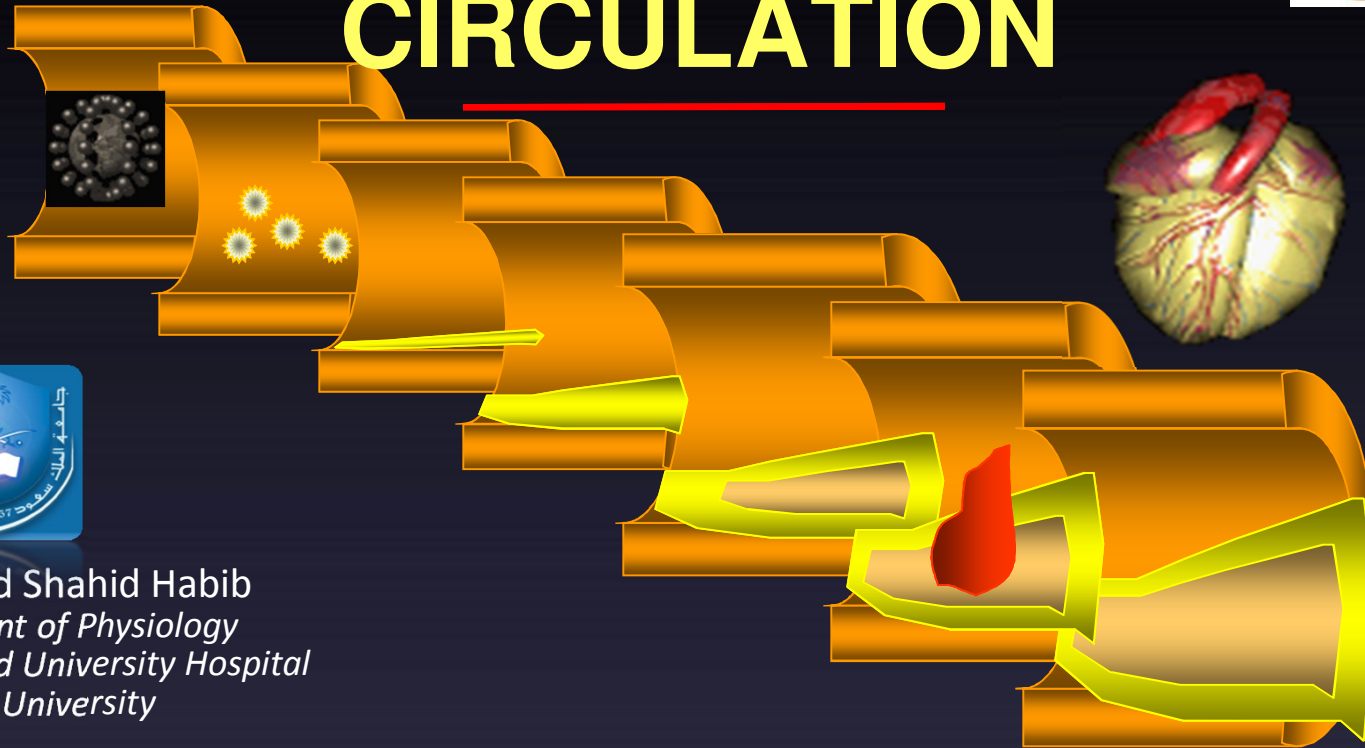


CARDIOVASCULAR SYSTEM CORONARY CIRCULATION



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OBJECTIVES

❖ **At the end of the lecture you should be able to**

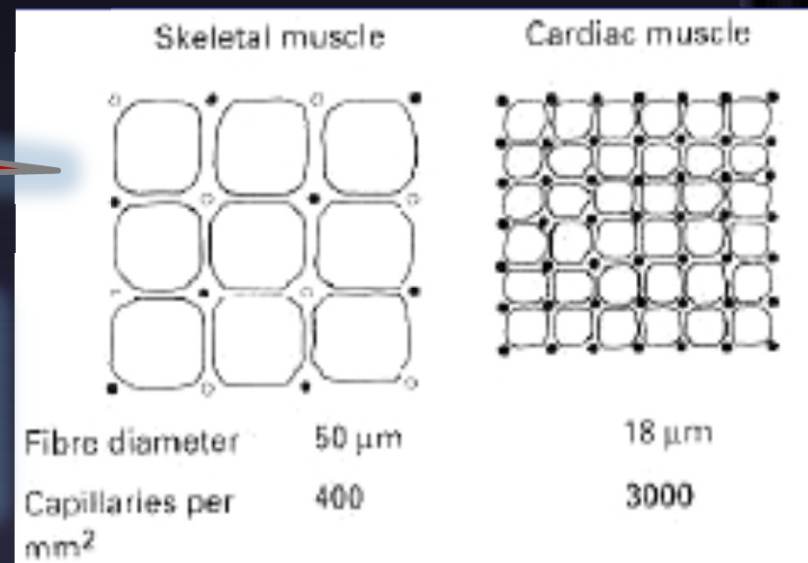
- **Facts about Coronary blood flow**
- **Normal Coronary blood flow**
- **Coronary blood flow in systole & diastole**
- **Discuss regulation of coronary blood flow.**
- **Explain and differentiate between angina and myocardial infarction**

IMPORTANT ! WHY?

- ❖ One third of all deaths in the world result from coronary artery disease.
- ❖ Almost all elderly people have at least some impairment of the coronary artery circulation.

