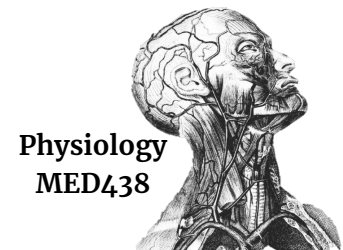
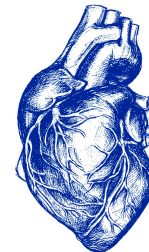


# Lecture 14

## Coronary circulation

- **Red:** important
- **Black:** in male / female slides
- **Pink:** in female slides only
- **Blue:** in male slides only
- **Gray:** extra information

[Editing file](#)



# Objectives:

## Boys slides objectives:

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

## Girls slides objectives:

- Coronary circulation & areas of supply.
- Coronary collateral circulation.
- Coronary dominance.
- Coronary blood flow & factors affecting it .
- Control of coronary blood flow.

# General info about this lecture

## -Prevalence of coronary artery disease :

- 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.

## -Facts about coronary blood flow :

- Two-thirds of coronary blood flow occurs during Diastole . **Maximal flow** occurs during early diastole. **(isometric relaxation phase)**
- Coronary blood flow in humans at rest is about 225-250 ml/min , about 5% of cardiac output.
- 70% of O<sub>2</sub> is extracted from the blood by the myocardial tissues of the heart, while the rest of the body tissues is only 25%. (the heart has more mitochondria (40% of the cell), which means it needs more O<sub>2</sub>)
- During times of extreme demand, coronary arteries can dilate up to 4 times greater than normal.
- During increased heart rate, diastole is **shorter**, so coronary blood flow will be **reduced**.

# Coronary Circulation

- Consist of:

## 1 Arterial supply

- Cardiac muscle is supplied by two coronary arteries:
  1. Right coronary artery (RCA)
    - ➔ divides into: (RPD) & (AM)
  2. Left coronary artery (LCA)
    - ➔ divides into: (LAD) & (CX)
      - Both arise from the **coronary sinuses** at the aortic root, just superior to the aortic valve cusp.
      - They wrap with their branches around the outside of the heart to supply all cardiac muscle with blood.

## 2 Venous drainage

## 3 Lymphatic drainage

# Coronary Sinus (Origin of coronary arteries)

### 01

- The aortic valve has **three** cusps:
  1. Left coronary cusp (LCC).
  2. Right coronary cusp (RCC).
  3. Posterior non-coronary cusp (NCC).

### 02

- There may be variations in the number, shape & location of **coronary ostia** or origins of the **coronary arteries**, most of which are of **No** clinical significance.

### 03

- Coronary arteries deliver **oxygenated** blood to the cardiac muscle.

# Coronary Arteries Of The Heart

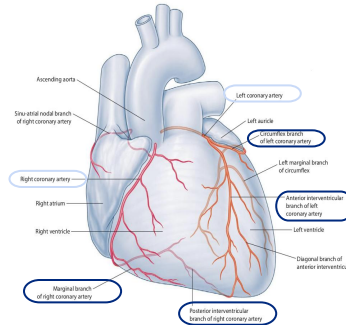
## Coronary circulation

### Right coronary artery (RCA)

- (RCA) is **smaller** than the (LCA).
- Arises from the **right coronary sinus**.
- Curves posteriorly & descends downward on the posterior surface of the heart.
- Terminates by anastomosing with the (LCA).

### Left coronary artery (LCA)

- Also known as: the left main coronary artery (**LMCA**).
- **Larger** than the (RCA).
- Arises from the **left coronary sinus**.
- Runs for 10-25mm before bifurcating. It **Terminates** by anastomosing with the (RCA).
- Supplies blood to the **left side** of the heart muscle (left ventricle & left atrium).



