I. Experimental problems

SOME ULTRASTRUCTURAL ASPECTS OF ENDOTHELIAL REACTIVITY

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Key-words: endothelial cell — reactivity — ultrastructure — permeability—metabolism — Weibel-Palade bodies

Blood vessel endothelium is an active mediator between blood and periendothelial tissues (5). In this sense, the investigation of the endothelial cell (EC) reactivity towards different stimuli has a particular importance for characterization of the biological properties of the endothelium. Besides it enables the determination of the reaction capacity limits of the endothelium. There are numerous data from in vitro studies (6) concerning this problem while, to our knowledge, there are no reports about endothelial reactivity in situ, i. e. about the total and real effect of the stimuli.

Material and methods

The investigations were carried out on 30 male Wistar rats treated with serotonin (0.125 mg/100 g), histamine (0.125 and 0.250 mg/100 g) as well as on 10 spontaneously hypertensive rats (SHR) at the stage of stabilized hypertension (9, 12). Some of them were intravenously injected with ferritin. Materials for the TEM investigation were taken from the aorta, pulmonary trunk, caval veins, femoral artery and femoral vein, from the microcirculatory vessels of the gut and pancreas. The observations were carried out on an JEM 7A electron microscope.

Results and discussion

It was established that independently of the localization and type of the vessel the stimuli applied induced some changes in the ECs which pertained first and foremost to their synthetic-metabolic functions and permeability properties.

Synthetic-metabolic changes

First of all they were manifested with an activation of the rough endoplasmic reticulum (RER) and Golgi complex (Gc) predominantly in arterial vessel ECs (fig. 1-a); in this respect the fenestrated capillaries in the gut and the pancreas were slightly affected. Similar data concerning hypertension were reported by other authors, too (3, 11). By this way, the EC demonstrates morphological readiness for production and secretion of matrix elements for the periendothelial space. This was expressed by an overall thickening and multiplication of the basement membrane and by an increase of the collagen fibers.

It is of particular importance to point out the increased number of Weibel-Palade bodies under serotonin treatment and in SHR (fig. 1-b). This effect is si-

milar to that observed in muscular arteries under renal hypertension (2, 7). Factor VIII (von Willebrand's factor) (1, 6) present in them is related to platelet adhesion on the luminal EC surface. Therefore, we suggest that the quantity of the cell-bound factor VIII increases which may result in an activation of platelet adhesion. It is known that in this process a number of endothelium damag-

