FUNCTIONAL MORPHOLOGY OF THE VASCULAR PART OF THE TRANSPORT SYSTEM OF THE PANCREAS

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The vascular part of the pancreatic transport system consists of the capillaries, the pericapillary space, and the intercellular spaces. On the surface of the gland cells and fibroblasts there are cytoplasmic lamellae, facing the pericapillary and intercellular spaces. Injection of ferritin showed that they fulfill the role of a metabolite-distributive complex between the pericapillary and intercellular spaces. The vascular part of the pancreatic transport system is responsible for supplying raw materials to the gland cells and conveying hormones, destroyed cell structures, and some digestive enzymes into the capillary system of the gland.

KEY WORDS: pancreas; cytoplasmic lamellae; metabolite-distributive complex.

The pancreatic transport system consists of two parts: the vascular part and the ducts. The vascular part consists of capillaries, the pericapillary space, and the intercellular spaces. In the modern view [1, 2, 4], this part of the transport system is responsible for supplying the gland cells with metabolites required for the synthesis of specific secretions, and for the removal of pancreatic hormones into the vascular system. A study of the ultrastructural organization of the vascular part of this transport system [2] showed that on the surface of the gland cells there are cytoplasmic lamellae, which can separate the pericapillary space from the intercellular spaces. It was accordingly postulated [1] that the cytoplasmic lamellae fulfill the role of a metabolite-distributive complex, by means of which the asynchronous function of the gland cells is regulated. However, this hypothesis requires convincing experimental evidence.

The object of this investigation was to continue the study of the structure and function of the vascular part of the pancreatic transport system.

EXPERIMENTAL METHOD

Grass frogs, chickens, and albino rats were used. Under ether anesthesia ferritin was injected intravenously into the animals in a dose of 20 mg/100 g body weight, and 20 min later the material for investigation was taken intravitally. Pieces of the pancreas were fixed for 1 h in 3% glutaraldehyde, then postfixed in Millonig's mixture at pH 7.3 for 3 h, dehydrated in acetone, and embedded in Epon–Araldite. The pieces were then stained with 0.5% uranyl acetate in 70° acetone. Ultrathin sections were cut and examined in the IEM 100 B electron microscope.

EXPERIMENTAL RESULTS

The vascular part of the pancreatic transport system of the grass frog, chicken, and albino rat obeys the same principle in its structure. It consists of capillaries with a fenestrated endothelium, a pericapillary space, and intercellular spaces. Cytoplasmic lamellae, projecting into the intercellular spaces and into the pericapillary space, are present on the lateral surfaces of the gland cells and on fibroblasts. In some areas the cytoplasmic lamellae of neighboring cells, overlapping each other, separate the intercellular spaces from

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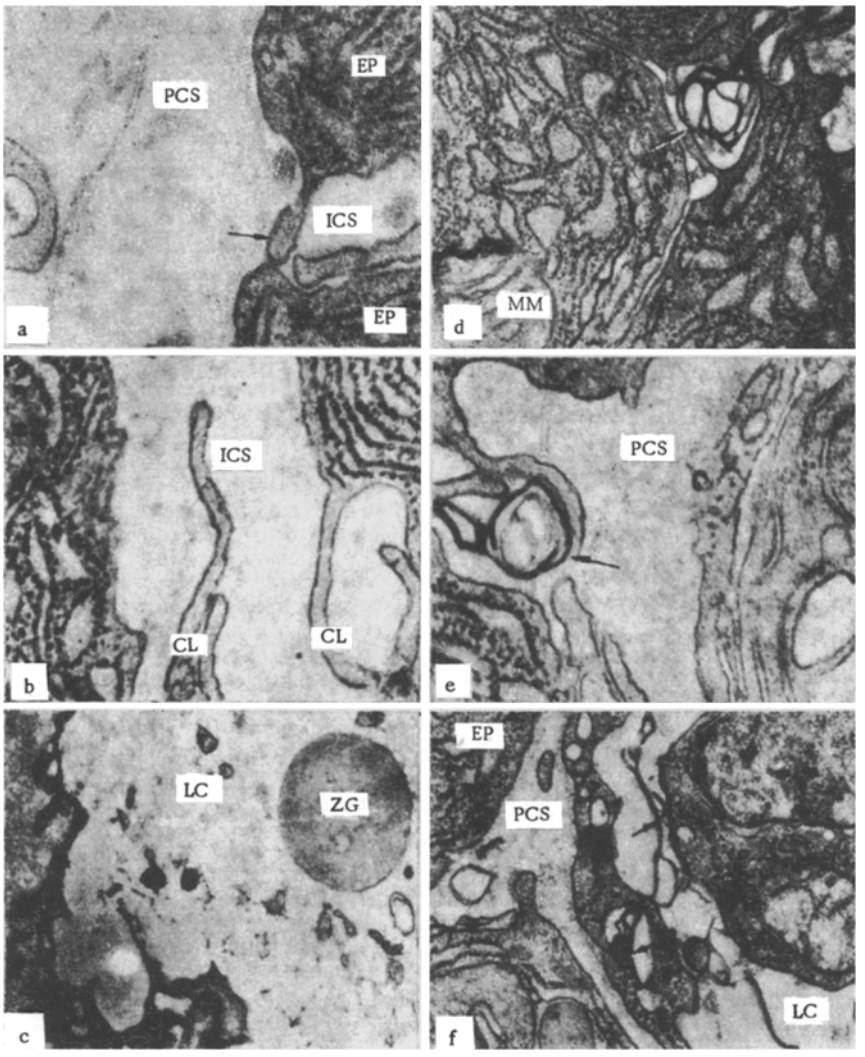

