CHAPTER-I

ARRHYTHMIA

BY:

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- Irregular heart beat (or) loss of cardiac rhythm
- Cardiac arrhythmia is the disturbance of normal rhythm of the heart may be due to
  - alterations in impulse generation or
  - disturbances in impulse conduction or
  - a combination of both these factors
- Normal range 70-80 beats/min
Mechanism

- Abnormal impulse formation
- Abnormal impulse conduction (or)

A combination of both may give rise to arrhythmias.

*Abnormal impulse formation may stem from:*

  - Depressed automaticity, as in escape beats and bradycardia
  - Increased automaticity, as in premature beats, tachycardia, and extra-systole
  - Depolarization and triggered activity, leading to sustained ectopic firing

*Abnormal impulse conduction results from:*

  - A conduction block or delay
  - **Re-entry** occurs when an impulse is rerouted through certain regions in which it has already travelled. Thus the impulse depolarizes the same tissue more than once, producing an additional impulse. Re-entry sites include the SA and AV nodes as well as various accessory pathways in the atria and ventricles
Mechanism of arrhythmia

- **Alteration in Automaticity**
  - **Abnormal automaticity**
  - The sinus node contains pacemaker cells that have spontaneous firing capacity. This is called *normal automaticity*. **Abnormal automaticity** occurs when other cells start firing spontaneously, resulting in premature heartbeats.
  - **Increased sinus node activity is normally due to the sympathetic nervous system.**
  - Sympathetic stimulation or an increase in circulating catecholamine acting via the B$_1$-adrenergic receptors which increase the rate of phase 4 depolarization.
Triggered activity

- During triggered activity heart cells contract twice, although they only have been activated once. This is often caused by so called afterdepolarizations (early or delayed afterdepolarizations EADs / DADs) caused by electrical instability in the myocardial cell membrane.
Altered impulse conduction

- **Re-entry pathway**
  Conduction defect → impulse recirculate in the heart → repetitive activation without need for further any new impulse to be generated

- **Conduction block**
  Even under physiological conditions, conduction through SA node and AV node is slow. It may be further slowed by ischemia or myocardial infarction causing partial to complete A-V block.
Tachyarrhythmias (↑HR)

Enhanced Automaticity

↑

Altered Impulse Formation

Decreased Automaticity

↓

Bradyarrhythmias (↓HR)

Reentry

↑

Altered Impulse Conduction

Conduction Blocks
A. Normal

Nerve impulse

Ventricle wall

B. Unidirectional Block

Impulse is blocked in one direction

Impulse travels in the retrograde direction and reenters the conduction pathway, causing an extra or irregular heart beat.
Classification of Arrhythmia

I. Arrhythmia arising in the sinus
   a. Sinus tachycardia
   b. Sinus bradycardia
   c. Sinus arrhythmia

II. Arrhythmia arising in the atria
   a. Premature atrial contraction
   b. Supra ventricular tachycardia (SVT)
   c. Atrial flutter
   d. Atrial fibrillation
   e. WPW syndrome
III. Arrhythmia arising in the conductive system
   a. SA block
   b. AV block

IV. Arrhythmia arising in the ventricle
   a. Premature ventricular contraction (PVC)
   b. Ventricular tachycardia
   c. Ventricular fibrillation
Sinus bradycardia

- Reduction in the discharge of impulses from SA node
- Heart rate less than 60/min
- **Causes:** disease in SA node, hypothermia, hypothyroidism, congenital heart disease, atherosclerosis, drugs like beta-blocker, digitalis.
- **Symptoms:** fatigue, dizziness, shortness of breath, lack of concentration, difficulty in exercising
- prolonged R-R interval
- PQRST complex occur at normal intervals
Sinus tachycardia

- Increase in the discharge of impulses from SA node
- Heart rate more than 100/min
- **Causes**: fever, anemia, hyperthyroidism, hypersecretion of catecholamines, cardiomyopathy, cardiac failure, tea, coffee, tobacco & alcohol
- **Symptoms**: palpitations, dizziness, fainting, shortness of breath, chest discomfort
- Short R-R interval
- PQRST complex occur at normal intervals
Sinus arrhythmia

- Alternate periods of tachycardia and bradycardia
- Heart rate changes in relation to respiration
- Tachycardia occurs towards the end of inspiration and bradycardia occurs towards the end of expiration

**Mechanism**: reflex stimulation of the vagal nerve from the receptors in the lung.
- R-R interval varies
- Normal PQRST complex
Premature atrial contraction

