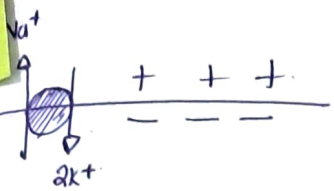
Cardiac Electrophysiology



- $Na^+ - K^+$ pump

$3Na^+$ out

$2K^+$ inside

→ Na → more Extracellular

→ K → more Intracellular.

→ since 3 positive charge goes out and 2 inside

⇒ outside → more positive compared to ~~Depolarized~~ inside.

out → + +

in → − −.

→ resting membrane potential.

how much voltage is inside cell as compared to outside.

→ RMP = −90mV.

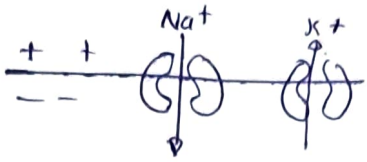
→ polarised state.

↓

Base line = (−90mV)

If more → more polarised

If <90 → less polarised.



→ ① When Na^+ channel open

sodium moves from out to in.

so inside becomes less negative.

ie, −90 → −70, −40 .... +30mV

ie, polarized.

Na^+ channel open.

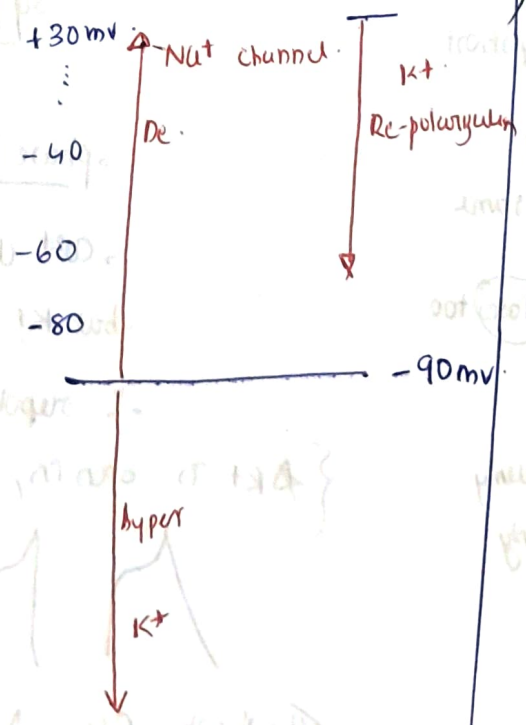
de-polarised.

② When K^+ channel open.

K^+ moves out.

so inside becomes more negative.

ie, → hyper polarization



- Na^+ channel opens

↓

depolarisation.

- K^+ channel opens.

If at −90mV → hyper pol.

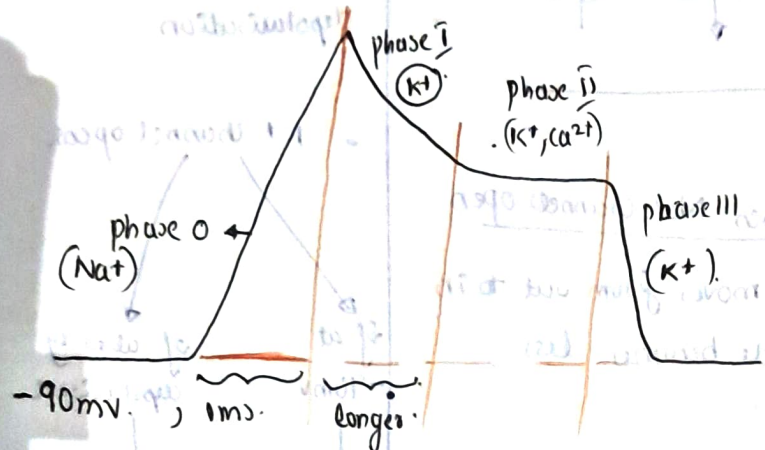
If already depolarised → Repolarisation.

