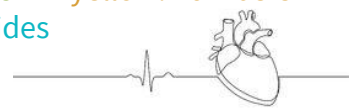
جامعة الملك سعود
King Saud University

Coronary Circulation

Index:
Red: important Grey: extra information Green: doctor's notes yellow: numbers
Purple: only in female slides Blue: only in male slides

Physiology Team437



MED437
KING SAUD UNIVERSITY

OBJECTIVES

by the end of this lecture you will be able to:

- Describe the control of tissue blood flow and state its physiological importance.
- Outline the distribution of cardiac output during rest and exercise.
- Explain the mechanisms of intrinsic and extrinsic regulation of tissue blood flow.
- Summarize the unique features of cardiac metabolism.
- Discussautoregulationandnervouscontrolofcoronarybloodflow.
- List the risk factors for coronary artery disease and outline ECG changes in myocardial ischemia and
- myocardial infarction.
- Coronary dominance.
- Collateral circulation.

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Coronary Circulation

- Consists of:
  - Arterial supply
  - Venous drainage
  - Lymphatic drainage

Arterial Supply

- Cardiac muscle is supplied by two coronary arteries:
  - Right coronary artery (RCA)
  - Left coronary artery (LCA)
- 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.

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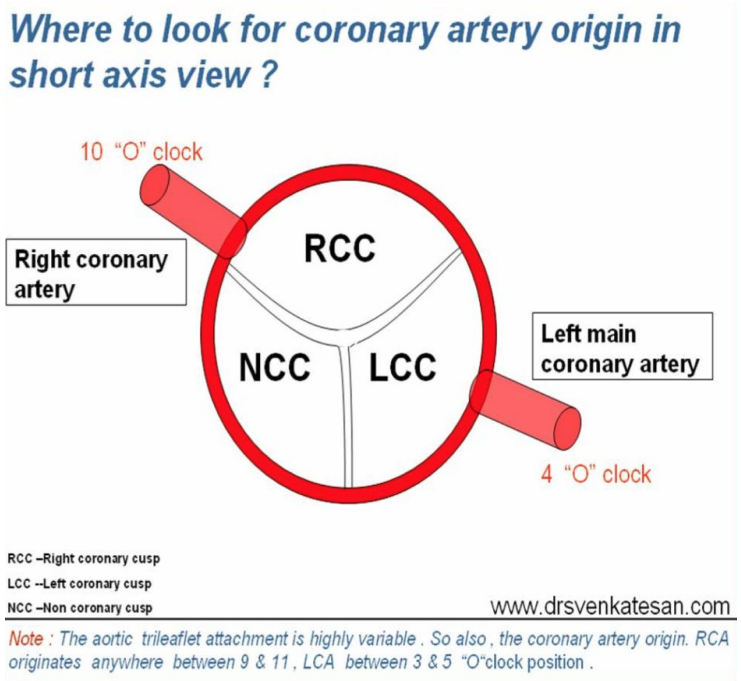
Coronary Sinus

- The aortic valve has three cusps:
  - Left coronary cusp (LCC).
  - Right coronary cusp (RCC).
  - Posterior non-coronary cusp (NCC).
- 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.
- Coronary arteries deliver oxygenated blood to the cardiac muscle.



