Scanning Electron Microscopic Observations on the Goat Parotid Glands

Syusaku SUZUKI, Hayao NISHINAKAGAWA and Junichi OTSUKA

*Laboratory of Veterinary Anatomy, Faculty of Agriculture,
Kagoshima University, Kagoshima-shi, Kagoshima 890*

(Received for publication December 28, 1979)

Abstract. Three-dimensional architectures of acini, intercalated ducts and striated ducts of the parotid gland in goats were observed by scanning electron microscopy. The lumina of both acini and intercellular canaliculi were conspicuously spacious, lined by numerous and long microvilli and including many smooth spherical materials together with apocrine-like processes. Some acinar cells contained only a few smooth spherical granules. The luminal surface of the intercalated duct was lined by many short microvilli which lay in parallel with the longitudinal axis of the luminal surface at a regular interval. The cells of the intercalated duct had a few smooth spherical granules. The cells of the striated duct had pentagonal or hexagonal surfaces, largely characterized by two features, in that some surfaces were flat or folded and others had ovoidal or spheroidal protrusions of various sizes. The epithelial cells of the striated duct did not contain any granules as were seen in the acinar cells and the intercalated duct cells.

It is well known that the ruminant parotid gland secretes an enormous amount of saliva with an intimate relationship with the digestive process of the rumen. However, little information is available on fine structures of the goat parotid gland, except for studies by light and transmission electron microscopy [5, 12].

In our laboratory, fine structures of acini, intercalated ducts and striated ducts of the gland have been already studied [8], but scanning electron microscopic (SEM) studies have not yet been designed, though some SEM studies can be found on the salivary glands of rats and dogs [1, 6, 7, 9].

The present study, therefore, was performed to observe the fracture surface of the goat parotid gland obtained by freeze-cracking in dimethylsulfoxide (DMSO), by scanning electron microscopy. Structural and functional secretory mechanisms of the ruminant parotid gland are the major title

of discussion of this paper.

Materials and Methods

Four adult Saanen goats were killed by cutting the common carotid artery under local procaine anesthesia.

For SEM, tissue blocks of the central part of the parotid gland were removed quickly and cut into smaller blocks about 5×5×20 mm. These small blocks were fixed in a mixture of 2% glutaraldehyde and 5% formaldehyde, buffered with phosphate. After fixation, the blocks were cut into pieces about 3×3×8 mm and immersed in 40% DMSO. The pieces were frozen in Freon 22, fractured in liquid nitrogen, dehydrated in a graded series of ethanol and transferred into isoamyl acetate. Following complete dehydration, the pieces were transferred into liquid CO₂ according to the critical point drying method. The dried samples were coated either with gold or with carbon and gold palladium, and examined with an HSM-2A and a JSM-25 scanning electron microscope.

For transmission electron microscopy (TEM), tissue blocks of the parotid gland were fixed in a mixture of 1.25% glutaraldehyde and 1% osmium tetroxide adjusted to pH 7.4 by phosphate buffer. Then the blocks were dehydrated with ethanol and

embedded in Epon 812. Thin sections were stained with uranyl acetate and lead citrate and examined with a JEM-100 C transmission electron microscope.

Results

By a view of the fracture surface, the gland appeared to be divided into many lobules by intercalated loose connective tissues. In each lobule, acini, intercalated ducts and striated ducts were distinguished easily (Fig. 1).

Acinus: The parotid acini were composed of serous cells, surrounded usually by a small amount of loose connective tissues. The lumina of the acini and intercellular canaliculi were notably wide. On the luminal border of the acini as well as on the border of the intercellular canaliculi, there were studded well-developed long microvilli (Fig. 2). Both the acinar and the intercellular canalicular lumina were occupied by many smooth spherical materials of various sizes (Fig. 3) and some apocrine processes (Fig. 4) together with fractured materials (Fig. 5). The surfaces of fractured materials appeared as honeycombs with no spherical granules (Fig. 5). The acinar epithelia were usually composed of cuboidal cells, most of which had no granules but some of which contained only a few smooth spherical granules (Fig. 6).

By TEM, numerous long microvilli extended into the lumina of acini, and intercellular canaliculi were well developed. The acinar cells contained 3 kinds of granules, less dense, moderately dense and strongly dense (Fig. 7), the latter two kinds of which were observed in only a few cells.

Intercalated duct: The ducts were lined with simple cuboidal epithelial cells. In the luminal surfaces, groups of short microvilli ran parallel with the longitudinal axis of the lumen and were arranged at a regular interval. The epithelial cells had a few smooth spherical granules in the

supranuclear region (Fig. 8). By TEM, the epithelia of the intercalated ducts were composed of light cells alone, some of which had dense round granules in their apical portions (Fig. 9).

