MORPHOMETRIC STUDY OF THE ULTRASTRUCTURAL ORGANIZATION OF CAPILLARY ENDOTHELIOCYTES OF THE ILIAC LYMPH NODES IN PREGNANT RATS

N. A. Sklyanova, V. A. Shkurupii, and V. N. Grigor'ev

UDC 618.2-092.9-07:616.16-018.74-031:611.482]-091-076

KEY WORDS: lymph node; capillaries; pregnancy

Lymph nodes (LN) play an important role in the combined lymphatic and venous drainage of tissues. During pregnancy changes in the blood and lymphatic circulations in the utero-placental zone give rise to corresponding changes in the blood microcirculation in the regional LN of the uterus that are adaptive in character.

The aim of this investigation was to study the ultrastructural organization of endotheliocytes of blood capillaries in the iliac LN of rats during adaptation to pregnancy.

EXPERIMENTAL METHOD

Wistar rats aged 2.5-3 months and weighing 210-260 g (before pregnancy) were used. Counting by the stages of development of the extraembryonic organs, material for investigation was taken on the 11th, 17th, and 21st days of pregnancy. One right iliac LN was taken from each control and pregnant animal (five rats in each group). Material was fixed in 1% OsO_4 solution in phosphate buffer (pH 7.3) and embedded in Epon. Sections were cut from the material prepared for electron microscopy, stained with toluidine blue, and used to choose the area of cortex containing capillaries. Of 15 blocks from each animal, five blocks were selected as satisfying these demands. Two transverse sections each, cut through the arterial (diameter 2-7 μ) and venous (over 7 μ) portions of the capillaries [4], obtained from each block of material from LN were chosen for morphometric investigation. The objects for study were photographed under an instrumental magnification of 4200. Open square test systems were used, with final magnification of 70,000, and the ultrastructural organization of the endothelial cells of the arterial and venous portions of the capillaries of LN were investigated in accordance with general recommendations [3]. Differences between mean values were considered to be significant at the $p < 0.05$ level (Student's t test).

EXPERIMENTAL RESULTS

The volume of LN increased sharply (by 134.4%) toward the 17th day of pregnancy compared with the control, and remained increased (by 65.6%) until the end of pregnancy (Fig. 1). According to data in the literature [2], this was due largely to circulatory disturbances in utero-placental region at the stage of organogenesis of the placenta.

A sharp increase in the area of internal cross section of the venous part of the capillary by 57.4% and in the area of internal cross section of the arterial part of the capillary by 52.9% by the 11th day of pregnancy was observed (Fig. 2). During the same period the volume of the medullary intermediate sinuses was increased by 58% (Fig. 1). On the whole these data indicate manifestations of stasis in the system of the caudal vena cava during pregnancy, suggesting the probable formation of structural mechanisms of unloading of the vascular bed. The sharp increase in the number of fenestrae in the endothelium in both arterial and venous portions of the capillaries may be regarded as an "emergency" mechanism for the realization of this process (Table 1).

As was stated previously [1], the process coupled with activation of micropinocytosis of the luminal part of the plasmalemma of the capillary endothelial cells can be regarded as another mechanism of unloading the microcirculatory bed, realized at the subcellular level.

Laboratory of Lymphology, Institute of Physiology, Siberian Branch, Academy of Medical Sciences of the USSR, Novosibirsk. Central Research Laboratory, Novosibirsk Medical Institute. (Presented by Academician of the Academy of Medical Sciences of the USSR V. V. Kupriyanov.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 104, No. 11, pp. 630-633, November, 1987. Original article submitted October 23, 1986.

 0007-4888/87/0011-1626$12.50

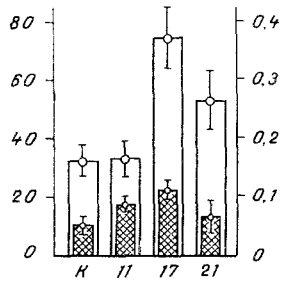

Fig. 1

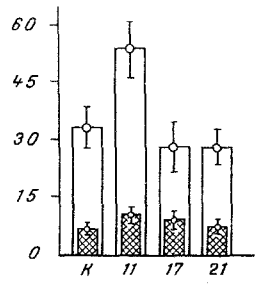

Fig. 2

Fig. 1. Results of determination of volumes of iliac LN (unshaded columns) and of its medullary intermediate sinuses (shaded columns) in male rats at different stages of pregnancy. Abscissa, stage of pregnancy (in days); ordinate, on left — volume of LN (in mm^3); on right — volume of medullary sinus (in mm^3). K) Control (nonpregnant rats).

Fig. 2. Results of determination of area of transverse section through capillaries (in μ^2) in iliac LN of female rats at different stages of pregnancy. Unshaded columns — venous portion, shaded — arterial portion. Remainder of legend as to Fig. 1.

In fact, as the results (Table 1) show, the number of micropinocytotic vesicles connected with the luminal portion of the plasmalemma of the endothelial cells of both arterial and venous portions of the capillaries was increased during pregnancy. The number of cytoplasmic micropinocytotic vesicles also rose sharply. Thus active transport of lymph from the pericapillary space into the blood stream takes place through the endothelial barrier of the microcirculatory bed. Under conditions of maximal severity of the manifestations of stasis in the vascular bed (Figs. 1 and 2), the increase in the number of micropinocytotic vesicles distributed freely in the cytoplasm was the structural basis for activation of transendothelial channel formation (Fig. 3), the possibility of which was mentioned previously [5, 6]. With compensation of the circulatory disorders the need for transendothelial channels disappeared, and by the 21st day of pregnancy their number was sharply reduced; under these circumstances the number of cytoplasmic vesicles was significantly increased (Table 1, Fig. 3). This was evidently due to fragmentation of the transendothelial channels into micropinocytotic vesicles. Since the number of luminal and basal micropinocytotic vesicles decreased in the arterial portion but remained at its former level in the venous portion, the additional population of cytoplasmic micropinocytotic vesicles could evidently have arisen only from transendothelial channels.

