Neural Mechanisms

Neural Mechanisms The nervous system is responsible for adjusting cardiac output and peripheral resistance in order to maintain adequate blood flow to vital tissues and organs. Centers responsible for these regulatory activities include the cardiac centers and the vasomotor centers of the medulla oblongata.

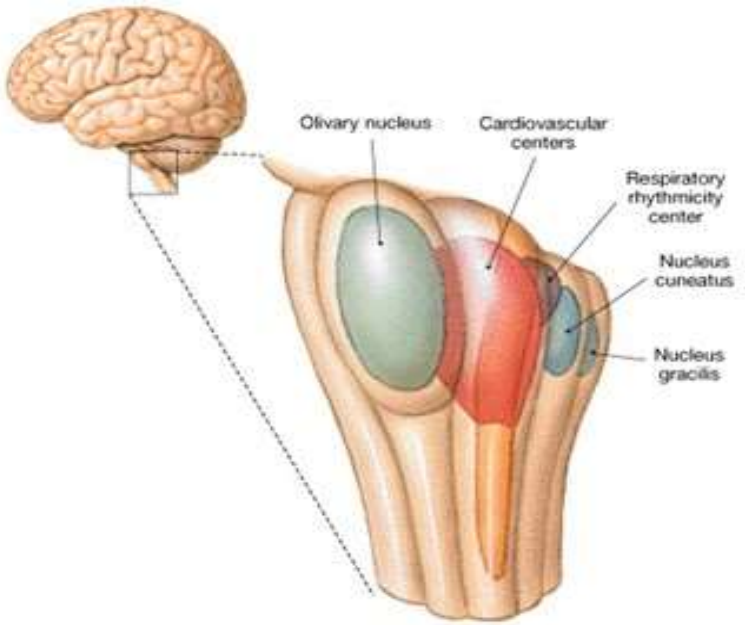
It is difficult to distinguish the cardiac and vasomotor centers anatomically, and they are often considered to form complex **cardiovascular (CV) centers**.

In functional terms, however, the cardiac and vasomotor centers often act independently.

Each cardiac center consists of a cardioacceleratory center, which increases cardiac output through sympathetic innervation, and a cardioinhibitory center, which reduces cardiac output through parasympathetic innervation.

The vasomotor centers contain two populations of neurons: (1) group responsible for widespread vasoconstriction and (2) group responsible for the vasodilation of arterioles.

Medulla oblongata



Control of Vasoconstriction. some neurons innervating peripheral blood vessels in tissues are adrenergic; that is, they release the neurotransmitter norepinephrine (NE). The response to NE release is the stimulation of smooth muscle in the walls of arterioles, producing vasoconstriction.

Control of Vasodilation. The stimulation of vasodilator neurons relaxes smooth muscle cells in the walls of arterioles, producing vasodilation. The relaxation of smooth muscle cells is triggered by the appearance of NO in their surroundings. The vasomotor centers may control NO release indirectly or directly. The most common vasodilator synapses are cholinergic—their synaptic knobs release ACh. In turn, ACh stimulates endothelial cells in the area to release NO, which causes local vasodilation. Another population of vasodilator synapses is nitroxidergic—the synaptic knobs release NO as a neurotransmitter. Nitric oxide has an immediate and direct relaxing effect on the vascular smooth muscle cells in the area.

Reflex Control of Cardiovascular Function

The cardiovascular centers detect changes in tissue demand by monitoring arterial blood, with particular attention to blood pressure, pH, and the concentrations of dissolved gases. The baroreceptor reflexes respond to changes in blood pressure, and the chemoreceptor reflexes monitor changes in the chemical composition of arterial blood. These reflexes are regulated through a negative feedback loop: The stimulation of a receptor by an abnormal condition leads to a response that counteracts the stimulus and restores normal conditions.

Baroreceptor Reflexes

The baroreceptors involved in cardiovascular regulation are located in the walls of (1) the carotid sinuses, expanded chambers near the bases of the internal carotid arteries of the neck (see Figure 1), (2) the aortic sinuses, pockets in the walls of the aorta adjacent to the heart (see Figure 2), and (3) the wall of the right atrium. These receptors are components of the baroreceptor reflexes, which adjust cardiac output and peripheral resistance to maintain normal arterial pressures.

