PROTEIN DIGESTION IN EARLY POSTNATAL ONTOGENY

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Newborn rats aged 3 days, removed from their mothers for 3 h, were given 0.4 ml of a 20% aqueous solution of human albumin by mouth. Pieces of tissue from the proximal jejunum and the renal cortex of the animals were investigated electron-microscopically by Gomori's reaction for acid phosphatase. In early postnatal ontogeny protein is absorbed in the intestine by pinocytosis, after which it is transported into the Golgi complex and discharged into the intercellular space, from which it enters the lymphatic capillaries. The accumulation of electron-dense protein-containing cytosomes, with high acid phosphatase activity, could be seen in the proximal tubules of the kidneys. It is postulated that the kidneys have a proteolytic digestive function in early postnatal ontogeny.

KEY WORDS: protein digestion; digestion in ontogeny; proximal tubules of the kidney.

In early postnatal ontogeny digestion in the gastrointestinal tract is inadequately developed: intraluminal digestion is imperfect because of the undifferentiated nature of the secretory epithelium of the stomach and pancreas [1, 3, 5]. In newborn animals, for instance, the absorption of milk proteins and of exogenous proteins has been found to take place in an unchanged form, without preliminary hydrolysis and transport into the bloodstream [6, 7, 10, 12]. The subsequent changes taking place in these proteins and the tissues and organs that break them down into monomers before utilizing them are not yet known. Considering the extent of this unsolved problem it was decided to commence its study with objects whose proteolytic function is known in the adult animal. The greatest attention has been paid in this respect to the epithelium of the proximal tubules of the kidneys. Numerous experiments by various workers have been described, in which large quantities of foreign protein were injected parenterally and its hydrolysis in lysosomes of the proximal portion of the kidney nephron was then studied [2, 4, 8, 9, 13]. It is also known that even in the absence of loading, a certain proportion of the plasma proteins is filtered, reabsorbed by the proximal tubules, and then subjected to proteolysis [11].

The object of this investigation was to study the pathways of intracellular protein transport in the intestine and the possiblity of its hydrolysis in the kidney in early postnatal ontogeny.

EXPERIMENTAL METHOD

Newborn rats aged 3 days were removed from their mothers for 3 h and then given by mouth 0.4 ml of 20% aqueous solution of human albumin, after which they were killed at intervals of 10, 30 and 60 min. Similar animals aged 3 days and taken from their mothers for 3 h were used as the control. Pieces of tissue from the proximal jejunum and the renal cortex were fixed in 1% buffered osmium tetroxide solution and taken through alcohol before being embedded in Epon 812. The ultrastructural detection of acid phosphatase, as an indicator of the lysosomes, was carried out by Gomori's method.

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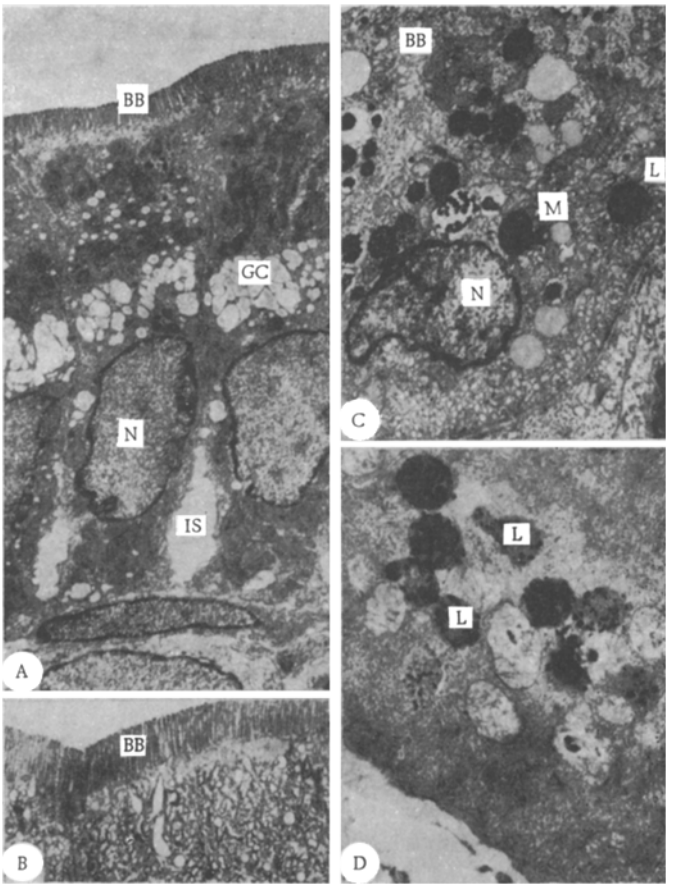

Fig. 1. Enterocytes 30 min (A, B) and epithelium of the proximal renal tubules (C, D) 1 h after oral administration of protein: N) nucleus; BB) brush border; M) mitochondria; GC) Golgi complex; IS) intercellular space; L) lysosomes; D) detection of acid phosphatase activity. Magnification in A and C 7500×, in B 10,000×, in D 15,000×.

EXPERIMENTAL RESULTS

The electron-microscopic investigation of the intestine revealed changes in the ultrastructure of the enterocytes at all times of the experiments. The character of these changes was uniform, but they were more marked 30 min after oral administration of the protein (Fig. 1A, B). The apical part of the cells was filled with numerous pinocytotic invaginations and vesicles, among which large vacuoles filled with contents of average electron density were distributed (Fig. 1B). Contents of the same density were found in the dilated cavities of the rough endoplasmic reticulum and the vacuoles of the Golgi complex; numerous globules separated from one another by an electron-dense membrane also were present in the Golgi complex, which covered a wide area and consisted chiefly of large vacuoles filled with the above-mentioned globules. Much smaller vacuoles, containing chiefly only one globule, were concentrated near the lateral plasma membrane. The intercellular spaces were greatly widened almost everywhere except in the apical part. They contained fairly closely packed globules similar to those described in the Golgi vacuoles.

Clusters of these globules were also found in the intercellular spaces of the tunica propria of the intestinal mucous membrane, and in the lumen of the lymphatic capillaries, whereas the blood vessels contained no globules.

In the proximal renal tubules of the young rats aged 3 days numerous pinocytotic invaginations and vesicles could be seen 1 h after oral administration of the protein. Circular electron-dense cytoplasmic particles surrounded by a single membrane were detected in the middle and basal parts of the cells (Fig. 1C). The cytochemical reaction for acid phosphatase showed that the electron-dense cytosomes contained large quantities of the reaction end-product. These cytosomes were very similar to the particles described in the literature that are found after protein loading (Fig. 1D).

Clearly, therefore, in early postnatal ontogeny protein is transported from the intestinal lumen into the blood stream. The intracellular transport of protein takes place through pinocytosis and the activity of the Golgi complex, with liberation of the contents of its vacuoles into the lateral intercellular space. The appearance of food proteins in the blood is followed by their filtration and subsequent reabsorption by the epithelium of the proximal tubules. The high activity of hydrolytic enzymes in the cytosomes absorbing protein is evidence of its breakdown. The existence of a proteolytic apparatus in the kidney accordingly becomes of great physiological significance during this period of the animal's life, for the absence of any substantial intraluminal digestive function of the intestine is compensated by the intracellular digestion of proteins in the epithelium of the proximal renal tubules. Evidently the decisive role in this process does not belong to the kidney alone. The study of intracellular protein digestion in other organs and tissues will be the subject of future investigation.

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