- Early extra beats that originate in the atria
- These are quite common and benign
- **Causes**: emotions, excessive ingestion of coffee or alcohol, excessive smoking, hyperthyroidism
- **Symptoms**
  - Premature ventricular contractions often cause no symptoms. But you may feel an odd sensation in your chest, such as:
  - Fluttering
  - Skipped beats or missed beats
- Abnormal P wave
- P waves are small or shapeless
Supra ventricular tachycardia

- SVT is a series of three or more PAC
- Which may occur for a few beats or continuously for several hours or days
- Increase in heart rate 150-250/min

**Causes:** emotions, excessive ingestion of coffee or alcohol, excessive smoking, hyperthyroidism

**Mechanism:** AV nodal re-entry, SA nodal re-entry.

Persistence of SVT in a patient lead to cardiac failure.
- P wave merges with T wave
- Narrow QRS complex

**Symptoms**: palpitations, chest discomfort, dizziness, dyspnea, sweating, fatigue
Atrial fibrillation

- Atrial fibrillation is characterized as an extremely rapid (400 to 600 atrial beats/min) and disorganized atrial activation. There is a loss of atrial contraction (atrial kick), and supraventricular impulses penetrate the atrioventricular (AV) conduction system in variable degrees, resulting in irregular ventricular activation and irregularly irregular pulse (120 to 180 beats/min).

- Electricity travelling in a chaotic fashion, causing upper chambers to quiver (like bag of worms) and contract inefficiently

- Most common in elderly people those with heart diseases

- **Mechanism**: Due to circus movement of impulses within atrial musculature

- **Causes**: IHD, MV disease, cardiac surgery, pericarditis

- **Symptoms**: palpitations, light headness, chest pain, dyspnea, weakness
J. Atrial fibrillation

Impulses take chaotic, random pathways in atria

Baseline coarsely or finely irregular; P waves absent. Ventricular response (QRS) irregular, slow or rapid
Atrial flutter

- The atria are stimulated quickly that they cannot contract or squeeze
- Heart rate 220-350/min
- The maximum rate of conduction by AV node is about 230-240/min so during atrial flutter the second degree heart block occurs.
- The ratio between atrial beats and ventricular beats is 2:1 or sometimes 3:1
- **Causes**: IHD, MV disease, cardiac surgery, pericarditis, cardiomyopathy, ASD
P wave have tooth like appearance (flutter wave)
**Mechanism**: atrial re-entry

**Symptoms**: palpitations, flutter feeling in the heart, dyspnea, anxiety, feeling light headed
Wolff-Parkinson-White syndrome (WPW)

- There's an extra conduction pathway (by pass), the electrical signal may arrive at the ventricles too soon. This condition is called Wolff-Parkinson-White syndrome (WPW).
- Wolff-Parkinson-White syndrome is a condition in which there is an abnormal extra electrical pathway of the heart. The condition can lead to episodes of rapid heart rate (tachycardia).
- Wolff-Parkinson-White syndrome is one of the most common causes of fast heart rate disorders in infants and children.

- **Cause:** congenital disorder
- **Symptoms:** heart palpitations, dizziness, feeling lightheaded or faint, shortness of breath (dyspnea), anxiety, rarely cardiac arrest (sudden death)
Normal electrical pathways

Abnormal electrical pathway in Wolff-Parkinson-White syndrome

Wolf-Parkinson-White (preexcitation) Syndrome

delta wave
delta wave
SA Block

- The impulses from SA node are not transmitted to AV node due to defect in internodal fibres
- AV node acts as a pacemaker
- Absence of P wave
AV Block

- AV block is disturbances in the conduction of the atrial impulses through the AV conductive system

A. Incomplete block
   i) First degree AV block
   ii) Second degree AV block

B. Complete or third degree AV conduction

First degree AV block
- There is a delay in conduction of every impulse passing through AV node
- Rhythm is regular and no beat is dropped
- ECG shows PR interval prolongation
Four Types of AV-block
(PQ interval > 0.2 s)

First - degree 1:1 AV - block

Second - degree AV - block

Wenchebach block (type I)

Second - degree AV - block

Mobitz II block (no warning)

Third - degree AV - block

Complete AV - block (Adam Stokes disease in AV or His-bundle)

Fig. 11-12

KMce
Causes of $1^0$ block

- CAD, rheumatic fever, acute infectious diseases. Congenital heart disease, ASD, digitalis, propranolol

