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SECRETION FROM HUMAN APOCRINE GLANDS: AN ELECTRON MICROSCOPIC STUDY

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Electron microscopic examination of apocrine glands revealed three types of secretion: merocrine, apocrine, and possibly holocrine. In the merocrine type of secretion numerous vesicles originating in the Golgi area discharged their granular contents into the lumen of the gland. In the apocrine type of secretion three stages were observed: (1) formation of an apical cap; (2) formation of a dividing membrane at the base of the apical cap; and (3) formation of tubules above the dividing membrane that extended parallel to the membrane and led to a separation of the apical cap from the underlying cell. In the holocrine type of secretion individual secretory cells or even strands of secretory cells were discharged into the lumen of the gland.

In 1917 Schiefferdecker [1] described the mode of secretion occurring in apocrine glands as decapitation secretion whereby portions of the cells are released into the lumen. However, most authors who have studied the apocrine glands by electron microscopy have doubted that decapitation secretion exists in them because they did not find cellular debris in the lumina of these glands [2–6]. Yamada [6] considered decapitation secretion as an artifact caused by dehydration, since it was seen only in the light microscope but not in the electron microscope.

Some of the authors who doubt the existence of decapitation secretion believe that the only type of secretion occurring in apocrine glands is merocrine secretion in which small vesicles are discharged into the glandular lumen [3–5,7]. Other authors, however, observed, in addition to merocrine secretion, the discharge of cellular contents into the lumen through discontinuities in the luminal plasma membrane of secretory cells [2,8–10]. As an additional feature, Braun-Falco and Rupec [10] described suggestive holocrine secretion in which entire cells or groups of cells were shed into the lumen of the gland.

The only authors who so far, on electron microscopic examination, have described findings suggestive of decapitation secretion are Kurosomi et al [11] and Hashimoto et al [9]. Kurosomi and co-workers did not actually observe decapitation to take place, but they observed apical caps which at their base had a dense area which they believed to be the site of decapitation and therefore called this area a "demarcation zone." The dense area contained membrane-like structures. Hashimoto et al [9] observed cellular debris in the lumen just above a cell which contained a horizontal membrane immediately beneath the luminal plasma membrane. These authors believed that the apical portion of the secretory cell had escaped into the lumen through a defect in the luminal plasma membrane. They believed that the rather thick horizontal membrane represented a newly formed plasma membrane below the old defective plasma membrane of the cell.

The present study was undertaken to elucidate the mode of secretion in the apocrine glands of the human axilla. It was found that merocrine, apocrine, and possibly holocrine secretion occur in the axillary apocrine glands.

MATERIALS AND METHODS

For the purpose of obtaining axillary apocrine glands, two 4-mm excisions were carried out on a healthy 31-year-old female and one 4-mm excision on a healthy 63-year-old male after the subcutaneous injection of 1.5 ml of 1% lidocaine containing epinephrine at a concentration of 1:100,000. In addition, two scalpel excisions measuring 5.0 x 2.0 cm and 4.0 x 1.5 cm, respectively, were carried out on two male patients, 21 and 25 years old, after the subcutaneous injection of 6.0 ml of 1% lidocaine containing epinephrine at a concentration of 1:100,000. Both patients had hidradenitis suppurativa, but only normal tissue from the edge of the excision was used for this study. The specimens were sectioned into small slices while immersed in cacodylate-buffered Karnovsky's solution (pH 7.2) and were fixed in this solution for 1 to 5 days. The slices then were rinsed overnight in cacodylate buffer, postfixed for 1 hr in 1% osmium tetroxide, rinsed for 1 hr in cacodylate buffer, and stained en bloc in 50% ethanol containing 1% uranyl acetate. Subsequently, the slices were dehydrated and embedded in epoxy resin. Thin sections were cut with a Reichert OM II ultramicrotome. They were stained in uranyl acetate and lead citrate. Electron micrographs were taken with a JEOL 100 B electron microscope.

For this study 242 blocks were screened by light

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microscopy and 54 of them were studied with the electron microscope.