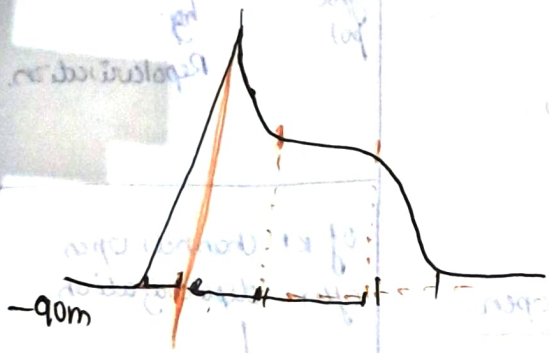
If K^+ channels open after depolarization.

↓

Repolarization occurs

Action Potential of heart





phase - 0 → depolarization due to opening of Na^+ channels.

→ but within very short time.

i.e, large number of channels (open) at same time suddenly.

- also, suddenly (close) too

- Na^+ → phase 0
- large no: open suddenly & also closes suddenly

phase - I

- opening of K^+ channels
- longer duration
- but change in potential is lesser.
- i.e, K^+ channels only open slowly.

- phase II

- K^+ channels are still open but Ca^{2+} channels will open too
- Ca^{2+} conc. is ↑ extracellularly
- so it moves in
- but K^+ move out
- ∴ net effect = 0.

so plateau

- phase III

- Ca^{2+} channels close
- but K^+ still open

∴ repolarization.

{ ∵ K^+ is open in, I, II, III }

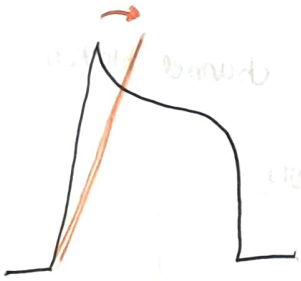
That's why ECG looks like this Lol!

Effect of diff drugs on Action Potential.

• APD = repolarization + dep.

① Na+ channel blocker.

• Sodium causes depolarization
. So if sodium channels are blocked... Sturge amount of sodium can't enter suddenly.
ie, time of duration ↑.



ie, they decrease slope of phase 0.
ie, ↓ $\frac{dv}{dt}$ of phase 0.

Here, dep - same duration,
so APD ↑ due to ↑ repolarization duration.

• But, it doesn't sodium ch. blockers also ↓ APD since it ↑ depolarization duration?

↓

Um, NO!! cause it's negligible.

If
rep → 799 ms)
dep → 1 ms). - doesn't change a thing hon...

↓

atleast not significantly I mean

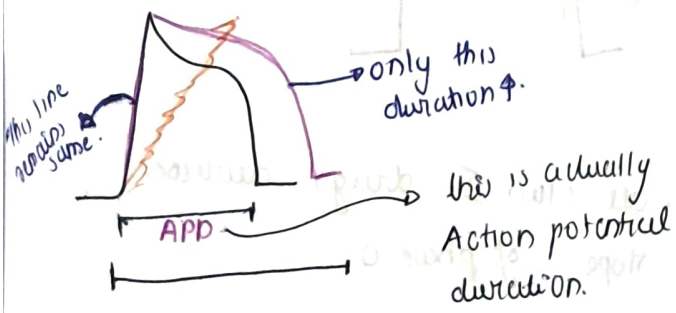
Na+ # → Slope decrease.
K+ # → action potential ↑ duration

with the logic..

K+ opener → ↓ APD.

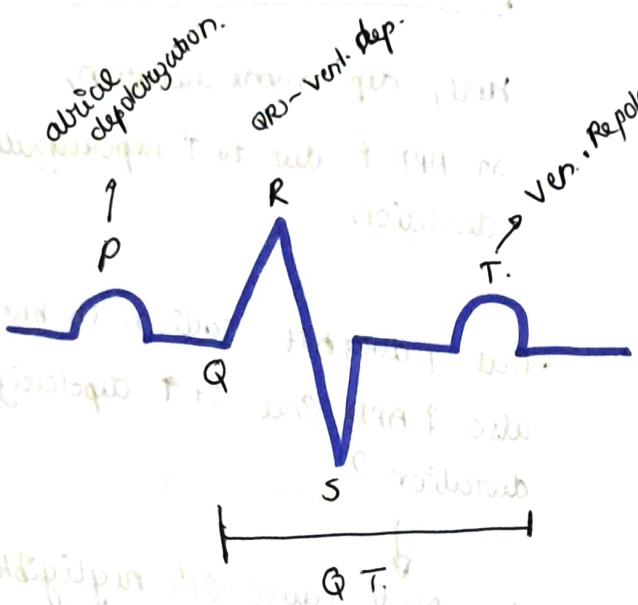
② K+ channel blocker.

ie, duration of phase I, II, III ↑.



ie, K+ channel blocker ↑ APD.