$2^0$ Heart block

- Intermittent interruption of AV conduction so that some of the impulses are conducted to the ventricles and others are blocked
  - Mobitz type 1
    - Missing of one complete block
    - Gradual increase in PR interval
ii. Mobitz type 2

- The ventricle fails to respond to the atrial contraction periodically.
- ECG: for 5 QRS complexes there are 6 P waves (6:5 block)

**Causes:** acute rheumatic carditis, CAD, dipherial carditis

B. Complete block (3:0 block)

- There is a permanent interruption of AV conduction so that all supraventricular impulses are blocked.
- The rate QRS complex is almost half that of P wave.

**Causes:** inferior wall MI, congenital complete AV Block, CAD, ASD, VSD
Premature ventricle contraction

- PVC is an abnormal heartbeat, or arrhythmia, in which the ventricle contracts early without receiving a signal from the AV node.
- P wave absent, QRS complex is wide and tall
Ventricular fibrillation

- Ventricles fire in a fast and uncontrolled manner, this cause the low chamber to quiver and not pump blood
- Heart rate 400-500 beats/min
Causes of VF

- CAD, hypothermia, electric shock, severe hypokalemia, some drugs like digitalis, adrenaline

**Symptoms**: unconsciousness in seconds, seizures, irreversible brain damage, if not treated immediately leading to death
Ventricular tachycardia

- Ventricular tachycardia (VT) is a rapid heartbeat that starts in the ventricles.
- This may cause the heart to pump less effectively, causing a decrease in blood pressure, which may lead to fainting.
causes: MI, cardiomyopathy, valular heart disease, heart surgery, myocarditis, heart failure

Symptoms: Palpitations, Fatigue, Chest pressure or pain, Shortness of breath, Fainting, syncope, Lightheadedness or dizziness

Mechanism: re-entry circuit within ventricle

ECG shows QT interval prolongation
Torsades de Pointes

TdP is a rapid form of polymorphic VT associated with evidence of delayed ventricular repolarization due to blockade of potassium conductance. TdP may be hereditary or acquired

• QRS amplitude varies and the QRS complexes appear to twist around the baseline. Torsade de pointes is associated with a prolonged QT interval, which may be congenital or acquired

Causes: heart disease (infection, CAD, valvular heart disease, digitalis, metabolic disturbances, systemic hypertension, corpulmonale, hyperkalemia, COPD
Torsade de pointes  ventricular tachycardia
**Ventricular Proarrhythmia**

Proarrhythmia refers to development of a significant new arrhythmia (such as VT, ventricular fibrillation [VF], or TdP) or **worsening** of an existing arrhythmia. Proarrhythmia results from the same mechanisms that cause other arrhythmias or from an alteration in the underlying substrate due to the antiarrhythmic agent.

**Incessant Monomorphic Ventricular Tachycardia**

Although the proarrhythmia associated with type 1c agents was initially thought to occur within several days of drug initiation, risk may persist throughout treatment. Factors that predispose patients to this type of proarrhythmia include underlying ventricular arrhythmias, ischemic heart disease, and poor left ventricular function.
TREATMENT
Ventricular Action Potential

- **Class IA:** e.g., quinidine
  - Moderate Na⁺-channel blockade
  - ↑ ERP
- **Class IB:** e.g., lidocaine
  - Weak Na⁺-channel blockade
  - ↓ ERP
- **Class IC:** e.g., flecainide
  - Strong Na⁺-channel blockade
  - → ERP
<table>
<thead>
<tr>
<th>Class</th>
<th>Basic Mechanism</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Sodium-channel blockade</td>
<td>Reduce phase 0 slope and peak of action potential.</td>
</tr>
<tr>
<td>IA</td>
<td>- moderate</td>
<td>Moderate reduction in phase 0 slope; increase APD; increase ERP.</td>
</tr>
<tr>
<td>IB</td>
<td>- weak</td>
<td>Small reduction in phase 0 slope; reduce APD; decrease ERP.</td>
</tr>
<tr>
<td>IC</td>
<td>- strong</td>
<td>Pronounced reduction in phase 0 slope; no effect on APD or ERP.</td>
</tr>
<tr>
<td>II</td>
<td>Beta-blockade</td>
<td>Block sympathetic activity; reduce rate and conduction.</td>
</tr>
<tr>
<td>III</td>
<td>Potassium-channel blockade</td>
<td>Delay repolarization (phase 3) and thereby increase action potential duration and effective refractory period.</td>
</tr>
<tr>
<td>IV</td>
<td>Calcium-channel blockade</td>
<td>Block L-type calcium-channels; most effective at SA and AV nodes; reduce rate and conduction.</td>
</tr>
</tbody>
</table>
## Class IA