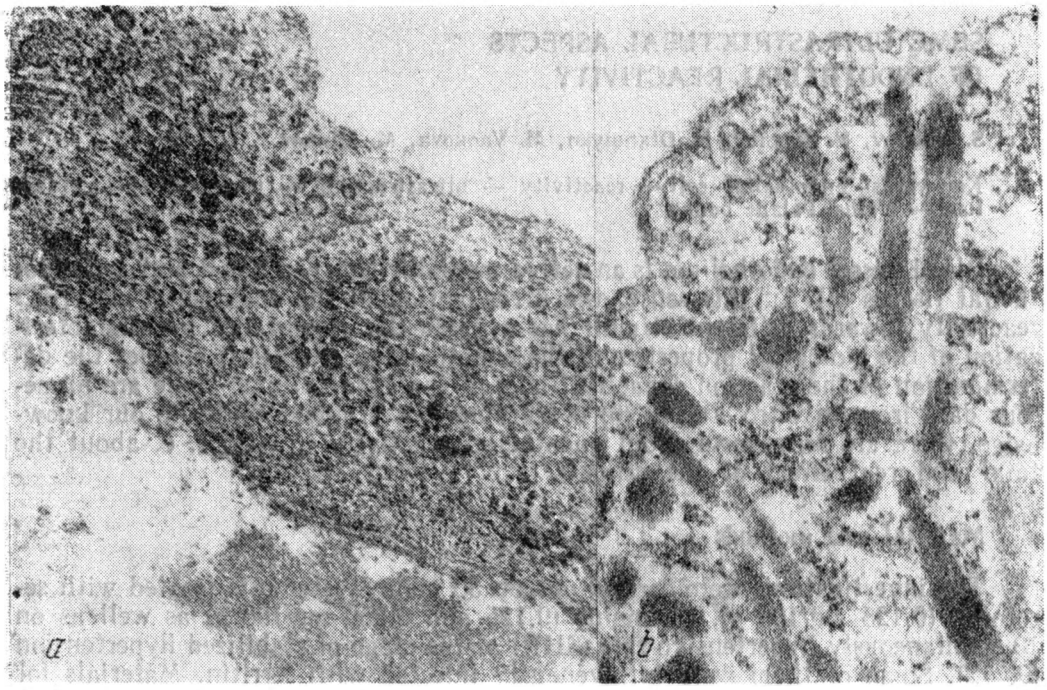

Fig. 1. Endothelial cell from SHR aorta. a) Gc activation. Magnification 20 000×2.2. b) Increased number of Weibel-Palade bodies. Magnification 30 000×2.2.

ing substances are liberated including serotonin. The latter probably affects EC in the above mentioned sense (13). Thus, at endothelial level, in most vessels a peculiar vicious circle of endothelial-platelet interactions is to be proposed, namely: serotonin — EC — increased number of Weibel-Palade bodies — activated platelet adhesion — serotonin, etc. After serotonin and histamine treatment lysosomes also increase and autophagia processes activate, respectively. In almost all ECs luminal bullous evaginations are detected which correlate with the stigmatae described in the literature (8).

Permeability changes

First of all we established a biostatistically increased number of micropinocytotic vesicles (MPV) by 30—50 per cent in any localization. This is presented on table 1 which shows their mean values in the thoracic aorta. MPV exhibited an increased tendency towards multivesicular transcellular channel formation (fig. 2). Thesse data correlated with the phenomena of periendothelial oedema established in all the vessels and resembled the results reported by other investigators (4) obtained in hypoxic-anoxic conditions. We established after serotonin and histamine treatment in the postcapillary vessels of the gastrointestinal tract

Table 1

Mean values of micropinocytotic vesicles in the thoracic aorta

Stimulus	Luminal MPV	Abluminal MPV	Intracellular MPV
SHR	58.01±0.49	55.05±0.51	64.14±0.47
serotonin	58.13±0.58	54.28±0.62	73.06±0.75
histamine	55.06±0.51	51.18±0.41	60.45±0.47
control	40.51±0.43	33.03±0.29	44.97±0.48