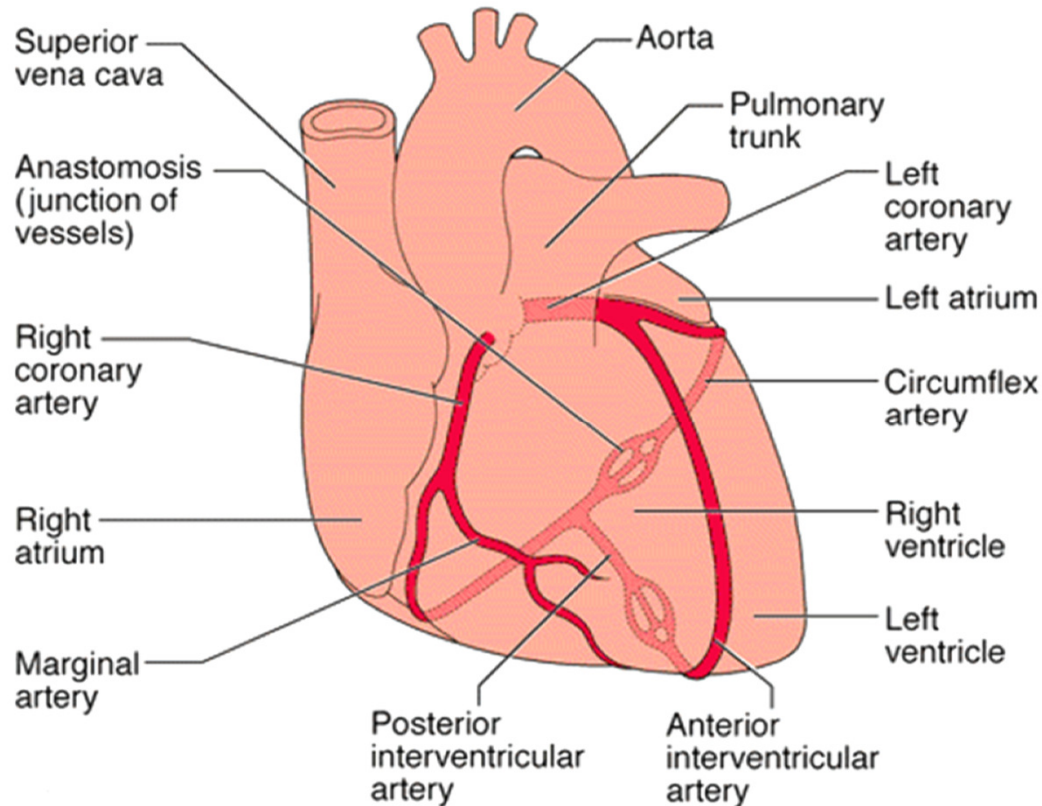
Capillary Density in the Heart

Heart uses primarily free fatty acids and to lesser extent glucose and lactate for metabolism.

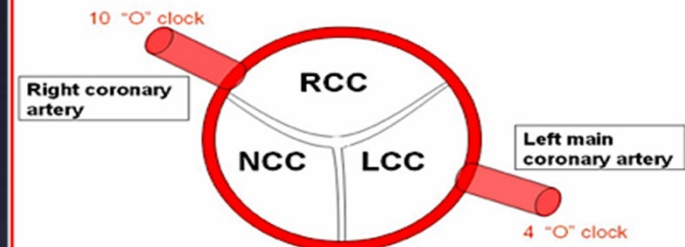


Coronary arteries

- Left main coronary artery divides into left anterior descending artery (anterior interventricular) and circumflex artery.
- Right coronary artery divides into smaller branches, including the right posterior descending artery (posterior interventricular) and the acute marginal artery.



Where to look for coronary artery origin in short axis view ?



RCC - Right coronary cusp
LCC - Left coronary cusp
NCC - Non coronary cusp

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Note : The aortic trileaflet attachment is highly variable . So also , the coronary artery origin . RCA originates anywhere between 9 & 11 , LCA between 3 & 5 "O" clock position .

Coronary Dominance

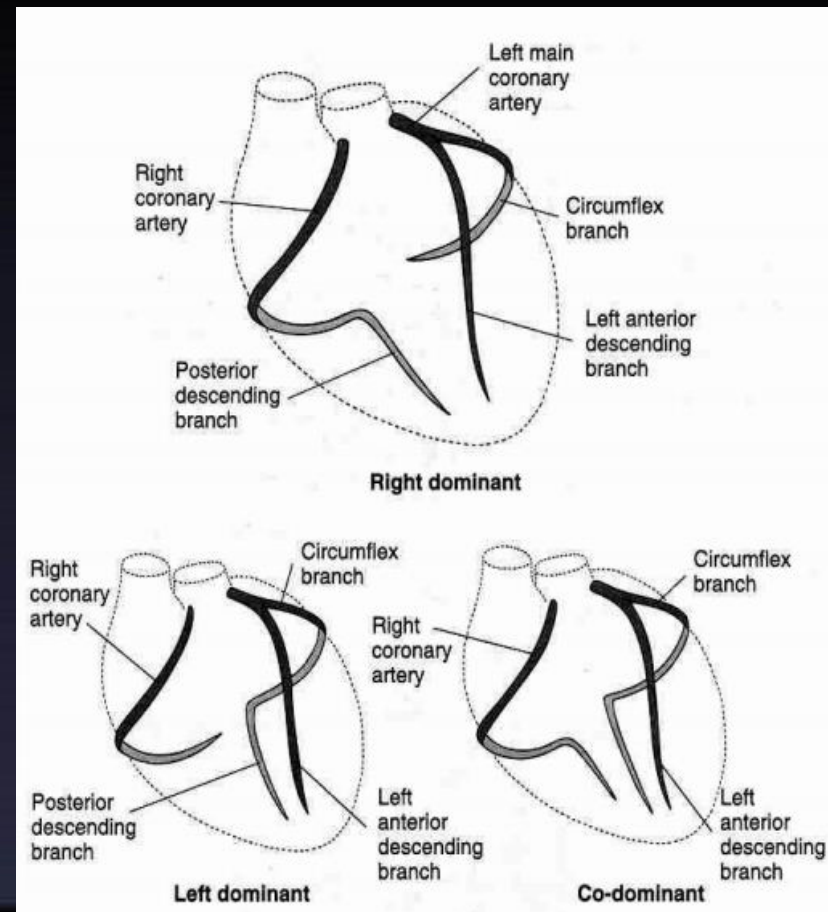
Coronary dominance depends on which artery (or arteries) gives rise to the posterior descending artery (PDA), that runs along the posterior side of the heart & supplies the AV- node.

