AUTOREGULATIONOF CEREBRAL BLOOD FLOW

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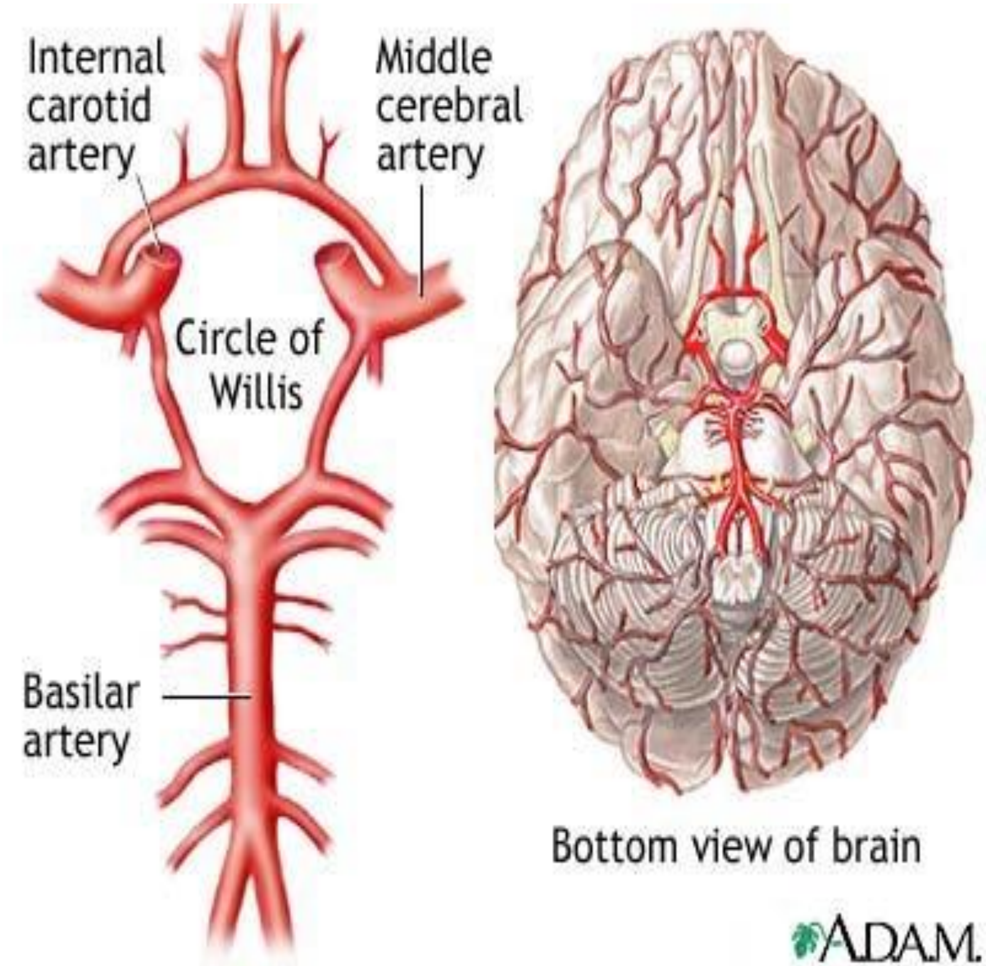
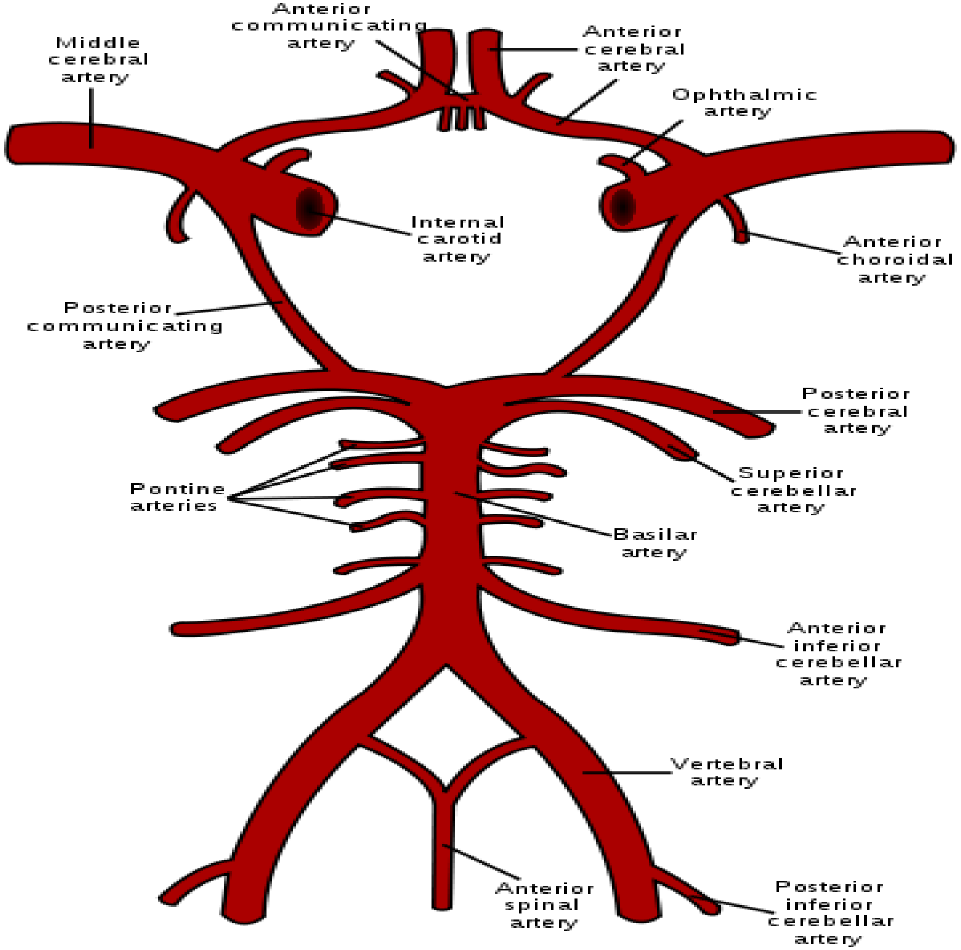
CEREBRAL CIRCULATION



