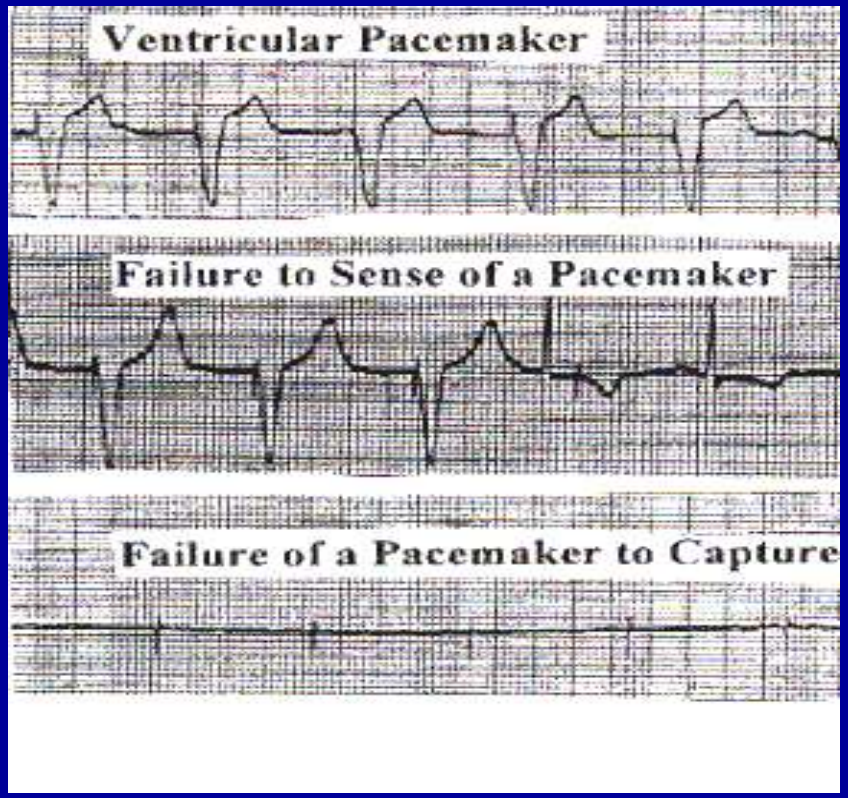
Pacemaker


Pulse Generator
Pacing Leads
Left Atrium
Left Ventricle
Right Atrium
Right Ventricle


Pacemaker
Charge from electrode
In a dual-chamber pacemaker one lead or electrical wire stimulates the right atrium and one stimulates the right ventricle to beat properly.

Pacemaker Problems:

- Failure to sense
- Failure to capture



Sudden cardiac death(SCD)

- Sudden cardiac death (SCD) is used to describe cardiac arrest with cessation of cardiac function, whether or not resuscitation or spontaneous reversion occurs
- Patients who do not die after cardiac arrest should be said to have experienced aborted SCD

Sudden cardiac death(SCD)

Definition by WHO

- Sudden collapse of cardiac function occurring within one hour of symptoms

Sudden cardiac death(SCD)