- Two main branches:

1. **Right posterior descending artery (RPD)**
2. **Right acute marginal artery (AM)**

- Two main branches:

1. **Left anterior descending artery (LAD)**
2. **Circumflex artery (CX)**

# Right Coronary Artery

Female slides

## Main branches

### Right posterior descending artery (RPD)

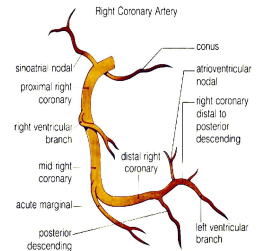
- Also called **posterior interventricular artery**.
- Curves posteriorly & descends downward on the posterior surface of the heart.
- Supplies blood to the RA, RV, bottom portion of the LV, & posterior **1/3** of the **IV septum**
- Branches into AV nodal artery, which supplies AV - node ( in **60-90 %** of hearts & the surrounding myocardium).

### Right acute marginal artery (AM)

- Runs down the **right margin** of the heart. .
- Supplies blood to the **right margin of the RV**, with **minimal supply** to the **apex**.

## Smaller branches

1. **Atrial branch**, gives off: SA nodal artery, which supplies the SA-node in **60%** ( 50-73 % ) of hearts & the surrounding myocardium.
2. **Right conus arteriosus artery**
3. **Right anterior ventricular artery**.
4. **Septal perforator (SP) artery**.



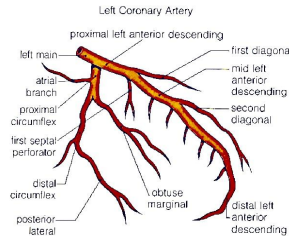
## Main branches

### Left anterior descending artery (LAD)

- Also called **anterior interventricular artery**.
- Considered the **most critical** vessel in terms of myocardial blood supply, as it supplies **45-55%** of the left ventricle (the anterior & apical part of the heart):
  - The **anterolateral** of the left ventricle.
  - The **apex** of the heart.
  - The anterior  $\frac{2}{3}$  of the **IV septum**.
  - The **front** of the **right ventricle**.
  - The **right & left bundle branches**.

- **Further divides into:**

1. **Diagonal arteries.**
2. **Left conus arteriosus artery.**
3. **Septal perforator (SP) artery.**



### Circumflex artery (CX)

- Encircles the heart muscle.
  - Supplies blood to the lateral & posterior surface of the heart: left atrium, the posterolateral of the left ventricle.
- **Further divides into:**
    1. **Left obtuse marginal (OM) artery**» which supplies the left ventricle.
    2. **SA nodal artery**» which supplies the SA- node in **~40%** of hearts and the surrounding myocardium.
    3. **Left branch to the AV- Bundle.**
    4. **Posterior ventricular branch.**
    5. **Anterior ventricular branch.**

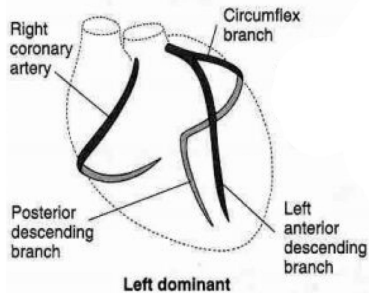
# Coronary dominance

- 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**

There is 3 types:

**Left dominant**

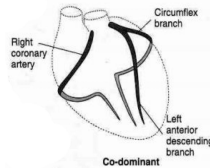
The PDA arises from **LCA**  
(10-15 % of the population)



**Co-dominant**

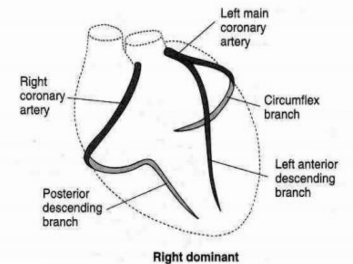
**RCA** gives rise to the PDA and then ends, while the **CX** supplies the PLA branches.

- CX may also supply a left PDA that runs parallel to the right PDA



**Right dominant**

The PDA arises from **RCA**  
(60-70 % of the population)





# Cardiac Anastomosis

- The two coronary arteries **anastomose in the myocardium.**

## Extracardiac anastomosis

**The coronary arteries anastomose with:**

1. Vasa vasorum of the aorta
2. The bronchial arteries
3. Phrenic arteries
4. Internal thoracic arteries
5. Vasa vasorum of pulmonary arteries

# Collateral Circulations

- Collateral circulation is a **network of extra-cardiac channels** formed of tiny blood vessels.
- Under normal conditions it is **NOT** open.
- It opens in emergencies when the **coronary arteries are blocked:**

**A** When the coronary arteries **narrow** to the point that blood flow to the heart muscle is limited (**coronary artery disease**), collateral vessels may enlarge & become active.

