Blood stream, equation of continuity

The flow of blood in the bloodstream as a physical phenomenon is studied by the subfield of biomechanics, which is called **biorheology** (the form *biorheology* is also used). The term **hemodynamics** is sometimes used to describe blood flow itself.

Physical features of the bloodstream

From a physical point of view, blood and the bloodstream have several properties that make them more difficult to study. These are mainly the following factors:

- Blood is a complex mixture, low-molecular and high-molecular substances are dissolved in it, and a considerable amount of formed elements, especially erythrocytes, are suspended in the blood. As a result, blood behaves like non-Newtonian fluids.
- The chemical composition of blood changes depending on the passage through the bloodstream.
- The physicochemical properties of blood can also change depending on temperature, the temperature being different between the liver (the place with the highest temperature) and the acral parts of the body even under basal conditions.
- Blood is an aqueous solution, but the endothelial lining of the vessels is hydrophobic.
- There are physiological mechanisms ensuring blood coagulation in case of injury or inflammation.
- Circulation is driven by the contractions of the heart, the course of the pressure wave therefore has a rather complicated shape.
- Vascular walls are flexible, the mechanical properties of vessels can change the muscle fibers in their walls.

Blood plays an important role in a number of physiological processes. These are in particular the following processes:

- Substance exchange including respiratory gas exchange.
- Transport of hormones.
- Transpost of heat, in warm-blooded animals it is mainly about cooling the metabolically active core.
- Hydrodynamic support of some organs. In vertebrates, this function is usually limited.

Distribution of vessels from a biomechanical point of view

From a functional point of view, blood vessels can be divided into three types:

- elastic vessels
- resistance vessels
- capacitive vessels

Strong vessels are anatomically large arteries, especially the aorta. They are characterized by a relatively elastic wall. During systole, when more blood is expelled into the bloodstream, the blood vessels dilate. In fact, part of the kinetic energy supplied to the blood by the heart is thus absorbed into the potential energy of their wall. During diastole, the vessel wall passively contracts and the potential energy of the higher wall tension is converted back into the kinetic energy of the blood. Practically, this means that the elasticity of the wall of the large arteries ensures a smoother flow of blood.

Resistance vessels are anatomically primarily smaller arteries and especially arterioles. They are characterized by the fact that they have a relatively large amount of muscle tissue (muscular-type arteries) in the wall, which contracts or, on the contrary, relaxes according to the needs of the organism. These vessels mainly regulate blood flow to the rest of the organs. By their activity, they increase the peripheral resistance of the blood stream. An example of the activity of these arteries are the changes in the blood supply to the muscles during work, when with increasing consumption, the supply vessels relax, the lumen transparency increases and more blood flows into the muscle. Conversely, when the periphery cools, the supply arteries contract, reducing heat loss.

Capacity vessels are anatomically primarily veins. They are characterized primarily by the fact that a larger portion of blood is present in them at any given moment.

From the point of view of pressures, the bloodstream can be divided into a high-pressure part (arteries) and a low-pressure part (veins).

Capillary bed

The capillary bed is characterized primarily by the fact that it is at the level of the capillaries that substances are exchanged between blood and tissues. The capillary network is very rich, especially in organs demanding the supply of oxygen and nutrients. Although most capillaries are closed and blood does not pass through them, the cross-section of all capillaries is still much larger than the cross-section of arteries or veins.

Continuity equation

For more information see Continuity Equation.

The continuity equation is actually a formulation of the law of conservation of mass. Actually, it is just a mathematical notation of the knowledge that if an incompressible liquid with a volume of V_I flows into an arbitrary volume filled with an incompressible liquid during a given time, the volume of the liquid that has flowed out must be V_O identical. If we consider a discrete case, namely that the given volume has a finite number of inlet tubes ("fittings") n in which the liquid flows with a constant flow rate Q_i, the equation of continuity can be write in the form:

$$\sum_{i=1}^{n} Q_i \cdot t = 0$$

Actually, it would be possible to reprimand the time, but that would not lead to useful results. It is better to realize that the shape in the sum can be expressed in terms of the cross-section S_i of a given tube and the velocity v_i in a given tube. Then we get the usual form:

$$\sum_{i=1}^{n} S_i \cdot v_i = 0$$

A lot flows from this for your own hemodynamics. If we imagine the effective cross-sections of the blood stream according to its floors, then the arterial part has the smallest cross-section, the venous part has a much larger one, and the capillaries have by far the largest cross-section. This also corresponds to the fact that the blood flow has the highest speed in the arteries, the smallest in the veins and the smallest in the capillaries.

However, it should be emphasized that this is only an approximation based on the idea of a steady flow of an ideal liquid while neglecting the influence of the gravitational field. When considering the influence of the gravitational field, the continuity equation turns into Bernoulli's equation.