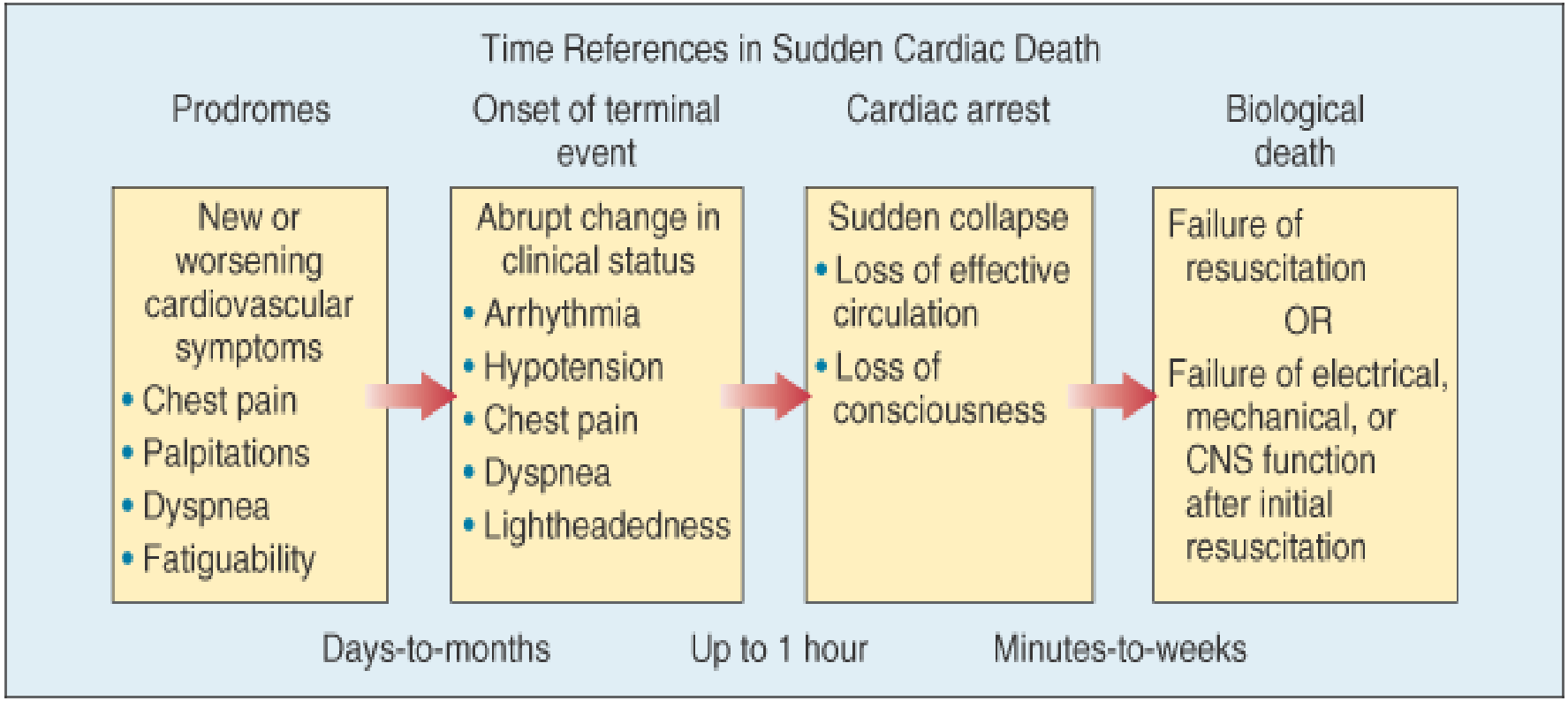
Pathophysiology

- The vast majority of cases of SCD are due to ventricular arrhythmias
- Ventricular tachycardia (VT) or ventricular fibrillation (VF) account for the majority of episodes
- This almost always occurs in the setting of underlying myocardial disease
- More than 80% of SCD events occur in individuals with coronary artery disease (CAD)

Sudden cardiac death(SCD)

Symptoms & signs

- Chest pain
- Dyspnea
- Fatigue
- Palpitations
- Syncope


Time References in Sudden Cardiac Death
Prodromes
Onset of terminal event
Cardiac arrest
Biological death
New or worsening cardiovascular symptoms
• Chest pain
• Palpitations
• Dyspnea
• Fatiguability
Abrupt change in clinical status
• Arrhythmia
• Hypotension
• Chest pain
• Dyspnea
• Lightheadedness
Sudden collapse
• Loss of effective circulation
• Loss of consciousness
Failure of resuscitation
OR
Failure of electrical, mechanical, or CNS function after initial resuscitation
Days-to-months
Up to 1 hour
Minutes-to-weeks

Major Causes of Sudden Cardiac Death

Ischemic heart disease

- Coronary artery disease with myocardial infarction or angina
- Coronary artery embolism
- Nonatherogenic coronary artery disease (arteritis, dissection, congenital coronary artery anomalies)
- Coronary artery spasm

Nonischemic heart disease

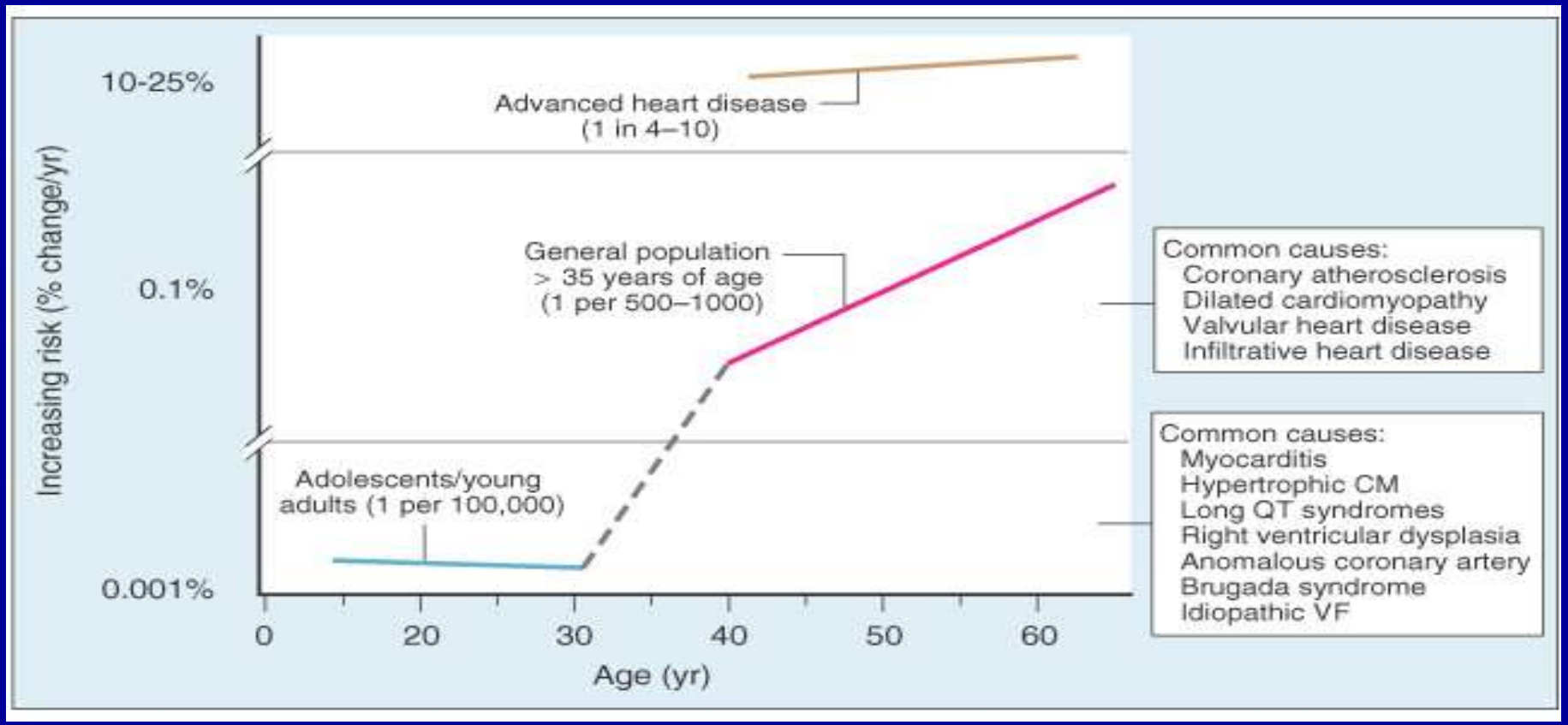
- Hypertrophic cardiomyopathy
- Dilated cardiomyopathy
- Valvular heart disease
- Congenital heart disease
- Arrhythmogenic right ventricular dysplasia
- Myocarditis
- Acute pericardial tamponade
- Acute myocardial rupture
- Aortic dissection