Comparing with ECG.



Since atrial repolarization is hidden, here we... let's look at ventricle alone.

- 1 Cardiac cycle → vent (dep + rep.)
- ie, QRS + T
- ie, **QT Interval = APP.**

so drugs that ↑ APD

↓

Causing QT prolongation

↓

Torsades de pointes → arrhythmia due to ↑ QT interval.

↳ K+ blocker

↑ QT interval causes arrhythmia → T.d.p.

Anti-Arrhythmic Drugs.

Classification: Vaughan Williams classification. {based on mechanism of action}

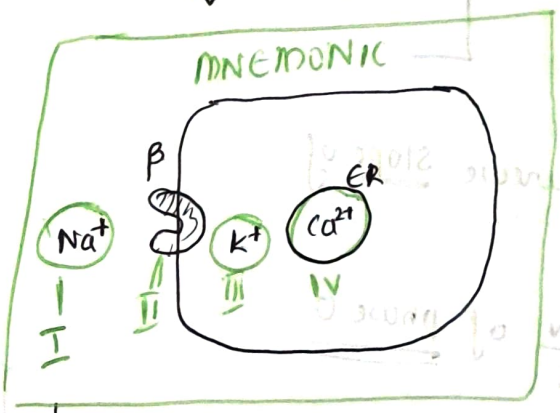
Class I – Na^+ channel blockers

Class II – β blockers.

III – K+ channel blockers.

IV – Ca^{2+} channel blockers

V – others.



Class I.

Na^+ ⇓.

- all class I drugs decrease slope of phase 0.

• Class I is further subdivided into a, b, c.

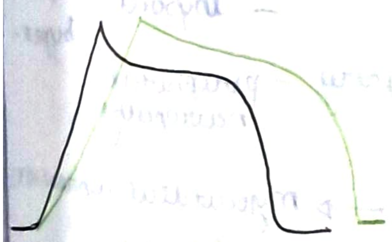
Based on effect on potassium channels too.

Ia = Na^+ # (+) K^+ #.

Ib = Na^+ # (+) K^+ opener.

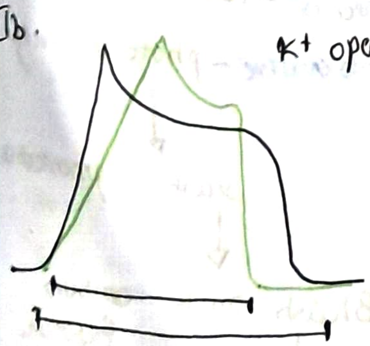
Ic = Na^+ # (+) No effect on K.

Ia — K^+ #.



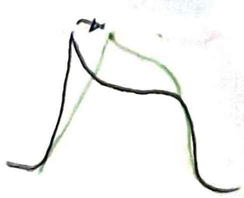
APD ↑.

Ib. — K^+ opener.



APD ↓

Ic



• Which class I drug group causes Torsades de pointes
↓
Class Ia.

Class Ia

↑ QT

• Quinidine
• procainamide
] torsades de pointes

Queen, prince

Ib

→ are only used in Ventricular arrhythmias

• Lignocaine — Leg
• phenytoin — fan
• tocainide — toe.

Ic

• Encainide
• Flecainide

↓ used in WPW syndrome.
Wolf parkinson white syndrome
↓
there is aberrant pathway.
but definitive Rx
↓
laser ablation of aberrant pathway.

Class II

β blockers.

β_1 receptors are present on heart and causes tachycardia.

• β# so can reduce Tachycardia.

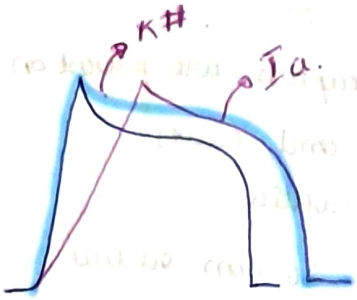
ie, β# are used in (freq. asked) arrhythmias with Tachycardia
↓
Tachy arrhythmias.

