MORPHOLOGICAL ASPECTS OF ASYNCHRONOUS SECRETION OF PANCREATIC CELLS

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An electron-microscopic study of the pancreas of several vertebrates showed that asynchronous secretion of the pancreatic cells is controlled by means of cytoplasmic cell appendages that determine the selective access of primary materials to the gland cells. The outflow of hormones and other metabolites from the intercellular spaces into the pericapillary space is also controlled in the pancreas by means of cytoplasmic appendages.

KEY WORDS: pancreas (secretion); cytoplasmic appendages.

The following periods or phases of activity are conventionally distinguished in the secretory cycle of pancreatic cells: entry of raw materials from the blood into the cell, synthesis of the primary secretion, its maturation, accumulation, and liberation [1, 2]. The first phase has received least study. According to many workers [1-3], the entry of the raw materials into the gland cells starts with their transfer through the capillary wall into the pericapillary space. The subsequent pathways of transport have received little study. Some workers [2] consider that the raw materials pass from the pericapillary space into the cell through the basal part of the plasma membrane, whereas others [3] deny that this could occur on the grounds that in this part of the plasma membrane there are no carrier enzymes. In their opinion, raw materials pass from the pericapillary space initially into the intercellular spaces, and later they pass through the plasma membrane of the lateral surfaces of the cells into their cytoplasm. Histochemical evidence in support of this view is given by the existence of carrier enzymes in the plasma membrane of the lateral surfaces of the cells [3]. However, these views regarding methods of transport of the raw materials do not explain why, with the asynchronous type of pancreatic secretion, some intercellular spaces are distended and filled with the same contents as the pericapillary space, whereas others are strongly contracted and appear empty.

All that can be postulated is that where the pericapillary space connects with the intercellular spaces, there ought to be certain structural formations which allow or prevent access of the raw materials to particular pancreatic cells. The investigation described below was carried out to study this problem.

EXPERIMENTAL METHOD

The pancreas of the grass frog, Horsfield's terrapin, the hen, rat, and cat were investigated. Pieces of the organ were fixed in 3% glutaraldehyde for 1 h, then treated with osmium in Millonig's mixture for 2 h, dehydrated in alcohols, and embedded in Durcupan. Sections were stained by Reynolds' method [4] and examined in the UÉMV-100K electron microscope.

EXPERIMENTAL RESULTS

The observations showed that in all species of animals studied the pancreatic secretory cells were in various phases of the secretory cycle. Pinocytotic vesicles and fenestrated areas, indicating the transport of raw materials through the capillary wall into the pericapillary space, were often observed in the endo-

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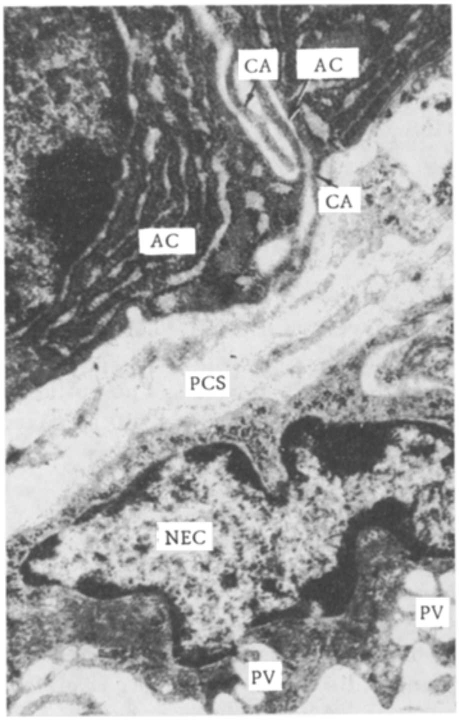