No structural heart disease

- Primary electrical disease (idiopathic ventricular fibrillation)
- Brugada syndrome (right bundle branch block and ST segment elevation in leads V1 to V3)
- Long QT syndrome
- Preexcitation syndrome
- Complete heart block
- Familial sudden cardiac death
- Chest wall trauma (commotio cordis)

Noncardiac disease

- Pulmonary embolism
- Intracranial hemorrhage
- Drowning
- Pickwickian syndrome
- Drug-induced
- Central airway obstruction
- Sudden infant death syndrome


10-25%
0.1%
0.001%
Increasing risk (% change/yr)
Advanced heart disease
(1 in 4–10)
General population
> 35 years of age
(1 per 500–1000)
Adolescents/young
adults (1 per 100,000)
0
20
30
40
50
60
Age (yr)
Common causes:
Coronary atherosclerosis
Dilated cardiomyopathy
Valvular heart disease
Infiltrative heart disease
Common causes:
Myocarditis
Hypertrophic CM
Long QT syndromes
Right ventricular dysplasia
Anomalous coronary artery
Brugada syndrome
Idiopathic VF

SCD & ischemic heart disease

Incidence of VT and VF after ST-elevation MI

- VF:4.2 %
- VT:3.5 %
- Both VF and VT:2.7 %

80 to 85 % of these arrhythmias occurred in the first 48 hours.

Hypertrophic cardiomyopathy

- Most common cause of SCD in young(age ≤ 35 y/o)
- SCD is primarily related to VT or VF.
- The mechanism of arrhythmia in this setting is not clear
- Autosomal-dominant inherited disease

Valvular disease

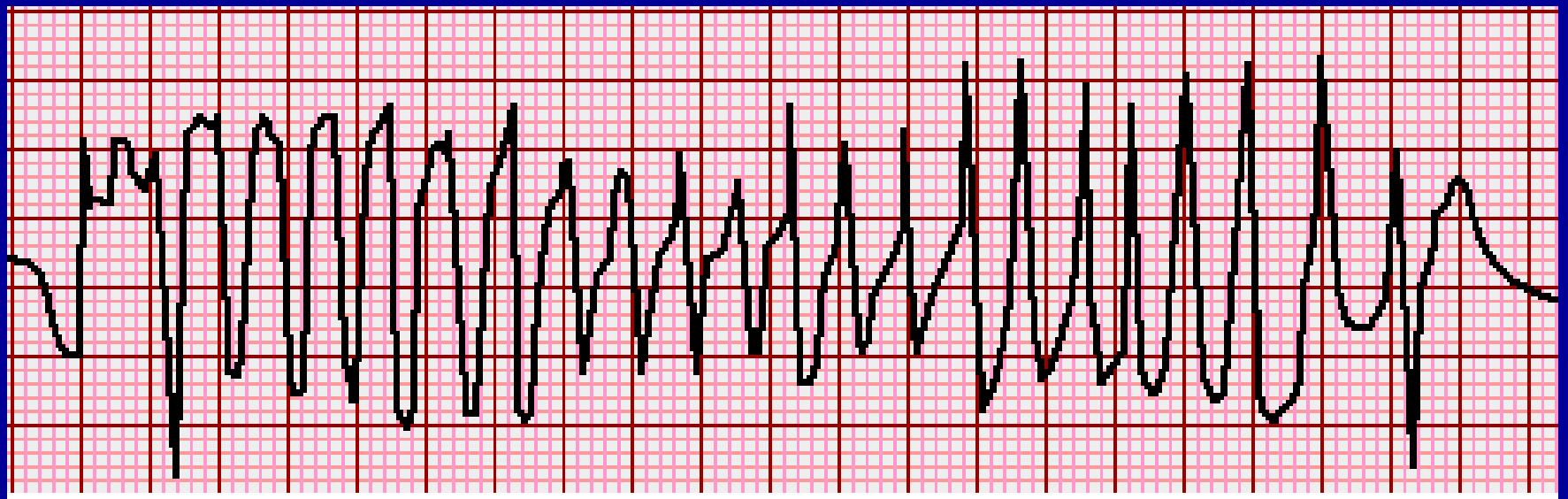
- Aortic stenosis (predominate)
- The mechanism of sudden death is unclear, and both malignant ventricular arrhythmia and bradyarrhythmia have been documented

Absence of structural heart disease

- Long QT syndrome
- Wolff-Parkinson-White (WPW) syndrome
- Commotio cordis

Long QT syndrome

- Prolonged QT interval
- Polymorphic ventricular tachycardia (VT) called torsade de pointes



Torsade de pointes This is an atypical, rapid, and bizarre form of ventricular tachycardia that is characterized by a continuously changing axis of polymorphic QRS morphologies.

Definition of Normal, Borderline, and Prolonged Corrected QT Interval (QTc) in Seconds According to Age and Gender

	1-15 yrs	Men	Women
Normal	0.44	<0.43	<0.45
Borderline	0.44-.046	0.43-.045	0.45-.0.47
Prolonged (upper one percent)	>0.46	>0.45	>0.47

QTc = QT interval ÷ square root of the RR interval (in msec)

Causes of the Long QT Syndrome

Congenital
- Jervell-Lange-Nielsen syndrome
- Romano-Ward syndrome
- Idiopathic

Acquired

Metabolic disorders
- Hypokalemia
- Hypomagnesemia
- Hypocalcemia
- Starvation
  - Anorexia nervosa
- Liquid protein diets
- Hypothyroidism

Bradyarrhythmias
- Sinus node dysfunction
- AV block – second or third degree

Antiarrhythmic drugs
- Quinidine
- Procainamide or N-acetylprocainamide
- Disopyramide
- Amiodarone
- Sotalol
- Dofetilide, sematilide, ibutilide, bepridil, mibefradil

Antimicrobial drugs
- Erythromycin, clarithromycin, telithromycin, azithromycin (minor)
- Pentamidine
- Some fluoroquinolones (eg, sparfloxacin, gatifloxacin, levofloxacin, moxifloxacin)
- Other – Spiramycin, chloroquine, halofantrine mefloquine

