"Cardiophysiology"

Important Definitions:

- **Cardiac Output:** Amount of blood from each ventricle pumped/minute **(CO = SV x HR)**
- **Stroke Volume:** Volume of blood ejected/beat
- **Heart Rate:** Number of heart beats/minute

Requirement for Effective Operation:

1- Contraction of individual cardiac muscle cell must occur in Regular + Synchronized **pattern [Not arrhythmic]**
2- The valves must be fully opened **[Not stenotic].**
3- The valves must NOT leak **[Not regurgitated].**
4- The muscle contraction must be forceful **[Not fainted].**
5- The ventricles must be filled adequately during diastole.

"Starling's Law of the Heart":

- As Cardiac filling increases in diastole →The volume ejected during systole increases.
- With other factors equal, stroke volume increases as cardiac end diastolic volume increases.

✓ **Importance of starling's law : it is the Primary:** [1]- regulators of **CO**.
[2]- Intrinsic mechanisms.

Autonomic Neural Influences:

"In response to changing in haemostatic needs of the body"

	Sympathetic	Parasympathetic
Fibers:	**Adrenergic** sympathetic fibers.	**Cholinergic** parasympathetic fibers "Vagus nerve".
Site of Action:	Cardiac cells.	SA node, AV node, atrial muscles.
Neurotransmitter:	Norepinephrine [Noradrenalin]	Acetylcholine.
Receptors:	β 1 adrenergic receptor.	Muscarinic receptors.
Net Results:	1- ↑ Heart rate. 2- ↑ Action potential conductive velocity.(APVC) 3- ↑ Force of contraction	1- ↓ Heart rate "SA node". 2- ↓ APVC "AV node". 3- ↓ Contraction of **atrial** muscle cells "NOT ventricle"
Overall:	Sympathetic → ↑ Cardiac pumping.	Parasympathetic → ↓ Cardiac pumping.

The Vasculature:

- All the circulatory system lined by single endothelial layer **"Including the heart".**

☒ Types:

- Heart → Aorta → Arteries → Arterioles → Capillaries.
- Capillaries → For exchange of materials between blood and interstitial fluid.
- Venules → **Veins** → Heart
- Veins have valves → only one way of the flow.

☒ Peripheral veins play an important role in controlling CO:

- They are known as capacitance vessels = more than 50% of blood are in veins + venules.
- Changes in venous volume greatly influences cardiac filling, therefore cardiac pumping.

Control of Blood Vessels:

☒ Neural and chemical controls are important in arterioles, venules, and veins.

1- Arterioles:

- **Neural:** Sympathetic nerves innervate the arterioles → release norepinephrine → act on α-adrenergic receptors on the smooth muscles → contraction → constriction of the vessels → ↑ vascular resistance → ↓ blood flow.
- **Chemical:** ↑ Tissue metabolic rate → arteriolar dilation → ↑ tissue blood flow.

2- Venules and Veins:

- The same mechanism discussed above for arterioles.
- ↑ Sympathetic → ↓ venous volume.
- Venoconstriction → ↑ cardiac filling → ↑ COP **"Starling's Law"**

Cardiac cell Action Potential:

☒ Depolarization:

- If Na^+ enters the cell → ↑ +ve charge inside the cell.

☒ Repolarization:

- K^+ goes out of cell → ↑ -ve charge inside the cell.
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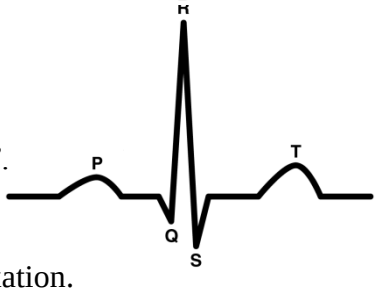
ECG:

❖ **Main Features:**

1- **P Wave:** Atrial depolarization "Contraction".
2- **QRS Complex:** Ventricular depolarization "Contraction".
3- **T Wave:** Ventricular repolarization "Relaxation".



