# Effects of electric current on the organism

The effects of electric current on the organism can be both negative and positive (useful for therapy). The negative effects depend on a number of factors that determine how the organism will react to the passing current. They can be divided into direct (passage of electric current through tissues) and indirect (burns when clothing ignites, fractures). Contact with electric current does not always cause acute damage, it can also have late effects, appearing after a long time. The degree of negative consequences depends, among other things, on the provision of quality first aid.

## Factors affecting the effect of electric current

The effect of electric current on the human organism is influenced by a number of factors. It depends on the type of current, its intensity, voltage and frequency, the impedance of the human body, the path of the current, the time of passage of the current and the physiological and psychological state of the organism.

### A type of current

Both types of current cause breakdown of blood and cell membranes, muscle spasms. Alternating current also carries risks of heart fibrillation (see Disturbance of the bioelectrical rhythm of the heart). The most dangerous AC frequency values are 30-150 Hz. (50-60 Hz currents are commonly used)

### Current magnitude

The degree of damage to the organism is directly proportional to the size of the flowing current. For a better idea, the following breakdown: [1]

- 0,5 to 1 mA – the threshold for the perception of electricity current,
- 1 to 8 mA – irritation in the nerves, rise in blood pressure,
- 6 to 15 mA – causes a tetanic convulsion, the person cannot relax
- 25 mA – tetanic spasm of the respiratory muscles
- 60 mA – trembling of the heart chamber (fibrillation), temporary cardiac arrest
- above 80 mA – usually permanent cardiac arrest

### Resistance

Resistance mainly affects the size, i.e. the direction of the current flowing (according to Ohm's law). The degree of thermal effects also depends on it (see Thermal damage).

It consists of two basic components: the resistance of the body itself and additional resistances such as clothes and shoes. These can act as insulators, especially if they are made of non-conductive material (rubber soles).

The body's resistance is highly individual. In general, the greatest resistance is provided by skin, bone, and adipose tissue; the smallest, on the other hand, moist or liquid components such as internal organs and body fluids. The resistance of the body also affects the psychological state, or psychosomatics (e.g. sweating, degree of blood flow to the skin, i.e. its moistening and possible change in resistance).

### Tension

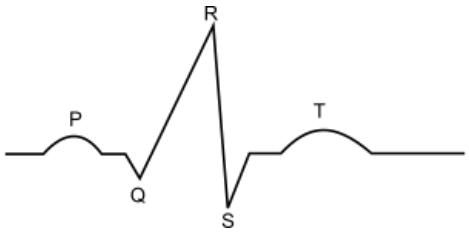
Voltages below 1000 V are low, others are high. The effect of low voltage depends on the surrounding environment of the organism (See Safe values) especially on humidity. In any case, it can be said that low voltages affect the bioelectrical balance of tissues, while high voltages cause thermal damage. There does not even have to be physical contact between the conductor and the organism, as an electric arc can occur at a distance (See Lightning strike).

### Direction

Current passes through the body (according to Ohm's law) along the path of least resistance. In case of current passing between both lower limbs, burns and muscle spasms occur. When passing between the right leg and the hand, there are burns again, the convulsions can also affect the diaphragm, thus secondarily endangering breathing. However, the most serious is the passage of the current through the heart - that is, between the left hand and any other limb; risk of ventricular fibrillation. Hitting the head and passing the current further into the body is also very dangerous; the nervous system is affected on a far more extensive level - cardiac arrest, breathing, tonic-clonic convulsions - at high intensities, the brain tissue is also thermally damaged, which entails a number of secondary changes.

### Exposure time

The risk of damage to the organism first increases with exposure time, but after a certain time the current becomes "saturated" and time no longer plays a role. At the same time, the effects on the function of the heart result from the ECG . The cardiac cycle, which lasts approximately 0.8s, contains the so-called vulnerable phase - the time corresponding to the repolarization of the ventricles (T wave on the ECG), when the heart is most prone to fibrillation. If the current passes through the body for more than 0.8s, the heart is 100% affected in the vulnerable phase, with a shorter exposure, the probability of fibrillation and possible arrest decreases.



