



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.

■ 3. CORONARY PERFUSION PRESSURE

Perfusion pressure is the balance between mean arterial pressure and venous pressure (Chapter 102). Thus, coronary perfusion pressure is the balance between mean arterial pressure in aorta and the right atrial pressure. Since right atrial pressure is low, the mean arterial pressure becomes the major factor that maintains the coronary blood flow. Range of mean arterial pressure at which the coronary blood flow can be maintained is given above.

■ 4. NERVOUS FACTORS

Coronary blood vessels are innervated both by parasympathetic and sympathetic divisions of autonomic nervous system. It is not known whether the autonomic nerves have direct effect on blood flow in various conditions. However, these nerves influence the coronary blood flow indirectly by acting on the musculature of heart.

For example, stimulation of sympathetic nerves increases the rate and force of contraction of heart. This in turn, causes liberation of more metabolites which dilate the blood vessels and increase the coronary blood flow. Similarly, when parasympathetic nerves are stimulated, the cardiac functions are inhibited and the production of metabolites is less. Coronary blood flow decreases.

■ APPLIED PHYSIOLOGY – CORONARY ARTERY DISEASE

Coronary artery disease (CAD) is the heart disease that is caused by inadequate blood supply to cardiac muscle due to occlusion of coronary artery. It is also called coronary heart disease.

■ CORONARY OCCLUSION

Definition

Coronary occlusion is the partial or complete obstruction of the coronary artery.

Cause

Coronary occlusion is caused by atherosclerosis, a condition associated with deposition of cholesterol on the walls of the artery. In due course, this part of the arterial wall becomes fibrotic and it is called **atherosclerotic plaque**. The plaque is made up of cholesterol, calcium and other substances from blood. Because of the atherosclerotic plaque, the lumen of the coronary artery

becomes narrow. In severe conditions, the artery is completely occluded.

Development of atherosclerotic plaque is common in coronary arteries near the origin from aorta. This plaque activates platelets, resulting in **thrombosis** and the blood clot is called **thrombus**. When three fourth of the lumen of the coronary artery is obstructed either by atherosclerotic plaque or thrombus, the blood flow to myocardium is reduced. It results in **ischemia** of myocardium. Coronary thrombosis is associated with **spasm** of coronary artery.

Smaller blood vessels are occluded by the thrombus or part of atherosclerotic plaque, detached from coronary artery. This thrombus or part of the plaque is called **embolus**.

■ MYOCARDIAL ISCHEMIA AND NECROSIS

Myocardial Ischemia

Myocardial ischemia is the reaction of a part of myocardium in response to hypoxia. Hypoxia develops when blood flow to a part of myocardium decreases severely due to occlusion of a coronary artery.

Blood flow is usually restored if a small quantum of myocardium is affected by ischemia due to obstruction of smaller blood vessels. It is due to rapid development of **coronary collateral arteries**.

Necrosis

Necrosis refers to death of cells or tissues by injury or disease in a localized area. Ischemia leads to necrosis of myocardium if a large part of myocardium is involved or the occlusion is severe involving larger blood vessels. Necrosis is irreversible.

■ MYOCARDIAL INFARCTION – HEART ATTACK

Myocardial infarction is the necrosis of myocardium caused by insufficient blood flow due to embolus, thrombus or vascular spasm. It is also called heart attack. In myocardial infarction, death occurs rapidly due to ventricular fibrillation.

Myocardial Stunning

Myocardial stunning is a type of transient mechanical dysfunction of heart, caused by a mild reduction in blood flow. A substantial reduction in coronary blood flow causes ischemia followed by necrosis. A mild reduction in blood flow causes only ischemia and it may not be sufficient to cause necrosis of myocardium. However,