RESULTS

Description of the Secretory Cells

On electron microscopic examination at low magnification there were two kinds of cells identified: an inner row of secretory cells and an outer row of myoepithelial cells (Fig. 1). The secretory cells showed numerous folded basal processes extending to the basal lamina in the interspaces between the myoepithelial cells. The height of the secretory cells varied, often even within the same secretory tubule. The lower half of the cells contained the nucleus and rough endoplasmic reticulum which usually was arranged around mitochondria. Above the nucleus, a very active Golgi complex was found consisting of numerous tubules and saccules. The upper part of the cell contained the two types of granules specific for apocrine cells: light granules derived from mitochondria [9], and dark granules derived from the Golgi complex [9]. The luminal part of the plasma membrane had numerous microvilli. Many filaments were dispersed throughout the cytoplasm, either lying singly or aggregated into bundles. The cytoplasm appeared very dense, largely as the result of the presence of numerous filaments.

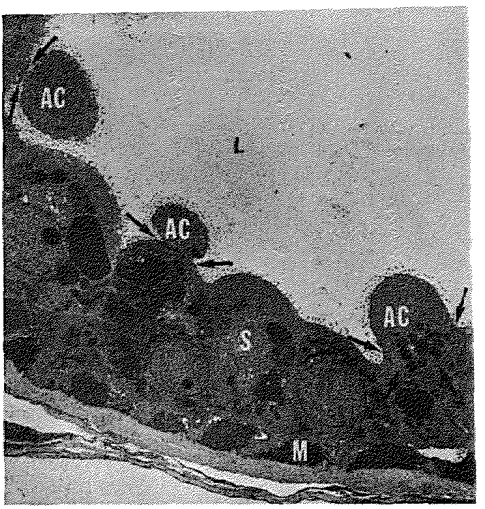

FIG. 1. Portion of a secretory tubule. The cells are in different stages of secretion. Three secretory cells have formed apical caps (*AC*); in each cell one sees beneath the apical cap a horizontal dividing membrane (*arrows*). *L*, lumen; *S*, secretory cell; *M*, myoepithelial cell; (× 12,500).

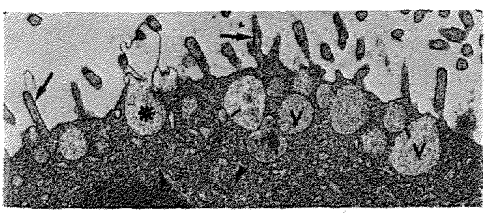

FIG. 2. Merocrine secretion. The luminal portion of a secretory cell shows the merocrine type of secretion in which numerous vesicles (*V*) containing granular material are being discharged into the lumen. One vesicle is just beginning to discharge its contents into the lumen of the gland (*). The secretory cell shows numerous filaments in its cytoplasm (*pointers*) and possesses microvilli that extend into the lumen (*arrows*) (× 14,000).

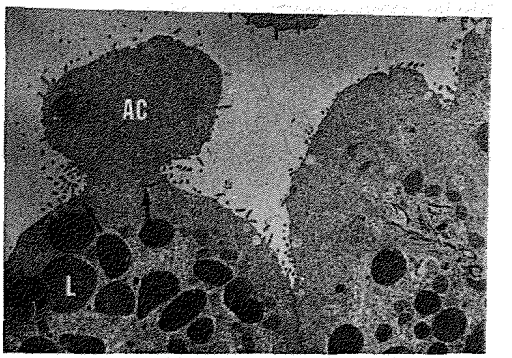

FIG. 3. Apocrine secretion. During the apocrine type of secretion a secretory cell has formed an apical cap (*AC*) below which a dividing membrane has started to form (*arrows*). *L*, light granule; (× 7,600).

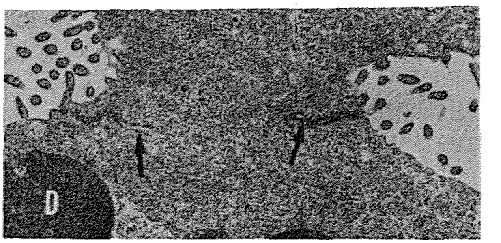

FIG. 4. Apocrine secretion. Higher magnification of Figure 3 shows the beginning formation of the dividing membrane (*arrows*) at the base of the apical cap. *D*, dark granule; (× 15,000).