Tachy.

atrial Tachycardia.	ventricular tachycardia.
atrial flutter	ventricular flutter.
atrial fibrillation	ventricular fibrillation

Class III

K+ channel blockers



look at diff between Ia & K+ #

Both will cause QT prolongation ★

B Bretylium → earlier used in ventricular fibrillation

I Ibutilide.

N - No

D - Dofetilide.

Dronedarone.

A Amiodarone.

S Sotalol.

Ibutilide, Dofetilide, Dronedarone, Amiodarone, Sotalol → treatment of Atrial fibrillation

- controls ventricular rate
- control atrial rate → Sinus rhythm → Ibutilide. dofetilide.

Amiodarone → longest acting, mech. of action of all class.

Sotalol → β-blocker.

Amiodarone has all mechanism ie, Na+ #, K #, Ca2+ #, β#

But most significant - K#

ie, Amiodarone can be used in almost all Types of arrhythmia ★

Pharmacological Defibrillator ★

- But why here?
- It is β blocker
- But arrhythmia treatment is due to K# property

So Sotalol → Class II & III features

But Amiodarone can't be used in?

QT prolongation vala arrhythmia ie, T. dp. as it is a K# blocker.

Dis a β blocker?

but doesn't end in LOL y?

It is a non-competitive ★ β blocker

Amiodarone S/E

The - thyroid < hypo / hyper.

periphery - peripheral neuropathy

my → myocardial depression

Lung → lung fibrosis

Liver → Hepatotoxicity

Cornea - corneal deposits

photosensitive - photosensitivity

rash, pigmentation

Bluish rash on sun Exposure

Blue man Syndrome. ★

myocardial depression. why?

blocks β receptors
Na+ #
K+ #
Ca^{2+} #

blocks both of stimulatory ones → depression

Amiodarone.

can cause hypo/hyper.

Cause Iodine causes hypo/hyper depending on concentrations.

~40% Iodine is present.

So effects Thyroid function

So we developed drug that has every ppty same but no Iodine content.

DRONE DARONE

doesn't effect thyroid.

Class IV

L-type Ca^{2+} #.

{on CVS}.

Verapamil ✓

Diltiazem. ✓

dipines ✗ {Dihydro pyridines}.

Dipines → peripheral Ca^{2+} #.

no action on heart.

not used ✗

verapamil, Diltiazem

Blocks Ca^{2+} channels.

depression of heart

so used in tachy arrhythmia.

Tachy

A Tachy: AFL, AF

V tachy: VFL, VF.

• β #, Ca^{2+} are both used in tachyarrhythmia.

ie, they can be used Interchangeably.

But

NEVER COMBINE BOTH

Causes severe Brady cardia & AV Block.

Never give

β # + Ca# together.

Severe Cardiac depression

DOC for prophylaxis of Paroxysmal supraventricular Tachycardia.

PSVT.

VERAPAMIL

PSVT.

Class V

① Digoxin → used in atrial fibrillation associated with congestive heart failure.

- not when only AF is present.
- cause we have β#, Ca^{2+} # etc..
- Digoxin has severe S/E in comparison.
- so only given in AF + CHF combo.

② Magnesium

DOC for Torsades de pointes.

DOC for TDP in pediatrics → propranolol

③ Atropine.

Bradycardia, AV block } DOC

④ Adenosine.

↓

Shortest acting

↓

$t_{1/2}$ < 10 seconds.

DOC → PSVT Rx.

↓

adenosine.

- paroxysmal – might.
- usually HR Normal
- but they suddenly get Tachycardia all of a sudden.
- and that's life threatening arrhythmia
- Adenosine is highly effective in PSVT

↓

given IV – through central veins ☆

as $T_{1/2}$ is < 10s

so that doesn't take that much time in reaching ♡.

- also we give syringe push.
- Not given slowly.

Called Rapid IV push

not as slow IV infusion

- what happens when PSVT occurs at home?

- physiological methods to ↓ heart rate. (vagus stimulation).

① Carotid sinus massage.

- vagus stimulation
  ↓
  parasympathetic right?
  ↓
  ↓ HR.

② Valsalva manouver.

close eyes, nose, puff up cheeks.
due to vagus stimulation.

③ Sudden cold water exposure.

due to vagus stimulation.