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Structural changes of the lymphomicrocirculatory bed of fibrous membranes with compression injury of soft tissues of the extremities

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Objective: Investigation of the state of the lymphocytocirculatory bed directly in the region of compression and in remote organ from it in the early postcompression period of the crush syndrome of severe degree.

Materials and methods: The experiments were performed among 60 adult rats weighing 180-250 g, which were divided into 2 groups: I - intact animals (control) - 20; II - model of postcompression period of the crush syndrome of severe degree - 40.Reproduction of the model of crush syndrome of severe degree was achieved by squeezing two pelvic limbs of rats for 8 hours under intramuscular ketamine anesthesia.

Results: The overall assessment of changes in the lymphomacirculatory bed during postcompression period of the crush syndrome severe degree has shown a growing in dynamics (after 1 and 3 days) pathological restructuring of the architectonics of microvascular networks, recalibration of diameters of all links in the direction of decrease, which are accompanied by dystrophic changes in histostructure of their walls.The severity of changes in the lymphatic bed of the subcutaneous fascia of the thigh in 1 day after postcompression period of crush syndromeis caused by impaired local hemodynamics.A large degree of changes in the lymphatic bed in the fibrous capsule of the kidney in 3 days postcompression period of the crush syndrome is explained by the maximum accumulation of myoglobin in the blood and urine.

Cunclusion: The first day of postcompression period of the crush syndrome of severe degree is accompanied by significant changes in the microangioarchitecture of the lymphatic bed with the recalibration of their diameters downward.In 3 days the progression of these changes is determined on the background of the microcomplex microcomplex dissection.

Keywords: lymphocirculatory bed, compression injury, soft tissue, fibrous membranes

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Compression syndrome is a life-threatening, severe trauma caused by prolonged compression of soft tissues. The significance of studying crush syndrome is associated not only with the growth of natural disasters, man-made disasters, but also with many not yet fully clarified or controversial issues of pathogenesis, including the mechanisms of blood disorder and lymph circulation.

Analysis of the literature data showed that questions of the state of the regional hemo-and lympho-microcirculatory bed remain poorly studied, especially in "non-compressed" tissues, while they determine the severity of the generalized response of the body in response

to compression [3, 6-8]. Ischemic toxicosis, leading to the death of the majority of people affected by SDS, develops during the period of decompression, from admission to the body (re-perfusion) from long-compressed tissue of ischemic toxins and cytolysis products [4]. The metabolic acidosis that develops at the same time is the cause of endotoxicosis, leading to systemic microcirculation in organs and tissues with impaired renal function, liver, gastrointestinal tract, and heart [1, 2, 5, 6].

The lymphatic system is part of the lymphoid (immune system) in its organization and function. With the participation of lymphatic vessels, all lymph passes through lymph nodes (filtered), into which lymph fluid that is absorbed into lymphatic capillaries turns into lymphatic fluid, together with metabolic products contained in it and found in foreign tissues.

The role of the lymphatic system is not in duplicating the venous bed and removing water from organs and tissues and substances dissolved in it, but in removing everything that may be dangerous for the body.

Purpose: study of the state of the lymphomicrocirculatory bed directly in the area of compression and in the organs distant from it in the early post-compression period, severe degree of pressure syndrome.

Materials and methods

The experiments were performed on 60 polo-mature outbred rats of both sexes, weighing 180-250 g., on the basis of the department of morphofunctional research at the Research Institute of Human Ecology in Mountain Territories at the Dagestan State Medical University.In accordance with the objectives of the study, the experimental animals were divided into 2 groups: I - intact animals (control) - 20; II - Severe postcompression period of crush syndrome model - 40. Reproduction of the Severe crush syndrome model was achieved by the well-known method [1] by squeezing 2 rat limbs of rats for 8 hours under intramuscular ketamine anesthesia (at a rate of 25 mg / g of body weight). After decompression, animals were observed in the first 72 hours (3 days), corresponding to the postcompression period of crush syndrome severe [5]. For morphological studies, animals were overrun by narcosis overdose 1 and 3 days after decompression (20 each).In all groups of experiments, film preparations of the subcutaneous fascia of the thigh, kidney fibrous capsule and small intestine mesentery, which after fixation in 10% neutral formalin were impregnated with nitric acid silver according to B., were investigated. A.T. Kupriyanov (1965) and stained with hematoxylin-eosin. A morphometric analysis of the impregnated preparations was carried out using a “MOV-15” screw eyepiece micrometer, with an increase of x120.