Antihistamines
- Terfenadine
- Astemizole

Psychotropic drugs
- Thioridazine
- Phenothiazines
- Butyrphenones
- Tricyclic or tetracyclic antidepressants
- Haloperidol
- Selective serotonin reuptake inhibitors
- Risperidone
- Very high dose methadone

Other drugs
- Vasodilators – Prenylamine
- Diuretics – Via electrolyte changes
- Serotonin antagonist – Ketanserin
- Motility drugs – Cisapride, domperidone
- Droperidol – may be safe at the low doses used by anesthesiologists (0.625 to 1.25 mg)
- Ranolazine
- ?HIV protease inhibitors
- Miscellaneous – Organophosphate insecticides, probucol, cocaine, terodiline, papaverine, Chinese herbs, chloral hydrate, arsenic trioxide, cesium chloride, levomethadyl

Other
- Mitral valve prolapse
- Myocardial ischemia or infarction
- Intracranial disease
- HIV infection
- Hypothermia
- Connective tissue diseases with anti-Ro/SSA antibodies

Wolff–Parkinson–White (WPW) syndrome

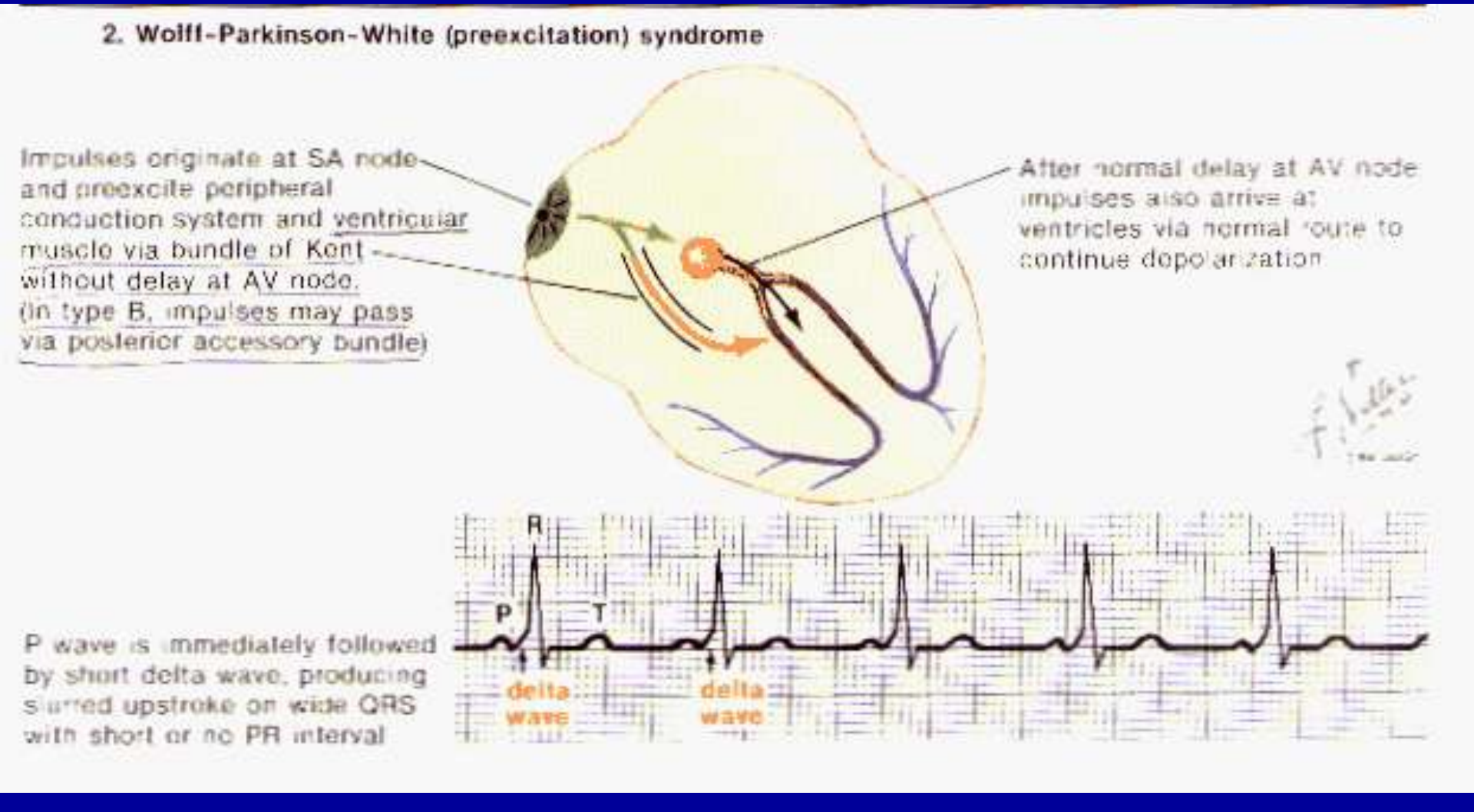
The type of pre-excitation syndrome:

existence of an atrioventricular accessory pathway bundle of Kent)

Atrial fibrillation (AF) with a rapid ventricular response was the most common

VT/VF may occur

Wolff–Parkinson–White syndrome



Wolff–Parkinson–White (WPW)

A supraventricular rhythm originating in the SA node with normal & regular P-waves

PR interval is abnormally short (< 0.12 sec)