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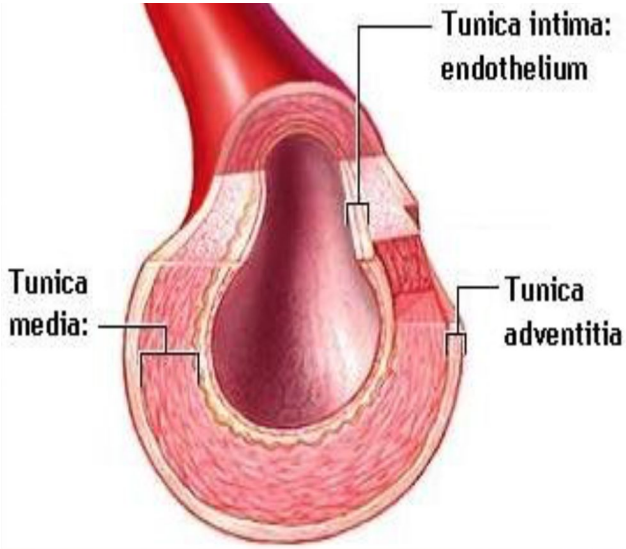
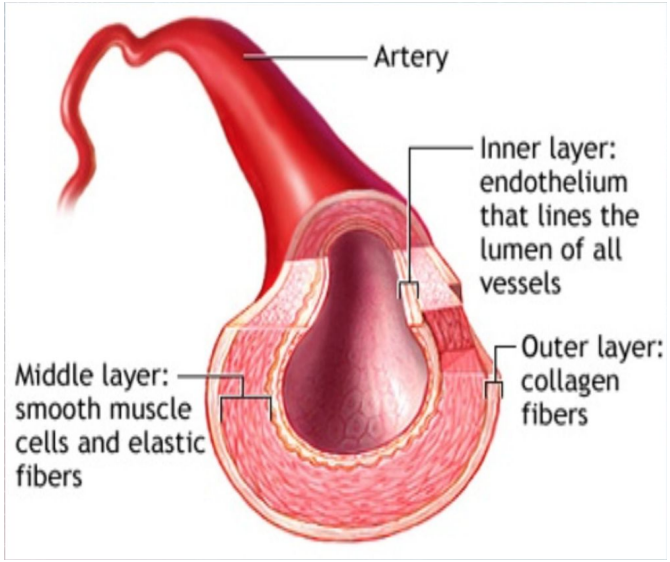
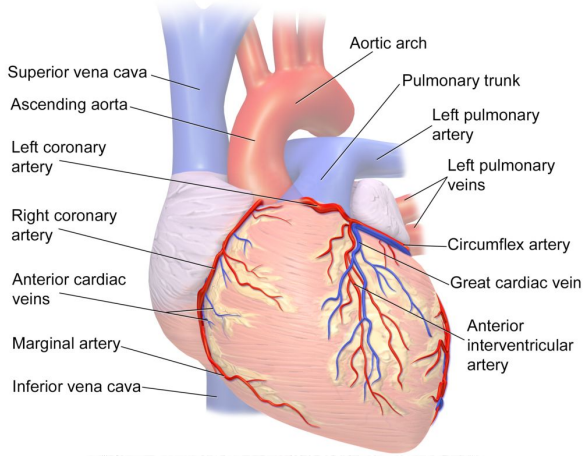
Arterial Wall

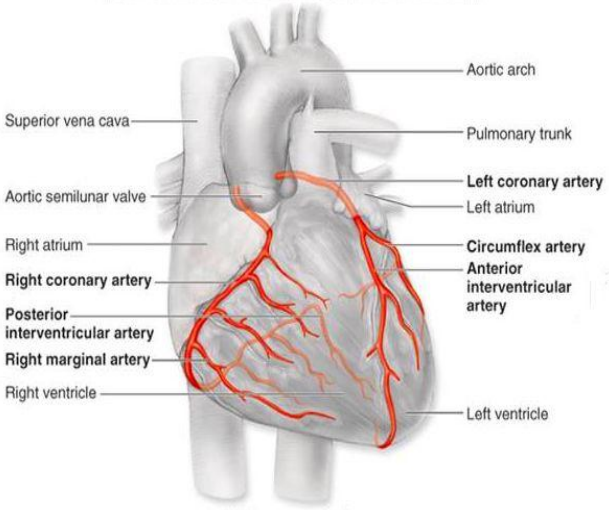




Left Coronary Artery

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





Left Coronary Artery

Two main branches:

- Left anterior descending artery (LAD): Also called **anterior interventricular artery**.
- Circumflex artery (CX)

Left anterior descending artery (LAD):