The Circle of Willis is the joining area of several arteries at the bottom (inferior) side of the brain. At the Circle of Willis, the internal carotid arteries branch into smaller arteries that supply oxygenated blood over 80% of the cerebrum.

CEREBRAL CIRCULATION



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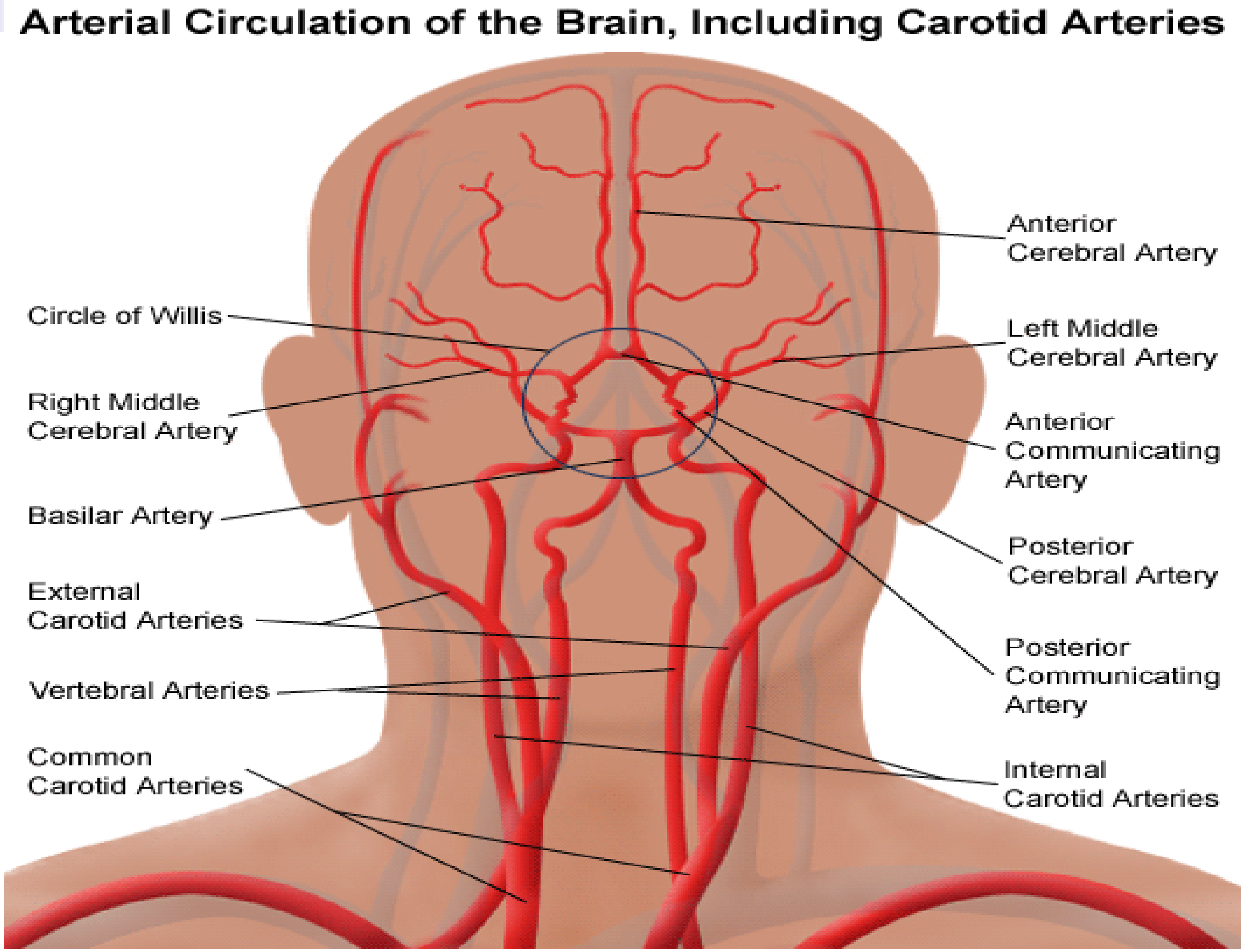