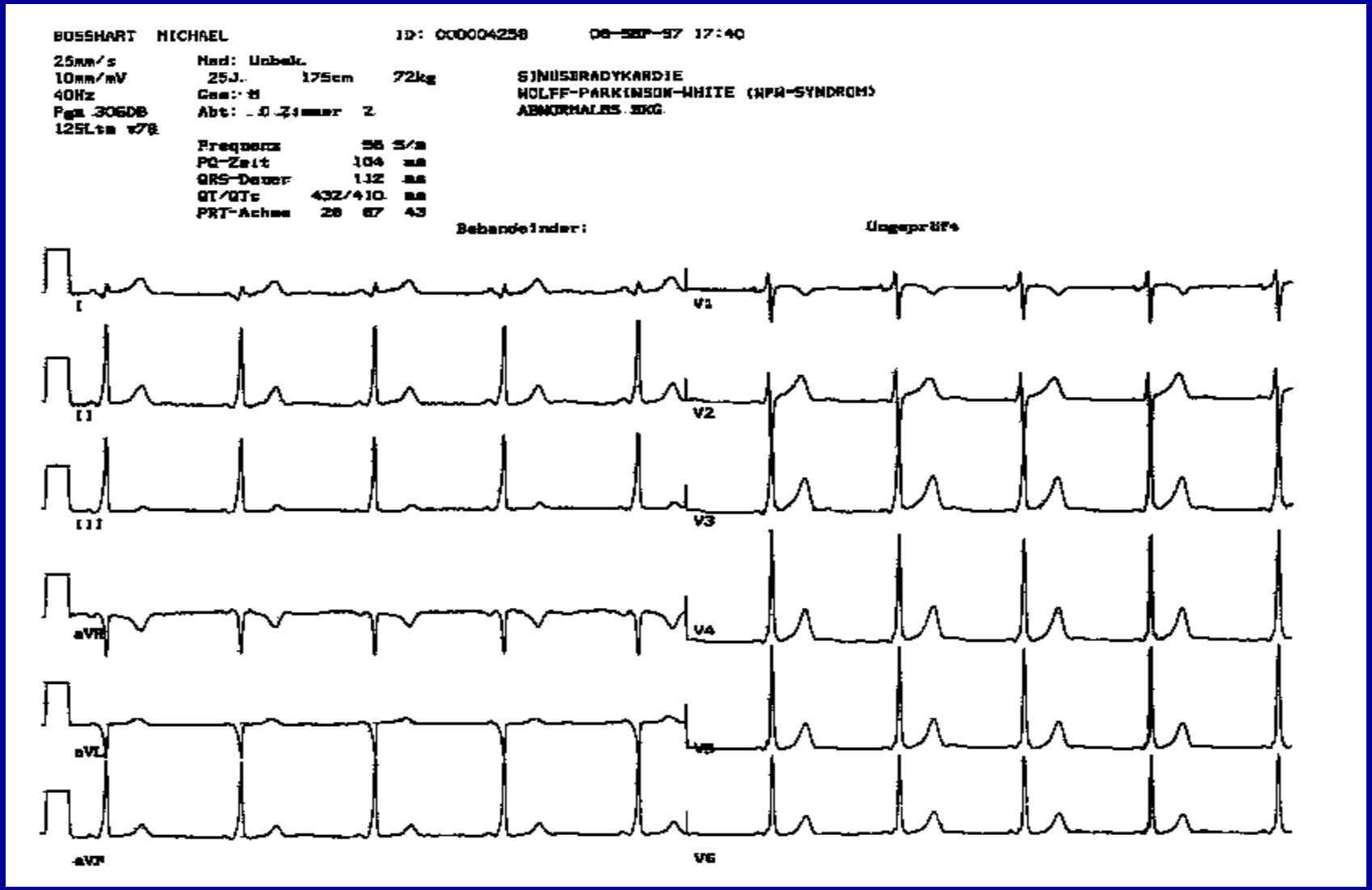
QRS is wide with a *"slurred upstroke"* (AKA the delta-wave)

Delta-waves are due to the accessory conduction pathway (bundle of Kent) from the atria to the ventricles, that bypasses the AV node

Must manifest a tacchycardia at some point in time

Treatment: III class, Procainamide, radiofrequency ablation

WPW syndrome

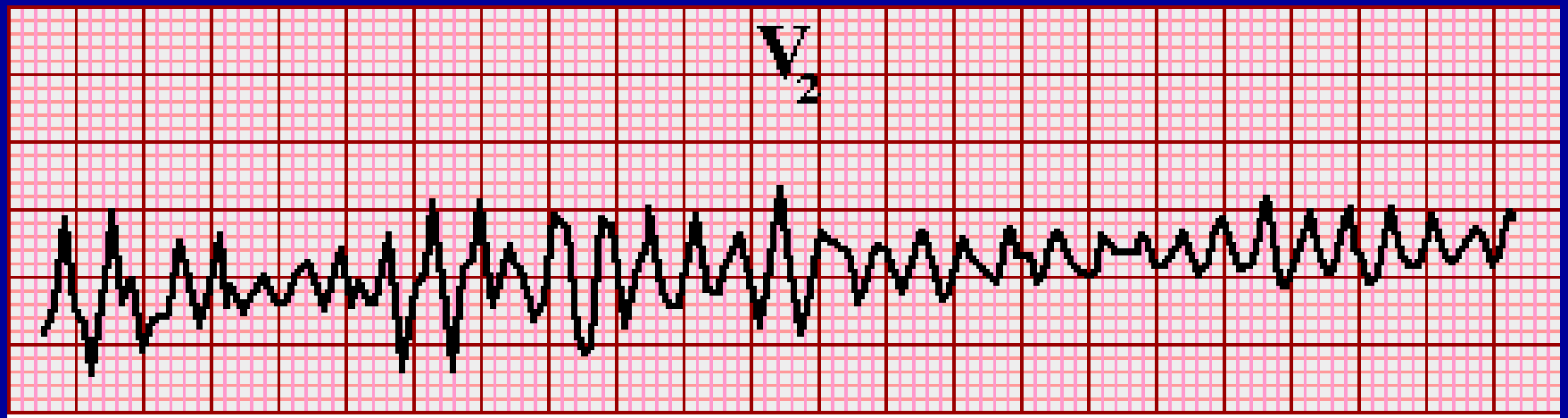


Commotio cordis

- Refers to SCD that most often occurs in young athletes who have been struck in the precordium with a projectile object such as a baseball, hockey puck, or fist
- The most common arrhythmia is VF

4 rhythms that produce pulseless arrest:

- pulseless ventricular tachycardia (VT)
- ventricular fibrillation (VF)
- asystole
- pulseless electrical activity (PEA)



Ventricular fibrillation There is a complete absence of properly formed QRS complexes and no obvious P waves. A recent onset (eg, within minutes) of the arrhythmia is suggested by the coarse morphology of the fibrillatory waves.