Right dominant The PDA branch arises from the RCA (60%-70% of population)

Left dominant or The PDA arises from the LCA (10%-15% of population)

Co-dominant.

- RCA gives rise to the PDA and then ends, while the CX supplies the PLA branches
- CX may also supply a left PDA that runs parallel to the right PDA



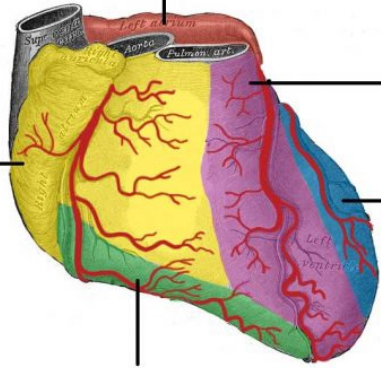
Left Circumflex Artery
Supplies the left atrium
and left ventricle

Left Anterior Descending Artery
Supplies the right ventricle, left ventricle
and interventricular septum

Left Marginal Artery
Supplies the left ventricle

Right Coronary Artery
Supplies the right atrium
and the right ventricle

Right Marginal Artery
Supplies the right
ventricle and the apex



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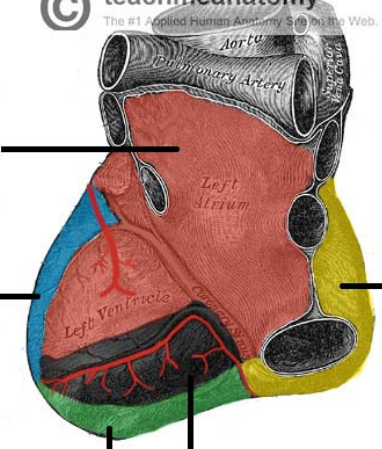
Left Circumflex Artery
Supplies the left atrium
and ventricle

Left Marginal Artery
Supplies the left ventricle

Right Coronary Artery
Supplies the right atrium
and right ventricle

Right Marginal Artery
Supplies the right
ventricle and apex

Posterior Interventricular Artery
Supplies the right and left ventricles,
and the interventricular septum



FACTS ABOUT CORONARY BLOOD FLOW

- ❖ Two-thirds of coronary blood flow occurs during diastole .
- ❖ Five percent of cardiac output goes to the coronary arteries.
- ❖ Seventy percent of oxygen is extracted by the myocardial tissues of the heart, in comparison to the rest of the body at twenty five percent.
- ❖ During times of extreme demand, the coronary arteries can dilate up to four times greater than normal
- ❖ Coronary blood flow in Humans at rest is about 225-250 ml/minute, about 5% of cardiac output.
- ❖ At rest, the heart extracts 60-70% of oxygen from each unit of blood delivered to heart [other tissue extract only 25% of O₂].

Effect of Tachycardia on coronary blood flow:

During increased heart rate, period of diastole is shorter therefore coronary blood flow is reduced to heart during tachycardia.

CORONARY BLOOD FLOW

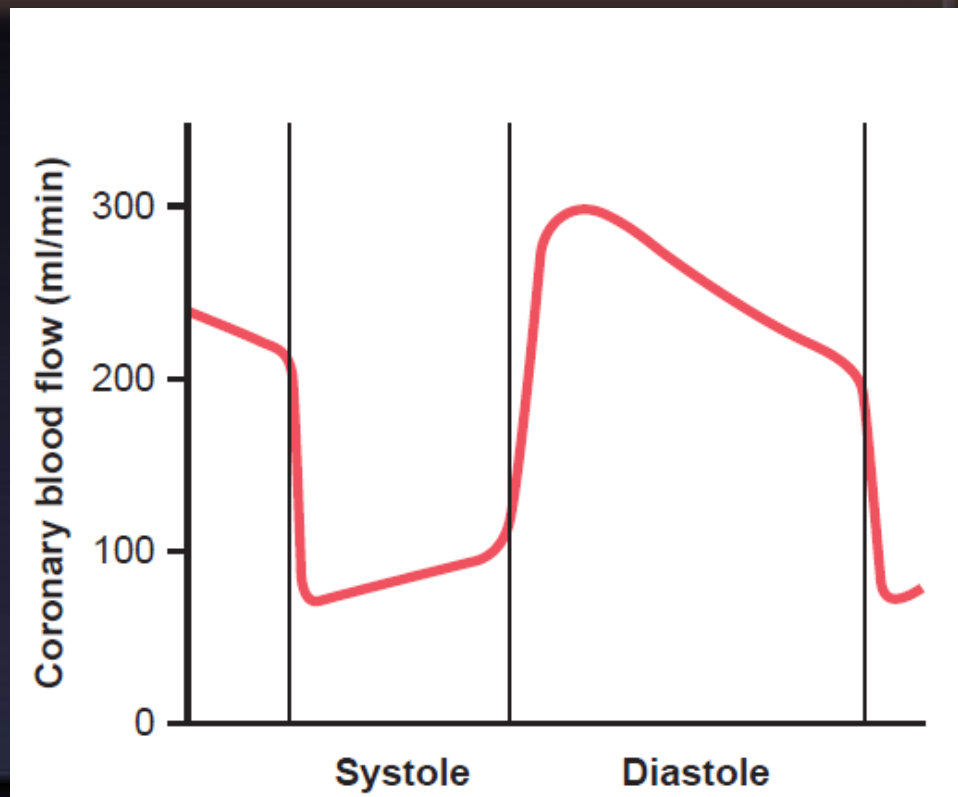
- Why heart is extracting 60-70% of O₂?
- **Because heart muscle has more mitochondria, up to 40% of cell is occupied by mitochondria, which generate energy for contraction by aerobic metabolism, therefore, heart needs O₂.**
- **When more oxygen is needed e.g. exercise, O₂ can be increased to heart only by increasing blood flow.**