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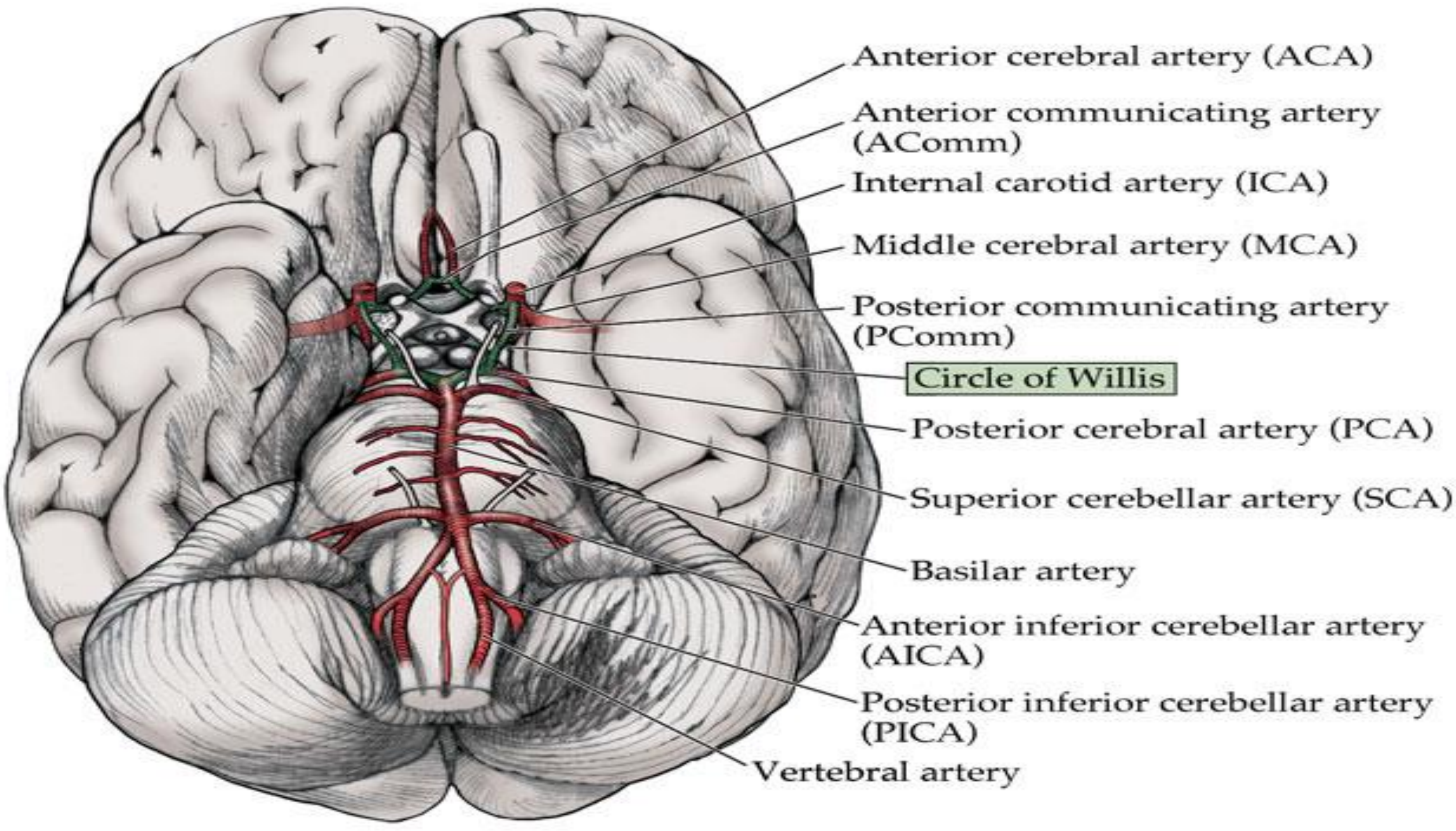


CEREBRAL CIRCULATION

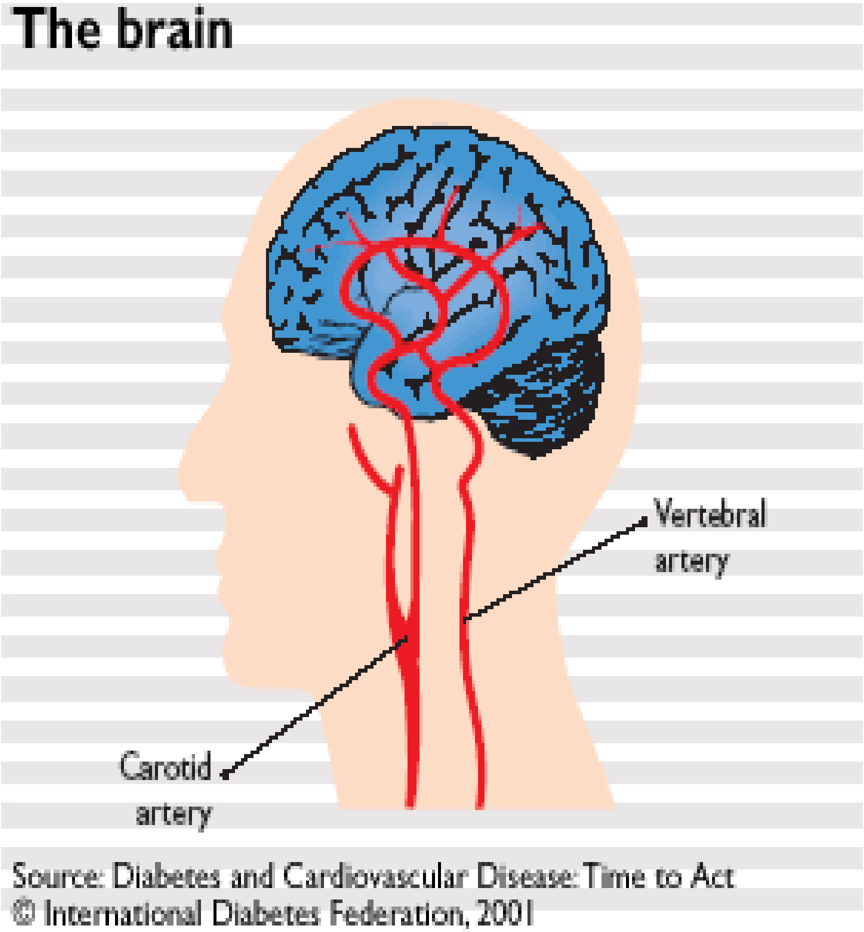
The Circle of Willis is a vital formation of arteries at the base of the brain OR

