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Functional morphology and biochemistry of the nasal mucosa with special attention to glycoprotein and glycosyltransferase

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Mucosal pathology of the upper airway has been studied morphologically and physiologically by many researchers, and there are an almost countless number of excellent results. However, very little work has been done on the relationship between the mucosal function and the infection on the cellular or tissue level. We have so far studied the pathology of the nasal mucosa, not only ultrastructurally (Ohyama, 1977; Ohyama et al., 1984), but also biochemically (Ohyama et al., 1982; Fukuda et al., 1984).

The purpose of the present study is to determine the basic properties of nasal mucosal pathology by histochemical SEM and by biochemical analysis of glycoproteins. And, on the basis of the results obtained, we would like to discuss for the defence mechanism of the airway, the possible relationship between glycoproteins in the mucociliary system and the actual nasal infection.

MATERIALS AND METHOD

Twenty specimens of nasal and sinus mucosa, which were obtained by means of surgery from the patient with chronic sinusitis, were used in this study.

1. Coloured scanning electron microscopic histochemistry using secondary electrons and backscattered electrons.
   In general, when ordinary scanning electron microscopy (SEM) is used, the image of the secondary electron (SE) seems very effective because it gives us three-dimentional information of the surface of the specimen. But this image does not give any information on the constitutional picture of the sample. On the other hand, the image of the backscattered electron (BSE) permits us to obtain contrasts according to the difference in atomic numbers and besides that, information about the depth becomes available as well.

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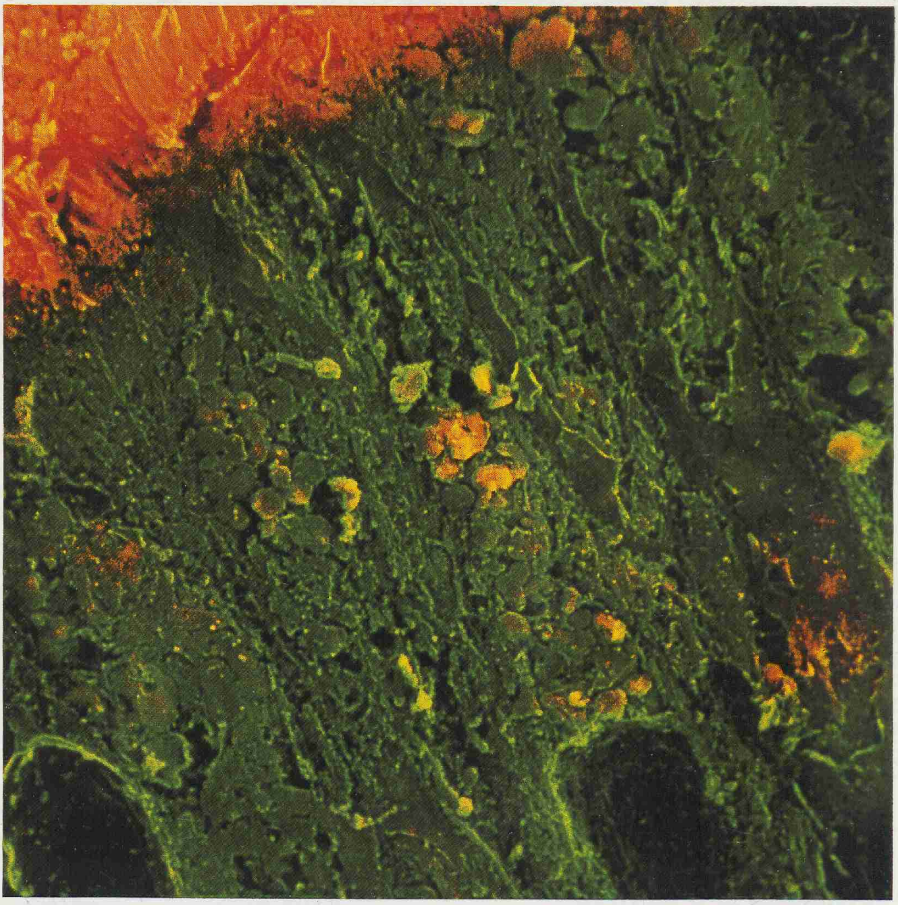

Figure 1. Coloured SEM image rat nasal mucosa.