Microscopy and microphotography were carried out using a special video decomplex based on a Wilomed microscope (Germany) interfaced with a computer. All quantitative results of the study were processed statistically using the Statistica applied software package - 6.0, 2001. Student's t-test, the paired Wil-coxon, Mann-Whitney criterion was used. The critical level of statistical significance is $P \leq 0.05$.

Results and discussion

The analysis of impregnated microfractures in the I group of experiments showed that in the fibrous capsula of kidney more often than in the mesentery of small intestine and subcutaneous fascia of the thigh in intact rats, links of the lymphatic bed are detected. Lymphatic capillaries in the studied objects form characteristic “blind” outgrowths with relatively even, clear contours and a straight-line course (Fig. 1).

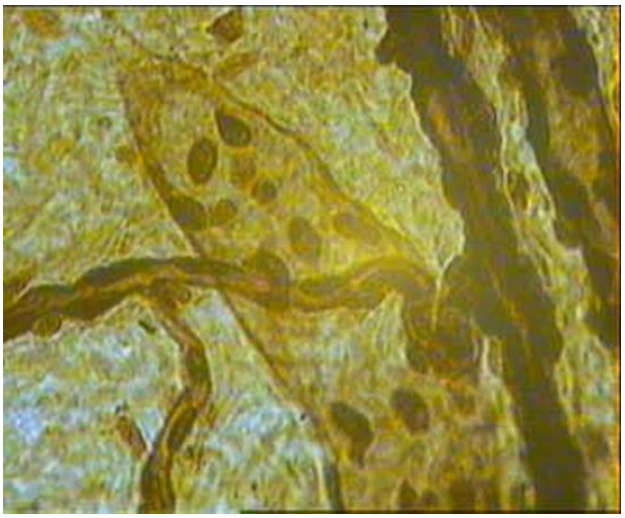

Figure1. Lymphatic capillary fragment with smooth, clear contours in the subcutaneous femur fascia of an intact rat. Impregnation with silver nitrate by V.V. Kupriyanov. Microphoto Magnification × 200.

As the number of nuclei of the endothelial cells of the capillary walls increases and the valves appear in the lumen, they become lymphatic postcapillaries. Morphometry showed a wide range of variation of their diameters for the studied objects. Thus, the diameter of the lymphatic capillaries in the fibrous capsule of the kidney on average was 49 ± 0.02 μm; in mesentery of small intestine - 65.3 ± 0.01 mi-

crons, and in subcutaneous fascia of the thigh - 51.3 ± 0.04 microns. The diameter of the forestry complex significantly exceeded the diameter of the capillaries and, on average, ranged from 77.0 ± 0.03 in the fibrous capsule of the kidney to 81.2 ± 0.05 in the subcutaneous fascia of the thigh and 83.7 ± 0.03 in the mesentery of small intestine. Postcapillaries, merging and increasing in diameter, formed collecting lymphatic vessels, which had a rectilinear or slightly wavy course and were often accompanied by blood vessels.The walls of the drugs were distinguished by a more dense concentration of round or oval in shape of endothelial cells. In the lumen of the drug, located independently of the blood vessels, well-differentiable double-leaf valves were found.

Morphometry showed a wider range of variations in their diameters in the studied objects. Thus, the median diameter of drugs in the subcutaneous fascia was 94.0 ± 0.02 μm, in the kidney fibrous capsule - 94.4 ± 0.01 μm, and in the mesentery of small intestine, - 102.7 ± 0.06 μm (Table 1).

Given the high variability of the boundaries of the fluctuations of the diameters of the links of the lymph channel in the studied objects, we found it possible to distinguish 2 metric classes of microvessels:

1) small vessels - I class,
2) large vessels - class II.

The representation of the indicated classes of microvessels (in%) by research objects and links of the lymphoma microcirculatory bed of intact rats in the total sample of diameters is indicated in Table 2.

Analysis of impregnated mesentery of small intestine, kidney fibrous capsule and subcutaneous fascia of the thigh preparations after 1 day of severely severe postcompression period of crush syndrome revealed signs of severe structural reorganization of the lymphatic channel of these objects in the form of: non-uniform distribution and density of vascular networks and deformation of the walls of the links of the lymphatic bed.

Certain differences were revealed in the degree of reaction of the lymphatic bed of the studied objects, which allows us to speak of their greater or lesser involvement in the complex of pathological restructuring. Constant signs of restructuring, characteristic of all objects, were changes in the microangioarchitecture of the lymphatic bed with deformation and rarefaction of the lymphovascular networks, most pronounced in the subcutaneous fascia of the thigh, where oval or polygonal capillary networks acquired angular shapes.