Grouping of arteries near the base of the brain which is called the *Arterial Circle of Willis*.

It is named after an English physician named Thomas Willis, who discovered it and then published his findings in his 1664, a seminal peace on the inner workings of the brain entitled, *Cerebri anatomi* (from the Latin for "Anatomy of the Brain").

CEREBRAL CIRCULATION

The brain receives its blood supply from four main arteries: the **two internal carotid arteries** and the **two vertebral arteries.** The clinical consequences of vascular disease in the cerebral circulation is depend upon which vessels or combinations of vessels are involved.



CEREBRAL CIRCULATION

The vertebral arteries unite to form Basilar artery

The basilar artery and the carotids form the circle of Willis below the hypothalamus

The circle of Willis is origin of six large vessels supplying the cerebral cortex

Substances injected into one carotid artery distributed almost completely to the cerebral hemisphere on that side. Normally no crossing over occurs probably because the pressure is equal on both sides

CEREBRAL BLOOD FLOW

Normal Rate of Cerebral Blood Flow

Normal blood flow through the brain of the adult person averages 50 to 65 milliliters per 100 grams of brain tissue per minute.

For the entire brain, this amounts to 750 to 900 ml/min, or 15 per cent of the resting cardiac output.

REGULATION OF CEREBRAL BLOOD FLOW

Regulation of Cerebral Blood Flow

As in most other vascular areas of the body, cerebral blood flow is highly related to metabolism of the tissue. At least three metabolic factors have potent effects in controlling
cerebral blood flow: (1) carbon dioxide concentration, (2) hydrogen ion concentration,
and (3) oxygen concentration.

REGULATION OF CEREBRAL BLOOD FLOW

Increase of Cerebral Blood Flow in Response to Excess Carbon Dioxide or Excess Hydrogen Ion Concentration.

An increase in carbon dioxide concentration in the arterial blood perfusing the brain greatly increases cerebral blood which shows that a 70 per cent increase in arterial PCO_2 approximately doubles cerebral blood flow.

REGULATION OF CEREBRAL BLOOD FLOW

Carbon dioxide is believed to increase cerebral blood flow by combining first with water in the body fluids to form carbonic acid, with subsequent dissociation of this acid to form hydrogen ions. The hydrogen ions then cause vasodilation of the cerebral vessels—the dilation being almost directly proportional to the increase in hydrogen ion concentration up to a blood flow limit of about twice normal. Any other substance that increases the acidity of the brain tissue, and therefore increases hydrogen ion concentration, will likewise increase cerebral blood flow. Such substances include lactic acid, pyruvic acid, and any other acidic material formed during the course of tissue metabolism.

REGULATION OF CEREBRAL BLOOD FLOW

Importance of Cerebral Blood Flow Control by Carbon Dioxide and Hydrogen Ions. Increased hydrogen ion concentration greatly depresses neuronal activity. Therefore, it is fortunate that an increase in hydrogen ion concentration also causes an increase in blood flow, which in turn carries hydrogen ions, carbon dioxide, and other acidforming substances away from the brain tissues.

Loss of carbon dioxide removes carbonic acid from the tissues; this, along with removal of other acids, reduces the hydrogen ion concentration back toward normal.Thus, this mechanism helps maintain a constant hydrogen ion concentration in the cerebral fluids and thereby helps to maintain a normal, constant level of neuronal activity

REGULATION OF CEREBRAL BLOOD FLOW

Oxygen Deficiency as a Regulator of Cerebral Blood Flow. Except during periods of intense Brain activity: The e rate of utilization of oxygen by the brain tissue remains within narrow limits—almost exactly 3.5 (± 0.2) milliliters of oxygen per 100 grams of brain tissue per minute. If blood flow to the brain ever becomes insufficient to supply this needed amount of oxygen, the oxygen deficiency mechanism for causing vasodilation immediately causes vasodilation, returning the brain blood flow and transport of oxygen to the cerebral tissues to near normal.

REGULATION OF CEREBRAL BLOOD FLOW

Decrease in cerebral *tissue PO2 below about 30 mm Hg (normal value is 35 to* 40 mm Hg) immediately begins to increase cerebral blood flow.

