Morphological Characteristics of Tissue Damages at Electric Injury

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Printed in: Georgian Medical News, Tbilisi, 2009

The diagnosis of injuries due to technical electricity still remains one of the most interesting topics of Forensic Medicine [1; 4; 5] Of particular interest is electricity apply on the body when there is no characteristic electricity lesion that creates certain diagnostic difficulties [2; 6; 8]. There is not very large spectrum of scientific studies of this type of electric injury where authors describe structural and biochemical changes of tissues that do not form the characteristic pattern of injury valuable for forensic diagnosis [1; 3; 4; 5; 7].

The matter is of particular importance as technical domestic electricity apply is widely used method of torture and other cruel, inhuman and degrading treatment or punishment and due to its diagnostic difficulties the forensic medical report could not strongly state a physical evidence of torture. The "electric torture" mostly considers the applying of electricity to the wet skin that reveals minimal or even no resistance to electricity and thus forms no characteristic macro-morphological pattern.

The purpose of study was to reveal the morphological pattern of different tissues mostly vulnerable to electric currency and affected by technical domestic electricity and determine the possible diagnostic criteria of this damage.

The pilot part of the study was experimental. As the material of study have been used four adult (of 10-11 months, 250-300 gr.) Wistar white rats from vivarium of Tbilisi State Medical University, from common genetic line, with sex randomization. The animals were kept in mild quarantine conditions on 20°C of ambient temperature.

As an experimental model has been chosen the applying of free endings of metallic wire, switched by another end to the technical electricity source (220 v), to the front legs of the animal, previously moistened by water. The electricity course between the front legs formed complete electric loop, passing through the heart of the animal and resulted in death due to cardiac arrest. In all four animals the electricity applies resulted in cardiac arrest within approximately three minutes.

For morphological study the samples have been taken from the skin at the point of electric wire apply and internal organs: heart, kidneys and suprarenal glands. The material have been put into the buffer: formalin 40% - 100ml; NaH_2PO4 - 4g; Na_2HPO4 - 6,5g; AD - up 1l; and incubated for 24 hours. Formalin fixed specimens were put for dehydration into the alcohol 70° for 24 hours, then in alcohol 90°- 24h, trice in alcohol 96° for 24 hours each, then on room

temperature in solution of alcohol-ether 1:1 for 15 min and twice in Chloroform for 3 min each, then infiltrated with I paraffin on 37°C - 30 min, II and III paraffin on 56°C for 45 min each and then blocked in paraffin on room temperature. The blocks were stored at +4°C. Paraffin blocks were sectioned on a rotation microtome. Sections were put into the thermostat on 56°C for 20 min and then dewaxed. The sections were stained by routine Hematoxilin-Eosin for histological study. Light microscopy has been performed by Spencer microscope (X600 magnification, ocular X15, objective X40, and X1350 magnification, ocular X15, objective X90, oil immersion).

The study revealed in **skin** at the site of electricity apply the wavy structure of epidermal squamous layer is preserved, in some places it is prominently thinned and discontinued; the multi-layer structure of epidermal cells in this region is damaged as well. The papillary and reticular structure of dermis is preserved; the dermal vessels are widened and hyperemic, the picture of stasis is revealed. The spaces around vessels are widened; the connective tissue fibers are swelled and loosened. The structure of hair follicules is preserved, in some places the discontinuity of follicular layer is shown.

In two animals the **kidney** cortical glomerules showed intra-capillary erythrocyte diapedeses, the Bowman's capsule is detached from glomerular structure due to presence of edematous fluid. The tubules are widened, with erythrocyte diapedeses it them; in some sites the desquamated epithelial cells with erythrocytes completely fill the tubular lumen. The stoma is edematous; the connective tissue fibers are homogenized. In other two animals kidney the prominent parenchimatous and stromal edema is visible, as well as diapedesis of erythrocytes in tubules and glomerules, in intra- and extra-capillary spaces; the edematous changes are more prominent in medullar part of the organ.

In three animals the capsule of **suprarenal glands** is ruptured. The structure of cortical glomerular, fascicular and reticular layers is preserved. The precapillaries and especially capillaries are hyperemic and the picture of stasis is visible, the pericapillar space is somehow enlarged. In one animal the suprarenal cortex shows prominent glomerular, reticular and fascicular layers; the capillary hyperemia and stasis is visible; there are presented pretty large regions of fat depletion.