Table 1. The average values of the diameters of the links of the lymphatic bed of fibrous membranes in rats in the dynamics of the early postcompression period ofcrush syndrome (in microns; impregnation with silver; 15; n = 100; M ± m)

Object	Intact group			After 1 day.			After 3 days.		
Links of the channel	Lymph capillary	Lymph-type post-pillars	Lymph-tic vessel	Lymph capillary	Lymph-type post-pillars	Lymphatic vessel	lymph capillary	Lymphatic postcapillary	Lymphatic vessel
Subcutaneous fascia of the thigh	51,3± 0,04	77± 0,03	94± 0,02	25± 0,03 *	56,3± 0,01*	82,3± 0,03	37,2± 0,01	48± 0,03	71± 0,05
Fibrous capsule of the kidney	49± 0,02	81,2± 0,05	94,4± 0,01	37,5± 0,01*	67,5± 0,02	79,3± 0,07	33± 0,02	60,5± 0,03	72± 0,06
Mesentery of small intestine	65,3± 0,01	87,3± 0,03	102,7± 0,06	51,5± 0,03*	76± 0,01	91,3± 0,04	43± 0,04	70± 0,05	85,6± 0,03

Note: * - P≤0.03 compared with the intact group.

For all the objects studied, a large number of lymphatic vessels were found with deformed “corroded” contours, with local zones of narrowing gaps. This type of adjustment was most pronounced in the kidney fibrous capsule and subcutaneous fascia of the thigh. A rather convincing picture of the reduction nature of the vascular reorganization of the lymphatic bed after 1 day of the postcompression period of crush syndrome is also confirmed by the results of morphometry of capillary diameters, which more accurately allow us to estimate the intensity of their decrease in all studied objects (Table 1).The table shows a significant narrowing of the diameters of the lympatic vessels by 48 and 23% (of indicators in the intact group) in the kidney fibrous capsule and subcutaneous fascia of the thigh, which is confirmed by the

distribution of these vessels into classes in the form of an increase in the share of small vessels of class I (Table 3).

Table 2. The proportion of morphometric classes of the main links of the lymphatic bed of the studied objects of intact animals (%; n = 100)

An object	Links of the lymphatic bed		
	Lymphatic capillary	Lymphatic postcapillaries	Lymphatic vessel
Mesentery of small intestine	Class I - 30% (from 10 to 67 microns) Class II - 70% (from 68 to 124 microns)	Class I-18% (from 25 to 84 microns) Class II-82% (from 85 to 144 microns)	Class I-60% (from 50 to 103 microns) Class II - 40% (from 104 to 156 microns)
Fibrous capsule of the kidney	Class I-58% (from 14 to 48 microns) Class II-42% (from 49 to 82 microns)	Class I-62% (28 to 79 microns) Class II - 38% (from 80 to 130 microns)	Class I - 16% (from 53 to 96 microns) Class II - 54% (from 97 to 157 microns)
Subcutaneous fascia of the thigh	Class I-40% (from 13 to 50 microns) (Class II - 60% (from 51 to 102.6 microns)	Class I-27% (23 to 77 microns) Class II - 73% (from 78 to 154 microns)	Class I-49% (from 41 to 94 microns) Class II - 51% (95 to 188 microns)

Along with a decrease in the diameters of the lymphatic capillaries, their density per unit area, on individual preparations in kidney fibrous capsule and subcutaneous fascia of the thigh there were signs of a more complex restructuring, when only strands or outlines of their contours were in place of the “empty” capillaries (Figure 2). Changes in the lymphatic postcapillaries for all objects were also of a reduction nature with violation of the typical patterns of transfer of lymphatic capillaries to postcapillaries and were accompanied by deformation, argilophilia of both vessel walls and valve apparatus (Fig. 3).

Table 3. Changes in the share of morphometric classes of links of the lymphatic bed of the studied objects in the dynamics of the early post-compression period of crush syndrome (in%)

		Intact animals			After 1 day			After 3 days		
Object of study	Classes	Lymphatic capillary	Lymphatic postcapillary	Lymphatic vessel	Lymphatic capillary	Lymphatic postcapillary	Lymphatic vessel	Lymphatic capillary	Lymphatic postcapillary	Lymphatic vessel
Mesentery of the small intestine	I	30	18	60	47	29	67	53	35	78
	II	70	82	40	53	71	33	47	65	22
Fibrous capsule of the kidney	I	58	62	46	69	76	52	72	80	70
	II	42	38	54	31	24	48	28	20	30
Subcutaneous fascia of the thigh	I	40	27	49	75	46	66	80	52	69
	II	60	73	51	35	54	34	20	48	31