TABLE 1. Results of Counting Micropinocytotic Vesicles and Fenestrae in Endotheliocytes from Arterial and Venous Portions of Capillaries from Rat Iliac LN (M ± m)

Feature studied	Control (nonpregnant rats)	Stage of pregnancy, days		
		11	17	21
Arterial portion				
Microvesicles				
luminal	8,9±0,70	11,7±0,95*	15,37±1,30*	12,53±1,03*
basal	13,4±1,06	20,5±1,60*	19,84±1,39*	15,05±1,34
cytoplasmic	89,62±14,96	206,76±31,42*	191,97±27,83*	257,61±37,35*
Fenestrae	0,08±0,049	0,56±0,300	1,52±0,340	2,02±0,700
Venous portion				
Microvesicles				
luminal	11,6±1,20	15,4±2,27	24,68±1,63*	26,89±2,00*
basal	16,39±1,58	27,30±3,27*	23,72±1,19*	28,03±2,16*
cytoplasmic	140,14±24,52	336,83±55,24*	225,87±26,42*	344,16±41,98*
Fenestrae	0,02±0,020	0,48±0,190	2,30±0,560	0,60±0,340

Legend. Number of luminal and basal micropinocytotic vesicles counted per mean length of luminal and basal portions of plasmalemma of capillary cells. Number of cytoplasmic micropinocytotic vesicles counted per average cross section of cytoplasm of capillary cells. Asterisk indicates significant difference from control.

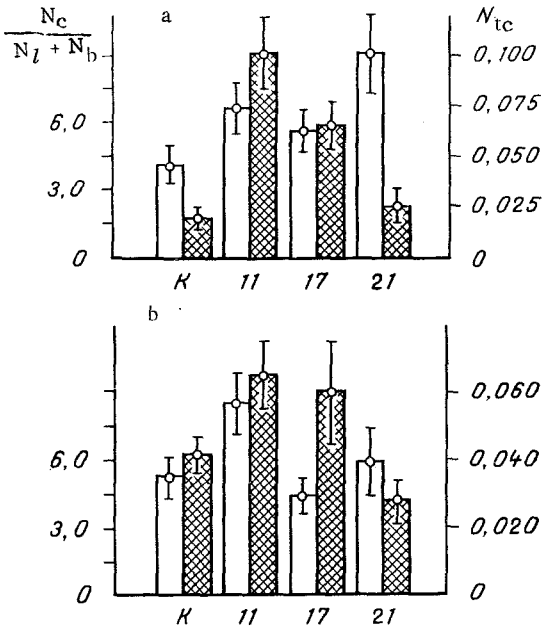

Fig. 3. Determination of ratio of cytoplasmic vesicles to total number of luminal and basal vesicles (unshaded columns) and number of transendothelial channels (shaded columns) in endothelial cells of arterial and venous portions of capillaries of iliac LN of female rats at different stages of pregnancy. N_c, N_l, and N_b) Number of cytoplasmic, luminal, and basal vesicles, respectively, per section through capillary; N_{tc}) number of transendothelial channels per section through capillary. a) Arterial portion; b) venous portion of capillary. Remainder of legend as to Fig. 1.

As regards the function of this increased lymph transport from the pericapillary space into the blood (lymph–blood), realized by activation of micropinocytotic vesicle formation on the basal portion of the plasmalemma, it can be postulated that this process compensates to some degree the function of the placenta, connected with removal of metabolites from the fetus. However, the direction of transport of the liquid contents of the blood and lymph both through the fenestrae and through the transendothelial channels will evidently be determined by the difference between the pressures in the blood capillaries and in the pericapillary space.

The similarity of the character of the structural transformations taking place at the cellular and subcellular levels of organization in both the venous and arterial portions of the capillaries during pregnancy (Table 1; Fig. 3) is noteworthy, and it enables this portion of the vascular system of LN to be regarded as a unique "load-shedding microregion". Structural transformations of this kind evidently are adaptive in connection with the change in conditions of the microcirculation in the lymph–blood system during pregnancy. Consequently, a change in the conditions of the microcirculation during pregnancy is coupled with development of a combination of adaptive structural changes in the capillaries of LN, realized at different structural levels of organization. Among these must be included enlargement of the lumen of the arterial and venous portions of the capillaries, increase in volume of the intermediate sinuses, increased fenestration of both parts of the capillaries, a sharp increase in the formation of micropinocytotic vesicles, stimulation of transendothelial channel formation, and the acquisition of certain similar structural features of the venous and arterial portions of the capillaries.

LITERATURE CITED

1. Yu. I. Borodin and V. N. Grigor'ev, The Lymph Node during Circulatory Disturbances [in Russian], Novosibirsk (1986).
2. Yu. I. Borodin, N. A. Sklyanova, Yu. I. Sklyanov, and S. V. Patrusheva, Arkh. Anat., No. 4, 18 (1986).
3. E. R. Weibel, Morphometry of the Human Lungs [Russian translation], Moscow (1970).
4. V. A. Shakhlamov, Capillaries [in Russian], Moscow (1971).
5. R. R. Bruns and G. E. Palade, J. Cell Biol., 37, No. 3, 277 (1968).
6. F. J. Cornillie and J. M. Lauweryns, Cell Tissue Res., 237, No. 2, 371 (1984).