Asystole

Asystole is defined as a cardiac arrest rhythm in which there is no discernible electrical activity on the ECG monitor.

Asystole is sometimes referred to as a "flat line." Confirmation that a "flat line" is truly asystole is an important step.

Ensure that asystole is not another rhythm that looks like a "flat line." Fine VF can appear to be asystole, and a "flat line" on a monitor can be due to operator error or equipment failure

The following are common causes of an isoelectric line that is not asystole:

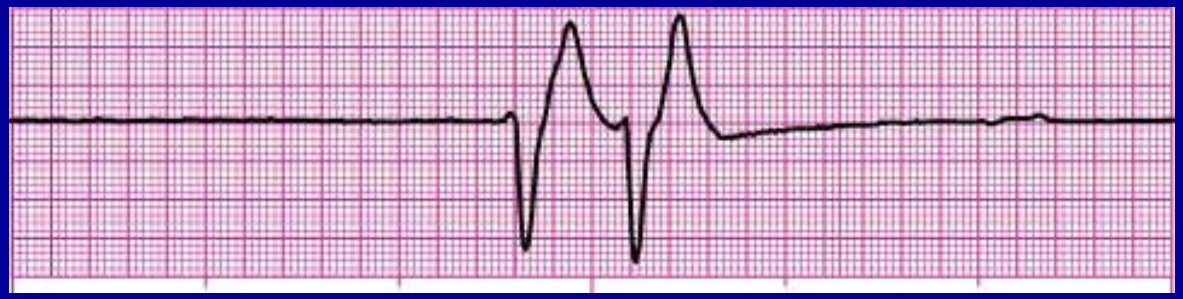
1. **loose or disconnected leads;**
2. **loss of power to the ECG monitor;**
3. **low signal gain on the ECG monitor.**

Asystole for many patients is the result of a prolonged illness or cardiac arrest, and prognosis is very poor.

Few patients will likely have a positive outcome and successful treatment of cardiac arrest with asystole will usually involve identification and correction of an underlying cause of the asystole.

Agonal rhythm/asystole

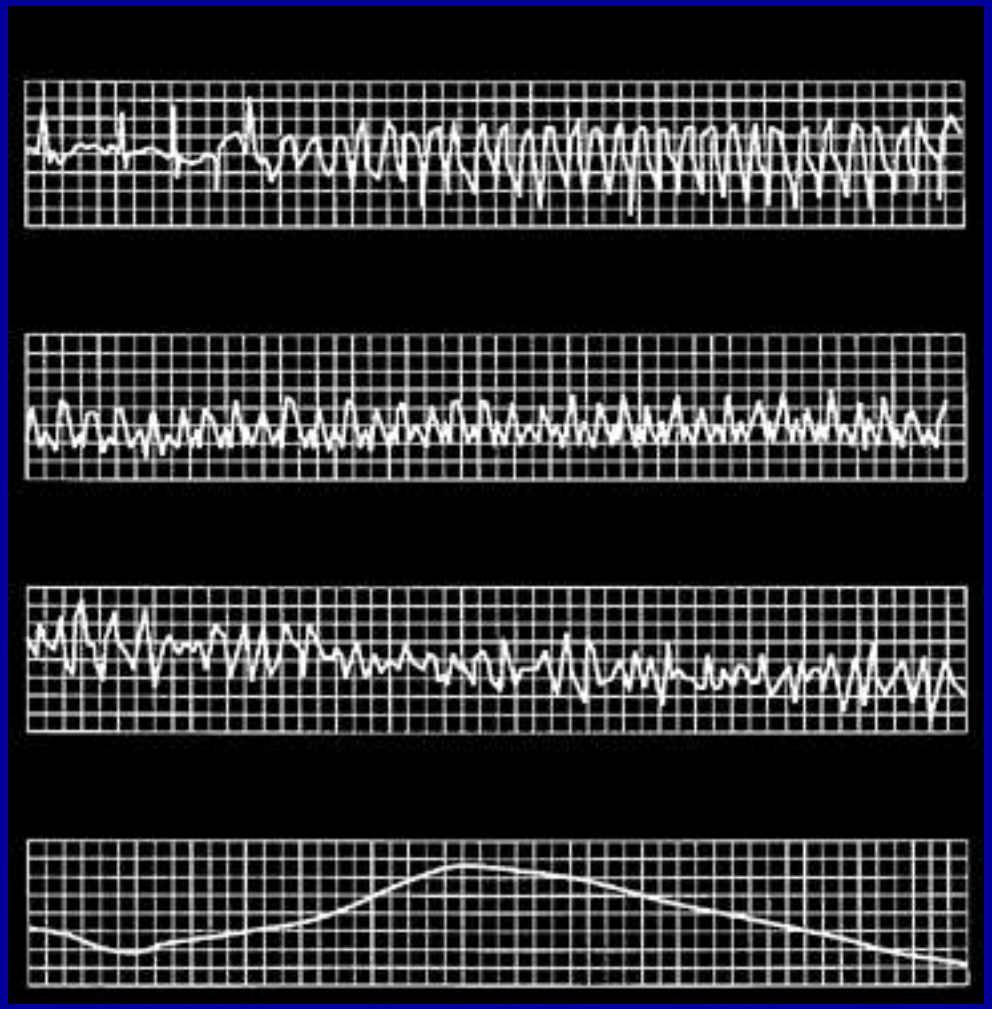
- **Ventricular rhythm** — **Two ventricular complexes to none**
- **Ventricular rate** — **None**
- **Atrial rhythm** — **None**
- **Atrial rate** — **None**
- **PRI:** — **None**
- **QRS:** — **0.14 sec to none**