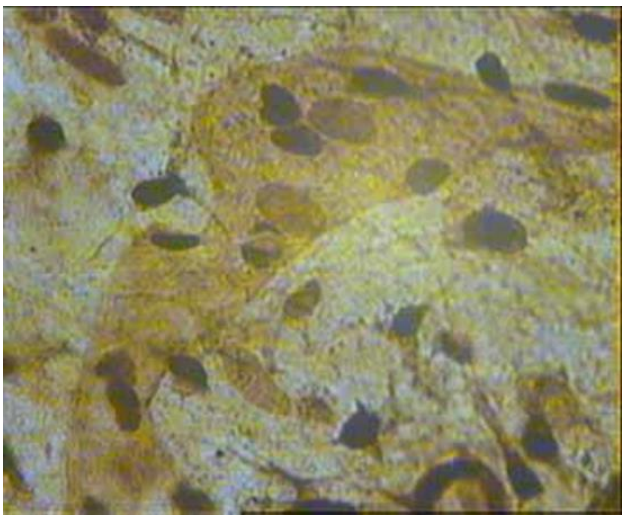

Figure 2. Lymphatic capillary with deformed, fuzzy contours in rat subcutaneous femur fascia. After 1 day, the post-compression period of crush syndromesevere. Silver impregnation according to V.V. Kupriyanov. Microphoto Magnification × 200**.**

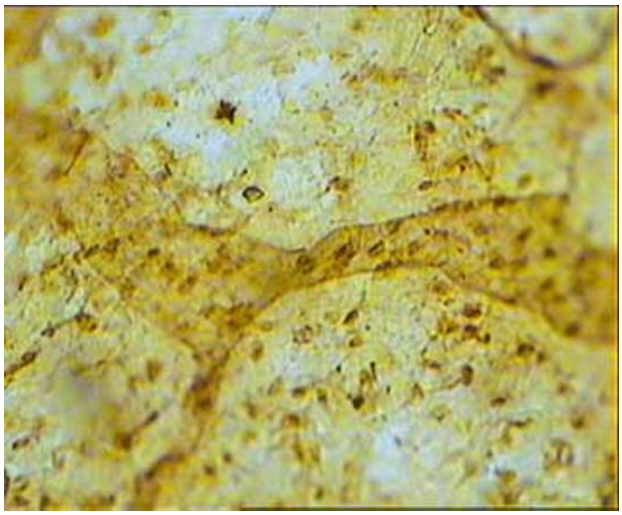

Figure 3. "Desolate" lymphatic capillary in the form of a cord in the mesentery of small intestine of a rat. After 1 day post-compression period of crush syndrome severe. They are preserved with silver nitrate by V.V. Kupriyanov. Microphoto magnification × 100.

Morphometry showed a reduction in their diameters in all studied objects.Thus, the maximum decrease in their diameters was noted in kidney fibrous capsule and subcutaneous fascia of the thigh by 26.8 and 23%, respectively (as compared to intact; P≤0.05). At this stage of observation, the morphological restructuring of drugs of the studied objects was also accompanied by a complex of structural changes, more pronounced in the kidney fibrous capsule and subcutaneous fascia of the thigh. On impregnated the kidney fibrous capsule and subcutaneous fascia of the thigh preparations, against the background of comparatively wide sinuses, fragments of significant narrowing of the ampoule zones were found (Fig. 4).

Deformation of the contours of drugs was accompanied by the porosity of their walls, which indicated the severity of degenerative, dystrophic processes in them. The morphometry of the diameters of drugs also showed their recalibration in the direction of decreasing, especially in kidney fibrous capsule and subcutaneous fascia (by 14 and 9% compared with the intact group; P≤0.05). Three days after the decompression of the crush syndromof a severe degree, the examination of the impregnated preparations of mesentery of small intestine, kidney fibrous capsule and subcutaneous fascia revealed a slight stabilization of the pathological restructuring of the architectonics and structure of the lymphoid channel in the field of compression, while maintaining and even progressing it "Remote organs", especially in the subcutaneous fasciaThus, subcutaneous fascia, after 3 days, the postcompression period showed a slight increase in the function-generating lymphatic vessels with clear, even contours, however, in the mesentery of small intestine, kidney fibrous capsule, the deformed lymphatic capillaries with areas of local diameter reduction still prevailed. Blood cells were found in the lumen of individual deformed lymphatic vesselss. The results of morphometry of the diameter of the lymphatic vesselss showed their further narrowing, especially in the mesentery of small intestine and subcutaneous fascia by 30 and 16% (as compared with the previous observation period;P≤0,05).