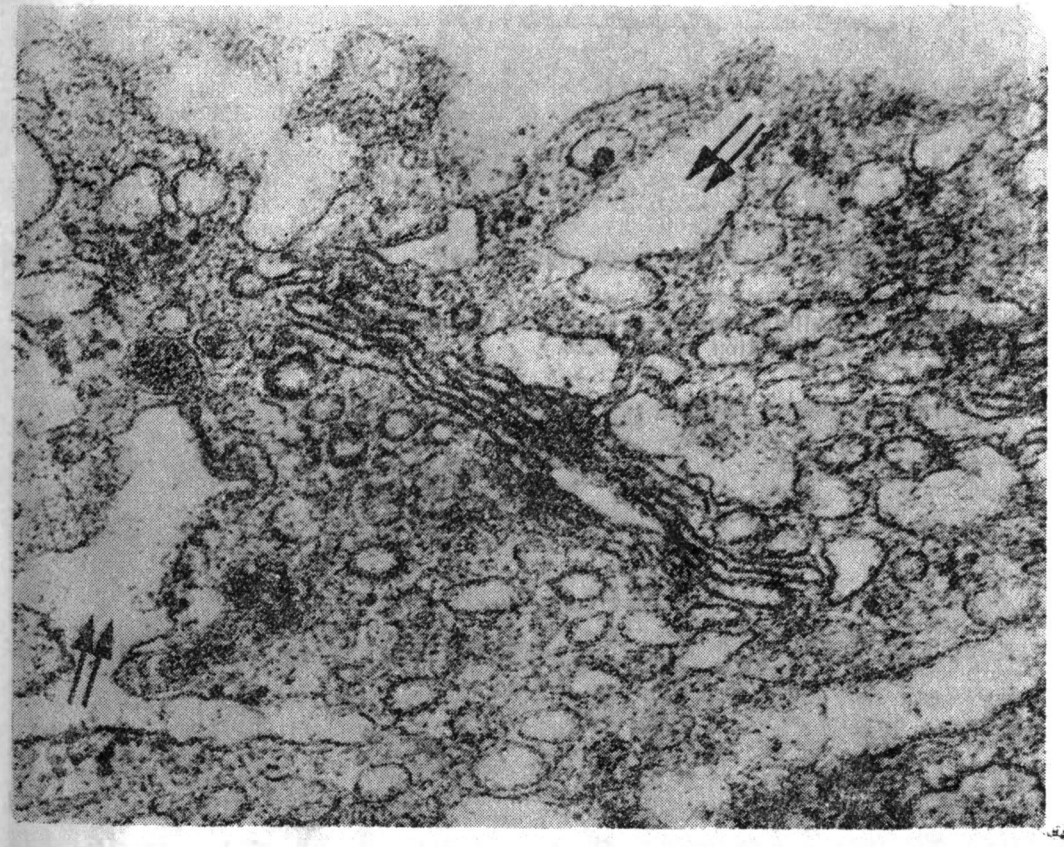

Fig. 2. Endothelial cell from rat intestinal mucous capillary after histamine treatment (0.250 mg/100 g b. w.). Transcellular channels of greater size (arrows). Magnification 50 000×2.2.

and, occasionally, in the large arteries, «openings» of the intercellular junctions (fig. 3) as well as the occurrence of focal endothelial lesions which may cause alterations of the barrier function of the endothelium (10). After histamine treatment an increase of the fenestrated areas of capillary EC at places where they are normally absent (stomach) can be observed. It is evident that the ECs respond to the administration of biogenic amines no only by MPV increase but also by more profound changes leading to permeability modulation with essential values for the vascular wall and the pericapillary space. The fenestrated capilla-

ries of the gut and the pancreas are relatively resistant in this respect. The comparative data about the capillary vessels in the exocrine pancreas and the islets of Langerhans (fig. 4) are particularly indicative: in the former MPVs are consi-

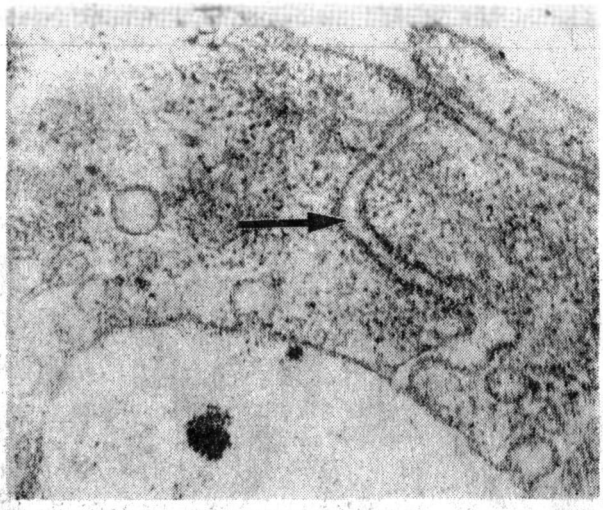

Fig. 3. Open intercellular junction (arrow) in rat endothelium after i. v. serotonin application — 90 sec. Magnification 60 000×3.25.