This is fortuitous because brain function becomes deranged at not much lower values of PO2, especially so at PO2 levels below 20 mm Hg. Thus, the oxygen mechanism for local regulation of cerebral blood flow is a very important protective response against diminished cerebral neuronal activity and, therefore, against derangement of mental capability.

REGULATION OF CEREBRAL BLOOD FLOW

Autoregulation of Cerebral Blood Flow When the Arterial Pressure Changes. **Cerebral blood flow is "autoregulated"** extremely well between arterial pressure limits of 60 and 140 mm Hg. Mean arterial pressure can be decreased acutely to as low as 60 mm Hg or increased to as high as 140 mm Hg without significant change in cerebral blood flow. Hypertension, autoregulation of cerebral blood flow occurs even when the mean arterial pressure rises to as high as 160 to 180 mm Hg. If the arterial pressure falls below 60 mm Hg, cerebral blood flow then does become severely decreased.

REGULATION OF CEREBRAL BLOOD FLOW

Role of the Sympathetic Nervous System in Controlling Cerebral Blood Flow. The cerebral circulatory system has strong sympathetic innervation that passes upward from the superior cervical sympathetic ganglia in the neck and then into the brain along with the cerebral arteries.

REGULATION OF CEREBRAL BLOOD FLOW

Role of the Sympathetic Nervous System in Controlling Cerebral Blood Flow.

This innervation supplies both the large brain arteries and the arteries that penetrate into the substance of the brain. However, transection of the sympathetic nerves or mild to moderate stimulation of them usually causes very little change in cerebral blood flow because the blood flow autoregulation mechanism can override the nervous effects.

REGULATION OF CEREBRAL BLOOD FLOW

The sympathetic nervous system normally constricts the large- and intermediate-sized brain arteries enough to prevent the high pressure from reaching the smaller brain blood vessels. This is important in preventing vascular hemorrhages into the brain—that is,
for preventing the occurrence of “cerebral stroke.”

CEREBRAL BLOOD FLOW

The arteries and arterioles supply blood to the brain are highly specialized, include both vascular smooth muscle and endothelial cells that are unlike vascular cells from the peripheral circulation or other vascular beds.

The vascular smooth muscle is highly responsive to changes in pressure, a process called myogenic activity, that contributes to autoregulation of cerebral blood flow. The endothelial cells in the brain circulation are also highly specialized and provide a barrier to fluid movement called the blood-brain barrier. When these normal cell processes fail or altered such as in hypertension

CEREBRAL CIRCULATION

Fainting: Temporary loss of consciousness, weakness of muscles, and inability to stand up, caused by sudden loss of blood flow to the brain.

Fainting is a relatively common symptom caused by a variety of problems relating to changes in blood pressure.

The American Heart Association reports that fainting is responsible for 3% of all visits to emergency rooms and 6% of all admissions to hospitals.

CEREBRAL CIRCULATION

Stroke: Stroke occurs when the blood supply to a part of the brain is blocked resulting in the death of an area within the brain.

If a large vessel is blocked the outcome may be rapidly fatal or may lead to very severe disability.

If smaller blood vessels are blocked the outcome is less severe and recovery may be good. The most common types of disability are the loss of functions of one side of the body and speech problems.

CEREBRAL CIRCULATION

Principal types of stroke:

Thrombotic: Stroke due to the blockage of an artery leading to or in the brain by a blood clot.

Haemorrhagic: Stroke due to bleeding from a ruptured blood vessel, usually a consequence of hypertension.

Embolic: Stroke due to the formation of a blood clot in a vessel away from the brain. The clot is carried in the bloodstream until it lodges in an artery leading to or in the brain.

The thrombotic and haemorrhagic forms are common,

CEREBRAL CIRCULATION

Transient ischaemic attack: When blood supply to a part of the brain is temporarily interrupted without producing permanent damage.

Recovery may occurs within 24 hours.

Usually result from small blood clots or clumps from plaques of atheroma which get carried into the blood circulation producing transient blockages.

Occasionally these clots may get carried from the heart or arteries leading to the brain (e.g. carotid arteries), rather than from within the cerebral circulation itself.

CEREBRAL CIRCULATION

Dementia: This may result from repeated episodes of small strokes which produce progressive damage to the brain over a period of time.

The main clinical feature of dementia is a gradual loss of memory and intellectual capacity.

Loss of motor function in the limbs and incontinence can also occur.

CEREBRAL CIRCULATION

Figure 1. Cross sectional view of atheromatous plaque with blood clots formed in contact with its wall. Such blood clots can become loose and migrate toward the brain.