Therefore, when we combine these two images of the same visual field, we can see both, the three-dimensional and the constitutional pictures of the specimen in a single image. Then, in order to obtain a better emission of BSE from a sample stained with a heavy metal, such as silver, lead and ruthenium in its object spot, we photographed the SE image and the BSE image which were then filtered and synthetically processed in colour (Tanaka, 1979; Hanamure, 1982). For a better demonstration of the BSE image of secretory granules in the mucous membrane, a cracked surface of the specimens was stained by ruthenium red before fixation with osmium tetraoxide. After dehydration with graded series of ethanol, drying by the CPD method and coating with platinum ion sputtering apparatus, the specimens were observed with field

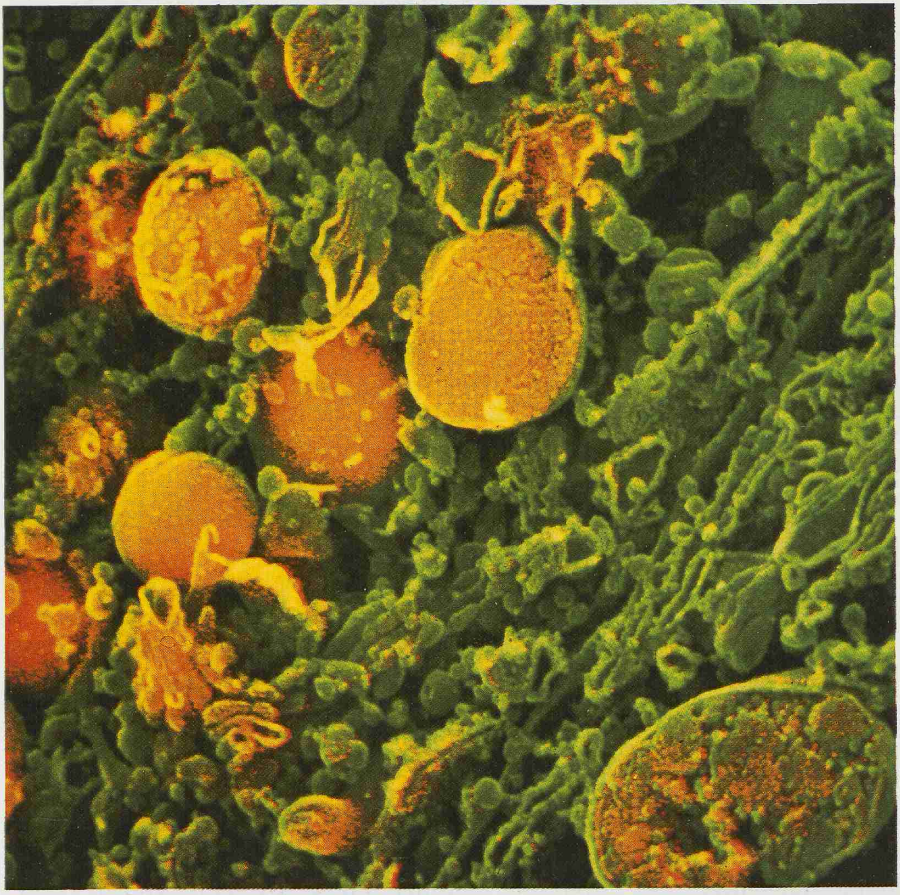

Figure 2. Coloured SEM image of the secretory granules in the goblet cell. Approximately 80.000 ×.

emission SEM (Hitachi HFS-2ST) in which the BSE detector was newly prepared.

2. Glycoprotein analysis of maxillary sinus mucosa.
   So far many investigations have been carried out on the secretory glycoproteins. The outline of which has now become considerably clearer. In accordance with the above, we have been studying the membrane glycoprotein which plays an important role in the cell functions. Some of these glycoproteins we would like to present here.
   By means of affinity chromatography on various lectins such as ConA, RCA, WGA, PNA, UEA, an analysis was made of the ratio of the membranous constituents to the secretory one. We also examined the activity of sugar trans-

ferase acting a part in the stage of biosynthesis of glycoproteins on the nasal mucosa. At the same time, the amount of sialic acid in the specimens was measured by the thioharbituric acid method.

RESULTS

1. Coloured SEM findings of glycoproteins of the nasal mucosa. Figure 1 shows a demonstrable coloured SEM image of the ciliated epithelium in the nasal mucosa of the rat. It appears that the mucous layer and some secretory granules in the goblet cells are stained orange. In one of the SEM images, highly magnificated (Figure 2), an intimate relationship among endoplasmic reticulum, Golgi apparatus and microsomes, which play a role in the process of producing secretory granules, seems to be clearly demonstrated in micro-architectural significance. And it is strongly suggested that these secretory granules are composed of a sort of glycoprotein, and the biosynthesis of oligosaccharide units in glycoproteins probably occurs in the Golgi apparatus. Similar ultrastructural characteristics were also observed in the human sinus mucosa (Ohyama et al., 1984).
2. Biochemical findings of glycoproteins of the sinus mucosa. Glycoproteins profiles of the nasal polyp were found to be generally similar to those of maxillary sinus mucosa: components of molecular weights with values of 65,000, 60,000, 30,000 and 25,000 daltons in ConA, WGA and RCA receptors were seen. In PNA receptors, maxillary sinus mucosa and nasal polyps revealed a single glycoprotein of the molecular weight of about 65,000 daltons. In contrast, nasal papilloma scarcely contained this band and maxillary cancer contained none of the PNA receptor (Fukuda et al., 1984).
   Figure 3 shows the glycoprotein ratio in total amount of protein in the maxillary sinus mucosa of the chronic sinusitis (Matsuyama and Ohyama, 1984). A comparative study of the sugar transferase activities between 9 cases of polypous sinus mucosa and 6 fibrous ones was made. The sialyltransferase activity was found to be higher in the polypous mucosa than in the fibrous ones (Matsuyama and Ohyama, 1984) (Figure 4). But there was no difference between the two groups in fucosyltransferase activity. As regards the amount of sialic acid, there was no definite difference between both mucosa groups.