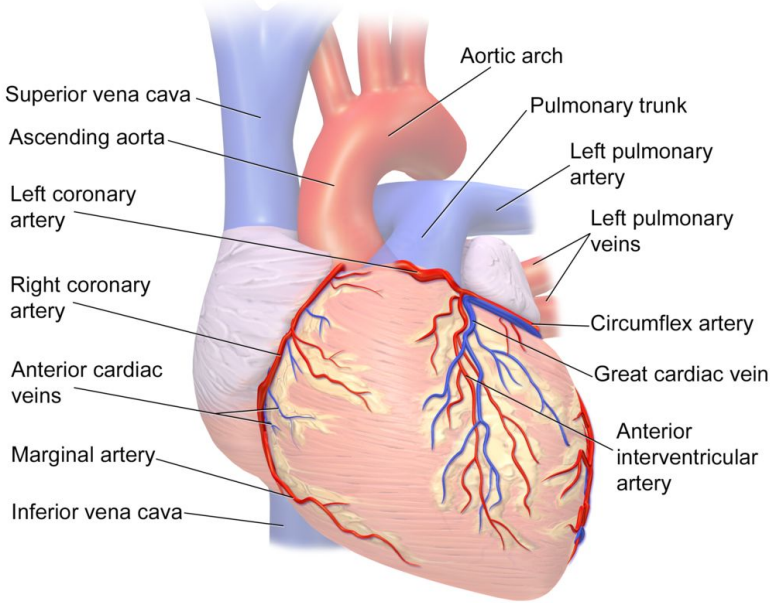
• Considered the most critical vessel in terms of myocardial blood supply, as it supplies 45-55% of the left ventricle (the anterior & apical part of the heart):
• The anterolateral of the left ventricle.
• The apex of the heart.
• The anterior ⅔ of the IV septum.
• The front of the right ventricle.
• The right & left bundle branches.
• Further divides into:
• Diagonal arteries.
• Left conus arteriosus artery.
• 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:
• Left obtuse marginal (OM) artery, which supplies the left ventricle.
• SA nodal artery, which supplies the SA-node in ~40% of hearts and the surrounding myocardium.
• Left branch to the AV- Bundle.
• Posterior ventricular branch.
• Anterior ventricular branch.

Right Coronary Artery

- The right coronary artery (RCA) is smaller than the left coronary artery.
- Arises from the right coronary sinus.
- Curves posteriorly & descends downward on the posterior surface of the heart.
- Terminates by anastomosing with the left coronary artery.
- Supplies blood to the right atrium, the SA (sinoatrial) & AV (atrioventricular) nodes, right ventricle, bottom portion of both ventricles, & back of the septum.



Two main branches:
1- Right posterior descending artery (RPD) :Also called anterior interventricular artery.
2- Right acute marginal artery

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Cardiac Anastomosis

Cardiac anastomosis:

• The two coronary arteries anastomose in the myocardium.

- Extra cardiac anastomosis: the two coronary arteries anastomose with,
  - • Vasa vasorum of the aorta.
  - • Vasa vasorum of pulmonary arteries.
  - • Internal thoracic arteries.
  - • The bronchial arteries.
  - • Phrenic 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:

1. 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.
2. 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.

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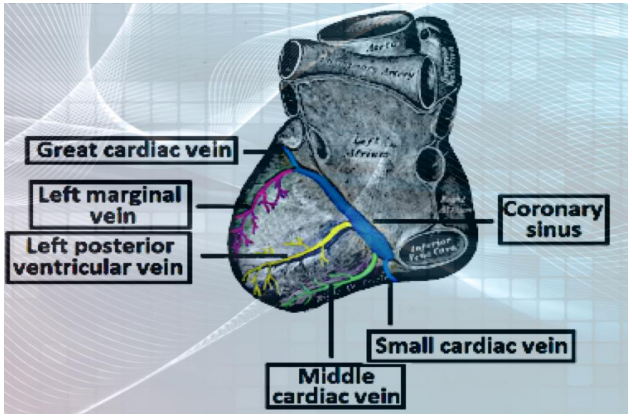
Venous Drainage Of The Heart

- Venous drainage brings deoxygenated cardiac blood back to the heart.
- Most of the venous blood return to the heart into the right atrium through the coronary sinus via the cardiac veins.
- 5- 10% drains directly into heart chambers, right atrium & right ventricle, by the anterior cardiac vein & by the small veins that open directly into the heart chambers.

Venous Drainage Of The Heart

- Cardiac venous drainage occur through:
  - Coronary sinus, which lies in the posterior part of the atrioventricular groove & is a continuation of the great cardiac vein.
  - Anterior (great), middle & small cardiac veins.
  - Smallest cardiac veins (Venae Cordis Minimae).