Atrial fibrillation, flutter; supraventricular & ventricular tachyarrhythmias

<table>
<thead>
<tr>
<th>Drug</th>
<th>Mechanism</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quinidine*</td>
<td>Anticholinergic (moderate)</td>
<td>Cinchonism (blurred vision, tinnitus, headache, psychosis); cramping and nausea; enhances digitalis toxicity</td>
</tr>
<tr>
<td>Procainamide</td>
<td>Anticholinergic (weak)</td>
<td>Lupus-like syndrome in 25-30% of patients relatively short half-life</td>
</tr>
<tr>
<td>Disopyramide</td>
<td>Anticholinergic (strong)</td>
<td>Negative inotropic effect</td>
</tr>
</tbody>
</table>

## Class IB

Ventricular Tachyarrhythmias (VT)

<table>
<thead>
<tr>
<th>Drug</th>
<th>Route</th>
<th>Action</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lidocaine*</td>
<td>IV only; VT and PVCs</td>
<td>orally active lidocaine analog</td>
<td>good efficacy in ischemic myocardium can cause pulmonary fibrosis</td>
</tr>
<tr>
<td>Tocainide</td>
<td>orally active</td>
<td>lidocaine analog</td>
<td></td>
</tr>
<tr>
<td>Mexiletine</td>
<td>orally active</td>
<td>lidocaine analog</td>
<td>good efficacy in ischemic myocardium</td>
</tr>
</tbody>
</table>

## Class IC

Life-threatening supraventricular tachyarrhythmias (SVT) and ventricular tachyarrhythmias (VT)

<table>
<thead>
<tr>
<th>Drug</th>
<th>SVT</th>
<th>VT</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flecainide*</td>
<td>SVT</td>
<td></td>
<td>can induce life-threatening VT</td>
</tr>
<tr>
<td>Propafenone</td>
<td>SVT &amp; VT</td>
<td></td>
<td>β-blocking and Ca** channel blocking activity can worsen heart failure</td>
</tr>
<tr>
<td>Moricizine</td>
<td>VT</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Increasing or decreasing the APD and ERP can either increase or decrease arrhythmogenesis, depending on the underlying cause of the arrhythmia. Increasing the ERP, for example, can interrupt tachycardia caused by reentry mechanisms by prolonging the duration that normal tissue is unexcitable (its refractory period). This can prevent reentry currents from re-exciting the tissue. On the other hand, increasing the APD can precipitate torsades de pointes, a type of ventricular tachycardia caused by after depolarizations.
antiarrhythmics can suppress abnormal automaticity by decreasing the slope of phase 4, which is generated by pacemaker currents.

**INDIRECT VAGAL EFFECTS**

The direct effect of **Class IA** antiarrhythmic drugs on action potentials is significantly modified by their **anticholinergic** actions. Inhibiting vagal activity can lead to both an increase in sinoatrial rate and atrioventricular conduction, which can offset the direct effects of the drugs on these tissues. Although a **IA** drug may effectively depress atrial rate during flutter, it can lead to an increase in ventricular rate because of an increase in the number of impulses conducted through the atrioventricular node (**anticholinergic effect**), thereby requiring concomitant treatment with a beta-blocker or calcium-channel blocker to slow **AV** nodal conduction. These anticholinergic actions are most prominent at the sinoatrial and atrioventricular nodes because they are extensively innervated by vagal efferent nerves.
MECHANISM OF ACTION As a class I, all of the agents work by blocking the rapid inward sodium current and thereby slow down the rate of rise of the cardiac tissue’s action potential. However, though this is a similar effect for all class I agents, differences in ERP effects had led to a sub classification of the class I agents into three subsets (IA, IB, and IC), based on these EP effects.
• Class II antiarrhythmics reduce sympathetic stimulation of the heart, decreasing impulse conduction through the AV node and lengthening the refractory period.
• Additionally, this class of antiarrhythmics slow the sinus rhythm without significantly changing the QT or QRS intervals, resulting in a reduced heart rate and a decrease in myocardial oxygen demand.
Class III antiarrhythmic drugs prolong the refractory period and action potential; they have no effect on myocardial contractility or conduction time.
Class IV antiarrhythmics are calcium-channel blockers. They inhibit AV node conduction by depressing the SA and AV nodes, where calcium channels predominate.
# Drug Classes Used in Arrhythmias