The microscopic study of animals' **hearts** in all cases revealed parenchymal and stromal edema of myocardium, dissociation of cardiomyocytes, accumulation of edematous fluid and massive diapedesis of erythrocytes in between them; in same regions there are revealed different local and diffuse fragmentations of cardiomyocytes.

Table. The morphological patterns of different tissues affected by electricity.

organ	tissue pattern
skin	• the wavy structure of epidermal squamous layer is preserved, in some places it is

	prominently thinned and discontinued; the multi-layer structure of epidermal cells is damaged; • the papillary and reticular structure of dermis is preserved; • the dermal vessels are widened and hyperemic, the picture of stasis is revealed; the spaces around vessels are widened; • the connective tissue fibers are swelled and loosened; • the structure of hair follicules is preserved, in some places the discontinuity of follicular layer is shown.
kidney	• cortical glomerules show intra-capillary erythrocyte diapedeses, the Bowman's capsule is detached from glomerular structure due to presence of edematous fluid; • the tubules are widened, with erythrocyte diapedeses it them; in some sites the desquamated epithelial cells with erythrocytes completely fill the tubular lumen; • the stoma is edematous, the connective tissue fibers are homogenized; • in some cases the prominent parenchimatous and stromal edema, diapedesis of erythrocytes in tubules and glomerules, in intra- and extra-capillary spaces are visible; • the edematous changes are more prominent in medullar part of kidney.
suprarenal gland	• the capsule is ruptured; • the structure of cortical glomerular, fascicular and reticular layers is preserved; • the precapillaries and especially capillaries are hyperemic and the picture of stasis is visible; • the pericapillar space is enlarged; • in some cases there are large regions of fat depletion.
heart	• parenchymal and stromal edema of myocardium; • dissociation of cardiomyocytes; • accumulation of edematous fluid and massive diapedesis of erythrocytes between cardiomyocytes; • in same regions there are revealed different local and diffuse fragmentations of cardiomyocytes.

As shown in table above, the microscopic study of slides taken from tissues damaged by electricity and dyed by routine Hematoxilin-Eosin reveals general structural changes that does not represent characteristic morphological pattern sufficient for diagnosis of electric injury. But there must be emphasized that even just general microscopic examination of material reveals the damages of cells prevalent along the electricity pathway to the tissue where the elongation and inter-orientation of cells' nuclei are noted. This phenomenon needs to be studied more deeply in detail as well by routine Hematoxilin-Eosin as other classical and modern morphological methods. The electricity damage of kidney and adrenal glands reflects the morphological pattern of stress that allows complex evaluation of damage but could have only orientating value for the estimation of cause of injury.

Due to results obtained from pilot part of the study there is considered in regard to determine the possible diagnostic criteria for electrical injury of tissues the experimental morphological study must continue on skin and myocardial material using routine Hematoxilin-Eosin as well as other classical and modern morphological methods of study.

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Key words: electric injury; electric lesion; electric torture; electric damage morphology; skin; kidney; suprarenal gland; heart.

Морфологические особенности повреждений тканей электрическим током

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Резюме

Целью исследования являлось изучение морфологической картины разных тканей, наиболее чувствительных к электрическому току и поврежденных техническим электричеством, для определения возможных диагностических критериев этого повреждения, с перспективой их применения при судебно-медицинской диагностике методов «электропыток». Пилотная часть исследования носила экспериментальный характер.

Микроскопическое изучение препаратов окрашенных гематоксилином и эозином выявило общие структурные изменения, которые не создают характерную морфологическую картину, пригодную для диагностики электрического повреждения. Не смотря на это, повреждение клеток выявляются по направлению электрического тока, что требует провести более обширное исследование с использованием разных классических и современных морфологических методов. Поскольку изменения тканей почек и надпочечников при электрическом повреждении не особенно отличаются от морфологической картины стресса, целесообразно продолжить экспериментальное исследование на материале кожи и миокарда с использованием дополнительных классических и современных морфологических методов.

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Summary

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The microscopic study of slides taken from tissues damaged by electricity and dyed by routine Hematoxilin-Eosin reveals general structural changes that does not represent characteristic morphological pattern sufficient for forensic diagnosis of electric injury. The electricity damage of kidney and adrenal glands reflects the morphological pattern of stress that allows complex evaluation of damage but could have only orientating value for the estimation of cause of injury.

Due to results obtained from pilot part of the study there is considered in regard to determine the possible diagnostic criteria for electrical injury of tissues the experimental morphological study must continue on skin and myocardial material using routine Hematoxilin-Eosin as well as other classical and modern morphological methods of study.