Fig 1

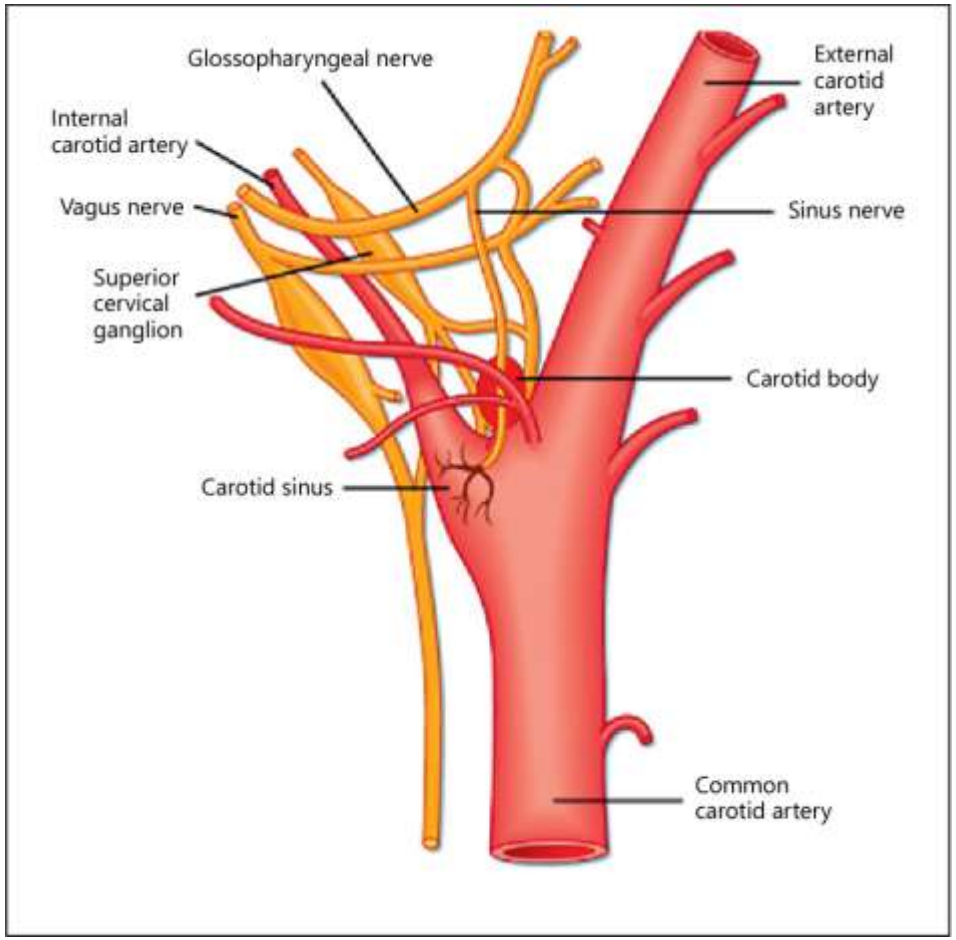
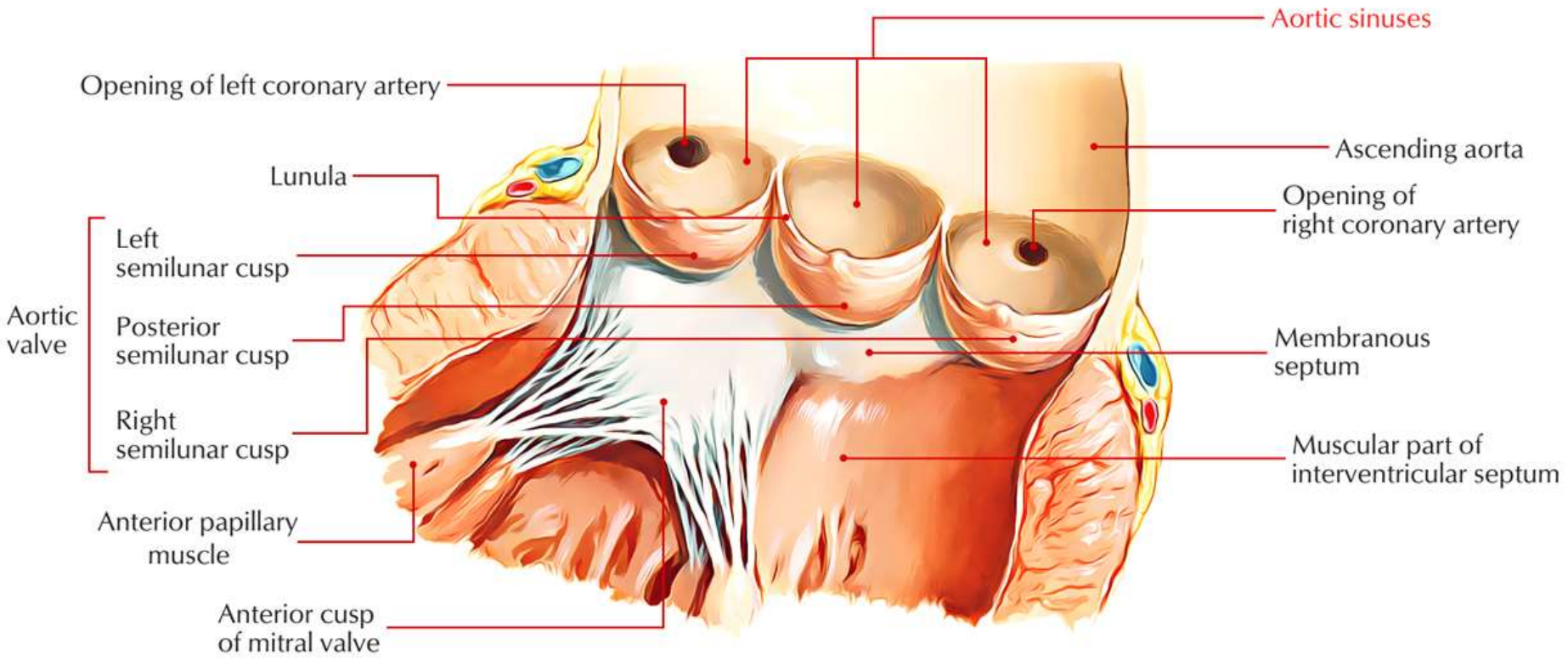