BLOOD FLOW TO HEART DURING SYSTOLE & DIASTOLE [PHASIC CHANGES]

During systole when heart muscle contracts it compresses the coronary arteries therefore blood flow is less to the left ventricle during systole and more during diastole.

Blood flows to the subendocardial portion of Left ventricle, occurs only during diastole

Therefore, this portion of Lt Ventricle is prone to ischemic changes & is most common site of myocardial infarction



PRESSURE GRADIENT BETWEEN AORTA & VENTRICLES AFFECTS CBF

CBF to the Right side is not much affected during systole..

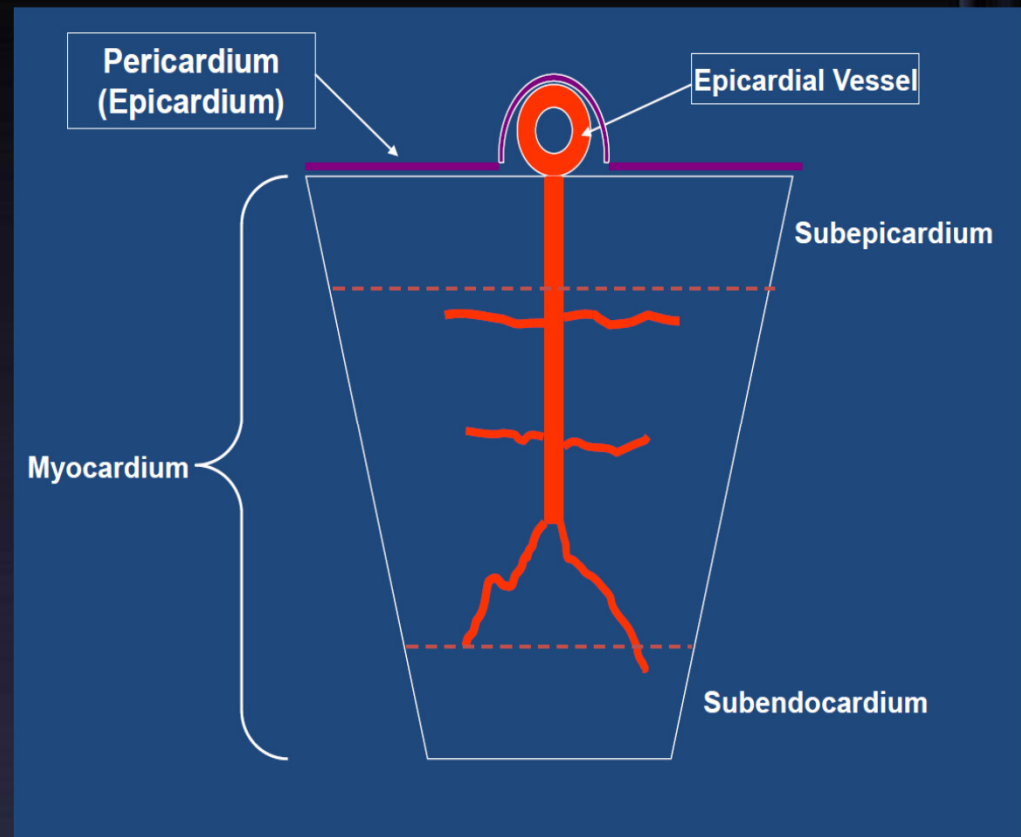
Pressure difference between the aorta & Right ventricle is greater during systole than during diastole, therefore more blood flow to Right ventricle occurs during systole

	Aorta	Pressure (mmHg) in		Pressure difference (mmHg) between aorta&	
		Left Ventricle	Right Ventricle	Left Ventricle	Right Ventricle
Systole	120	120	25	0	95
Diastole	80	2-0	2-0	80	80

Coronary Vascular Resistance

- **Epicardial conductance vessels:** Contribute only to a small % of resistance.
- **Intramyocardial vessels (arterioles):** Contribute most to total coronary vascular resistance.

As we know during systole blood flow to subendocardial surface of left ventricle is almost not there, **therefore**, this region is prone to ischemic damage and most common site of Myocardial infarction.



CORONARY BLOOD FLOW

- Why heart is extracting 60-70% of O₂?
- **Because heart muscle has more mitochondria, up to 40% of cell is occupied by mitochondria, which generate energy for contraction by aerobic metabolism, therefore, heart needs O₂.**
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REGULATION OF CORONARY BLOOD FLOW

- 1- Metabolic control**
- 2- Auto regulation**
- 3- Endothelial control of coronary vascular tone**
- 4- Extravascular compressive forces**
- 5- Neural control**

1- METABOLIC CONTROL

Coronary circulation is very sensitive to myocardial tissue oxygen tension.
Increased oxygen demand results in a lower tissue oxygen tension.