Coronary Circulation:

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: Coronary dominance

dominance depends on which artery (or arteries) supplies the AV- node. Usually, the right coronary artery is the dominant artery in 85-90% of hearts, as it supplies the AV- node.

A person can be:
- Right dominant,
- Left dominant (in 8-10%), or
- Co-dominant.

Balanced or co-dominance is found in 7-10% of population where the posterior inter ventricular artery is formed by both right coronary & Left CX arteries.

Clinical importance:
- In case of left dominance, a block in LCA will affect the entire left ventricle & IV septum.
- In case of right orbalanced dominance, a block in RCA will at least spares part of the septum (2/3) & the left ventricle.

Coronary Circulation:

Coronary blood flow

Coronary blood flow (CBF) at rest in humans is about 225-250 mL/min, which is about 5% of the cardiac output.
CBF increases in proportion to exercise or work output. At rest, the heart extract 60-70% of oxygen from each unit of blood delivered to the heart, due to presence of more mitochondria which generate energy for contraction by aerobic metabolism (other tissue extract only 25% of O2.)

Factors Affecting Coronary Blood Flow

- Pressure in the aorta.
- Chemical factors.
- Neural factors.

Changes In Coronary Blood Flow (CBF) During Systole & Diastole

- During systole, coronary arteries are compressed and the blood flow to the left ventricle is reduced.
- CBF to the right side of the heart is not much affected during systole,and so more blood will flow to the right ventricle than the left one.
- Explanation:Pressure difference between the aorta and the right ventricle is greater during systole than during diastole, therefore more blood flow to right ventricle occurs during systole.

Effect of Pressure Gradient between Aorta & Different Chambers of the Heart On Coronary Blood Flow

Pressure (mmHg) in			
	Aorta	**Left ventricle**	**Right ventricle**
Systole	**120**	**120**	**25**
Diastole	**80**	**0-2**	**0-2**

Pressure difference (mmHg) between aorta and	
Left ventricle	**Right ventricle**
0	**95**
80	**80**

Phasic Changes in Left Coronary Blood Flow During Systole & Diastole

- During systole, coronary arteries are compressed & the blood flow to the left ventricle is reduced.

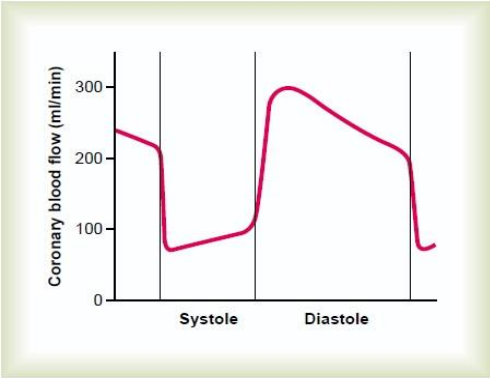


Figure 21–4

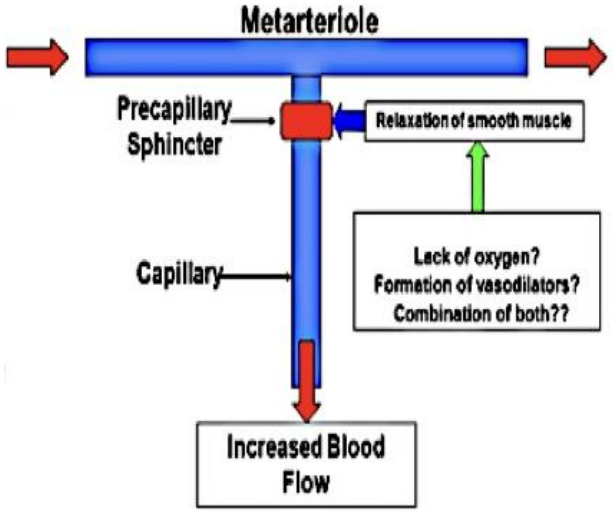
Phasic flow of blood through the coronary capillaries of the human left ventricle during cardiac systole and diastole (as extrapolated from measured flows in dogs).