Striated duct: The epithelial cells of the ducts were tall and columnar, and possessed centrally located nuclei. The cells had typical basal striations (so-called basal infoldings) and accumulated many spherical or ovoidal mitochondria closely to the basal infoldings. The luminal surfaces of these cells appeared pentagonal or hexagonal (Fig. 10), characterized by two features, in that some were flat or folded (Fig. 10) and others had ovoidal or spheroidal protrusions of various sizes (Fig. 11). The former flat or folded surfaces would mean that the cell margins were ridgy. Microvilli of the duct cells varied in height from long to short. In addition, some massive structures of a probable concentration of short microvilli or uncertain origins could be found (Figs. 10, 12). The epithelial cells did not contain any spherical granules.

By TEM, the apical surfaces of epithelial cells of the striated duct showed various forms, relatively flat, leaf-like and apocrine process-like. The cells themselves contained fine vacuoles and moderately dense vesicles in the apical portion of the cytoplasm with no secretory granules (Fig. 13).

Discussion

The acinar epithelium in the goat parotid gland was composed of only serous cells, as described in our previous report [8]. By TEM, these serous cells contain dense granules and pale granules. The number of the dense granules was less than that of the other. By SEM, most of the acinar cells do not contain any smooth spherical granules, but some do. Such granules were reported in the parotid

acinar cells in rats and dogs [6, 9], and also in the parotid intercalated duct cells in dogs [9], very similar to zymogen granules in the exocrine cells of the pancreas [2]. Those granules which contain enzyme proteins may be changed into spherical granules of high density, probably by the use of osmium tetroxide and aldehyde as conventional fixatives. In contrast, the granules of moderate and low density seem to contain a little amount of enzymes and a much amount of neutral mucopolysaccharides, because no such granules can be observed by SEM in terms of three-dimensional aspects.

By both SEM and TEM, the acini of the goat parotid gland reveal their wide lumina and intercellular canaliculi together with well-developed long microvilli extending into these lumina. Moreover, many spherical materials and apocrine processes are observed in the wide lumina. Such phenomena are not observed in non-ruminant animals such as dogs [8], horses [10] and rabbits [11]. In ruminants, the "continuous flow" of the parotid saliva is well documented [3-5]. The foregoing characteristics of the goat parotid gland are considered to be intimately associated with the salivation, but suggest a little secretion of serous substances and a much secretion of water with inorganic salts. It may be that well-developed microvilli can transport water, and that apocrine processes and spherical materials seen in the wide lumen can contain mucopolysaccharides including a little serous substances.

The intercalated duct cells contain a few dense spherical granules, suggesting that the cells can secrete serous substances just as can the intercalated duct cells of the dog parotid gland [9].

As regards the striated duct, the apical surfaces of the epithelial cells showed dif-

ferent specific forms perhaps due to secretory functional changes hitherto reported [9, 10, 12]. Those cells which have protrusions of apocrine-like processes may be at a secretory phase and those cells which have flat or folded surfaces may be at synthesizing and releasing phases of their products. Thus, the appearance of these apical surfaces of the striated duct cells may imply different functional phases of secretory cycles. Nevertheless, the striated duct cells do not show any morphologic evidence of secretion of granules by both TEM and SEM. Therefore, the striated duct cells of the goat parotid gland can secrete mainly a plenty of water. The prominent basal infoldings and numerous mitochondria also seem to be closely associated with the transfer of water.

Acknowledgements. The authors express their thanks to Prof. Dr. K. Mochizuki, Laboratory of Veterinary Anatomy, Faculty of Agriculture, University of Tokyo, for his kind guidance and encouragement during the course of this investigation and for reviewing the manuscript.

References

- [1] Brocco, S. L., and Tamarin, A. (1979). The topography of rat submandibular gland parenchyma as observed with S.E.M. *Anat. Rec.* **194**, 445-460.
- [2] Fujita, H., and Fujita, T. (1978). Textbook of histology part 2. Tokyo, Igakushoin Ltd. 142 (in Japanese).
- [3] Kay, R. N. B. (1958). Continuous and reflex secretion by the parotid gland in ruminants. *J. Physiol. (Lond.)* **144**, 463-475.
- [4] Kay, R. N. B. (1960). The rate of flow and composition of various salivary secretions in sheep and calves. *J. Physiol. (Lond.)* **150**, 515-537.
- [5] Kay, R. N. B. (1960). The development of parotid salivary secretion in young goats. *J. Physiol. (Lond.)* **150**, 538-545.
- [6] Kozaka, H. (1976). Scanning electron microscopic observations of the rat salivary glands. *Acta Anat. Nippon* **51**, 123-124 (in Japanese).
- [7] Shackelford, J. M., and Schneyer, L. H. (1971). Ultrastructural aspects of the main excretory