Fig. 1. Vascular part of the pancreatic transport system: a) ferritin in pericapillary space before cytoplasmic lamellae (arrow) of exocrine pancreocytes of rat pancreas (51,000 ×); b) ferritin in intercellular space of chicken pancreas (40,000 ×); c) zymogen granule in capillary lumen of grass frog pancreas (20,000 ×); d) myelinized mitochondrion in exocrine pancreocyte and disintegrated structures (arrow) in intercellular space of chicken pancreas (24,000 ×); e) disintegrated structures expelled (arrow) from intercellular space into pericapillary space of chicken pancreas (40,000 ×); f) disintegrated structures (arrow) in capillary lumen of chicken pancreas (20,000 ×). PCS) Pericapillary space, ICS) intercellular space, CL) cytoplasmic lamellae, EP) exocrine pancreocyte, LC) lumen of capillary, ZG) zymogen granule, MM) myelinized mitochondrion.

the pericapillary space, whereas in others they are absent, so that communication between these two parts of the transport system is undisturbed. Injection of ferritin showed how the spread of its particles outside the capillary system depends on the functional state of the cytoplasmic lamellae of the gland cells and fibroblasts. In areas where they blocked communication between the pericapillary space and intercellular spaces, no ferritin was observed to penetrate into the latter (Fig. 1a). Conversely, in areas where the pericapillary space was not blocked by cytoplasmic lamellae, ferritin penetrated freely into the intercellular spaces (Fig. 1b). These experiments confirmed the view [2] that the cytoplasmic lamellae of the gland cells and fibroblasts fulfill the role of a metabolite-distributive complex and control the movement of tissue fluid from the pericapillary space into the intercellular spaces. At the same time morphological evidence of movement of metabolites in the opposite direction, i.e., from the cell toward the capillary, was seen. Evidence of this was given by disinte-

grated cell structures and zymogen granules of exocrine pancreocytes (Fig. 1d, e, f) in the intercellular spaces and their subsequent transport into the pericapillary space and from it into the capillary system. In those cases when the cytoplasmic lamellae covered the communication between the intercellular spaces and pericapillary space, structures expelled from the cells were held up in the intercellular spaces.

It can be concluded from these findings that the movement of substances from the intercellular spaces into the pericapillary space is a controllable process also performed with the aid of the metabolite-distributive complex.

Expulsion of disintegrated cell structures into the intercellular spaces and their transport into the pericapillary space and capillaries under pathological conditions has also been observed in the liver, myocardium, and thyroid gland [3]. The writers' observations show that a similar pathway exists under normal conditions in the pancreas. As regards the concrete fact of the elimination of zymogen granules (Fig. 1c), conveying digestive enzymes into the intercellular spaces and capillary system, the blood level of pancreatic enzymes is evidently maintained by a mechanism of this sort.

It can be concluded from the facts described above that the vascular part of the pancreatic transport system consists not only of capillaries, the pericapillary space, and the intercellular spaces but also of a unique metabolite-distributive complex consisting of cytoplasmic lamellae of the gland cells and fibroblasts, with the aid of which metabolites are distributed between the pericapillary space and the intercellular spaces. Besides the functions of supplying raw materials to the gland cells and of removing hormones as described previously, the vascular part of the transport system is also responsible for the function of evacuation of disintegrated cell structures and of some digestive enzymes.

LITERATURE CITED

1. Yu. K. Eletskii and V. V. Yaglov, Abstracts of Proceedings of a Scientific Conference in Memory of Academician of the Academy of Medical Sciences of the USSR Professor D. A. Zhdanov. Problems Concerned with the Functional Anatomy of the Vascular System [in Russian], Moscow (1974), pp. 77-78.
2. Yu. K. Eletskii and V. V. Yaglov, Byull. Éksp. Biol. Med., No. 1, 84 (1976).
3. I. P. Lebkova, Arkh. Pat., No. 9, 25 (1973).
4. A. F. Baradi and D. J. Brandis, Z. Zellforsch., 101, 568 (1969).