**B** This allows blood to flow around the blocked artery to another artery nearby or to the same artery past the blockage, protecting the heart tissue from injury.

# Venous Drainage Of The Heart

A

Venous drainage brings deoxygenated cardiac blood back to the heart.

B

**Most** of the venous blood return to the heart into the right atrium through the coronary sinus via the **cardiac veins**.

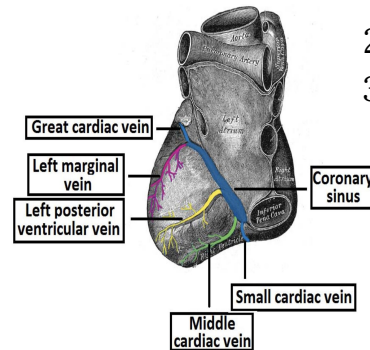
C

5- 10% drains **directly** into heart chambers, RA & RV, by » the **anterior cardiac vein** & the **small veins** that open directly into the heart chambers.

D

Cardiac venous drainage occur through:

1. **Coronary sinus**, lies in the posterior part of the atrioventricular groove & is a continuation of the great cardiac vein.
2. **Anterior (great), middle & small cardiac veins**.
3. **Smallest cardiac veins** (Venae Cordis Minimae).



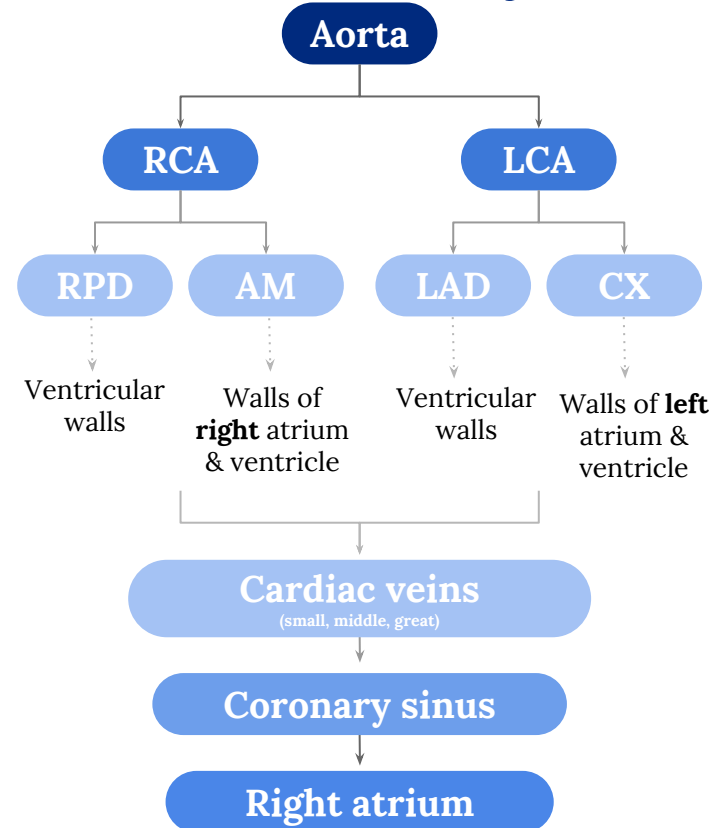
# Lymphatic Drainage Of The Heart

Lymphatics of the heart accompany the two coronary arteries & form two trunks:

**The right trunk** ends in the brachiocephalic node.

**The left trunk** ends into the tracheo-bronchial lymph nodes at the bifurcation of the trachea.

# Coronary circulation Summary

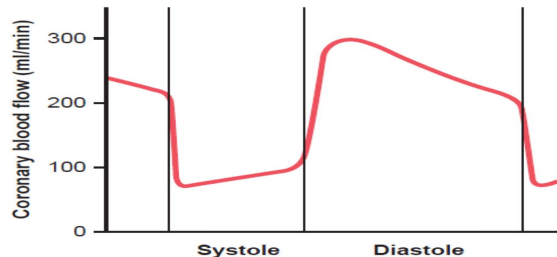


# Blood flow to Heart during systole and diastole

## In the left ventricle :

- During systole, when heart muscle contracts, it compresses the coronary arteries.