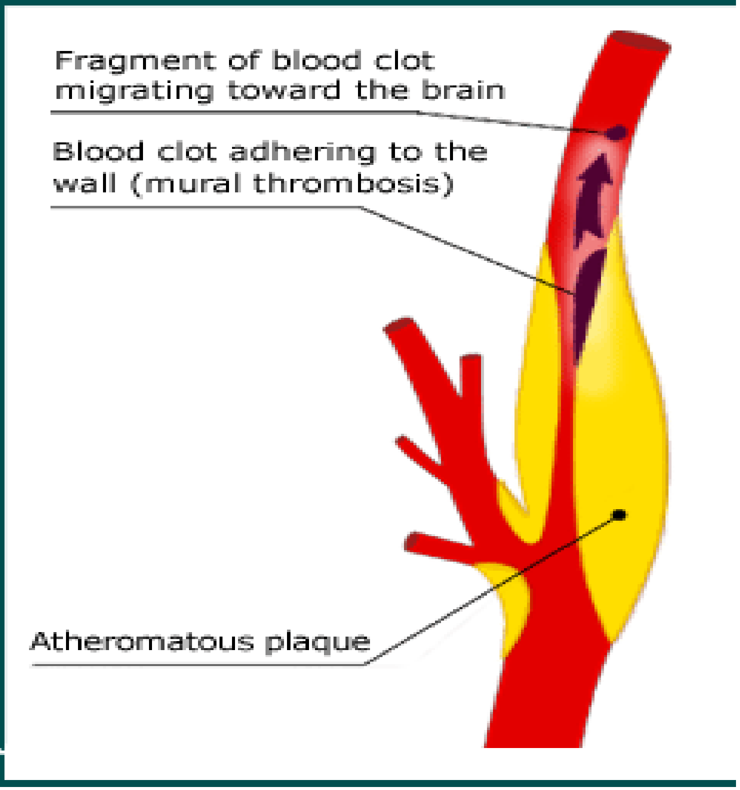
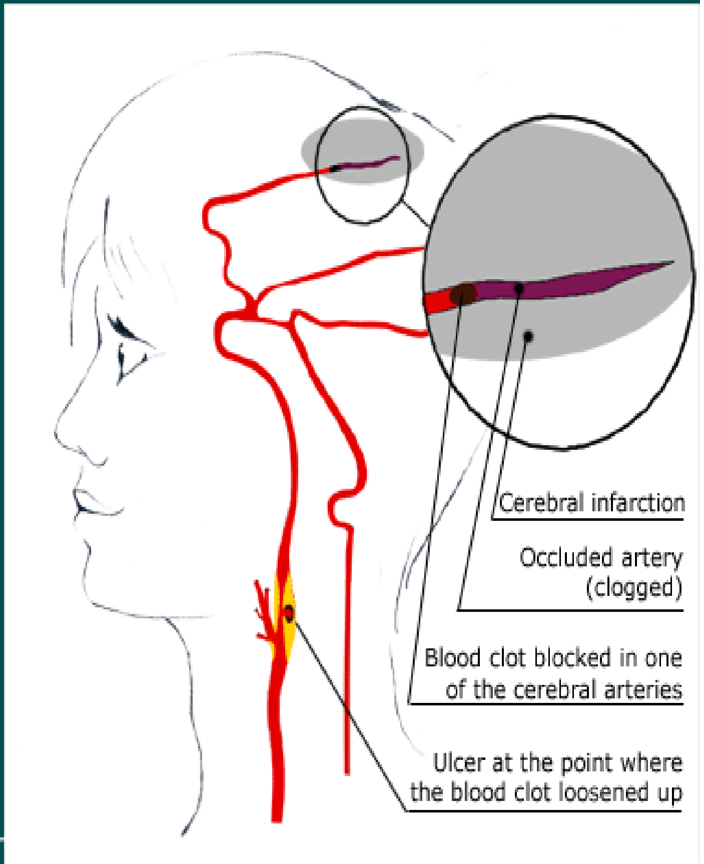


Figure 2. Cerebral infarction caused by an embolism originating in the carotid artery.



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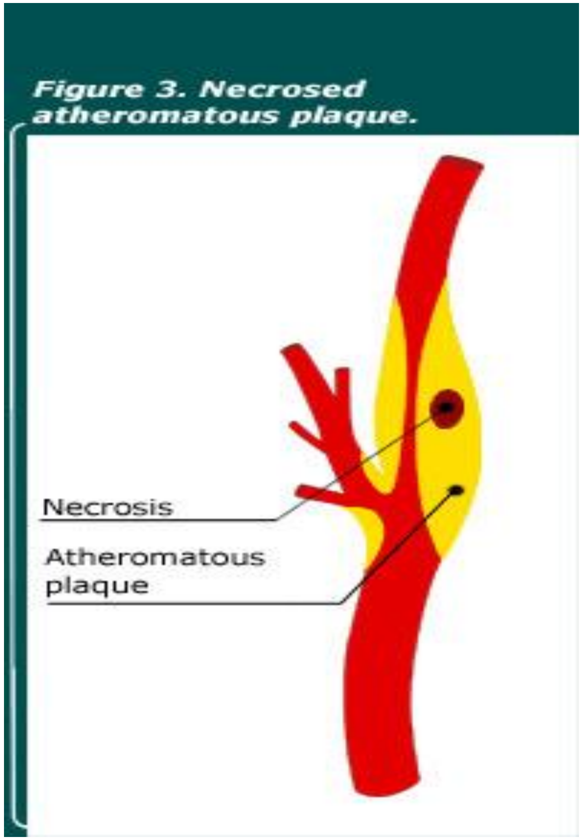