Cardiac Cycle: One complete cycle of contraction + relaxation.

☒ Left Pump

1- **Ventricular Diastole: [Relaxation of ventricles]**

a- Period of ventricular FILLING starts.
b- Atrioventricular valves OPEN.. Why?
Because the pressure in the ventricle falls below the pressure of the atriums.
E.g.: Mitral valve "Left Ventricle"
c- When did atrial contraction start?
✓ Atrial contraction is initiated near the end of ventricular diastole, by the depolarization of atrial muscles.
❖ **On ECG:** P wave means atrial contraction.

- SA node → Pacemaker
- AV node → delay [Atrial contraction + ventricular contraction]
- Blood from Atrium → Ventricle: Ventricular pressure ↓↓. Contraction of atrium pushes blood → When?! Near the end of ventricular diastole

2- **Ventricular Systole: [Contraction of ventricles].**
   a- Period of ventricular ejection starts.
   b- How does the contraction occur?
      Occurs when action potential breaks through the AV node, and sweeps, over the ventricular muscles
   c- AV valves CLOSE.. Why?
      Because when the ventricles contract, the ventricular pressure rise above the atrial pressure.
   d- Aortic valve OPEN.. Why?
      When left ventricular pressure exceeds aortic pressure, the aortic valve opens.

❖ **On ECG:** QRS complex means ventricular contraction.

☒ **Right pump:-**

❖ **The entire heart (right and left) served as union:**
- Both ventricles have synchronous systolic and diastolic periods.
- The valves of right and left heart normally close and open nearly in unison
- They must pump the same amount of blood and therefore must have identical stroke volume.

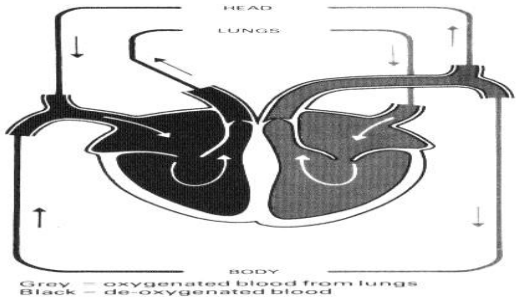
❖ **The major difference between Right and Left pump is :**
- The magnitude of the peak systolic pressure .
- The pressure developed by the Rt heart lower than those of left heart.

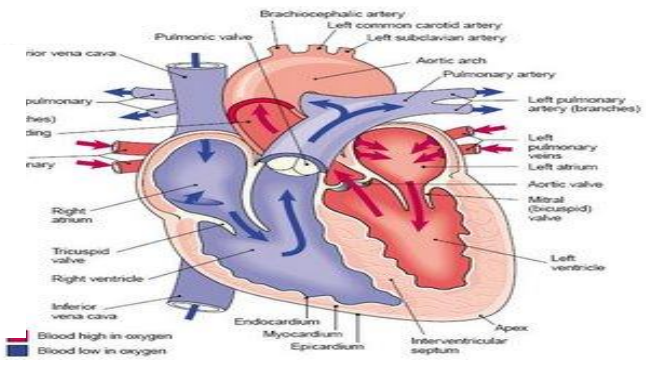
Cardiac cycle of right heart:-

The pressure pulsation that occur in the Right atrium are transmitted in retrograde fashion to the large vein of the heart, these pulsations can be visualized in neck over the jugular veins.(clinically important)

❖ **Series of right cardiac cycle :**

1- Atrial contraction . (produce **a wave** ; the first pressure peak)
2- Ventricular contraction " systole " (produce **c wave** ; caused by initial bulging of the tricuspid valve into the right atrium) .
3- Right atrial pressure falls after **c wave** ; because of
   - Atrial relaxation .
   - Downward displacement of the tricuspid valve during ventricular emptying .
4- Blood return from the peripheral organs by the veins to the right atrium , and the right atrium start to fill against the closed tricuspid valve , this produces pressure appear **as v wave .**
5- At the end of ventricular contraction " systole " , tricuspid valve opens and atrial pressure falls again as blood moves to the relaxed ventricle .
6- Then , right atrial pressure start to increase toward another **wave** .