→ therefore **much less blood flows** to the left ventricle during **systole** and **more during diastole**.



## In the right ventricle :

- The force of contraction of the right ventricle is far less than left ventricle, so the inverse phasic changes are only partial, **therefore CBF of right ventricle is not affected much during systole**.
- The pressure gradient between aorta & ventricles affects the CBF (fluids move from higher to lower pressure)
- Pressure difference between the aorta & right ventricle is greater during systole than diastole

→ therefore **more blood flow to the right ventricle during systole**

Notice the pressure difference between aorta and R-ventricle.

	Aorta	LV	RV	Aorta - LV	Aorta - RV
Pressure	120/80	120/2-0	25/2-0	0/80	95/80

# Coronary vascular resistance

- **Epicardial conductance vessels:**

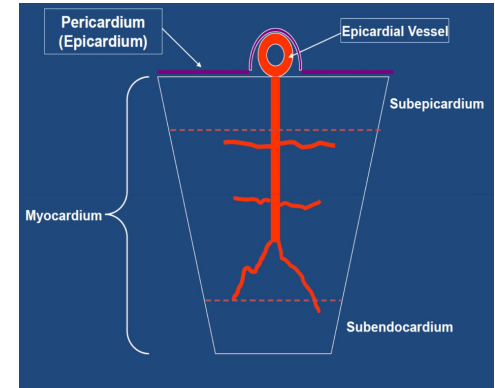
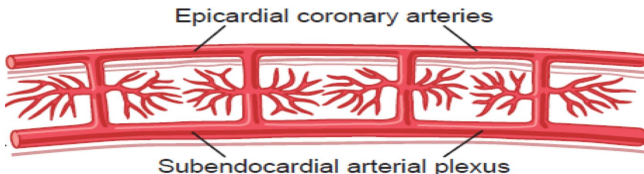
Contribute only to a small percentage of coronary vascular resistance.

- **Intramyocardial vessels (arterioles):**

Contribute to most of the total coronary vascular resistance.

Blood supply to the subendocardial portion if from the intramyocardial arteries.

- Blood flows to the subendocardial portion of left ventricle **only** during diastole, **therefore this portion of left ventricle is prone to ischemic changes & is the most common site of myocardial infarction.**
- However, the extra vessels of the subendocardial plexus normally compensate for this reduction .

