REMARKS CONCERNING THE NOMENCLATURE OF ELECTRICAL INJURIES

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The nomenclature of electrical injuries is non-uniform, due to the diversity of causative factors, electric current properties, and unexplained mechanisms of activity. The above-mentioned often renders impossible the comparison of results, and statistics. The translation from English nomenclature might often be inadequate, considering simple terms explaining the mechanism of injury and electric current injuries.

Division, classification, nomenclature

According to Shaw and Robson (1) there exist three types of skin damages following electrical injuries:
1. Contact burns at the entry and exit site of electrocution.
2. Electric arc burns.
3. Thermal burns after clothing catching fire.

Duis (2) distinguished the following:
1. Burns after direct contact with electricity:
   – electrothermal burns,
2. Integument burns without electrical current contact:
   – electric arc,
   – flame burns,
   – flash burns.

Another classification distinguishes the following:
– true electrical burns,
– thermal burns.

The former injuries lead towards deep tissue, muscular, and osseous damage, while the latter only concern the skin, being caused by flash and flame burns (3).

According to Esses and co-authors (4) electrical injuries can be divided as follows:
– flash burns,
– electric arc burns,
– „true” or direct burns.

The most commonly accepted classification of electrical injuries is as follows:
– direct,
– indirect.

Direct burns are diagnosed when the electrical current passes through the body leading towards the following:
– skin and deep tissue burns,
– damage and electrocution of internal organs by means of the electric current.

Indirect injuries can be caused by the following:
– direct electric arc burns, due to a high temperature of the arc (nearly 2500°C),
– combustibility of clothes and thermal burns (5).

The above-mentioned classifications are similar, apart from the nomenclature. They describe electrical and thermal injuries of the integuments. Other classifications consider the electric current as the causative agent and its influence on the sustained injuries.

The mechanism of integument and skin high-voltage injuries depends on the duration
A short-lasting contact leading towards muscular necrosis can cause burn wounds over the injury. Entry points include the hands and head, while the feet are considered as the exit point. The extent and depth of the burn wound is not adequate to the degree of deep tissue injuries. Typical injuries localized in the crease of the flexor muscles of the forearm are termed as the “burn kiss” (6). One can observe a current change above the crease, especially when the limb is wet and flexed.

Flash burns are usually superficial or intermediate. Isolated thermal burns of diverse depthness are usually associated with flame burns. The average surface of burn wounds in case of electrical injuries does not exceed 25% of the body mass.

In case of low-voltage current injuries changes are usually reversible. Although low-voltage injuries might seem non-serious the consequences are significant. Nearly 50-88% of all deaths are caused by electrical injuries. The above-mentioned leads towards cardiac and respiratory arrest (7, 8, 9).

Electric injuries of deep tissues lead towards necrosis of the muscles, bones, and vascular thrombotic lesions. The electric current passing through the heart can cause severe rhythm disturbances, atrial fibrillation, ventricular fibrillation, and cardiac arrest. The passage of the current through the brain can cause morphological changes and respiratory center paralysis (10).

The influence of electrical energy on the human organism is determined by the following:
1) type of current,  
2) the dose,  
3) current flow,  
4) exposition time,  
5) surface of contact,  
6) body resistance,  
7) current tension.

Burn wounds can be divided on the basis of the dose of the current. Low-voltage injuries occur in case of 1000 V electric current injuries. High-voltage injuries are diagnosed in case of values exceeding 1000 V. Low-voltage electrical burns are usually confined to the arms and mouth of children. A specific electrical injury is the electric arc burn, when the current is conducted through the ionized environment. The direct flow of the transmutable current through the human body can lead towards a series of neurological, cardiovascular, pulmonary, abdominal, osseous and articular disturbances, as well as damage to the vessels (11).

According to Lee and Frame (12) electrical burns can be divided as follows:
- low-voltage (<1000 V)  
  - contact,  
  - flash.
- high-voltage (≥1000 V)  
  - contact or electric arc,  
  - flash.

In 1961, Lee presented the following division of electrical injuries:
1. Injury caused by the transformation of electric to light energy, which most often leads towards eye damage.
2. Deep burn wounds caused by “Joule heat”, which result from electric arc injuries.
3. Electric shock which occurs in patients following long-lasting contact with the electric wire (“held on”), and those with short wire contact.

The so-called „held on” electric shock can also occur in case of medium-voltage electrical injuries, due to the long-lasting contact with the source of the current. The above-mentioned is usually accompanied by cardiovascular and thoracic symptoms. The passage of the current through the human body without evident electrocution symptoms is considered, according to Lee, as electric shock without long-lasting contact with the current (13).