Glossopharyngeal nerve
External carotid artery
Internal carotid artery
Vagus nerve
Sinus nerve
Superior cervical ganglion
Carotid body
Carotid sinus
Common carotid artery

Fig 2


Aortic sinuses
Opening of left coronary artery
Ascending aorta
Lunula
Opening of
right coronary artery
Aortic
valve
Left
semilunar cusp
Posterior
semilunar cusp
Membranous
septum
Right
semilunar cusp
Muscular part of
interventricular septum
Anterior papillary
muscle
Anterior cusp
of mitral valve

Aortic baroreceptors monitor blood pressure within the ascending aorta. Any changes trigger the aortic reflex, which adjusts blood pressure to maintain adequate blood pressure and blood flow through the systemic circuit.

In response to changes in blood pressure at the carotid sinus, carotid sinus baroreceptors trigger reflexes that maintain adequate blood flow to the brain. Because blood flow to the brain must remain constant, the carotid sinus receptors are extremely sensitive.

When blood pressure climbs, the increased output from the baroreceptors alters activity in the CV centers and produces two major effects (Figure 1a.):

1-A decrease in cardiac output, due to parasympathetic stimulation and the inhibition of sympathetic activity.

2- Widespread peripheral vasodilation.

- The decrease in cardiac output reflects primarily a reduction in heart rate due to the release of acetyicholine at the sinoatrial (SA) node.
- The widespread vasodilation lowers peripheral resistance, and this effect, combined with a reduction in cardiac output, leads to a decline in blood pressure to normal levels.

When blood pressure falls below normal, baroreceptor output is reduced accordingly. This change has two major effects:

1- An increase in cardiac output, through the stimulation of sympathetic innervation to the heart. This results from the stimulation of the cardioacceleratory centers and is accompanied by an inhibition of the cardioinhibitory centers.

2-Widespread peripheral vasoconstriction.

- The effects on the heart result from the release of NE by sympathetic neurons innervating the SA node.
- Atrial baroreceptors are receptors that monitor blood pressure at the venaecavae and the right atrium. The atrial reflex responds to a stretching of the wall of the right atrium.

Baroreceptor Reflexes