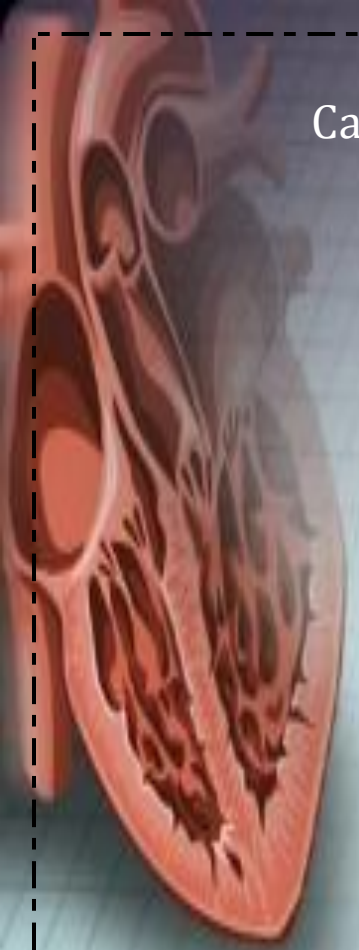
Cardiovascular Block



1st Lecture

CARDIAC CONTRACTILITY

Physiology Team - 430

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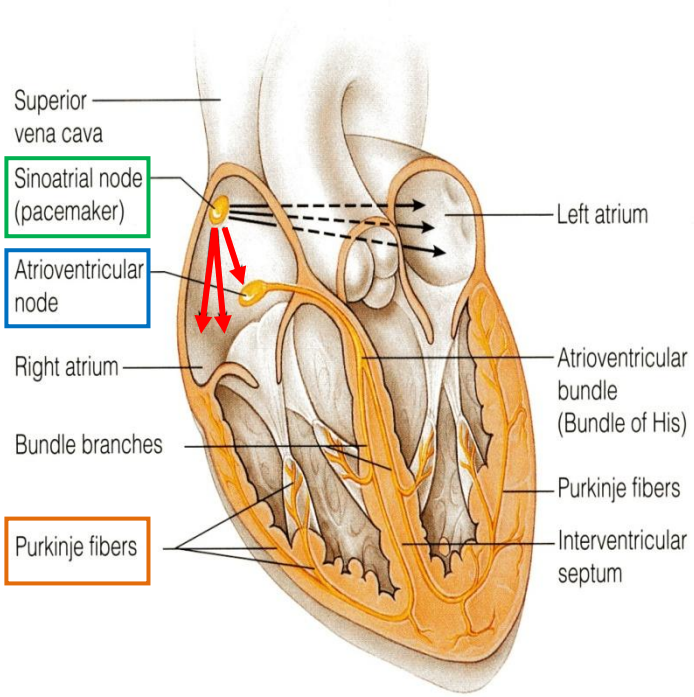
For You :

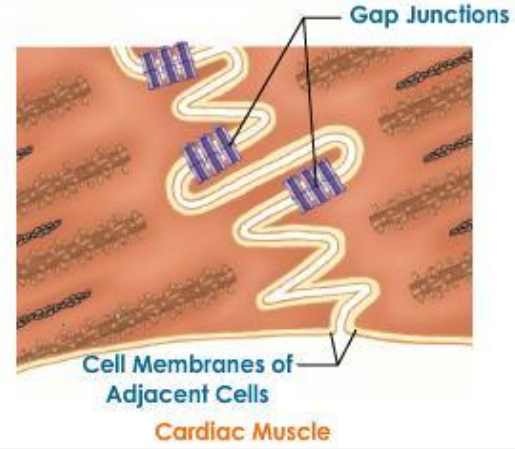
- **sinoatrial (SA) node :** located in the right atrium ➔ generate the impulse
- **Atrioventricular (AV) node** is located at the junction of the atria and the ventricles ➔ second generate of the impulse
- the impulse Transmitted from SA to AV by **3 connection** called : **internodal connection.**
- **Purkinje fibers** are located inside the walls of the ventricles **(penetrate myocardium)**



Three major types of cardiac muscle:

1- atrial muscle
2- ventricular muscle
3- specialized excitatory and conductive muscle fibers

Type 1 and 2 : like SK muscle in contract except duration (Longer in cardiac muscles)
Type 3 : contract feebly because contain a few contractile fibrils



How do the cardiac muscle contract?