Asystole

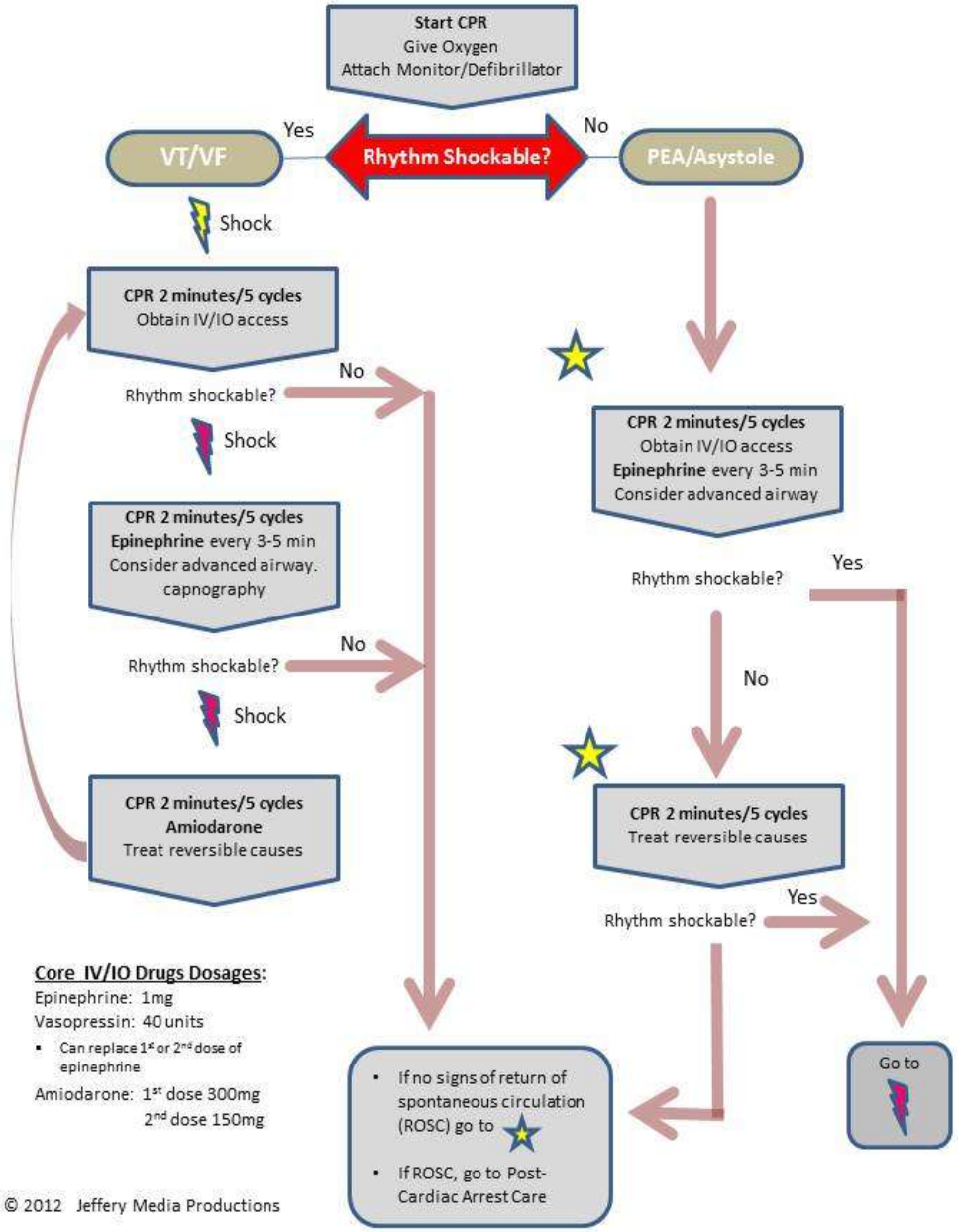
- Ventricular rhythm None
- Ventricular rate None
- Atrial rhythm None
- Atrial rate None
- PRI: None
- QRS: None

Rhythm Strip During Episode of Sudden Death



AHA ACLS Adult Cardiac Arrest Algorithm

Shout for Help/Activate Emergency Response



Core IV/IO Drugs Dosages:

Epinephrine: 1mg

Vasopressin: 40 units

- Can replace 1st or 2nd dose of epinephrine

Amiodarone: 1st dose 300mg
2nd dose 150mg

There are several important points that should be considered when initiating the pulseless arrest algorithm:

- High-quality CPR should be performed until the defibrillator is attached the patient.
- Interruptions in chest compressions should be kept to a minimum.
- Rapid use of the defibrillator should be emphasized.
- If possible, use a manual defibrillator over an AED since the use of the AED can result in prolonged interruptions in chest compressions for rhythm analysis and shock administration.

monitor

external paddles

adhesive pads

Examples of cardioversion equipment

Defibrillation and the Shock

- Most defibrillators used today are biphasic. Biphasic means that the electrical current travels from one paddle to the other paddle and then back in the other direction.
- The biphasic shock also requires less energy to restore normal heart rhythm and is believed reduce skin burns and cellular damage to the heart.
- When using a biphasic defibrillator in VF and/or pulseless VT, you will use a dose of 120-200 Joules to shock.
- Start with 120J and increase the dosing in a stepwise fashion up to 200 Joules as needed.

To ensure safety during the shock

- To ensure safety during the shock, providers should always announce the following statement, “I am going to shock on three.
  - One, I’m clear…
  - Two, you’re clear…
  - Three, everybody is clear.”