Heart Sounds :

(by knowing the causes of heart sounds, you can detect if there is any abnormality and what causes it)

S1 :

- soft, low pitched and prolonged sound
- At the beginning of systole .
- Caused by closure of AV valves .
- Heard clearly at the apex of the heart .
- Occurs immediately after QRS complex .

S2 :

- Short, sharp and high-pitched sound.
- At the very end of systole. (beginning of diastole)
- Caused by closure of Aortic and pulmonary valves .
- Occurs about the time of T wave .

S3 :

- Due to inrushing of the blood from the atria to the ventricles in the middle 1/3 of diastole. (after S2)
- Lower in pitch than S1 or S2 as it is not of valvular origin
- Best heard with the bell-side of the stethoscope

S4 :

- Due to contraction in the last 1/3 of the diastole (before S1)
- (it is the sound of blood being forced into a stiff/hypertrophic ventricle)
- Rare , It is a sign of a pathologic state
- Called a presystolic gallop or atrial gallop.

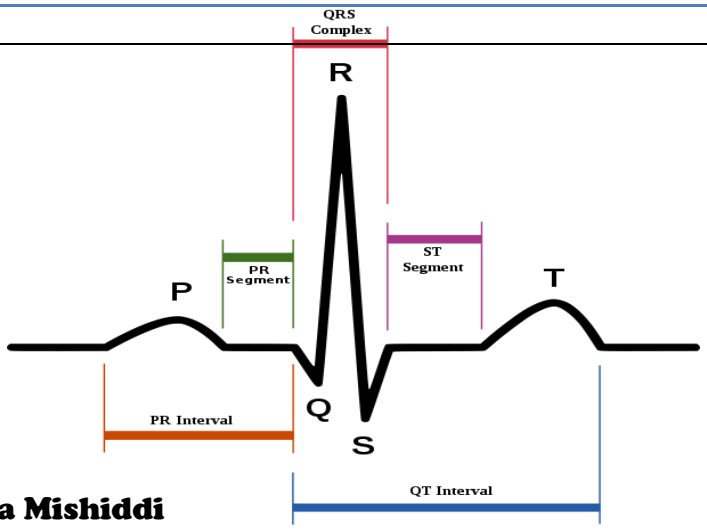
" Areas on the surface of the chest where the heart is auscultated "

Pulmonary valve (to pulmonary trunk)	second intercostal space	left upper Sternal border
Aortic valve (to aorta)	second intercostal space	right upper Sternal border
Mitral valve (to left ventricle)	fifth intercostal space	medial to left midclavicular line
Tricuspid valve (to right ventricle)	fourth intercostal space	lower left sternal border

Electrocardiography :

The isoelectric line is measured as the portion of the tracing following the T wave and preceding the next P wave

Feature	Description
RR interval	The interval between an R wave and the next R wave is the inverse of the heart rate. Normal resting heart rate is between 50 and 100 bpm
P wave	atrial depolarization,
PR interval	The PR interval is measured from the beginning of the P wave to the beginning of the QRS complex. The PR interval reflects the time the electrical impulse takes to travel from the sinus node through the AV node and entering the ventricles. The PR interval is therefore a good estimate of AV node function.
PR segment	The PR segment connects the P wave and the QRS complex
QRS complex	The QRS complex reflects the rapid depolarization of the right and left ventricles.
J-point	The point at which the QRS complex finishes and the ST segment begins. Used to measure the degree of ST elevation or depression present.
ST segment	The ST segment connects the QRS complex and the T wave. The ST segment represents the period when the ventricles are depolarized. It is isoelectric.
T wave	The T wave represents the repolarization (or recovery) of the ventricles.
ST interval	The ST interval is measured from the J point to the end of the T wave.
QT interval	The QT interval is measured from the beginning of the QRS complex to the end of the T wave.



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