It transmit impulses between muscle fibers though junctions called **gap junction** ,

Heart contractility :

The ability (force) of heart muscle to contract (shortened). It is the main function of cardiac muscle.

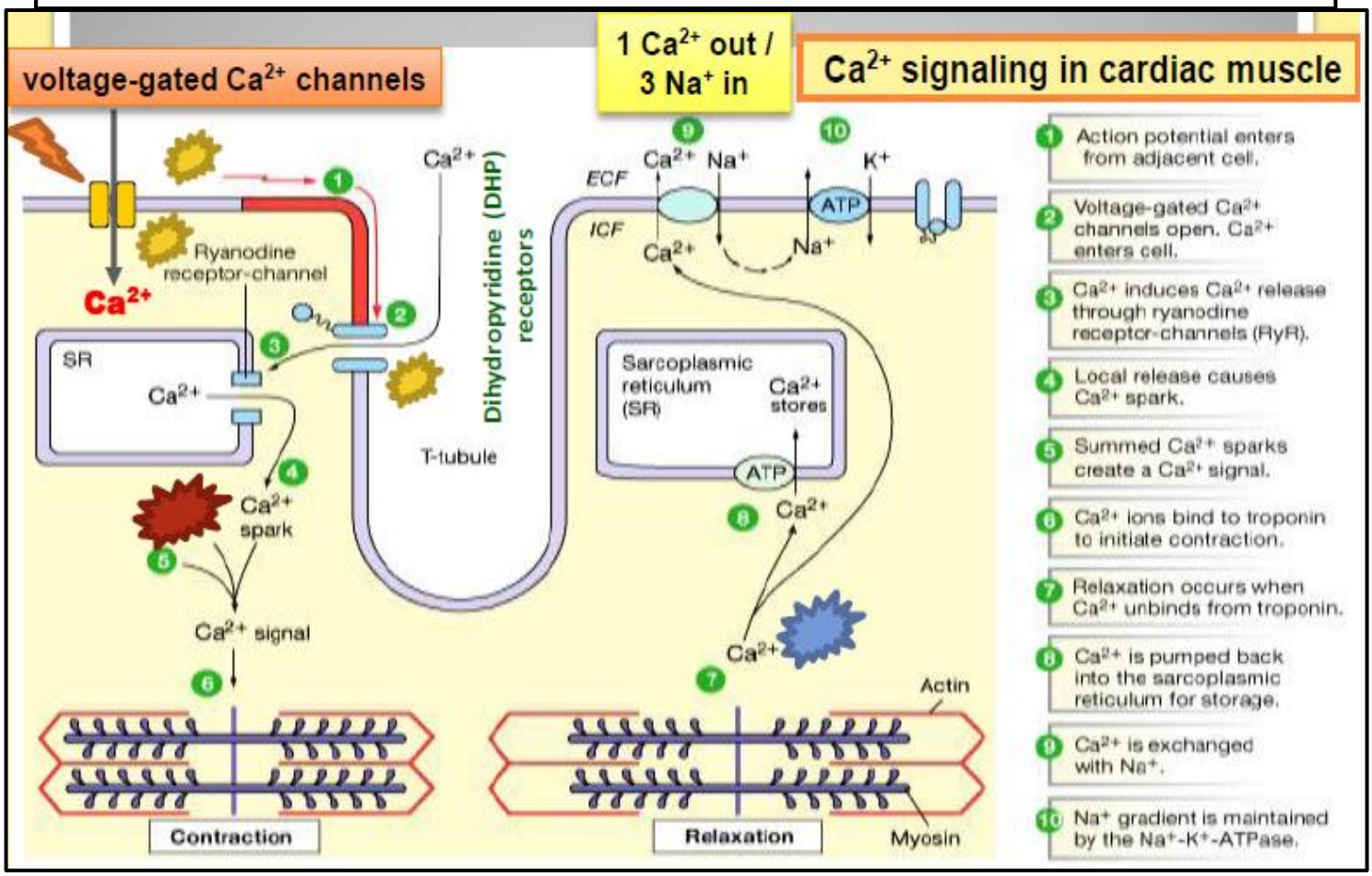
Excitation-contraction coupling :

The mechanism by which action potential (impulse) initiates contraction, cardiac & skeletal muscle have the same mechanism.

This process depends on Ca^{+2} present in extra cellular fluid.