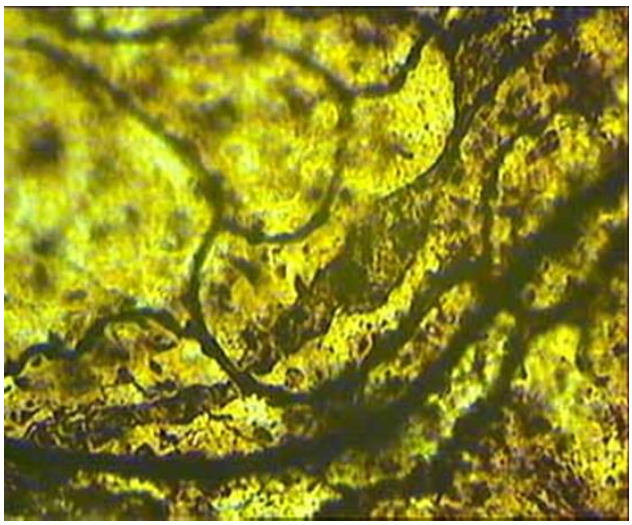

Figure 4. The reducing nature of changes in lymphatic postcapillaries with deformation, argyrophilia of the walls and valves in the fibrous capsule of the rat kidney. After 1 day postcompression period of the syndrome of long compression of a severe degree. Impregnation with silver nitrate by V. V. Kupriyanov. Micro photos. HC.×100.

3 days after decompression in all the studied objects were detected in the complete preservation of the signs of patologiche-tion of the restructuring of the Lymphatic postcapillaries and a collecting Lymphatic Vessels described in the previous monitoring phase. This fact was confirmed by the morphometry of their diameters with the distribution by classes, where their further reliable recalibration towards the decrease of the lumen, more pronounced in the subcutaneous fascia of the thigh and the Fibrous capsule of the kidney, is found. Thus, the overall evaluation of changes lymphomonocytosis bed in the early post-

compression period of crush syndrome, severe showed increasing in dynamics (through the 1 and 3 day) pathological reconstruction of the architecture of microvascular networks, the calibration of the diameters of all parts to decrease, accompanied by degenerative changes in the histological structure of their walls.

It is necessary to point out the unidirectional nature of the reorganization of the lymphoid bed in all studied objects, both in the "compression" area and far from it, although the degree of their reaction remains ambiguous, and among them there are no particular phenomena that go beyond the typical microvascular reactions.

The expression of changes in the lymphatic bed of the subcutaneous fascia of the femur after 1 day in the early post-compression period of the long-term compression syndrome is regarded as a manifestation of organ-specific changes [3] caused by violations of local hemodynamics. A large degree of changes in the lymphatic bed in the fibrous capsule of the kidney after 3 days of simulating the early post-compression period of the long-term compression syndrome is explained by the maximum accumulation of myoglobin in the blood and moche described in the works of J. Schuteu with co-authors (1981), I.I. Shimanko with co-authorship. (1983).

Findings

1. Severe lymphocirculation disorders are important in the pathogenesis of crush syndrome, and in the postcompression period, the lymphatic microcirculatory bed is the place of manifestation of the increasing synchronic changes of intraorganic microvessels in the subcutaneous fascia of the hip of the compressed limbs of the fibrous capsule of the kidney and Mesentery of the intestine. The first days of the early postcompression period of a long-term severe compression syndrome are accompanied by significant changes in the microangioarchitecture of the lymphatic bed of these objects with a recalibration of their diameters downward. After 3 days, the progression of these changes is determined against the background of the microcomplex microcomplex dissection.

2. Severe lymphocirculation disorders are important in the pathogenesis of cruch syndrom, and in the postcompression period, the lymphatic microcirculatory bed is the place of manifestation of the increasing synchronic changes of intraorganic microvessels in the subcutaneous fascia of the hip of the compressed limbs of the fibrous capsule of the kidney and Mesentery of the intestine. The first days of the early postcompression period of a long-term severe compression syndrome are accompanied by significant changes in the microangioarchitecture of the lymphatic bed of these objects with a recalibration of their diameters downward. After 3 days, the progression of these changes is determined against the background of the microcomplex microcomplex dissection.

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The authors declare the absence of overt and potential conflicts of interest related to the publication of this article.

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Authors' participation: concept and research design – M.A. Magomedov; collection and processing of materials - Kh.M. Magomedov; analysis of the data, writing a text. - A.A. Osmanova; editing the text – M.A. Magomedov.

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