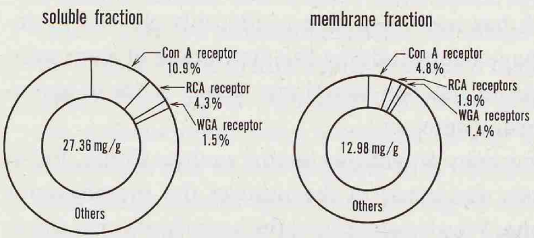

Figure 3.
Glycoproteins ratio in the total amount of protein in the pathological sinus mucosa.

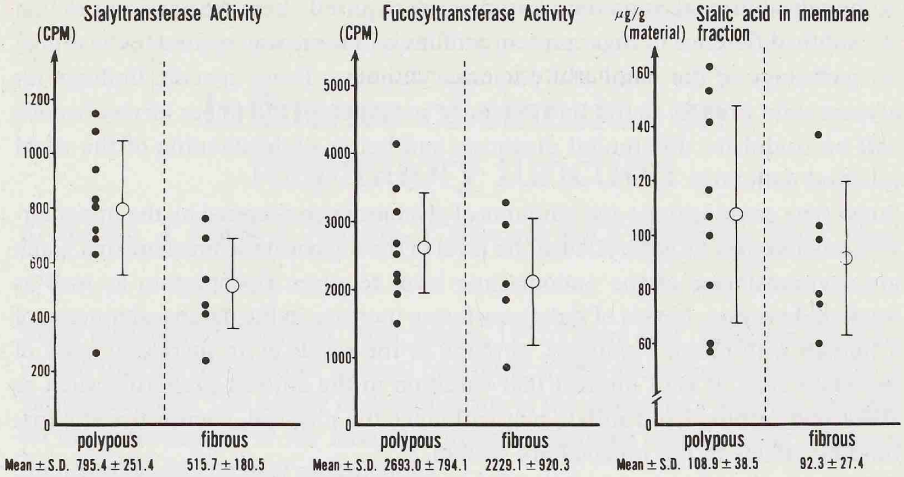

Figure 4. Correlation of glycosyltransferase activities with clinicopathological findings of the pathological sinus mucosa.

DISCUSSION

It is well known that acid mucopoly-saccharides and glycoproteins in the mucosa of the airway play important roles in the following matters:

1. control of electrolytes and water in the extracellular fluid;
2. resistance to virus or bacterial infections;
3. lubrication in mucociliary transport;
4. cleaning activity;
5. wound healing and
6. cell differentiation and transformation (Matsyama and Ohyama, 1984).

Nasal secretions are a complex mixture of secretory and transudatory fluids derived from sources within the nasal and paranasal mucosa. Important constituents include the mucous glycoproteins, other secretory proteins, immunoglobulins, lipids and their metabolites, salts and cell debris; the weight of mucous is determined by water for 95%. The glycoproteins are secreted by submucosal gland cells just as in case of goblet cells or/and by goblet cells of the respiratory mucosa in the nose. Under normal conditions there are a few mucous secreting cells in this organ (Ohyama et al., 1984). However, in the case of inflammatory diseases of the nose, the mucous secreting cells may proliferate in a manifest way. It is well known that these glycoproteins are made up of numerous oligosaccharide chains, which contain mainly five sugars: fucose, galactose, N-acetylglucosamine, N-acetylgalactosamine and sialic acid (Boat and Cheng, 1980).

We found large amounts of fucose and sialic acid in the mucous secreting cells of the pathological mucosa in the chronic sinusitis, compared to the amounts found in case of nasal allergy (Ohyama et al., 1984).

Although additional comparative studies are required, there are possibilities that the subtle difference in sugar protein profiles is in some way related to the mucosal pathology of the nasal and paranasal diseases. These specific findings for glycoprotein profiles found in the biopsy specimen of the upper airway lesions will be useful for differential diagnosis and better understanding of the nasal mucosal pathology.

Sugar type compositions and amounts of glycoproteins secreted by the upper airway mucosa may be controlled at the level of the biosynthetic mechanisms. Each glycosyltransferase at the endoplasmic level requires glycoprotein as well as nucleotide sugars. Levels of sialyltransferase increase in the paranasal mucosa of a human with chronic sinusitis, perhaps as the result of an increased mass of secretory cells. It is of interest that variation in the anionic properties such as sialic acid carboxyl and sulfate may influence the physical, chemical and virus-binding effects in the mucociliary system.

Further studies of sugar transferase levels, their cellular and subcellular distribution, availability and regulation mode of biosynthesis of glycoprotein in the upper airway mucosa are necessary.

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