Fig. 1

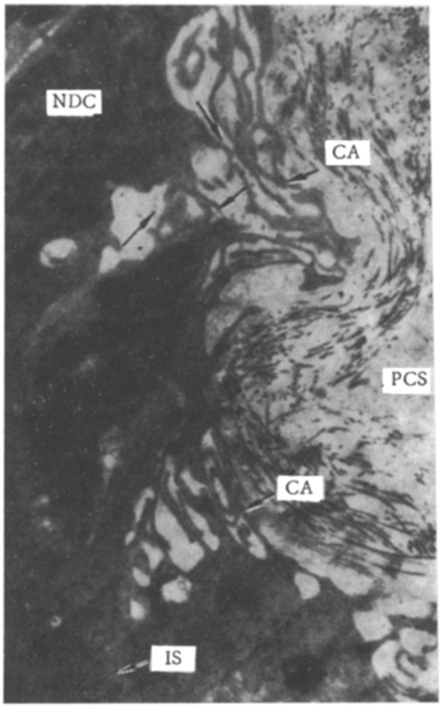

Fig. 2

Fig. 1. Pancreas of a hen. Cytoplasmic appendages of basal-lateral surfaces of acinar cells are arranged in strict order, closing the communication between the pericapillary space and intercellular space; 12,600×. AC) Acina cell; PCS) pericapillary space; CA) cytoplasmic appendages; NEC) nucleus of endothelial cell; PV) pinocytotic vesicle.

Fig. 2. Pancreas of grass frog. Different forms of arrangement of cytoplasmic appendages in cells of an efferent duct. One intercellular space is completely separated from the pericapillary space, another (indicated by arrow) retains some communication with it; 6000×. NDC) Nucleus of duct cell; IS) intercellular space; CA) cytoplasmic appendages; PCS) pericapillary space.

thelium of capillaries adjacent to glandular cells. The contents of the pericapillary space were in contact with the plasma membrane of adjacent acinar, duct, and endocrine cells. In the basal and lateral parts of these cells cytoplasmic appendages resembling thin plates or microvilli were found. They varied widely in their arrangement. In some acini, ducts, and islets the cytoplasmic appendages lay one behind the other to form a sort of lock, preventing access of the substances from the pericapillary space to the intercellular spaces (Fig. 1). In other acini they were firmly pressed against the surface of the cells, so that the way was open for the raw materials from the pericapillary space. Intermediate (between the two extreme states) types of relationship between the basal and lateral cytoplasmic appendages also were observed (Fig. 2). This polymorphism of the arrangement of these formations suggests that, functioning like a "lock," they control the selective access of metabolites from the pericapillary space to the intercellular spaces. However, the function of these cytoplasmic appendages is probably not confined purely to regulation of the flow of materials from the pericapillary space into the intercellular spaces. Liberation of secretory granules from the endocrine cells into the intercellular spaces and their transport into the pericapillary space, controlled by the cytoplasmic appendages, was constantly observed (Fig. 3). This indicates that they are a special type of regulator of the outflow of hormones and other metabolites from the intercellular spaces into the pericapillary space, from which these substances then enter the blood stream of the pancreas.

Cytoplasmic appendages of cells at the boundary of the communication between the pericapillary space and intercellular spaces have been found in the writers' laboratory in the liver (A. M. Astakhova) and parotid gland (G. K. Tsoi). These facts suggest that the mechanism regulating the distribution of metabolites between the pericapillary space and intercellular spaces described above is not characteristic of the pancreas alone, but is evidently a universal feature of all glandular organs.

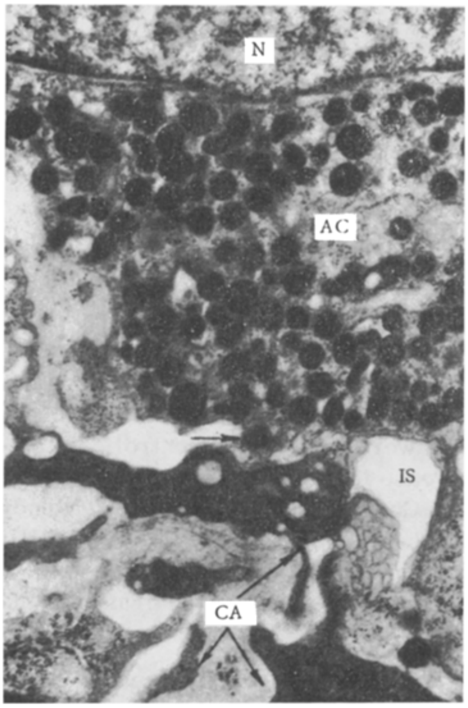

Fig. 3. Pancreas of grass frog. Liberation of secretory granules of A cells into intercellular space. Transport of granules is controlled by cytoplasmic appendages; 8,850×. AC) A cell; CA) cytoplasmic appendages; IS) intercellular space; N) nucleus of endothelial cell.

It can accordingly be concluded from these findings that the cytoplasmic appendages of the basal and lateral surfaces of cells play the role of a special metabolite-distributive device, ensuring the asynchronous functioning of the acinar, duct, and islet cells of the pancreas.

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