The Changes within the Cells of the Gastric Mucosa During Secretory Activity

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This study was undertaken in order to correlate the morphological variations of the secretory cells of the gastric glands with stages of functional activity. The detailed analysis of the changes of the known cytoplasmic and nuclear elements will be reserved for a later publication. The discussion is limited to the mitochondria and Golgi apparatus and to the cellular secretory products, such as pepsinogen granules and mucus.

The cycle of events within the cells could be most clearly demonstrated only by active stimulation. In the experiments to be described pilocarpine hydrochloride was employed because of its stimulating action on the mucosa of both the corpus and antrum. The stomachs of the animals studied did not show any pathologic changes and in the longer experiments returned to the phase observed in the controls.

METHOD OF STUDY

Young white rabbits of approximately the same weight were used for the experiments. Four of them belonged to the same litter, three to another. The animals were injected intramuscularly with 12.5 mgs. per kilogram of freshly prepared 1% aqueous solution of pilocarpine hydrochloride. Following this they received no food but were given small amounts of water. Two types of control animals were used. One was fed until the time of the experiment; the other was sacrificed after starvation for 27 hours. The pilocarpine hydrochloride was administered to animals which had been allowed to feed until the time of injection. They were sacrificed at various intervals thereafter. The stomach was immediately removed and the contents collected for acid and pepsin determinations. The tissue was placed into various fixatives for cytological study within twenty minutes after the death of the animals. The major portion of the gastric mucosa was frozen over carbon dioxide ice and extracted for acid and pepsin content.

OBSERVATIONS

In the fundus of the control animal starved for 27 hours the peptic or chief cells of the chief glands are filled with large, round secretory (pepsinogen) granules which occupy the entire cytoplasm and obscure the nucleus. The mitochondria can hardly be identified although short filaments are seen at the base of the cells. The pepsin content of the mucosa determined quantitatively is very high. The cells in the basal portions of the glands are more packed with granules than those in the superficial portions. In the corpus, however, the granules, although numerous, fill only the half of the cell near the lumen. The mitochondria form short, narrow filaments in the basal portions of the cells and extend to the region of the granules. The parietal or acid cells in both the fundus and the corpus contain numerous round granules uniformly distributed throughout the cytoplasm. These granules are smaller than the pepsinogen granules and possess different staining characteristics. The nature of the granules of the acid cells cannot be definitely stated at present.

In the second control animal which was fed until the time of the experiment the peptic cells of the
Fundus are similar to those in the corpus of the previous animal. The peptic cells of the corpus of this animal contain less secretory granules and more mitochondria. These differences in granule content coincide with the greater digestive activity in this animal. The acid cells are uniformly filled with numerous granules (Fig. 3). Throughout the mucosa the acid cells are similar in character (Fig. 1).

One hour after stimulation with pilocarpine the peptic cells are smaller. There are no secretory granules in the cells except in those in the basal portions of the glands. The mitochondria are scattered irregularly throughout the cytoplasm. The glandular lumina are wider. There is a greater amount of pepsin and acid in the gastric contents. The granules of the acid cells basal to the neck portions of the chief glands are markedly reduced in number, enlarged and stain more faintly so that the unchanged dark neck portions stand in sharp contrast (Fig. 2).

Three hours after the injection of pilocarpine the peptic cells show still fewer granules. There is, however, a small number of large granules in a few cells at the bases of the glands. The mitochondria are short, slender, wavy, more numerous and diffusely distributed throughout the cytoplasm. The pepsin content of the mucosa is markedly reduced; that of the contents is increased. The acid cells basal to the neck portions of the glands contain more granules than in the preceding animal. Clear areas appear in the cytoplasm around the nucleus (Fig. 4). Short, thick rods appear in the central portions of the cells. The acid cells in the most basal portions of the glands are still pale.

Six hours after the injection of pilocarpine the peptic cells are larger. Granules of different sizes appear at the free borders of the cells. This is especially prominent in the basal portions of the mucosa. The mitochondria are longer and for the most part, arranged parallel to the long axis of the cells. They are slender, wavy and often extend from the basal portions of the cells to the region of reappearance of the secretory granules. Many of the mitochondria have elliptical and round bulbous ends. A larger number of acid cells now have central clear peri-nuclear zones. The granules are accumulated concentrically around the border of the cell (Fig. 5). The rods in the central portions of the cells are more elongated and often curved.

Sixteen hours after the injection of pilocarpine secretory granules again fill the superficial portions of the peptic cells. The acid and peptic cells closely resemble those of the fed control animal. The pepsin content of the mucosa rises.

Simultaneously the Golgi apparatus in the peptic cells undergoes distinct variations in form and distribution. In the starved control animal where the peptic cells are packed with secretory granules the Golgi apparatus consists of a small, compact network or small fragments situated near the nucleus on the side toward the lumen. In the fed control where the secretory granules occupy only the superficial portions of the cells the apparatus forms a looser network which is lightly impregnated with osmic acid. It is situated between the nucleus and the free border and extends partially into the region of the secretory granules. With the disappearance of the granules the apparatus becomes more extensive and more darkly impregnated and is situated near the free border of the cell. This process progresses before any secretory granules have reappeared. During the elaboration of the secretory granules the apparatus lies wholly within the region of their formation. As the granules increase in number the apparatus becomes very extensive and appears to consist of impregnated fragments.