This causes:

Vasodilation and increased blood flow by chemical factors like:-

- 1- ↑ Adenosine
- 2- Lack of oxygen
- 3- ↑ Nitric oxide
- 4- ↑ Prostaglandins
- 5- ↑ K^+
- 6- ↑ H^+
- 7- ↑ Lactate
- 8- ↑ Adenine nucleotides

Adenosine, which is formed from ATP during cardiac metabolic activity, causes coronary vasodilatation.

2- AUTO REGULATION

- **Ability of a vascular network to maintain constant blood flow over a range of arterial pressures.**
- **Auto regulation is an independent determinant of coronary blood flow.**
- **The set point at which coronary blood flow is maintained depends on myocardial oxygen consumption (MVO₂).**

3- ENDOTHELIAL CONTROL OF CORONARY VASCULAR TONE

Damage to endothelial cells will lead to:

- 1- Decreased Nitric Oxide and Prostacyclin production.**
- 2- Increased Endothelin production.**

This will lead to:

- 1- Vasoconstriction.**
- 2- Vasospasm.**
- 3- Thrombosis.**

4- NEURAL CONTROL

- Coronary blood flow is controlled predominantly by local metabolic, auto regulatory, and endothelial factors.
- Neural control of the coronary circulation complements the above local effects.

Sympathetic Control:

Alpha = constrict coronary vessels.

Beta = dilate coronary vessels.

Beta₁ in conduit arteries.

Beta₂ in resistance arterioles.

Parasympathetic Control:

Acetylcholine

Vasodilation in healthy subjects.

Vasoconstriction in patients with atherosclerosis.

Vagal stimulation causes coronary vasodilatation.

However, parasympathetic distribution is not great. There is more sympathetic innervation of coronary vessels.

EFFECT OF SYMPATHETIC STIMULATION ON CORONARY BLOOD FLOW

Coronary arteries have:

- Alpha Adrenergic receptors, which mediate vasoconstriction (more epicardial)
- Beta Adrenergic receptors, which mediate vasodilatation (more in the intramuscular arteries)

Indirect effect of sympathetic stimulation:

Sympathetic stimulation in intact body will lead to release of adrenaline & noradrenaline, increasing HR & force of contraction .

Vasodilator metabolites will be increase leading to coronary vasodilatation.

Direct effect of sympathetic stimulation:

Experimentally, injection of noradrenalin after blocking of the beta adrenergic receptors in un-anesthetized animals elicits coronary vasoconstriction.

BENEFITS OF INDIRECT EFFECT OF NOR-ADRENERGIC DISCHARGE

- When systemic blood pressure decreases very low there is Reflex increase of nor adrenergic discharge.
- Increase CBF secondary to metabolic changes in the myocardium.
- In this way, circulation of the heart is preserved while the flow to other organs compromised.

5- EXTRAVASCULAR COMPRESSIVE FORCES

Left Ventricle

Early Systole > Initial Flow Reversal.

Remainder of Systole > Flow follows aortic pressure curve, but at a much reduced pressure.

Early Diastole > Abrupt pressure rise (80-90% of LV flow occurs in early diastole).

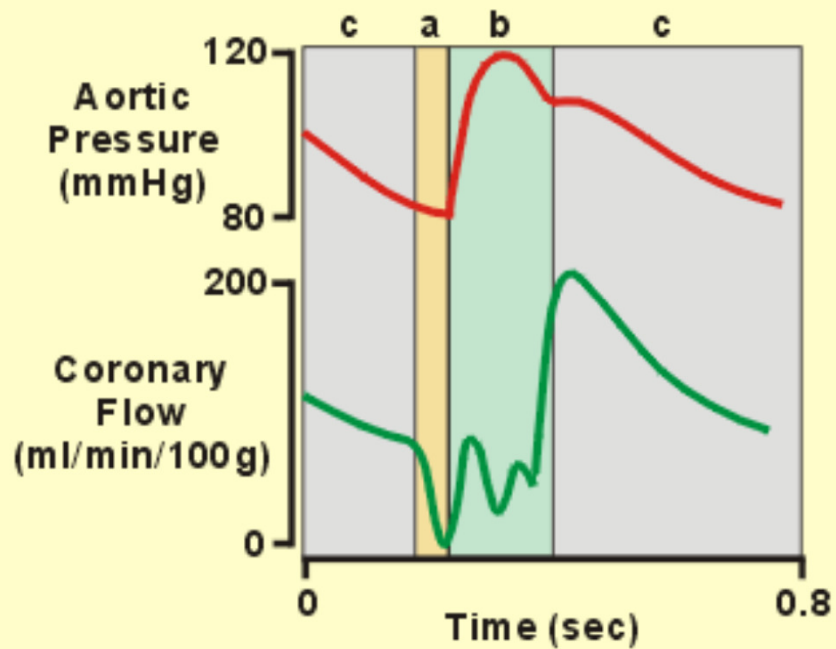
Remainder of Diastole > Pressure declines slowly as aortic pressure decreases.