Electrocardiogram

# Negative direct effects of electric current

### Disturbance of membrane polarization and heart bioelectrical rhythm

The intervention in the polarization of the membranes follows the direct passage of the current through the tissues. Every tissue is composed of cells that exhibit electrical properties under physiological conditions. These properties are determined by the existence of electrically charged particles that occur on both sides of the [cell membrane|cell membrane]]. A resting membrane potential is formed, which is given by the uneven arrangement of ions. The membrane reaches this state by active transport of ions with energy consumption. Their movement is a source of electric current, which is essential for the transmission of information typical of nervous tissue - active membrane potential. When a non-physiological current passes, membrane depolarization occurs the membrane potential increases. Excitement arises and spreads, but now pathologically without the will of the organism. The individual is at risk of convulsions, an uncontrollable contraction of the skeletal muscles, which will make it impossible to control (inability to let go of the current-carrying conductor and especially inability to breathe when the diaphragm, as the main respiratory muscle, is affected).

In the event that the current flows between the left hand and any other limb, in addition to the possibility of convulsions, there is a significant threat of fibrillation of the heart chambers. It can occur in addition to respiratory arrest and cardiac arrest. The heart works as a blood pump with a frequency of approximately 70 beats per minute. The generation and propagation of the excitation is ensured by the conduction system of the heart: the generation of the excitation is ensured by spontaneously depolarizing cells in the SA node and its subsequent conduction is again related to the transmission of an electrical signal. When passing an alternating current with a frequency of 50 Hz, for example, the heart tries to match the frequency of the passing current and tries to oscillate at a frequency of 50 beats per second. This disrupts the synchronization in the conduction of the impulse to contract the ventricles. The heart loses its ability to pump, its fibrillation occurs, which can result in the death of the affected individual.

### Thermal damage

As a result of the thermal energy generated during the passage of an electric current through the body (Joule heat: Q=U.I.t), electrical burns of varying extent can occur. The degree of damage depends mainly on the intensity of the current, the electrical resistance of the given tissue and the duration of the passage of the current. It enters the body at the moment of contact and never proceeds in a straight line, on the contrary, it follows the path of least resistance and can even branch out. Before leaving the body, the electrical current may pass through the internal structures and deeper tissues of the body. Electrical skin burns, which offers great resistance, can be found at the points of entry and exit of the current - so-called current marks, these are patches of gray skin. Furthermore, the bone offers great resistance, so extensive coagulation necrosis of the tissues surrounding it occurs, especially the skeletal muscles.

### Muscle tissue

Secondarily, myonecrosis occurs in the muscle that is bruised and damaged at all. Myoglobin is released into the body and accumulates in the tubules of the kidneys, which leads to their acute failure - anuria from myoglobinuria. The condition is very similar to crush syndrome. At the same time, anuria conditions (together with the previous action of the electric current) an increase in the concentration of potassium in the blood plasma (hyperkalemia).

### Vascular structures

As a result of the action of the electric current, the vascular structure is also damaged, because during the action of the current, the blood vessels become an excellent conductor. Thrombosis (later heart attack and ventricular fibrillation), aneurysms (later bleeding) can occur.

### Nervous structures

Damage to nerve tissue entails long-term consequences in the form of loss of mobility, local soreness, or numbness. Damage in the area of the neurovegetative system further results in palpitation, precordial pain, sleep and memory disorders.

# FIRST AID KIT

When providing first aid , it is important to pay attention to your own safety. The rescuer should never touch the victim until he is sure that he is no longer in contact with the source of electricity. of the current, or if it lies in an area where the current could break through. The first step is therefore to prevent the passage of current through the organism, which is done by turning off the electric current with a switch, turning off the fuses or safely removing the electric conductor from the surface of the body. When handling electrical conductors or with a live patient, dry rubber shoes, rubber gloves and other insulating materials must be used.