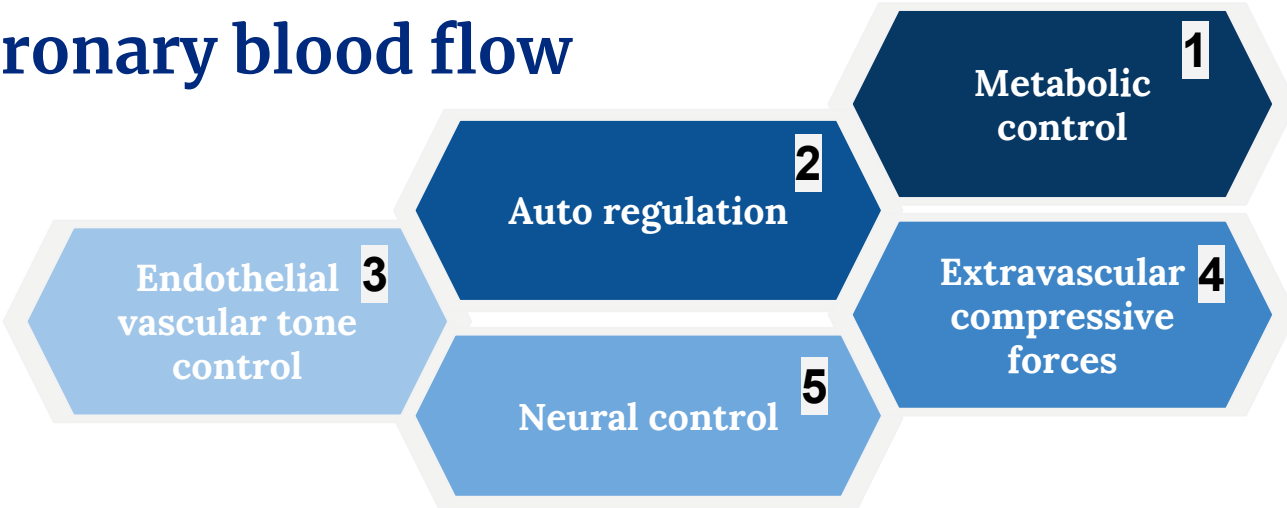
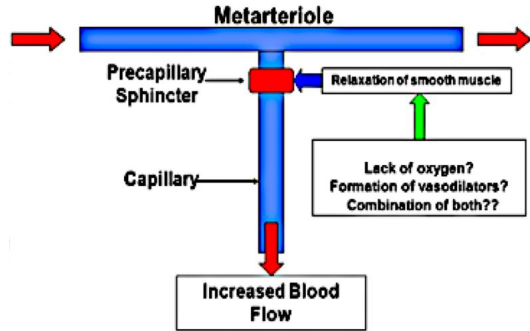


We have said earlier that during systole there is a decline in Coronary blood flow (**increase in coronary vascular resistance**), this is because of the compression on the intramyocardial arteries by cardiac muscles.

**But** the epicardial conductance vessels are not surrounded by muscles (no compression during diastole).

Therefore the vessels which are responsible of Coronary vascular resistance are the intramyocardial vessels **not** the epicardial vessels.

# Regulation of Coronary blood flow



## 1- Metabolic control (chemical factors) +

Coronary circulation is very sensitive to myocardial tissue oxygen tension. This causes vasodilation and increased flow due to chemical factors like: (increased O<sub>2</sub> demand results in a lower tissue O<sub>2</sub> tension)

- ↑**NO**
- ↑Prostaglandins
- Lack of O<sub>2</sub>
- ↑Adenine nucleotides
- ↑Adenosine contractility
- ↑Lactate
- ↑K<sup>+</sup> and H<sup>+</sup>
- **NOT ↑Ca because it does not affect CBF** only affects HR and

## 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 O<sub>2</sub> consumption.

## 3- Endothelial control of coronary vascular tone

Damage to the endothelial cell can lead to:



1. ↓ NO and prostacyclin (vasodilators) production.
2. ↑ endothelin production, which leads to:
  - Vasoconstriction
  - Vasospasm
  - Thrombosis

## 4- Extravascular compressive force

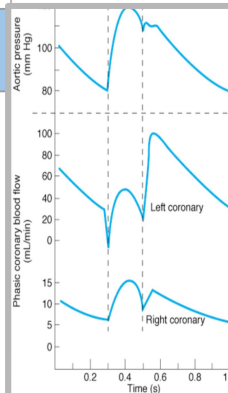
### Left ventricle

- **Earlier systole:** initial flow reversal.
- **Remainder of systole:** flow follows aortic pressure curve but at a much reduced pressure.
- **Earlier diastole:** Abrupt pressure rise (80-90 % of of LV flow in earlier diastole).
- **Remainder of diastole:** pressure decline slowly as aortic pressure decline.

### Right ventricle

- lower pressure generated by right ventricle in systole.
- No reversal blood flow during early systole.
- Systolic constitutes a much greater proportion of total blood flow.