Right Ventricle

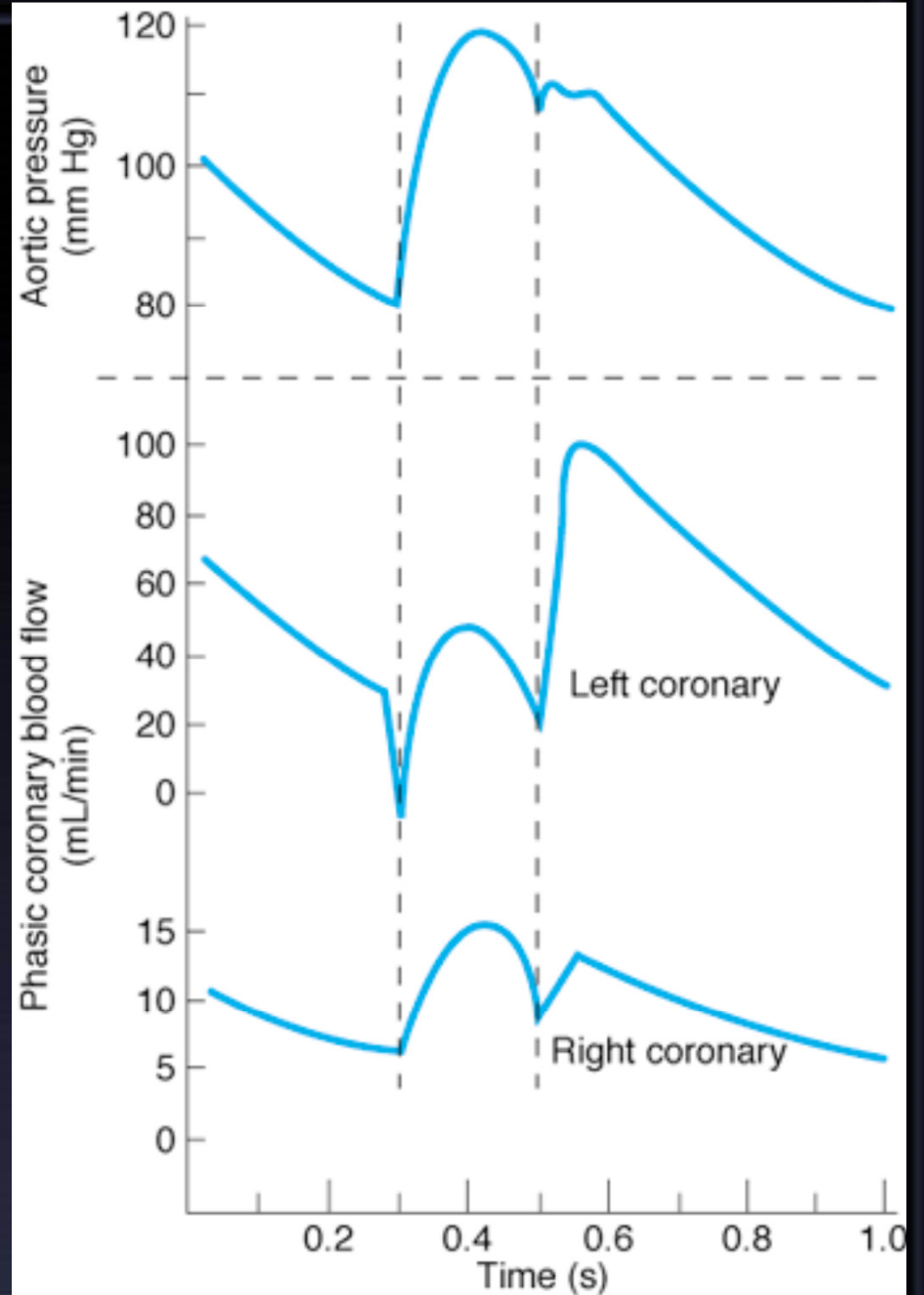
Lower pressure generated by thin right ventricle in Systole.

No reversal of blood flow during early systole.

Systolic blood flow constitutes a much greater proportion of total blood flow.



Pulsatile nature of left coronary artery blood flow. Flow is lower during phases of isovolumetric contraction (a) and ejection (b) than during diastole (c).



FACTORS INCREASING MYOCARDIAL OXYGEN CONSUMPTION

- 1- Increased Heart Rate.**
- 2- Increased Inotropy (Contractility).**
- 3- Increased Afterload.**
- 4- Increased Preload.**

Changes in preload affect myocardial oxygen consumption less than do changes in the other factors. % of O₂?

ANGINA:

Investigation:

ECG may be normal between attacks.
Exercise ECG – 75% positive, but a normal
results does not exclude the condition.

Treatment for attack:

Stop exercise

Glyceryl trinitrate 0.5mg under the tongue.

(side effects → headache)

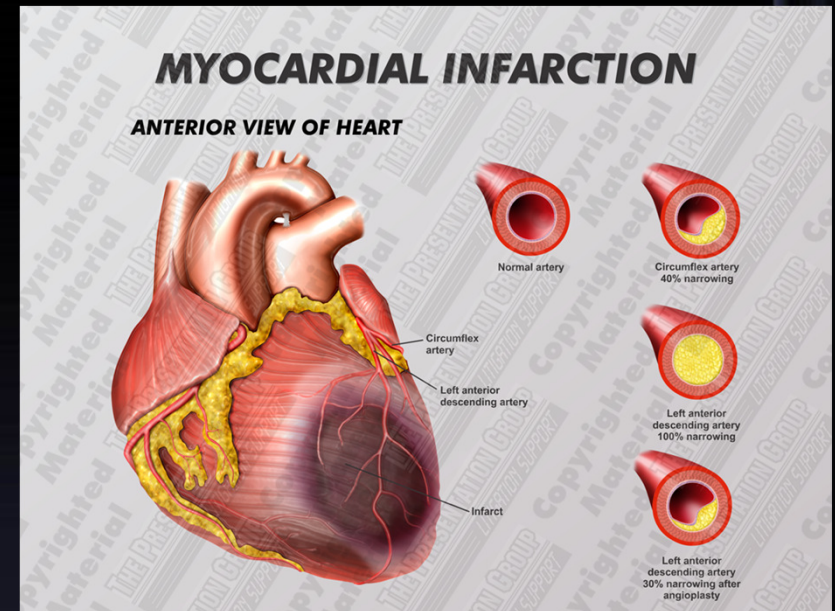


MYOCARDIAL INFRACTION:

Most common cause of death.
Clinical features:

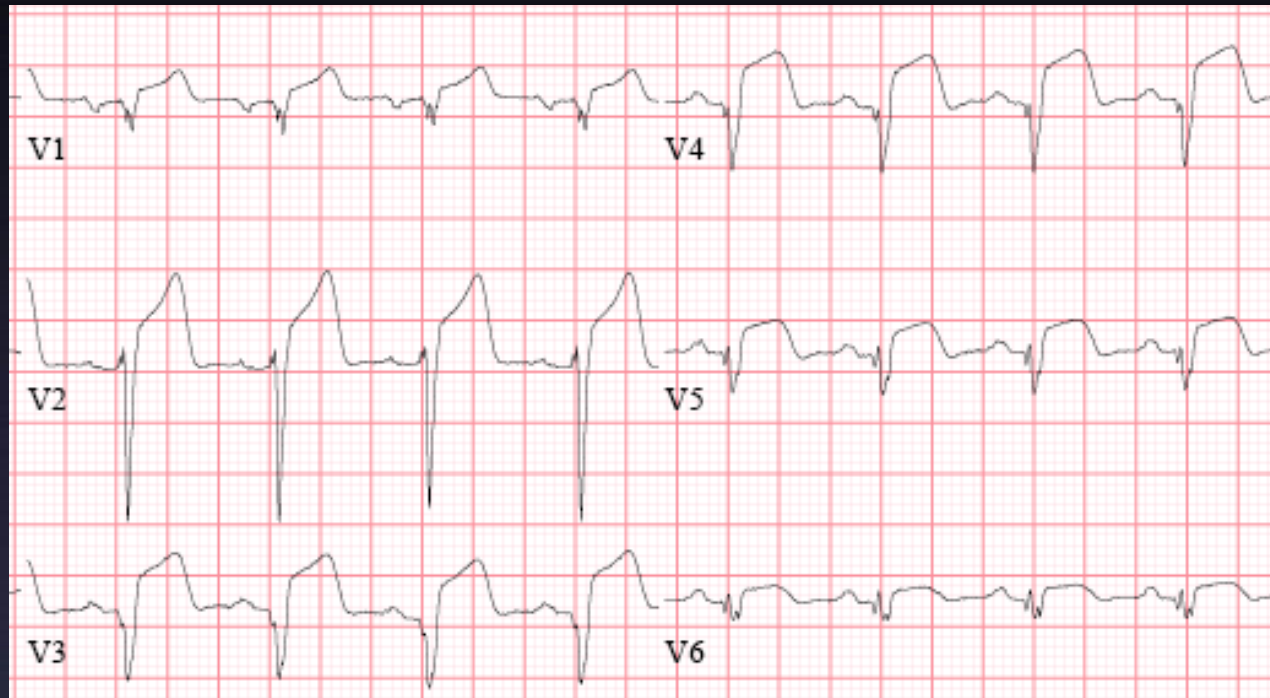
Chest pain – even at rest & last for hours. Severe pain – sudden onset, but can develop gradually.

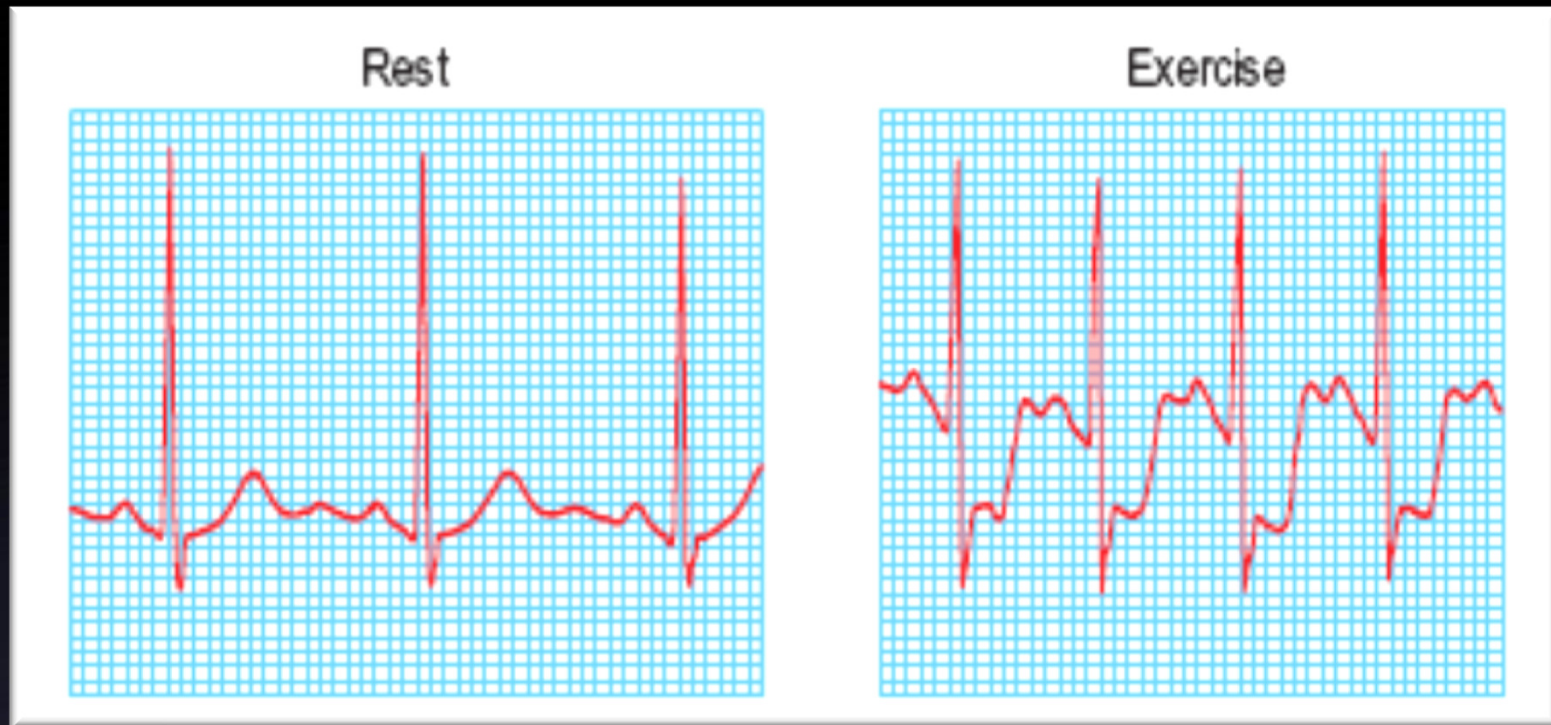
Associated with: sweating, vomiting. 20% no pain.
Hypotension.



