

Coronary Circulation

Chapter 108

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■ **DISTRIBUTION OF CORONARY BLOOD VESSELS**

■ **CORONARY ARTERIES**

Heart muscle is supplied by two coronary arteries, namely right and left coronary arteries, which are the first branches of aorta. Arteries encircle the heart in the manner of a **crow**, hence the name coronary arteries (Latin word corona = crown).

Right and Left Coronary Arteries

Right coronary artery supplies whole of the right ventricle and posterior portion of left ventricle. Left coronary artery supplies mainly the anterior and lateral parts of left ventricle. There are many variations in diameter of coronary arteries.

Variations in Coronary Arteries

1. In 50% to 60% of human beings, the right coronary artery is larger (right dominant) and supplies more blood to heart than left coronary artery
2. In 15% to 20% of human beings, the left coronary artery is larger (left dominant)
3. In 20% to 30% of human beings, both arteries supply almost equal amount of blood.

Branches of Coronary Arteries

Coronary arteries divide and subdivide into smaller branches, which run all along the surface of the heart. Smaller branches are called **epicardiac arteries** and give rise to further smaller branches known as **final arteries** or **intramural vessels**. Final arteries run at right

angles through the heart muscle, near the inner aspect of wall of the heart.

■ VENOUS DRAINAGE

Venous drainage from heart muscle is by three types of vessels.

1. Coronary Sinus

Coronary sinus is the larger vein draining 75% of total coronary flow. It drains blood from left side of the heart and opens into right atrium near tricuspid valve.

2. Anterior Coronary Veins

Anterior coronary veins drain blood from right side of the heart and open directly into right atrium.

3. Thebesian Veins

Thebesian veins drain deoxygenated blood from myocardium, directly into the concerned chamber of the heart.

■ PHYSIOLOGICAL SHUNT

Physiological shunt is the diverted route (diversion), through which the venous (deoxygenated) blood is mixed with arterial blood. Deoxygenated blood flowing from thebesian veins into cardiac chambers makes up the part of normal physiological shunt.

Other component of physiological shunt is the drainage of deoxygenated blood from bronchial circulation into pulmonary vein, without being oxygenated. Refer Chapter 119 for more details about physiological shunt.

■ CORONARY BLOOD FLOW AND ITS MEASUREMENT

■ NORMAL CORONARY BLOOD FLOW

Normal blood flow through coronary circulation is about 200 mL/minute. It forms 4% of cardiac output. It is about 65 to 70 mL/minute/100 g of cardiac muscle.

■ MEASUREMENT OF CORONARY BLOOD FLOW

Direct Method

Coronary blood flow is measured by using an **electromagnetic flowmeter**. It is directly placed around any coronary artery (refer Chapter 98 for details of electromagnetic flowmeter).

Indirect Method

1. By Fick principle

Coronary blood flow is measured by applying Fick principle (Chapter 98) using **nitrous oxide** (N_2O). The subject is asked to inhale a known quantity of the gas with atmospheric air. Then, blood samples are collected from an artery and from coronary sinus, by using a catheter. The blood flow is determined by using the formula:

$$\text{Blood flow} = \frac{\text{Amount of } N_2O \text{ taken up/minute}}{\text{Arteriovenous difference of } N_2O \text{ content}}$$

2. By using Doppler flowmeter

Piezoelectric crystals are used in the Doppler flowmeter probe, to transmit and receive the pulses of high frequency sound waves (Chapter 98). The Doppler flowmeter probe is mounted to a catheter and positioned at the ostium of right or left coronary artery to measure the velocity of phasic flow of blood. The cross-sectional area of the artery is determined by angiography. From velocity of blood flow and cross-sectional area, the volume of blood flow is calculated.

3. By videodensitometry

Videodensitometry is the technique used to measure both velocity of blood flow and the cross-sectional area of coronary arteries, simultaneously. From these two values, the coronary blood flow can be calculated.

■ PHASIC CHANGES IN CORONARY BLOOD FLOW

Blood flow through coronary arteries is not constant. It decreases during systole and increases during diastole (Fig. 108.1).

Intramural vessels or final arteries supplying myocardium are perpendicular to the cardiac muscles. So, during systole, the intramural vessels are compressed and blood flow is reduced. During diastole, the compression is released and the blood vessels are distended. So, the blood flow increases.