According to Yan and co-authors (14) electrical injuries can lead towards:
- electric shock,  
- contact electrical injuries,  
- electric arc burns.

Electric shock is observed immediately after electrocution, which leads towards transient coma, and cardiac and respiratory arrest. The above-mentioned was observed in 21% of all electrical injury cases. It is the manifestation of cardiovascular, cerebral, and respiratory symptoms after current passage through respective organs. The direct English translation of the word “shock” might, in case of electrical injuries, lead towards a false understanding of the nature and consequences of electric shock. The word “Shock” suggests the development of complications, such as respiratory and cardiac arrest, and coma, which without adequate medical management will not withdraw. The above-mentioned might lead towards oxy-
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gen distribution disturbances, cellular hypoxia and death. Thus, in case of such an interpretation the term “shock”, being similar to cardiac shock is justified. However, is every cardiac or respiratory arrest considered as “shock”? The treatment of shock is long-lasting (in case of burn shock up to 48 hours). Sudden electrical injury leading directly towards a life-threatening condition, due to respiratory and cardiac arrest can be termed in the Polish language as electrocution. This is contrary too electrical injuries, which are caused by the passage of electricity through the tissues, leading towards their necrosis. The translation from English of the word “shock“, is signified by electrocution applied in psychiatric treatment, as well as in case of death by means of the electrical chair. It is a form of electrical stimulation, and not a consequence of oxygen supplementation and consumption disturbances in cells.

Publications in English predominate in medical literature. Thus, nomenclature is based on the above-mentioned, considering electrical injuries. In Polish the direct translation of the definitions and expressions is often misfortunate. The acceptance of Polish terms facilitates the division of electrical injuries, enabling to standardize the principles of classification, evaluation and comprehension of scientific publications.

Literature data often mentions the terms electric shock, electrocution, electrical burn, electric arc burn, electric injury and others. According to Artz the term „electric burn“ includes all other meanings (15). According to the New Oxford American Dictionary electric shock should be understood as the sudden passage of electricity through the human body (16).

The often mentioned term electrocution signifies self-damage or fatal electric shock by means of an electric current. The etymology contains two words electro- and execution, which is evidence of the second meaning of the word electrocution- execution by means of the electric current.

Both expressions: electrocution and electrical burn differ in terms of quantity. The passage of the high-voltage electrical current through the cerebral tissue can lead towards necrosis. The passage of the current through the cerebral tissue can lead towards respiratory and cardiac arrest by means of different mechanisms, depending on the force of the damaging factor. Passage through the heart can lead towards rhythm disturbances, as well as cardiac and ensuing respiratory arrest. Electricity passing through the extremities can lead towards their necrosis and burn shock.

The effect of the electrical current of appropriate voltage can cause a tetanus muscular contraction of the skeletal and respiratory muscles, leading towards respiratory arrest. Once the electrical stimulation is stopped consequences of respiratory insufficiency remain. The above-mentioned is a form of electrocution, although of a different mechanism. Similarly, one may observe damage to the muscles, such as there disruption, rupture, and even bone fractures. The above-mentioned form of injury is termed “muscular electrocution tetany”.

The proposed classification of direct injuries, depending on the type of injury, and ensuing consequences is simple and explicit.

Direct injuries caused by the electric current:
1) electrocution caused by the passage of the electric current through the cerebral tissue or heart leading towards cardiac and respiratory arrest, or passage of the electric current through the body without deep tissue necrosis;
2) electrical burn- necrosis of the integuments and deep tissues (muscles), as a consequence of the passage of electricity through the body, which does not necessarily lead towards cardiac and respiratory arrest. Both conditions may occur simultaneously;
3) muscular electrocution tetany.

The division of the indirect injuries mostly concerns integument burns, being in accordance with other classifications.

The differentiation of a contact burn with the entry and exit lesions and electric shock might often pose a problem. Necrosis is characteristic of electrical burns, although in case of „hand-to-hand“ electricity passage it can also be typical of electrocution. The patients’ clinical condition determines the differentiation between electrocution and electrical burn. In case of the former the patient might not have any other symptoms connected with the passage of the electric current, after resuscitation. In case of the latter fluid resuscitation is required as well as long-lasting therapy. As
previously mentioned both conditions may occur simultaneously.

According to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care—Part 10.9: Electric Shock and Lightning Strikes the mechanism of electrical shock consists in the direct influence of the electric current on the heart, brain, cellular membranes, and smooth muscles of the vessels. Additional injuries consist in the conversion of electrical to thermal energy during the passage of the current through the human body (17).

The differentiation of the terms electrocution and electrical burn enables to determine the mechanism of injury.

REFERENCES


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