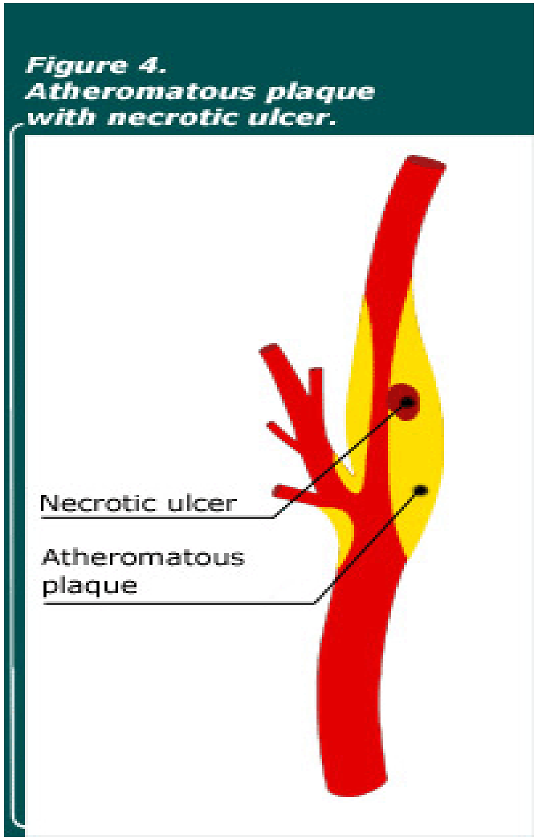

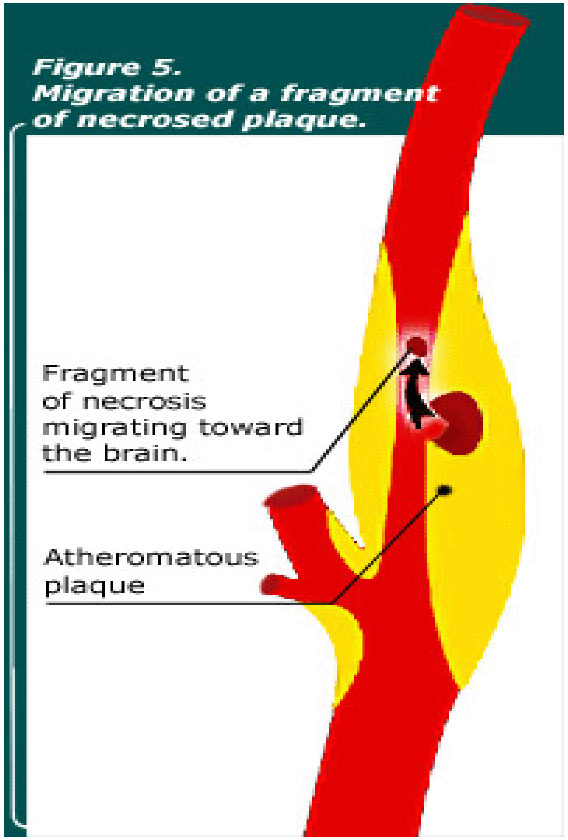

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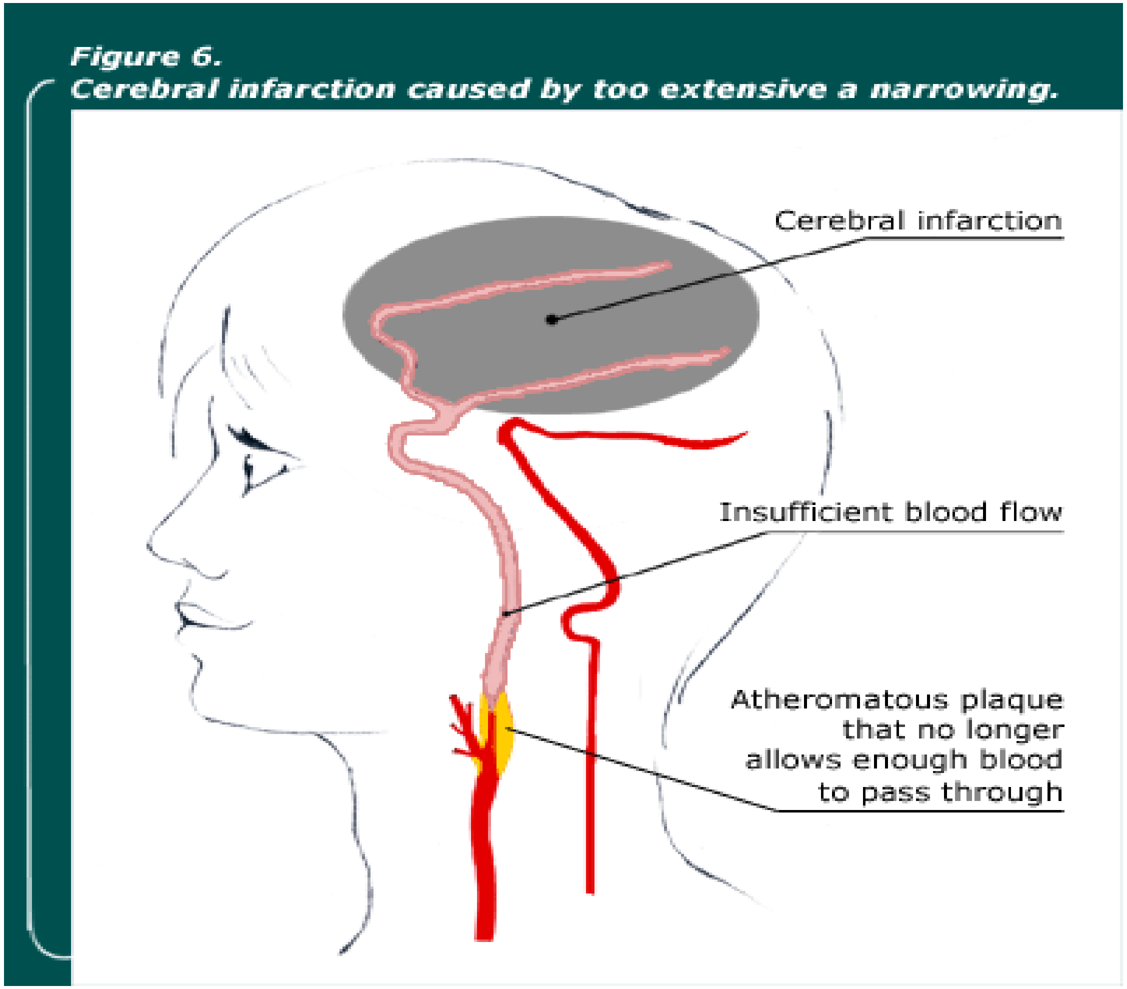