Secretory Mechanism of Aprocine Glands

Three mechanisms of secretion were observed in human axillary apocrine glands: merocrine, apocrine, and holocrine secretion.

Merocrine secretion. The apical portion of active secretory cells contained numerous vesicles within which was granular material (Fig. 2). The vesicles originated in the Golgi zone. The membrane of the vesicles was seen to fuse with the luminal plasma membrane of the secretory cells (Fig. 2) and, subsequently, the vesicles discharged their granular contents into the lumen of the gland.

Apocrine secretion. The earliest sign of decapitation secretion was found to consist of the formation of an apical cap over the entire luminal margin of the cells (Figs. 1, 3). Subsequently, a horizontal

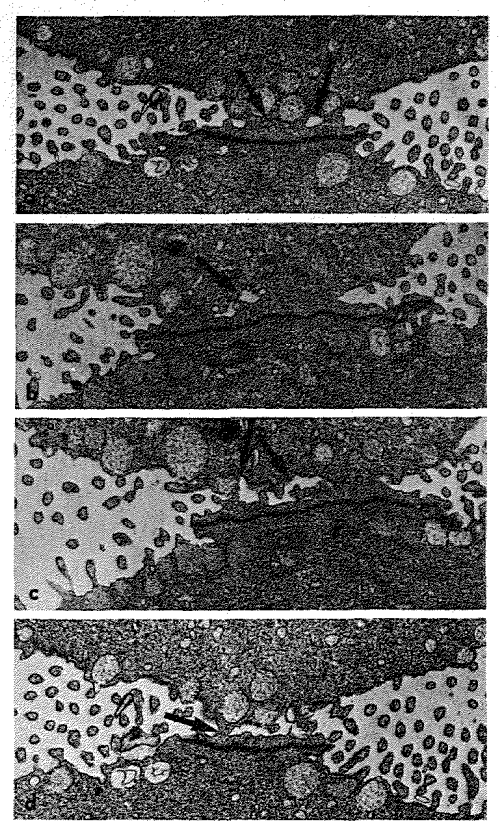

FIG. 5. Successive stages of apocrine decapitation (serial sections). *a:* Two small tubules (*arrows*) have formed above and parallel to the dividing membrane. *b:* In addition to an irregularly shaped long tubule (*arrow*), one tubule has fused with the plasma membrane on the right side of the cell. *c:* The long tubule (*arrows*) has further extended in length and has fused with the plasma membrane on the left side of the cell, leading to a separation of most of the apical cap from the main portion of the cell. *d:* Decapitation of the apical cap is almost complete. Only one narrow connection remains (*arrow*). All electron micrographs (× 13,000).

dividing membrane formed at the base of the apical cap (Figs. 3, 4). This dividing membrane was composed of two trilaminar membranes that usually were closely attached to one another. The dividing membrane terminated at each lateral cell margin in the plasma membrane. After the horizontal dividing membrane had formed, tubules began to appear above it and extended parallel to it at the base of the apical cap (Figs. 5*a*, *b*). As the tubules extended to each lateral margin, the membranes of the tubules fused with one another and also fused with the lateral plasma membrane of the cell (Figs. 5*c*, *d*). As the result of this fusion, a new plasma membrane formed on the underside of the apical cap and on the luminal side of the residual cell, leading to a detachment of the apical cap (Fig. 6). After the cell had lost its apical cap, the horizontal dividing membrane was located directly beneath the newly formed luminal plasma membrane in the uppermost portion of the cell (Fig. 6).

The decapitated portion of the cell usually contained numerous vesicles and occasionally a few of the two types of specific apocrine granules, but it never contained a nucleus. The luminal plasma membrane of the decapitated cell portion was well preserved and showed numerous microvilli.

Holocrine secretion. Occasionally, entire secretory cells and even strands of such cells showing varying degrees of disintegration were found in the lumen of a secretory tubule (Fig. 7). The detachment of the secretory cells was preceded by a disintegration of their folded basal processes through which these cells were attached to the basal lamina. Only rarely were there secretory cells with a ruptured luminal plasma membrane through which organelles had escaped into the lumen of the gland, as described by several authors [2,9,10]. This most likely also represents a form of holocrine secretion.