- Blood flow to the subendocardial portion of the left ventricle occurs only during diastole and is not there during systole.
- Therefore,this subendocardial region of the left ventricle is prone to ischemic damage and It's the most common site of myocardial infarction.

Chemical Factors Affecting Coronary Blood Flow

- Chemical factor causing Coronary vasodilatation (Increased coronary blood flow):
  - Lack of oxygen.
  - Increased local conc. of Co2.
  - Increased local conc. of H+ ion.
  - Increased local conc. of k+ ion.
  - Increased local conc. of Lactate, Prostaglandin, Adenosine, Adenine nucleotides.

- Note: An increase in Ca+2 conc. does not increase the CBF.



Neural Factors Affecting Coronary Blood Flow

1) Sympathetic stimulation.
2) Parasympathetic stimulation.

Effect of Sympathetic Stimulation On CBF

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	Direct effect of sympathetic stimulation
Sympathetic stimulation in intact body will lead to release of adrenaline & nor-adrenaline, increasing HR & force of contraction. However, coronaries will vasodilate due to the release of vasodilator metabolites. Example: Athletes	Experimentally, injection of nor-adrenalin after blocking of the Beta adrenergic receptors in un anesthetized animals elicits coronary vasoconstriction.

Neural Factors Affecting Coronary Blood Flow

- When systemic blood pressure decreases very low.
- 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.

Effect of Parasympathetic Stimulation on CBF

- Vagal stimulation (Parasympathetic) causes coronary vasodilatation.
- However, parasympathetic distribution is not great.
- There is more sympathetic innervation of coronary vessels.