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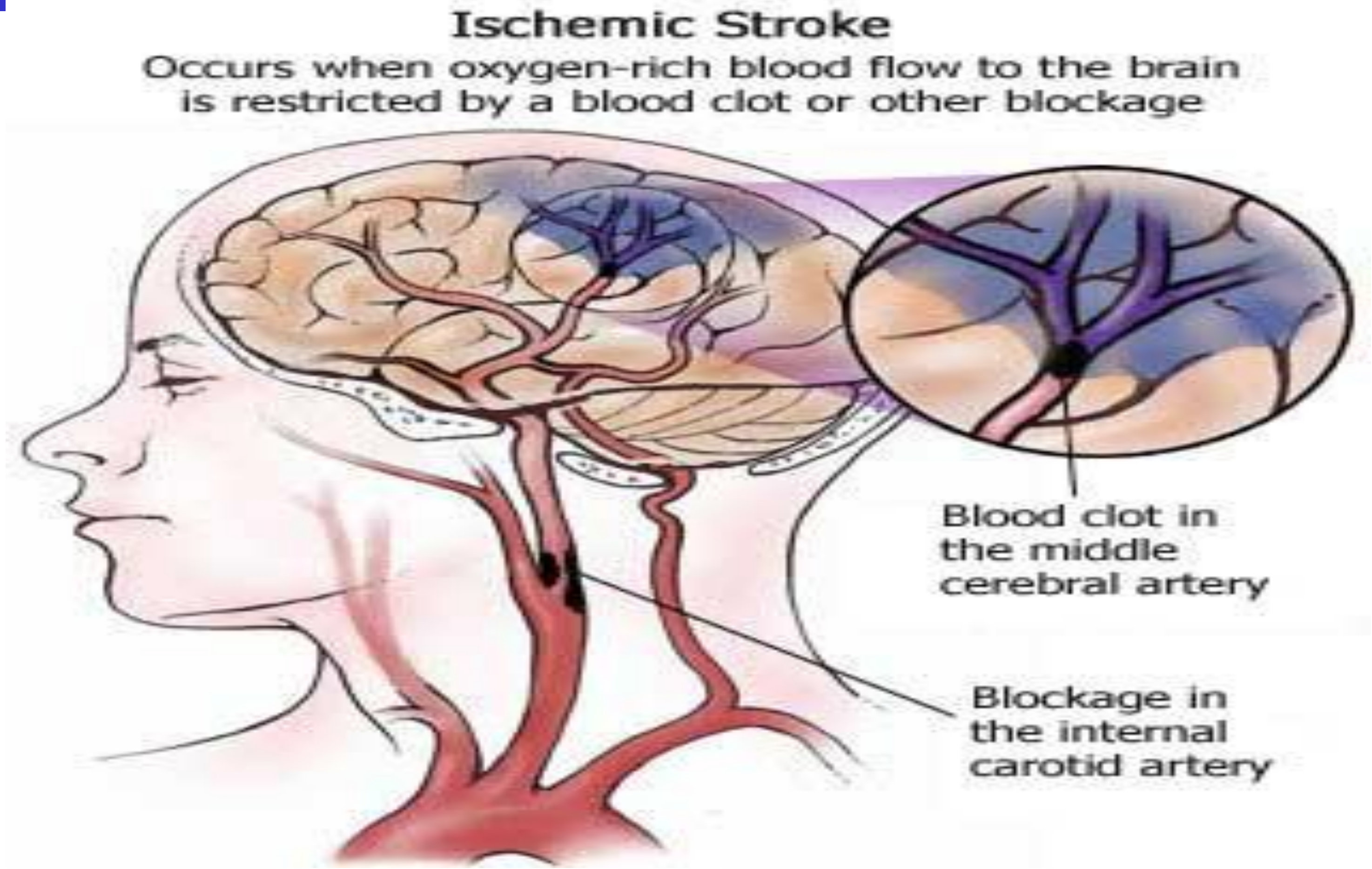

Factors disturb the autoregulation

A variety of noxious stimuli such as hypoxia due to occlusive cerebrovascular disease, trauma from head injury or surgery, or brain compression from tumors, hematomas or cerebral edema, results in the loss of normal cerebral blood flow (CBF) autoregulation.