INVESTIGATIONS:-

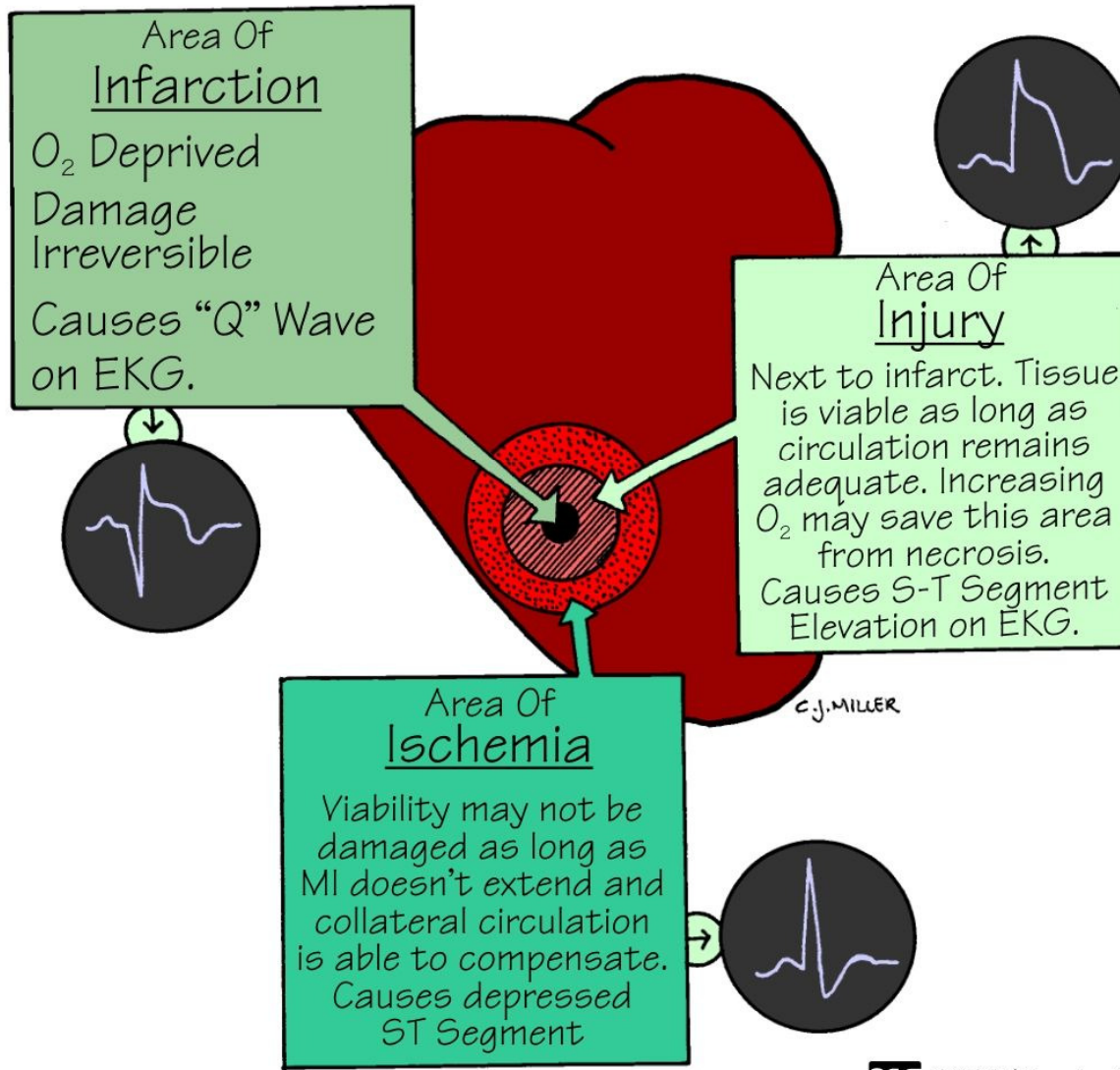
- Cardiac enzyme – CK (creatin kinase), AST (aspartate aminotransferase), LDH (lactic dehydrogenase)
- ECG: Q wave, ST elevation, T inversion. Q wave – full thickness infraction.





Electrocardiographic changes during exercise test. Upper trace – significant horizontal ST segment depression during exercise.

3 AREAS OF DAMAGE AFTER A MYOCARDIAL INFARCTION...





THANKS