DISCUSSION

The most interesting finding of this study on apocrine secretion is the observation of true decap-

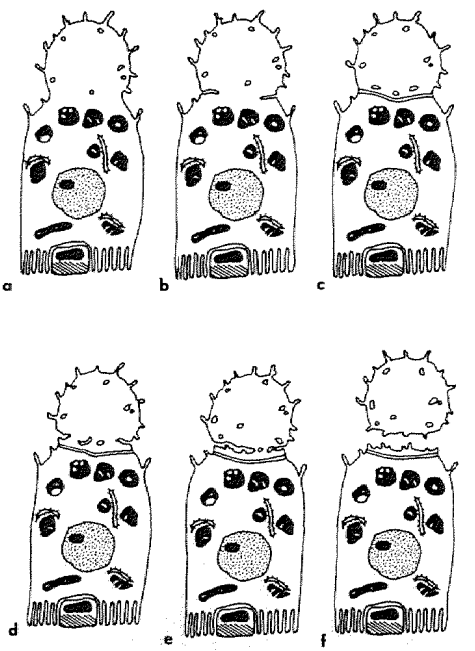

FIG. 6. Schematic drawing of apocrine decapitation. Formation of an apical cap (*a*); beginning formation of a horizontal dividing membrane (*b*); the dividing membrane extends beneath the entire apical cap (*c*); tubules have formed above and parallel to the dividing membrane (*d*); the tubule has extended to the lumen of the gland and thus separated part of the apical cap from the main portion of the cell (*e*); the decapitation is complete, with the dividing membrane remaining in the cytoplasm of the secretory cell close to the lumen (*f*).

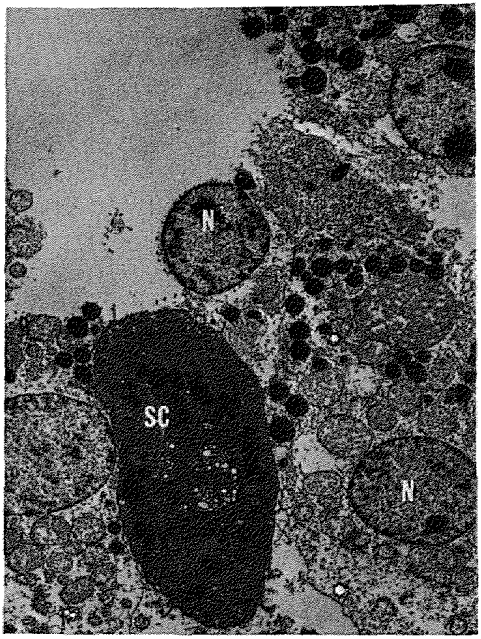

FIG. 7. Holocrine secretion. A strand of secretory cells is located in the lumen of a gland. All cells appear disintegrated with the exception of one well-preserved cell (*SC*). *N*, nuclei; (× 2,600).

itation secretion, the existence of which has been questioned by most observers to date. The decapitation takes place as follows: (1) formation of an apical cap; (2) formation of a horizontal dividing membrane at the base of the apical cap; and (3) appearance of tubules over and parallel to the dividing membrane, bringing about the decapitation of the apical cap by supplying the plasma membrane for both the undersurface of the apical cap and the luminal plasma membrane. It seems likely that the dividing membrane forms from numerous filaments present in the cytoplasm of the cell. The most likely function of this membrane is to preserve the integrity of the cell during the decapitation. The plasma membrane of the decapitating gland cell was never found to be defective. Decapitation secretion was a constant finding in our material. It was, however, not found in each secretory tubule, since there were always several tubules in each gland that were inactive.

Besides apocrine secretion, merocrine secretion was regularly observed, as described by several authors before [2–5,7,8,10]. Secretory cells undergoing decapitation secretion generally showed merocrine secretion in their apical cap.

The possible occurrence of holocrine secretion has been previously mentioned by Braun-Falco and Rupec [10]. The finding of entire cells, and even of strands of such cells, in the lumen of the gland seems to be in favor of this type of secretion.

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