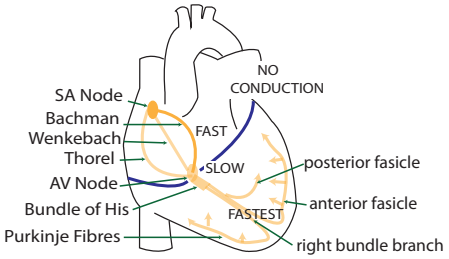
First 2009
VIVA 3

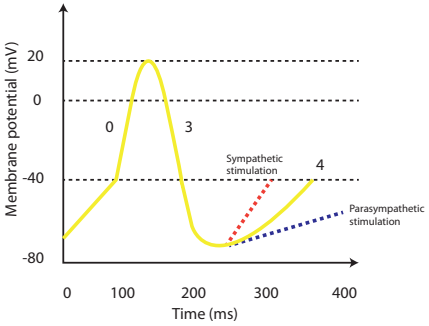
This viva will assess your knowledge of the action potential of the ventricle, sinus node and the atrioventricular node. It will also assess knowledge of anti-arrhythmic drugs.
From where does this action potential arise?

"Could you please draw the electrical conduction system of the heart"

Conduction speeds
AV and SA nodes 5 cm/sec
Atrial, HIS 100 cm/sec
Purkinje 500cm/sec



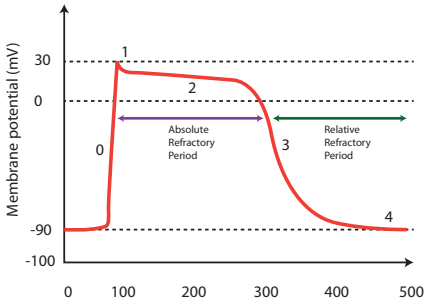
Please draw and describe the action potential of the SA Node



The sino atrial node and the AV node have the same ionic basis although the AV node is slower. The adjacent diagram represents the SA node. In the slow response cardiac action potential there is no resting state; rather there is a pacemaker potential which generates cardiac autorhythmicity. Phases 1 and 2 (of the fast response action potential) are absent in the SA/AV node as there is no depolarisation plateau.

PHASE 0 Depolarisation is produced by the opening of voltage-gated calcium channels (L-Type) and inward movement of positive ions.
PHASE 1/2 are absent
PHASE 3 Repolarisation occurs as Ca^{2+} channels close and and K^+ channels open. Efflux of K+ from within the cell repolarises the cell fairly rapidly.
PHASE 4 The pacemaker potential is produced by a fall in membrane potassium permiability and an increase in a slow inward current. The slow inward current consists of a voltage gated increase in calcium permiability (via T-Type channels) and activity of the electrogenic sodium-calium exchange system, driven by inward movement of calcium ions. This pacemaker activity brings the cell to threshold potential.

Please draw and describe the action potential of the ventricular myocyte



Ionic basis of the fast-response cardiac action potential Atrial and ventricular muscle and purkinje fibre action potentials differ from those in nerves as they are much longer in duration, with a distinct plateau phase when depolarisation is maintained.

PHASE 0 The cell is rapidly depolarised from the resting membrane potential by a rise in sodium permiability via fast sodium channels. The slope is almost vertical. The the membrane is less negative then many sodium channels will be closed, thus the response will not be as quick.
PHASE 1 Repolarisation begins to occur as sodium channels close and potassium channels open.
PHASE 2 A plateau occurs owing to the opening of L-type Ca^{2+} channels which offset the action of K channels and maintains depolarisation. During this time no further depolarisation is posible, this represents the absolute refractory period.
PHASE 3 The L-type Ca^{2+} channels close and K efflux now causes repolarisation as seen before this accelerates through positive feedback. It is now possible to cause another depolarisation although the force of the contraction will be diminished. This the relative refractory period.

Please classify and discuss the anti-arrythmic drugs

Vaughan Williams Classification

Class	Action	Effect	Drugs	Therapeutic Indications
I	Blocks Sodium Channels			
Ia		Prolongs refractory period of action potential	Procainamide	Atrial and ventricular arrhythmias especially post MI
Ib		Shortens refractory period of action potential	Lignocaine, Phenytoin	Ventricular arrhythmias post MI, digoxin induced arrhythmias
Ic		No effect on period of action potential	Flecainide	Refractory arrhythmias
II	Beta Adrenergic Blockers	Reduced SA firing	Propanolol* / Sotalol^	Rate control in AF, AT, Flutter and VT
III	Potassium Channel Blockers	Prolong refractory period of the action potential	Amiodarone#, Ilbutalide	AF / Flutter termination
IV	Calcium Channel Blockers	↓AV conduction, PR prolonged, decreased contractility	Verapamil, Diltiazem	SVT and AF or Flutter
OTHER	Blocks $Na^+/K^+_{ATPASE,}$ leads to ↑Ca^{2+}, ↓K^+, ↑Ach	Increased contractility and ↓AV conduction	Digoxin	AF rate control and heart failure
	Opens K^+ channels via adenosine receptors	Hyperpolarises myocardium , ↓AV conduct, ↓SA firing	Adenosine	Terminate SVT or reveal underlying rhythm in tachycardias
	Stimulates Na^+/K^+_{ATPASE}	Membrane stabilisation	Magnesium	VF / Torsades de Pointes

Notes
* Propanolol also has sodium channel blocking activity
^ Sotalol has two isomers, and is presented as a racemic mixture. One is an effective beta blocker and both have class III action potential prolongation activity
# Amiodarone is a special case. It blocks sodium, calcium, and potassium channels and exhibits beta blockade, although is usually categorised into Class III

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