AJPMHS GLOBAL RESEARCH NETWORK

AMERICAN Journal of Pediatric Medicine and Health Sciences
Volume 01, Issue 10, 2023 ISSN (E): 2993-2149

Modern Aspects of Electric Shock in Forensic Practice

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Abstract: Electrical injury is currently one of the pressing problems in all branches of medicine and is of great social importance due to the high mortality rate and significant disability of surviving patients. Forensic medical diagnosis of fatal injuries from technical electricity is of particular importance both in the investigation of cases and in substantiating the thanatogenesis of this condition. The article shows the relevance of studying forensic medical diagnostics of fatal injuries caused by technical electricity as the least studied problem of modern forensic medicine.

Keywords: exposure, electric current, damage, electrical injuries, protection, safety.

Relevance. Electrical injury is currently one of the pressing problems in all branches of medicine and is of great social importance due to the high mortality rate and significant disability of surviving patients [5, 19, 21, 34]. Scientific and technological progress and the active introduction of electrical technologies into human everyday life lead to an increase in the number of electrical injuries [1, 6, 10, 18, 26]. According to Koumbourlis A.C. (2002), 22–25 thousand people die every year in the world as a result of electric current [29]. Forensic medical diagnosis of fatal injuries from technical electricity is of particular importance both in the investigation of cases and in substantiating the thanatogenesis of this condition. The main diagnostic sign of death from electrical injuries is the presence of "electrical marks". Unfortunately, this symptom, according to various authors, is observed on average in 60–80% of cases [13, 15]. In other cases, the findings (conclusions) of a forensic medical examination are based on signs of rapid death and data from the circumstances of the case, which does not fully allow one to substantiate the thanatogenesis of electrical trauma. Despite the frequent absence of "electrical marks" in injuries caused by technical electricity, thanatogenetic criteria for this condition have not yet been developed [2, 7, 8].

When a person is injured by an electric current, deep functional disorders of organs and systems develop, primarily the central nervous system, circulatory and respiratory organs [2, 12]. Even short-term contact leads to the development of multiple organ failure [27, 28]. There are four clinical types of death from electric current: 1) sudden death at the scene; 2) delayed death, when the victim shows short-term signs of life (crying, convulsions); 3) interrupted death, when the victim can be temporarily brought out of unconsciousness, but death soon occurs; 4) late death, occurring unexpectedly a few days after electric shock [15]. There are also four degrees of severity of disturbances in victims of electrical trauma: 1st degree - tonic muscle contractions predominate without loss of consciousness. After the cessation of exposure to the current, victims experience pain, agitation (sometimes stunning), pallor and coldness of the skin, shortness of breath, tachycardia, increased blood pressure; 2nd degree – tonic convulsions are accompanied by loss of consciousness without pronounced cardiorespiratory disorders; 3rd degree - coma, acute respiratory and circulatory disorders are observed, hypotension develops, damage to internal organs is possible (ruptures of pulmonary vessels, focal necrosis of

parenchymal organs, retinal detachment). Sometimes primary damage to the central nervous system leads to a sharp inhibition of the centers of regulation of breathing and blood circulation, up to electrical lethargy, when signs of life are practically not detected during a traditional examination of the victim; 4th degree – ventricular fibrillation or apnea of central origin, clinical death (a feature of the latter is its prolongation to 7–10 minutes). Central apnea, which most often develops when an electric current passes through the head, is usually persistent and can recur in the post-resuscitation period [3, 4]. When passing through the body, the electric current, having physiological effects, causes muscle contractions. At the early stage of the study of electricity, this action was the only one that scientists knew about. Therefore, the first "measurements" of electric current were based on the experimenters' own sensations, who passed it through themselves. The electric current, overcoming the resistance of the skin and subcutaneous fat, passes through deeper tissues in parallel bundles along fluid flows, blood and lymph vessels, and the membranes of nerve trunks [11, 20]. This determines the high degree of vulnerability of blood vessels during electrical injury [30, 33]. Some authors highlight the fact of alteration of blood vessels when exposed to electric current, describe the characteristic features of vascular damage by electric current, and note manifestations of changes in vascular-platelet hemostasis, blood coagulation and fibrinolysis, leading to DIC. -syndrome, microcirculation disorders and endothelial dysfunction [32]. In severe cases, death of victims often occurs as a result of cardiac arrest [25].

Electric current is the directed movement of electric charges under the influence of an electric field. There are conduction current and convection current. Conduction current is the directional movement of charges in conducting bodies: electrons in metals, electrons and holes in semiconductors, ions in electrolytes, ions and electrons in gases. Convection current is the movement of charged bodies and the flow of electrons or other charged particles in a vacuum.