Status Check

Click for Answer

- **What is the most likely rhythm disorder that might result in a patient getting a pacemaker?**
  - **Sinus node disease**

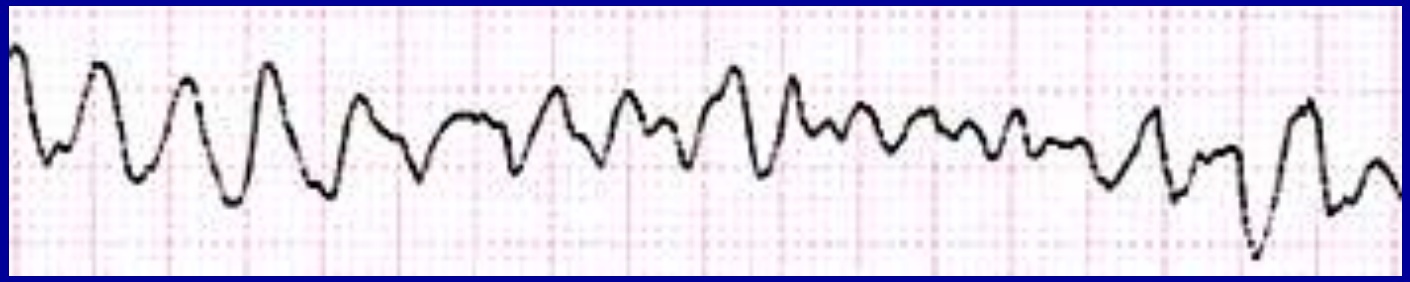
- **What are some symptoms a patient might complain of?**
  - **Fatigue, shortness of breath, palpitations, inability to perform activities of daily living, vertigo, syncope, racing heart at rest, slow pulse rate**

Status Check

Click for Answer

- What are some simple diagnostic tests used to make this diagnosis?
  - 12-lead ECG, Ambulatory ECG (Holter)

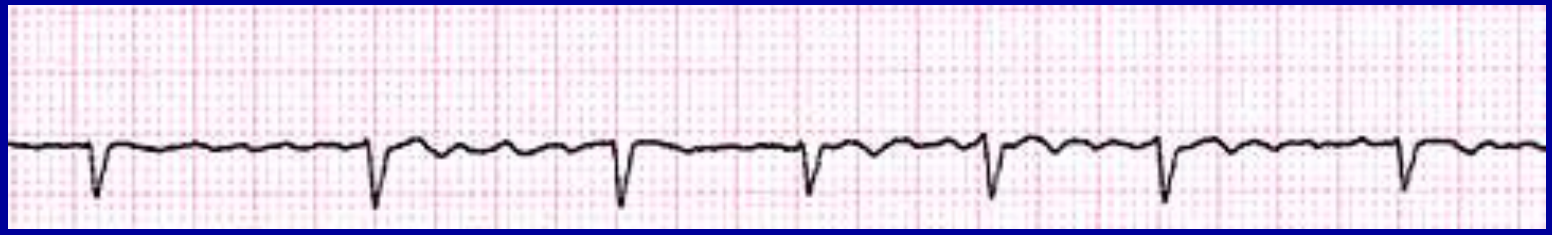
Status Check
Identify the Rhythm



- Ventricular Tachycardia
- Sinus Bradycardia
- Complete Heart Block
- Atrial Fibrillation
- Ventricular Fibrillation

Click for Answer

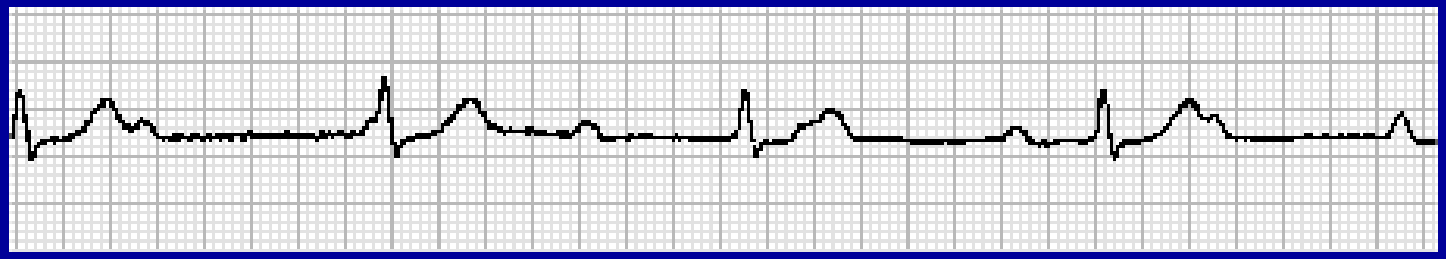
Status Check
Identify the Rhythm



- Ventricular Tachycardia
- Sinus Bradycardia
- Complete Heart Block
- Atrial Fibrillation
- Ventricular Fibrillation

Click for Answer

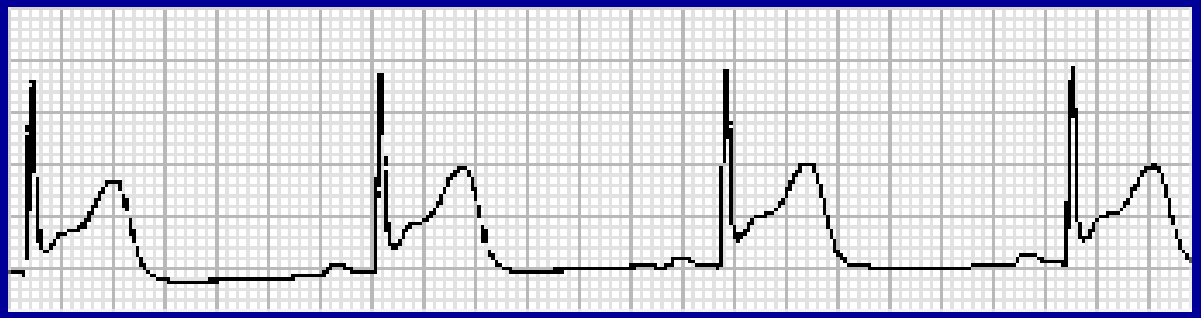
Status Check
Identify the Rhythm



- Ventricular Tachycardia
- Sinus Bradycardia
- Complete Heart Block
- Atrial Fibrillation
- Ventricular Fibrillation

Click for Answer

Status Check



Click for Answer

- Ventricular Tachycardia
- Sinus Bradycardia
- Complete Heart Block
- Atrial Fibrillation
- Ventricular Fibrillation