The second step – cardiopulmonary resuscitation , we start if the injured person is not breathing or does not have preserved heart activity. CPR must be quick and provided within a few minutes, we perform it until the arrival of the emergency services. The patient could also have suffered an injury to the cervical spine and it is necessary to provide him with care according to this condition (falling or being thrown often occurs during an electric shock). Acute treatment of burns at the point of entry and exit of the current can be performed by sterile covering of the burned area.

# Positive effects of electric current

Galvanic direct current or pulsed rectified alternating sinusoidal current is used for therapeutic purposes. A galvanic current of constant intensity is used in iontophoresis, i.e. a method where, after turning on the current, a medicinal substance in the form of ions is introduced into the bloodstream through the skin. The irritating effect of low-frequency pulsed currents is used during electrostimulation of peripheral motor neurons or directly of the muscle. It is used in patients after operations who cannot perform active movement. Thrombosis is prevented. Cardiostimulation works on the same principle, helping to keep the heart rate within the physiological range. Defibrillators are used for life-threatening ventricular fibrillation, when unsynchronized tremors of the heart muscle occur and the heart does not function as a blood pump. The electric discharge of the device depolarizes all myocardial cells at once and thereby induces the conditions for the re-emergence of physiological centers of excitation generation. A defibrillator is a device with charging capacitors that are connected to the patient using electrodes. This is followed by an electric discharge by rapidly discharging the energy accumulated on the capacitor. This energy must have a suprathreshold value to interrupt fibrillation. Energy values between 200 – 360 J are used. A charged capacitor has an energy of:

$$E = (1/2)\, C\, U^2$$

kde where C is the capacitance of the capacitor and U is the voltage between its plates.
Electroshock is used in psychiatry to treat depression and in some cases of schizophrenia. A low-frequency alternating sinusoidal current is used. High-frequency currents use the predominant thermal effect that passes through the tissue. Thanks to the high frequency, the current passes well both through the skin and other tissues without an irritating effect. The generation of heat will lead to vasodilatation, suppression of pain or improvement of tissue nutrition. Diathermy is therefore applied in diseases of the musculoskeletal system.

# Safe values for working with electric current

Safety regulations apply to work with electric current, which establish safe values for the human organism. The intensity of the current is particularly important, but it does matter whether it is direct current or alternating current. In general, the effect of electric current on the human organism is directly proportional to the magnitude of the passing current. For direct current, intensity values up to 10 mA are defined as safe, for alternating current up to 3.5 mA. The reason a person can tolerate more direct current than alternating current is that the most dangerous phase is when the current reverses its polarity, which occurs with alternating current. That's when the tissues are under the most stress. The limits of safe voltages depend again on the type of current, but significantly also on the surrounding environment in which a person is. Three are established according to safety: safe, dangerous and especially dangerous. A safe environment means climatic conditions with lower humidity and temperature, where the highest value for direct current is 100 V and for alternating current the value is 50 V. On the contrary, a particularly dangerous environment with high humidity will reduce the safe values to 24 V for direct current and 12 V for alternating current current. In the case of alternating current, its frequency is also important in hazard assessment. The most dangerous values are in the range of 50-60 Hz, which also corresponds to the most commonly used values in practice. In the case of alternating current, its frequency is also important in hazard assessment. The most dangerous values are in the range of 50-60 Hz, which also corresponds to the most commonly used values in practice. In the case of alternating current, its frequency is also important in hazard assessment. The most dangerous values are in the range of 50-60 Hz, which also corresponds to the most commonly used values in practice.

# Links

## Literature

Leoš Navrátil, Jozef Rosina and the collective, *Medical Biophysics*, 2013

## External links

https://web.archive.org/web/20160331222721/http://zdravi.e15.cz/clanek/sestra/kazuistika-popaleniny-zpusobene-elektrickym-proudem-374798

https://en.wikipedia.org/wiki/Electrical_burn

#### Reference


1. VLADIMÍR MEDUNA, CTIRAD KOUDELKA,. *Effects of electric current on the human organism, Ostrava, March 2006* [online]. [cit. 2013-12-01]. <fei1.vsb.cz/kat420/vyuka/Bakalarske/.../Ucinky%20el.%20proudu.pdf>.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