This graph shows the relationship between aortic pressure and CBF



# 5- Neural regulation:

## Sympathetic stimulation

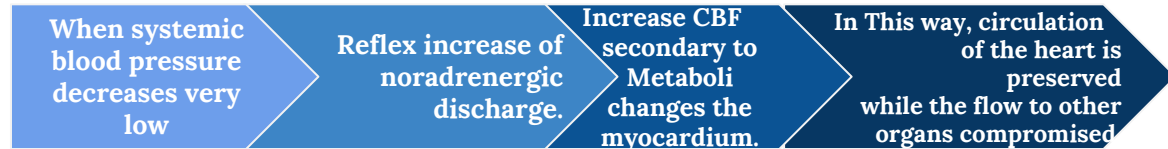
### Coronary arteries have:

- Alpha Adrenergic receptors, which mediate vasoconstriction (more epicardial (B1 with non-resistance Arteries))
- Beta Adrenergic receptors, which mediate vasodilation (more in the intramuscular arteries (B2 with resistance Arteries) )

### Effect of Sympathetic Stimulation:

**1- Indirect:** Sympathetic stimulation in intact body will lead to release of adrenaline & noradrenaline , increasing HR & force of contraction. However, coronaries will vasodilate due to the release of vasodilator metabolites. (Example: Athletes)

Benefits of indirect effect of  
**noradrenergic discharge :**



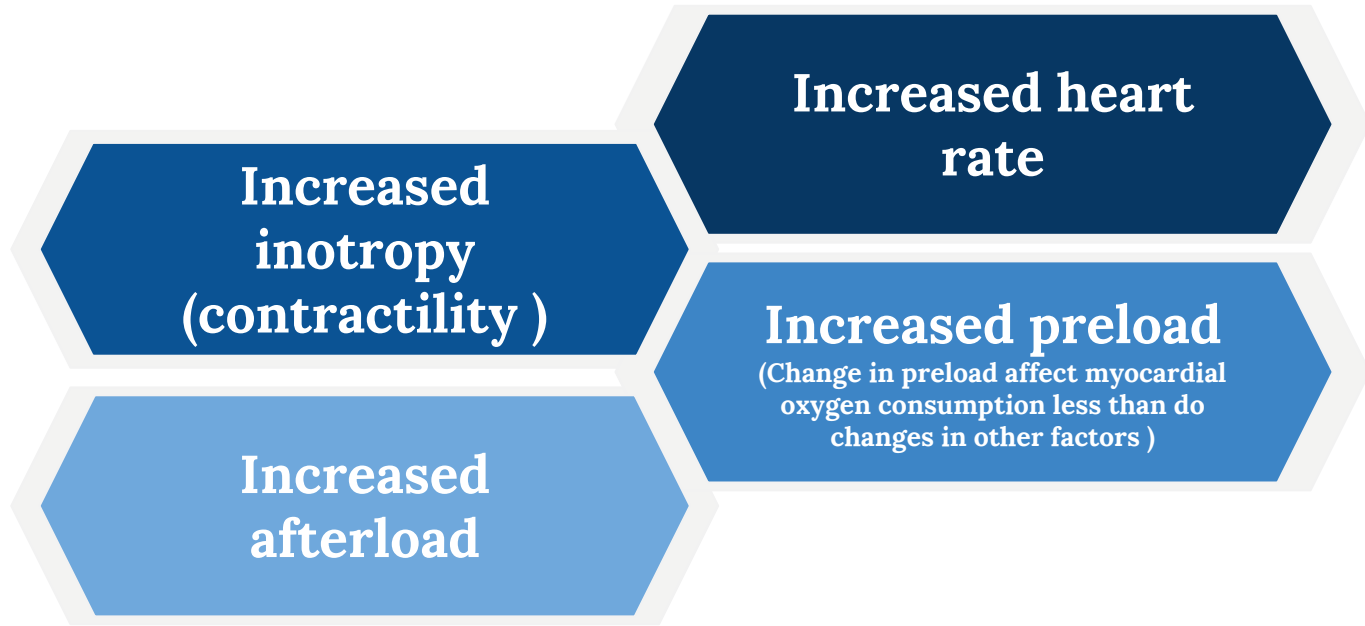
**2- direct:** Experimentally, injection of noradrenaline after blocking of the Beta adrenergic receptors in un anesthetized animals elicits coronary vasoconstriction.

