Lecture

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| Blood flow means the quantity of blood that passes a given point in the circulation in a given period of time. Blood flow is expressed in *milliliters per minute* or *liters per minute,* but it can be expressed in milliliters per second or in any other units of flow and time. |

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| The overall blood flow in the total circulation of an adult person at rest is about 5000 ml/min. |

Types of blood flow:

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| 1-Laminar blood flow : |

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| When blood flows at a steady rate through a long, smooth blood vessel, it flows in *streamlines,* with each layer of blood remaining the same distance from the vessel wall. This type of flow is called *laminar flow* or *streamline flow,*figure-1  Image3  Figure-1 Laminar blood flow  2- *Turbulent flow,* which is blood flowing in all directions in the vessel and in the form of eddies . The rate of blood flow becomes too great, when it passes by an obstruction in a vessel, when it makes a sharp turn.  The tendency for turbulent flow increases in direct proportion to the velocity of blood flow, the diameter of the blood vessel, and the density of the blood and is inversely proportional to the viscosity of the blood, in accordance with the following equation:  Re=v.d.p/ η  where Re is *Reynolds' number* and it predicts the tendency for turbulence to occur, ν is the mean velocity of blood flow (in centimeters/second), d is the vessel diameter (in centimeters), ρ is density, and η is the viscosity (in poise).Figure-2  turbulent blood flow  Figure-2 laminar & turbulent blood flow |

**Methods for measuring blood flow through a blood vessel:**

1. Electromagnetic Flowmeter.
2. Ultrasonic Doppler flow meter.

3- Fick principle (e.g. renal blood flow).

4- Plethysmograph (e.g. forearm blood flow).

**Regulation of blood flow**

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| **I-Local mechanism(intrinsic control):**can be divided into two phases: (1) acute control and (2) long-term control. |

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| **1-Acute Control of Local Blood Flow:**is achieved by rapid changes in local vasodilation or vasoconstriction of the arterioles occurring within seconds to minutes to provide very rapid maintenance of appropriate local tissue blood flow. |

**A**-**Metabolic autoregulation:**

Hypoxia could cause local vasodilatation because of decreased availability of oxygen to the smooth muscle fibers in the local blood vessels. Hypoxia also increases formation of *vasodilator substances* in the tissue cells. The vasodilator substances diffuse through the tissues to the arterioles to cause dilation. Some of the different vasodilator substances are *adenosine,carbon dioxide, adenosine phosphate compounds, potassium ions, and hydrogen ions*.

*adenosine* is an important local vasodilator for controlling local blood flow. For example, minute quantities of adenosine are released from heart muscle cells when coronary blood flow becomes too little, and this causes enough local vasodilation in the heart to return coronary blood flow back to normal.

**B-Myogenic autoregulation:** sudden stretch of small blood vessels causes the smooth muscle of the vessel wall to contract. Therefore, when high arterial pressure stretches the vessel, this in turn causes reactive vascular constriction that reduces blood flow nearly back to normal.

**C-Endothelial-Derived Relaxing or Constricting Factors:** The endothelial cells lining the blood vessels synthesize several substances that, when released, can affect the degree of relaxation or contraction of the arterial wall. Examples of these factors:

**-Nitric Oxide** (NO):-A Vasodilator Released from Healthy Endothelial Cells in response to a variety of chemical and physical stimuli.

-**Endothelin-A** Powerful Vasoconstrictor Released from Damaged Endothelium.

**2-Long-term control** : means slow, controlled changes in flow over a period of days, weeks, or even months.

**Mechanism of Long-Term Regulation :**

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| 1-**By decrease vascularity** : if the metabolism is decreased.  2-**Formation of new vessels**(**angiogenesis):** deficiency of tissue oxygen or other nutrients, leads to formation of the vascular growth factors (also called "angiogenic factors").They cause new vessels to sprout from other small vessels.  So oxygen is important not only for acute control of local blood flow but also for long-term control. One example of this is increased vascularity in tissues of animals that live at high altitudes, where the atmospheric oxygen is low. A second example premature human babies put into oxygen tents for therapeutic purposes. The excess oxygen causes almost immediate cessation of new vascular growth in the retina of the premature baby's eyes and even causes degeneration of some of the small vessels that already have formed. Then when the infant is taken out of the oxygen tent, there is explosive overgrowth of new vessels for the sudden decrease in available oxygen; there is often so much overgrowth that the retinal vessels grow out from the retina into the eye's vitreous humor and eventually cause blindness. (This condition is called *retrolental fibroplasia.*).  **3**-**Development of Collateral Circulation**:When an artery or a vein is blocked in any tissue of the body, a new vascular channel usually develops around the blockage and allows resupply of blood to the affected tissue.  **II-Systemic mechanism (extrinsic control):**  **1-Humoral Control of the Circulation**  Many circulating substances affect the vascular system.  A- **Vasoconstrictor agents** such as Epinephrine, nor-epinephrine, angiotensin II and vasopressin (ADH).  B- **Vasodilator agents** such as histamine, kinin, vasoactive intestinal  peptide (VIP), and atrial natriuretric peptide (ANP).  -**Vasoconstrictor agents:** |
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| **Norepinephrine and Epinephrine** |

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| *Norepinephrine* is an especially powerful vasoconstrictor hormone; *epinephrine* is less. |

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| When the sympathetic nervous system is stimulated during stress or exercise, the sympathetic nerve endings in the individual tissues release norepinephrine, which excites the heart and contracts the veins and arterioles. In addition, the sympathetic nerves to the adrenal medullae cause these glands to secrete both norepinephrine and epinephrine into the blood.   |  | | --- | |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | |  | | --- | |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | | |  | | --- | |  |  |  |  |  | | --- | --- | --- | | |  |  | | --- | --- | | |  | | --- | |  | | | | | |

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| **2-Nervous Regulation of the Circulation:** The nervous system controls the circulation almost entirely through the ***autonomic nervous system****.*   |  | | --- | |  |  |  | | --- | | By far the most important part of the autonomic nervous system for regulating the circulation is the *sympathetic nervous system*. The *parasympathetic nervous system,* however, contributes to regulation of heart function. | |