<table>
<thead>
<tr>
<th>Arrhythmias</th>
<th>Commonly Used</th>
<th>Also Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA node</td>
<td>CLASS II</td>
<td></td>
</tr>
<tr>
<td>Atria</td>
<td>CLASS II, CLASS IV</td>
<td>DIGOXIN, CLASS III, CLASS IC, CLASS IA</td>
</tr>
<tr>
<td>AV node</td>
<td>CLASS IV, CLASS II</td>
<td>DIGOXIN, CLASS IC</td>
</tr>
<tr>
<td>Accessory pathway</td>
<td>CLASS IC</td>
<td>CLASS II, CLASS IA</td>
</tr>
<tr>
<td>Ventricles</td>
<td>CLASS II, CLASS III</td>
<td>CLASS I</td>
</tr>
<tr>
<td>CLASS</td>
<td>DRUG</td>
<td>CARDIAC</td>
</tr>
<tr>
<td>-------</td>
<td>------------</td>
<td>---------</td>
</tr>
<tr>
<td>Ib</td>
<td>LIDOCAINE</td>
<td>-</td>
</tr>
<tr>
<td>Ib</td>
<td>MEXILETINE</td>
<td>-</td>
</tr>
<tr>
<td>Ib</td>
<td>TOCAINIDE</td>
<td>-</td>
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</table>
# ADVERSE DRUG REACTIONS

<table>
<thead>
<tr>
<th>CLASS</th>
<th>DRUG</th>
<th>CARDIAC</th>
<th>NON-CARDIAC</th>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASS I&lt;sub&gt;c&lt;/sub&gt;</td>
<td>Flecainide</td>
<td>Pro-arrhythmic Myodepressant</td>
<td>tremor</td>
<td>Use only if other agents have failed.</td>
</tr>
<tr>
<td></td>
<td>Propafenone</td>
<td>Pro-arrhythmic Myodepressant</td>
<td>GIT disturbances</td>
<td>Use only if other agents have failed.</td>
</tr>
<tr>
<td>CLASS II</td>
<td>Atenolol Metoprolol Sotalol</td>
<td>Myodepressant</td>
<td>Bronchoconstriction(β&lt;sub&gt;2&lt;/sub&gt;) Vasoconstriction Vivid dreams fatigue</td>
<td>Asthma, DM, Depression.</td>
</tr>
<tr>
<td>β blockers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLASS III</td>
<td>Amiodarone</td>
<td>Torsades De Pointes</td>
<td>Myopathy, neuropathy, hepatitis, photosensitivity</td>
<td>Thyroid disease</td>
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<tr>
<td></td>
<td>Bretylium</td>
<td>Hypotension</td>
<td>Sympathomimetic response, Nausea.</td>
<td></td>
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<tr>
<td>CLASS IV</td>
<td>Verapamil and Diltiazem</td>
<td>Heart block</td>
<td>Constipation, Headache, flushing, ankle edema.</td>
<td></td>
</tr>
<tr>
<td>ANTIARRHYTHMIC DRUG</td>
<td>OTHER DRUG</td>
<td>EFFECT</td>
<td></td>
<td></td>
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<tr>
<td>----------------------</td>
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<td></td>
<td></td>
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<tr>
<td>QUINIDINE</td>
<td>Warfarin, Class II, Class III, Class IV</td>
<td>Increase Anticoagulation, hypotension.</td>
<td></td>
<td></td>
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<tr>
<td>AMIODARONE</td>
<td>Warfarin</td>
<td>Enhanced anticoagulation.</td>
<td></td>
<td></td>
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<tr>
<td>PROCAINAMIDE</td>
<td>Cimetidine</td>
<td>Decreased renal clearance of procainamide.</td>
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<tr>
<td>Disopyramide</td>
<td>Anticholinergics</td>
<td>Increase Anticholinergics action</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pyridostigmine</td>
<td>Decrease Action of disopyramide</td>
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<td></td>
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<tr>
<td>Lidocaine</td>
<td>β blockers, cimetidine</td>
<td>decreased elimination of lidocaine</td>
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<td></td>
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</tbody>
</table>
Thank you