## Parasympathetic Stimulation

- Vagal stimulation causes coronary vasodilatation ,( vasoconstriction in atherosclerotic arteries ) (By Acetylcholine)
- However, **parasympathetic distribution is not** great as **sympathetic innervation of coronary vessels.**



# Factors increasing myocardial O<sub>2</sub> consumption



- **When more O<sub>2</sub> is needed (ex: exercise), O<sub>2</sub> can be increased to heart only by increasing blood flow.**

# Diseases linked with coronary circulation

## Angina

### Investigation

- ECG might be **Normal**, but does not exclude the condition.

### Treatment for the attack

- If exercise induced, stop exercise.
- Glyceryl trinitrate (0.5 mg sublingual)

## Myocardial infarction

### Investigations

- **Cardiac enzymes:** CK-MB, Troponin, AST, LDH, etc.
- **ECG:** deep Q wave, **ST elevation**, T inversion.

### Clinical features

- **Chest pain** (even at rest & lasts for hours) with sudden onset, but can develop gradually.
- **Associated with:** sweating, vomiting, hypotension.

- When the normal portion of the ventricular muscle contract, the ischemic portion of the muscles (whether is it dead or simply nonfunctional) is forced outward by the pressure developed inside, instead of contracting.

# Quiz

1. Coronary blood flow is regulated mainly by:
  - A. Autonomic nerve
  - B. Diastolic aortic pressure
  - C. Hormone
  - D. Local metabolism
2. why is the coronary blood flow to the left ventricle compromised during tachycardia ?
  - A. Declined cardiac output
  - B. Increased afterload
  - C. Period of diastole is shorter
3. When the posterior descending artery arise from left coronary artery, the type of dominance is :
  - A. Left dominant
  - B. Right dominant
  - C. Co-dominant

4. the blood vessels responsible to most of the total coronary vascular resistance are:

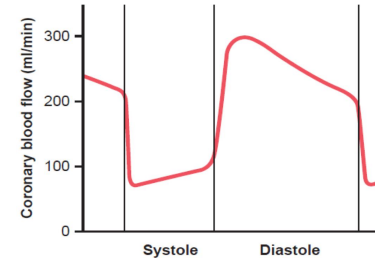
- A. Epicardial vessels
- B. Intramyocardial vessels
- C. Subendocardial vessels
- D. Edema

5. Which one of the following can induce Thrombosis?

- A. Endothelin
- B. Ca
- C. H+
- D. NO

SAQ:

1- in the following Graph:



A. describe what do you see

the graph shows the difference in coronary blood flow during systole (reduced) and diastole (increased)

B. predict the changes in this graph during tachycardia, and its effect in Coronary blood flow

there will be huge decrease in the periods of diastole, then the coronary blood flow will be reduced also ( because most of the blood flow occurs during diastole )

2- List the chemical factors that can cause vasodilation

Slide 14

# Leaders

Sedra Elsirawani

Abdulrahman Alhawas

# Members

- Lama AlZamil
  - Arwa AlEmam
  - Noura AlTurki
  - Ghada AlSadhan
  - Nouf AlShammari
  - **Nouf AlHumaidhi**
  - Taibah AlZaid
  - Ajeed AlRashoud
  - Reem AlGarni
  - Raghad AlKhashan
  - Leen AlMazroa
  - Sara Alarifi
  - Maha AlNahdi
- Badr Almuhana
  - Abdulrahman Almezaini
  - Omar Aldosari
  - Omar Alghadir
  - Ibrahim Alshaqrawi
  - Abdullah Aldawood
  - Abdullah Shadid
  - Meshari Alzeer
  - Mohammed Alhamad
  - **Abdullah Alassaf**
  - Khalid Alkhani
  - Amjad Albaroudi
  - Mohammed Alhuqbani

Thank you!

*“Principles for the Development of a Complete Mind: Study the science of art. Study the art of science. Develop your senses- learn how to see. Realize that everything connects to everything else.”*

Leonardo da Vinci