Electric shock occurs when you come into contact with an electrical circuit that contains voltage sources or current sources that can cause current to flow through the energized part of the body.

High voltage electric shocks occur infrequently, usually in inexperienced workers or in inquisitive children disassembling a plug socket or testing an electrical wire. When exposed to alternating current, entry and exit wounds are approximately the same size. Children with lip burns should be carefully examined for rupture of the labial artery 3 to 5 days after the injury. In an industrial enterprise, direct current injuries are most often observed, in which the flow of electrons has a direct direction along wires with positive and negative charges. When struck by direct current, a small entry wound and a much larger exit wound occur. These entry and exit wounds are lesions with a central zone of charring, a middle zone of coagulative necrosis that is whitish-gray in color, and an outer region of edematous tissue that is bright red in color. The passage of electric current from the point of contact to the ground is accompanied by the formation of heat in an amount directly proportional to the distance between these two points and the resistance of the intervening tissues. When exposed to alternating electric current, more severe consequences are observed than when passing direct current. Current passes through the body along the lines of least resistance. Dry skin has high resistance. Nerves, blood vessels, muscles and bones have more resistance and therefore suffer more damage. The damage caused by electrical current is similar to that observed with prolonged tissue compression, since their systemic effects are often the same. Thus, when a muscle is damaged, myoglobin is invariably released. The greatest threats to life are cardiac arrhythmias, renal failure due to precipitation of myoglobin and hemoglobin in the kidneys, and electrolyte disturbances such as hyperkalemia and hypocalcemia due to massive muscle breakdown. Several or even all major organs may be affected.

The severity of injury depends on the voltage, type and strength of current, duration of exposure and physicochemical properties of tissues [21, 23]. Electrical injuries can be caused by low voltage current (from 60 to 1000 W, usually 220 or 360 W) and high voltage (more than 1000 W). In the first case, unpleasant incidents usually occur in the home or office environment. Local

and general clinical pictures indicate moderate structural and functional damage to organs and tissues. However, in the most severe cases, they may be accompanied by the development of tetanic seizures and cardiac dysfunction [23]. Even short-term contact with a current-carrying surface leads to partial or complete necrosis of individual anatomical areas and the development of multiple organ failure [20, 23, 26]. In the most severe cases, the death of the victim occurs due to cardiac arrest or massive bleeding due to a violation of the integrity of the walls of large vessels [1, 10, 42]. Y.Y. Li et al. (2017) in their work described injuries in a patient who was admitted with severe high-voltage trauma to Guangzhou Red Cross Hospital, Jinan University Medical College, Guangzhou People's Republic of China. During the diagnosis, the following were revealed: third degree burns on a total area of 35.5% of the body surface, an open wound of the left half of the chest with exposure of the heart and damage to the myocardium and left lung. This led to the development of hydropericardium, hydrothorax and respiratory failure [32].

Forensic medical examination of electric shock involves establishing the cause and rate of death. For these purposes, the results of the autopsy of the corpse, forensic histological studies, the presence of electrical marks on the body of the deceased, confirmed by histological studies, and the absence of signs of injuries, diseases and poisonings that could cause death must be taken into account. The circumstances and conditions of death are also taken into account - information about the possible contact of the victim with a current-carrying conductor, which can be obtained based on the results of a technical examination. When an electrical injury occurs at work, the examination of a corpse has its own characteristics related to the specifics of the production cycle, the need to comply with a special regime and safety precautions. At the same time, the first priority is to ensure conditions that prevent electric shock to persons participating in the inspection of the scene of the incident. When examining the corpses of people who died from electric shock, morphological signs of rapid death, early autolysis in the pancreas, and the presence of primary urine in the capsules of the renal glomeruli are usually revealed. In case of asphyxial death, cyanosis is detected, in case of cardiac death - pallor. Fibrillation of the ventricles of the heart is manifested by its flabbiness and fragmentation of cardiomyocytes; anisocoria and bronchospasm may be noted [11, 31]. However, the noted tissue changes can also be detected in other pathological conditions.

Electric shocks are accompanied by the development of various pathological processes. They lead to the development of both local and general changes in the structure of organs and tissues, and in the most severe cases – multiple organ failure and death of the victim. Any place where a person lives and works, where his family members spend time, can become a place of danger. The "human factor," neglect of basic safety precautions, and poor control over children's behavior by parents are the reasons for the annual hospitalization of a large number of victims. Their treatment, which takes a long time, often requires the involvement of a multidisciplinary team of specialists and the performance of technically complex surgical interventions. However, despite the efforts expended, it is not always possible to completely restore a person's health, and in the most severe cases, life.

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