On picture:

The 3 receptors which are the source of Ca^{+2} entry (SR receptor is called RyR , TT's receptor is called DHP, and sarcolemma'a receptor is voltage gated Ca^{+2} channels) . **Read the 10 steps.**



In relaxation:
No Ca
3 Na out and 2 K in by ATPase

Cont. Excitation-contraction coupling :

AP passes through TT & myocardium membrane > Ca^{+2} enters through voltage channels and released from SR also TT receptor(DTH) > ↑ Ca^{+2} in cytoplasm > binds to troponin > cross bridge occurs > after contraction Ca^{+2} gets back actively to SR.

Factors affecting myocardial contractility (inotropes) :

1- innervation by :

- ANS, look below :

When SNS is stimulated, Noradrenaline & adrenaline levels ↑, leading to stimulation of adrenergic receptors that located in the endothelium:

- **Alpha1 (α_1), Alpha2 (α_2)**
- **Beta1 (β_1), Beta2 (β_2), &**
- **Dopamine (D)**

- Action of these receptors :

Alpha Receptors		Beta Receptors		Dopamine
Alpha1 (α_1)	Alpha2 (α_2)	Beta1 (β_1)	Beta2 (β_2)	Dopamine (D)
Cardiac	In peripheral vessels	Heart	• Bronchial smooth muscles • Skeletal muscles	
↑ Contractility w/out ↑ in rate	Mediate vasoconstriction	↑ Contractility w ↑ in HR	• Dilation of BSM • Vasodilation in SM • ? Some cardiac effects	• ↑ Renal & ↑ Coronary blood flow • Arterial vasodilatation

- ANS actions as following :

- Sympathetic NS ↑ force of contraction

- Parasympathetic NS (vagus) ↓ atrial force of contraction w no significant effect on ventricular muscle.

2- Oxygen supply:

Hypoxia contractility

3- [Ca^{2+}] & [K^{+}] ions in ECF:

- ↑Ca^{2+} in extra cellular fluid ↑ contractility (more Ca^{+2} entrance the more contraction will occur.

- ↑K^{+} ↓ contractility

4- Physical factors:

- Warming ↑ contraction. How? Increase substances movement.

- Cooling ↓ contraction. How? Substances freeze → no movement of Ca^{+2} or K^{+}

5- Hormonal & chemical factors:-

Positive (↑Cardiac Contractility)	Negative (↓Cardiac Contractility)
Digoxin, digitalis	Beta blockers (β blockers)
Adrenaline & Noradrenaline	Acetylcholine
Dobutamine	Ether
Dopamine	Some bacterial toxins (e.g. diphtheria toxins)
Isoprenaline	K^{+}
Alkalosis	Acidosis
Ca^{2+}	Ca^{2+} channel blockers
Caffeen	

We can benefit from these inotropes , however these substances may harm the heart :

Benefits	Risk
Improves cardiac performance	↑ Heart rate, causing further deterioration of failing heart pump
Improves myocardial contractility	↑ Myocardial oxygen requirements
↑ Blood pressure	Potentially arrythmogenic
	Can ↑ ischemia

-- Mechanical factors:

a. Cardiac ms obeys 'all or none law'

b. Cardiac ms can perform both **isometric** & **isotonic** types of contractions

c. Staircase phenomenon

d. Cardiac ms can't be tetanized

e. Starling's law of the heart

- Cardiac ms obeys all-or-non-rule :

Cardiac ms respond to threshold stimulus and what's above it, subthreshold can not get the muscle contracted, however during contraction muscle does not respond to any other stimulus.

- Isomeric contraction : occurs when no work is done by muscle, no change in length.

- Isotonic contraction : occurs when work is done by muscle and it's able to shorten itself

Staircase phenomenen: (to understand)

After brief rest, on stimulation at regular frequency, the force of contraction ↑ progressively to a maximum & then is maintained at a plateau

.

What are the causes of stair case phenomeno

↑ Ca accumulation

↑ Temp.

- Starling's low :

It states that the force of a muscle contraction is proportional to its initial length , initial length depends on diastolic volume **EDV= 130 ml** (normally) which is the venous return.

The c.muscle **relaxes** within limits in pre-load state.

-↑ As the pre-load → ↑ the tension on muscle

Length-Tension Relationship :

Passive tension is given by diastolic intraventricular pressure

Active tension is given by systolic intraventricular pressure

Total tension is the **sum** of the parallel elastic tension, i.e. 'passive' & 'active' tension

GooD LucK