- duct of rat submandibular gland. *Anat. Rec.* **169**, 679-696.
- [8] Suzuki, S., Kamei, K., and Otsuka, J. (1975). On the fine structure of salivary glands of goat and dog. 1. parotid gland. *Bull. Fac. Agr. Kagoshima Univ.* **25**, 25-41 (in Japanese).
- [9] Suzuki, S., Nishinakagawa, H., and Otsuka, J. (1980). Scanning electron microscopic observations of the dog parotid gland. *Bull. Fac. Agr. Kagoshima Univ.* **30**, 87-96 (in Japanese).
- [10] Suzuki, S., and Otsuka, J. (1977). On the fine structure of salivary gland of horse. 1. parotid gland. *Bull. Fac. Agr. Kagoshima Univ.* **27**, 95-104 (in Japanese).
- [11] Suzuki, S., and Otsuka, J. (1977). On the fine structure of salivary gland of rabbit. 1. parotid gland. *Bull. Fac. Agr. Kagoshima Univ.* **27**, 105-114 (in Japanese).
- [12] Takano, K., Kamiakito, Y., Arai, Y., Akita, T., Kutsuzawa, E., Ebashi, Y., and Ueki, M. (1977). Fine structure of the parotid gland of goat. *Nihon Univ. J. Oral Sci.* **3**, 105-113 (in Japanese).

要 約

ヤギ耳下腺の走査電子顕微鏡による観察：鈴木秀作・西中川駿・大塚閏一（鹿児島大学農学部家畜解剖学教室）——成熟ヤギの耳下腺の腺胞・介在部・線条部について、DMSO による凍結切断試料を作製し、走査電子顕微鏡を用い観察した。腺腔および細胞間分泌細管は広く、明瞭で、これらに面する細胞自由面には、長い微絨毛がきわめてよく発達していた。腺腔内には、アポクリン突起や分泌物と思われる球形の構造物が多数認められた。また、腺胞細胞内には、滑沢な球形顆粒が少数認められた。介在部は、比較的明瞭で、介在部管腔面には、数列の短かい微絨毛が長軸と平行に一定の間隔で配列し、細胞質には球形顆粒が少数認められた。線条部上皮細胞の管腔面は、5 ないし 6 角形を呈し、隣接する細胞辺縁はいくぶん隆起し、その表面構造は、さまざまな形状を示し、大きく 2 つの型がみられた。一つは、短かい微絨毛が比較的少ないものから多数存在するもの、他は、前者と形態的に全く異なり、細胞の頂部が膨隆していた。なお、線条部上皮細胞には、腺胞細胞および介在部上皮細胞にみられたような球形顆粒は認められなかった。

Explanation of Figures

- Fig. 1. Low magnification of scanning electron microscopic image of the fracture surface of the goat parotid gland. The gland is divided into lobules by loose connective tissues. The acini, intercalated duct and striated ducts are observed in the lobules. $\times 560$.
- Fig. 2. Acini showing wide acinar lumina and wide intercellular canalicular lumina. Numerous long microvilli extend into the lumina. $\times 5,600$.
- Fig. 3. Acinus including smooth spherical materials of various sizes in the wide lumen. $\times 3,580$.
- Fig. 4. Acinar lumen showing well-developed microvilli. Apocrine process is observed in the lumen. $\times 12,660$.
- Fig. 5. Fractured material. The fracture surfaces of acini show honeycombe-like forms with no spherical granules. $\times 3,580$.
- Fig. 6. Acini showing the wide lumen. Acinar cells contain a few smooth spherical granules. $\times 6,920$.
- Fig. 7. Transmission electron micrograph of acinar cells. Secretory granules of high, moderate and low densities are present in the apical portion. $\times 3,400$.
- Fig. 8. Luminal surface of the intercalated duct. Groups of short microvilli run parallel to the longitudinal axis of the lumen, and epithelial cells contain a few smooth spherical granules. $\times 3,580$.
- Fig. 9. Transmission electron micrograph of the intercalated duct cells. Dense granules are present in the epithelial cells. $\times 4,500$.
- Fig. 10. Luminal surface of the striated duct. The apical surfaces of the striated duct cells are pentagonal or hexagonal in outline. The surfaces are flat, folded or massive in structure. $\times 3,360$.
- Fig. 11. Luminal surface of the striated duct. The protrusions and some residual secretory materials are observed. $\times 1,030$.
- Fig. 12. Luminal surface of the striated duct. The surfaces are amorphous with numerous short microvilli, showing variable features. (cf. Figs. 10, 11.). $\times 3,580$.
- Fig. 13. Transmission electron micrograph of the striated duct cells. The surfaces of the epithelial cells of a striated duct show various forms, relatively flat or leaf-like. $\times 3,400$.