■ PHASIC CHANGES IN LEFT VENTRICLE

In left ventricle, during the onset of isometric contraction, blood flow declines sharply due to two reasons, namely increase in myocardial tissue pressure and decrease in aortic pressure.

During ejection period, rise in aortic pressure causes a sharp rise in flow into left coronary artery. However,

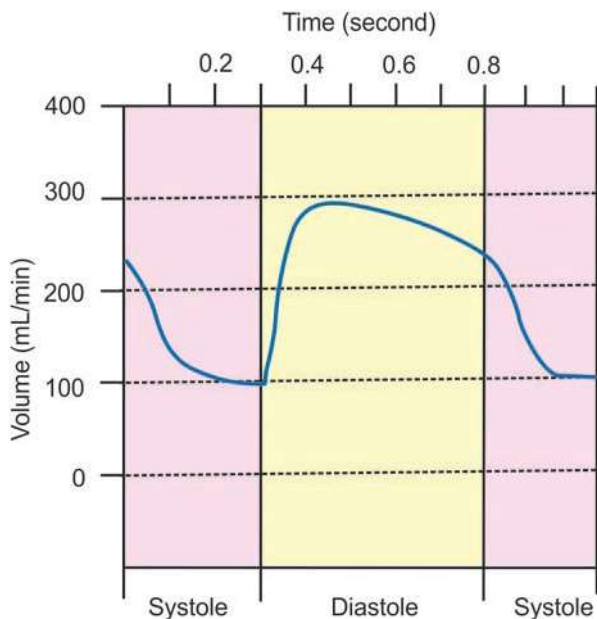


FIGURE 108.1: Phasic changes in coronary blood flow

the flow of blood through coronary capillaries is less. It is due to the high intramural myocardial pressure in the contracting ventricle. Decreased blood flow is maintained until the closure of aortic valve, i.e. till the end of systole.

During the onset of diastole, blood flow rises and it reaches the peak sharply. During the later part of diastole, the flow is reduced slightly along with decreasing aortic pressure. Once again, there is a sharp fall in flow during the onset of systole.

■ PHASIC CHANGES IN RIGHT VENTRICLE

A small amount of blood flows into right ventricle during systole. It is because the force of contraction is not as severe as in the case of left ventricle. Still, the amount of blood flowing is very much less than that during diastole.

■ FACTORS REGULATING CORONARY BLOOD FLOW

Autoregulation

Like any other organ, heart also has the capacity to regulate its own blood flow by autoregulation (Chapter 102). Coronary blood flow is not affected when mean arterial pressure varies between 60 and 150 mm Hg. Several factors are involved in the autoregulation mechanism.

Coronary blood flow is regulated mainly by local vascular response to the needs of cardiac muscle.

Factors regulating coronary blood flow:

1. Need for oxygen
2. Metabolic factors
3. Coronary perfusion pressure
4. Nervous factors.

■ 1. NEED FOR OXYGEN

Oxygen is the most important factor maintaining blood flow through the coronary blood vessels. Amount of blood passing through coronary circulation is directly proportional to the consumption of oxygen by cardiac muscle.

Even in resting condition, a large amount of oxygen, i.e. 70% to 80% is consumed from the blood by heart muscle than by any other tissues. In conditions associated with increased cardiac activity, the need for oxygen increases enormously.

Thus, the need for oxygen, i.e. hypoxia immediately causes coronary vasodilatation and increases the blood flow to heart.

■ 2. METABOLIC FACTORS

Coronary vasodilatation during hypoxic conditions occurs because of some metabolic products, which increase the coronary blood flow by vasodilatation.

Reactive Hyperemia

Reactive hyperemia is the increase in blood flow due to the vasodilator effects of metabolites.

Metabolic Products which Increase the Coronary Blood Flow

Adenosine

Adenosine is a potent vasodilator and it increases the blood flow to cardiac muscle. During hypoxia, ATP in the muscle is degraded in large amount, forming ADP. Some ADP molecules are further degraded into adenosine, which is released into tissue fluids of heart muscle.

Other substances

Other substances which increase the coronary blood flow by vasodilatation are:

- i. Potassium
- ii. Hydrogen
- iii. Carbon dioxide
- iv. Adenosine phosphate compounds.