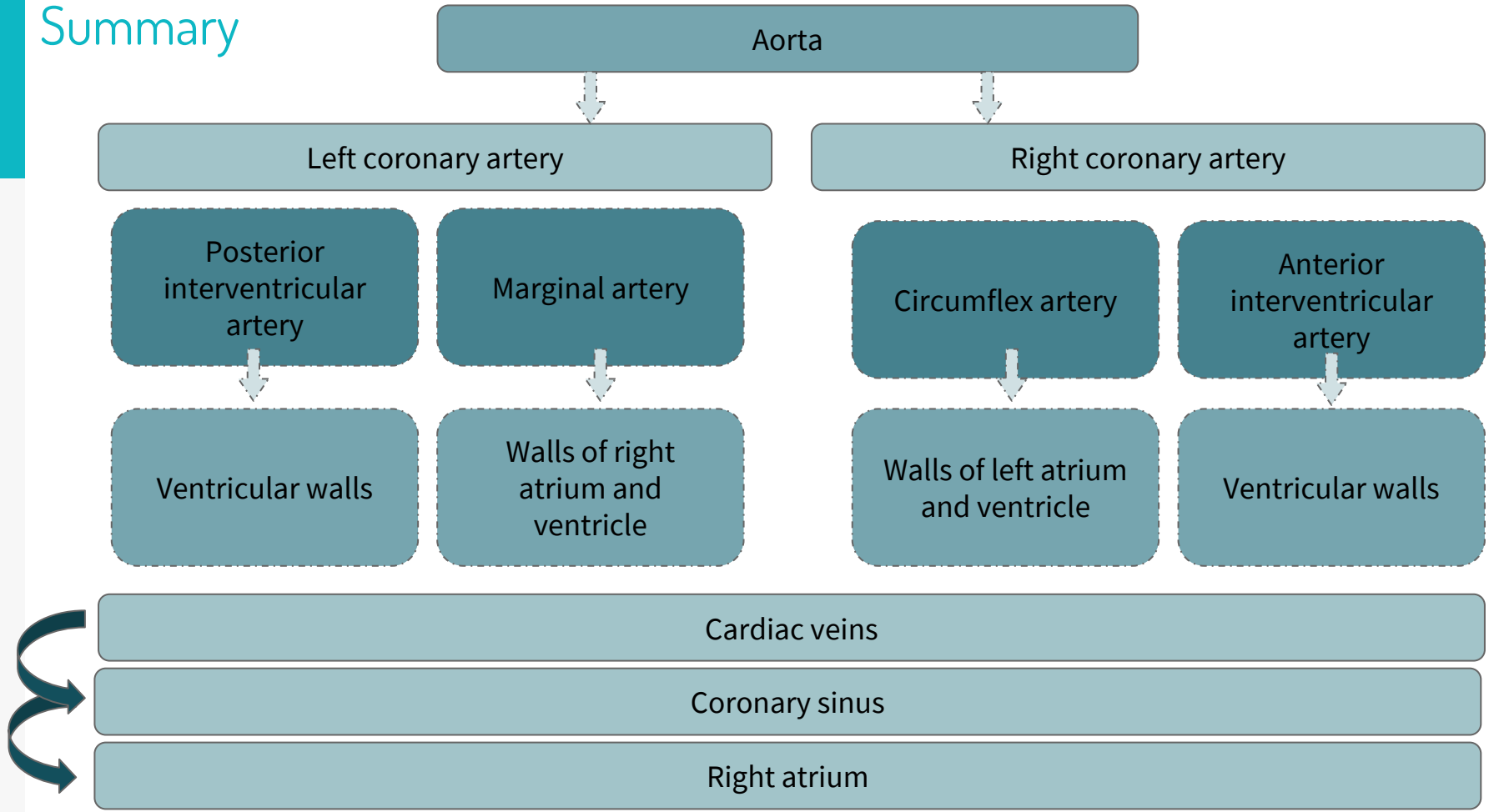
Effect of Tachycardia on CBF

- CBF is reduced with tachycardia, as the diastolic period will be shortened.

Control Of Coronary Blood Flow

- CBF shows considerable auto regulation.
- Local muscle metabolism is the primary controller:
  - ↦ Oxygen demand is a major factor in local coronary blood flow regulation.
- Nervous control of CBF:
  - ↦ Direct effects of nervous stimuli on the coronary vasculature.
  - ↦ Sympathetic greater effects than parasympathetic.

Summary


Aorta
Left coronary artery
Right coronary artery
Posterior interventricular artery
Marginal artery
Circumflex artery
Anterior interventricular artery
Ventricular walls
Walls of right atrium and ventricle
Walls of left atrium and ventricle
Ventricular walls
Cardiac veins
Coronary sinus
Right atrium

Quiz

1. when do the extra-cardiac channels open?

A) it's always open

B) In exercises

C) Emergency

D) sleeping

E) never

2..which of the following determines the coronary dominance ?

A) arteries supplies SA node

B) arteries supplies atrial muscles

C) arteries supplies AV node

D) arteries supplies ventricular muscles

E) arteries supplies Purkinje fibers

3. blood flow in right ventricle is:

A) greater during systole

B) greater during diastole

C) Same in systole and diastole

4..right trunk ends in:

A) tracheobronchial lymph nodes

B) cervical lymph nodes

C) spleen

D) brachiocephalic lymph node

E) axillary lymph nodes

5. Which of the following is a branch of left coronary artery:

A) atrial branch

B) septal perforator

C) Right acute marginal

D) circumflex artery

E) posterior interventricular artery

1- c
2-c
3-b
4-d
5-d

Thank you for checking our work

Team Leader:

العنود سلمان

Male Team:

أنس السويداء
أنس السيف
خالد شويل
ريان الموسى
سعد الهداب
سعود العطوي
سيف المشاري
عبدالجبار اليماني
عبدالرحمن آل دحيم
عمر الفوزان
فهد الحسين
نايف المطيري
نواف اللويمي
محمد الحسن
هشام الشايع
خالد العقيلي
سعد الفوزان
عبدالله الزيد
نواف اللويمي
عبدالمجيد الوردي
يزيد الدوسري

Female Team:

الآء الصويّغ
رناد المقرن
رهف الشنيبر
روان التميمي
روان مشعل
ريم القرني
ليلى الصباغ
فلوة السعوي
نورة بن حسن
نورة الحربي
نورة العثيم
مجد البراك
لينا العوهلي
عهد القرين
مها النهدي
مها بركة
سارة الفليج
هند العريعر
ريناد الغريبي
عائشة الصباغ
ميعاد النفيعي
سمية العقيفي
سارة البليهد

Any questions?

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