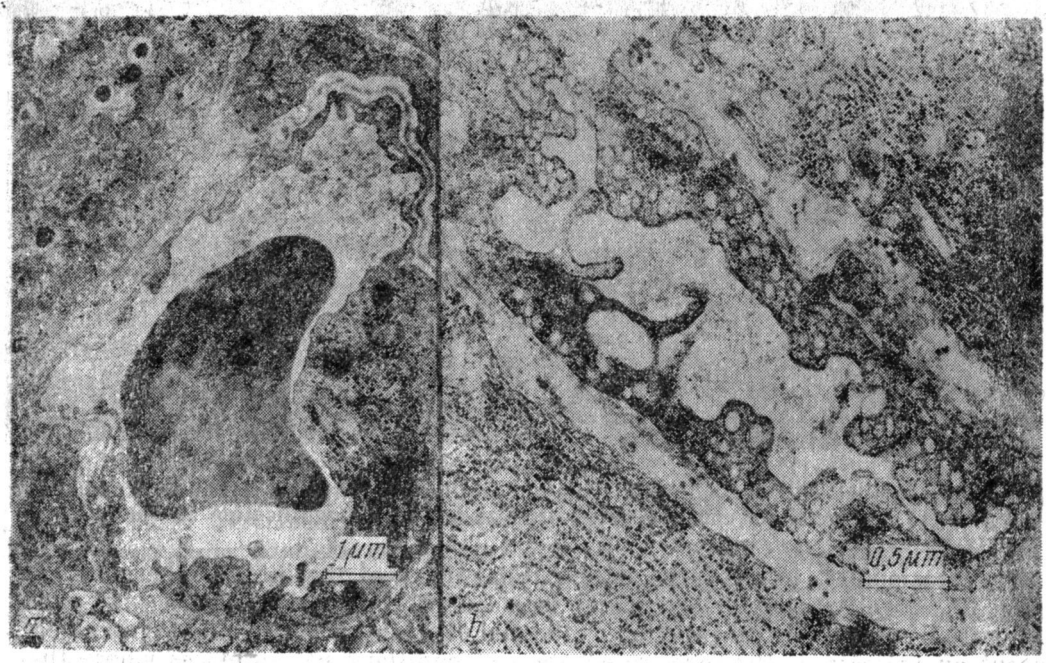

Fig. 4. Capillaries in both pancreas parts after i. p. serotonin application — 15 min. The vessels of the islets of Langerhans (a) do not show any significant changes while these in the exocrine part (b) show an increased vesiculation and form numerous projections. Magnification: a) 11 000×2.2 b) 20 000×2.2.

derably increased and luminal projections appear while the latter ones show no remarkable changes.

We can conclude that concerning reactivity ECs are characterized by numerous common reactions but they also demonstrate some topographic peculiarities and a certain specificity towards the particular stimuli. The effects are considered to be of general nature and can be regarded as summarized result from the direct influence of the stimulus, together with the effect of the neurohumoral mechanisms which are thus unlocked.

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НЕКОТОРЫЕ УЛЬТРАСТРУКТУРНЫЕ АСПЕКТЫ РЕАКТИВНОСТИ ЭНДОТЕЛИЯ

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РЕЗЮМЕ

С использованием электронно-микроскопской техники исследована реакция эндотелиальных клеток крупных кровеносных сосудов и капилляров некоторых органов (желудочно-кишечного тракта, поджелудочной железы) в условиях спонтанной гипертонии и при воздействии серотонином и гистамином. Установлены изменения синтетико-метаболитной и пермеабилитетной функций эндотелиальных клеток. Установлено также активирование зернистого эндоплазматического ретикулума, комплекса Гольджи, клеточной аутофагии, увеличение числа телец Weibel-Palade и лизомсом. Отмечено сигнификантное нарастание числа микропиноцитозных везикул с луменальной, аблуменальной и интрацеллюлярной локализацией, что сопровождается подчеркнутой склонностью к слиянию и образованию поливезикулярных трансцеллюлярных каналов. В некоторых органах (например в желудке) обнаруживается увеличение фенестрированных капиллярных участков. Установлено, что эпителиальные клетки фенестрированных капилляров более резистентны к примененным стимулирующим факторам по сравнению с эндотелиальными клетками остальных сосудов.