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Density of epithelial cells in the normal human nose and the paranasal sinus mucosa. A scanning electron microscopic study

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SUMMARY

214 biopsies of mucosa from various sites of the nose and paranasal sinuses were obtained post-mortem and examined using the scanning electron microscope. The density of ciliated cells was increased in the nasal cavity, in the antero-posterior direction. In paranasal sinuses the density of these cells was high, except near the ostium of the maxillary sinus, where the density was decreased by half.

Non-ciliated epithelial cells were found in relatively few areas: anterior aspect of the middle and lower turbinates, anterior septum. However, no uniform distribution of these cells was present. The density of goblet cells was significantly lower in the paranasal sinuses as compared to the nasal cavity, with the highest density being found near the ostium of the maxillary sinus.

INTRODUCTION

In most studies using the scanning electron microscope (SEM) only the 1/3 anterior of the inferior turbinate from normals and patients with various pathologies was investigated (Mygind, 1975; Petruson et al., 1984; Elvany et al., 1987). The information from these studies is limited, because quantitative data on various epithelial cells in the nose and sinuses are lacking, except in one semi-quantitative histological SEM study of the nasal epithelium in the rat (Theeuwes et al., 1976). The aim of the present study was therefore to assess the distribution and density of various epithelial cell types in the normal human nose and the paranasal sinus mucosa.

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MATERIAL AND METHODS

Mucosa was obtained from two male (72 and 78 years of age) and two female (58 and 62 years of age) corpses at 3–5 hours after death. The cause of death was a cardiopulmonary accident. The subjects had been before free from any nose and sinus pathology. Prior to death, no nasal intubation had been performed. Via sublabial approach, after chiseling away the hard palate and maxillary bone, mucosa samples were taken from the nose and sinuses, except the frontal sinus. The mucosa of the frontal sinus was taken via the anterior wall of the sinus. The size of mucosal strips ranged from 4–25 mm^2. Care was taken not to traumatize the specimen. The supportive tissue, e.g. bone or cartilage, was taken out to prevent the sample from shrivelling or curling during preparation. Samples were washed in saline and fixed by immersion in gluteraldehyde for 24 hours, dehydrated by graded series of alcohol, critical point dried with liquid carbon dioxide, coated with palladium gold, and examined with a Siemens scanning microscope. In spite of the careful sampling technique, 40 out of 214 specimens proved to be unusable. The ultrastructural features of the specimens were recorded and compared with a series of normal nasal mucosa biopsies obtained from patients during surgery. The specimens were studied at 400× magnification for making a clear distinction of the various cell types involved (Figures 1 and 2). The numbers of ciliated, non-ciliated and goblet cells were determined in various regions, 24 in the nasal cavity and 12 in the paranasal sinuses. The results were expressed as the percentage of surface occupied by each cell type. With respect to the goblet cells, the fact was kept in mind that their size depends very much on their phase of epocrinic secretion.

RESULTS

Examination of the mucosa showed that in the anterior region of the nose the transition from squamous to respiratory epithelium extended roughly to the same region in the four subjects examined. No difference was found between the left and right side. In the nasal cavity differences in the density of ciliated cells in various regions were found. On the lateral wall the density of those ciliated cells was increased in the antero-posterior direction (Figure 1). No ciliated cells could be found in the anterior aspect of the inferior turbinate.

However, more posteriorly the density of these cells ranges from 50% in the 1/3 middle to 100% in the posterior part of the inferior turbinate. A similar density pattern of ciliated cells was present on the medial turbinate, i.e. 16.7% in the anterior 1/3 and 87.7% in the posterior 1/3 region. On the floor of the nasal cavity the density of ciliated cells is among the highest and ranges from 43.1% in the anterior third to 93% in the posterior third (Figure 2). In the medial wall (septum side), on the levels of the lower and medium turbinates, the density pattern of epithelial cells is essentially the same as in the lateral wall. In all paranasal

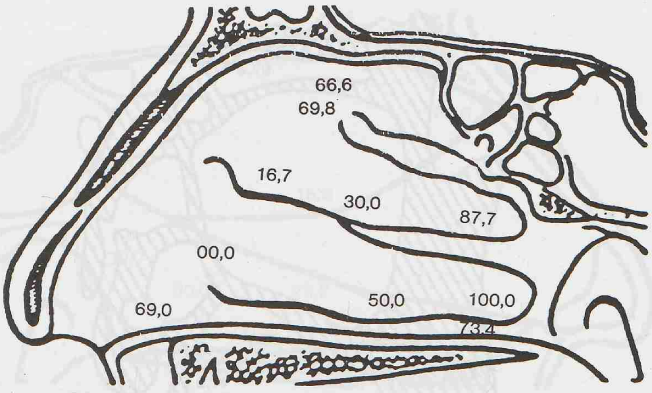

Figure 1. **Distribution of ciliated cells in the lateral wall of the nasal cavity.**

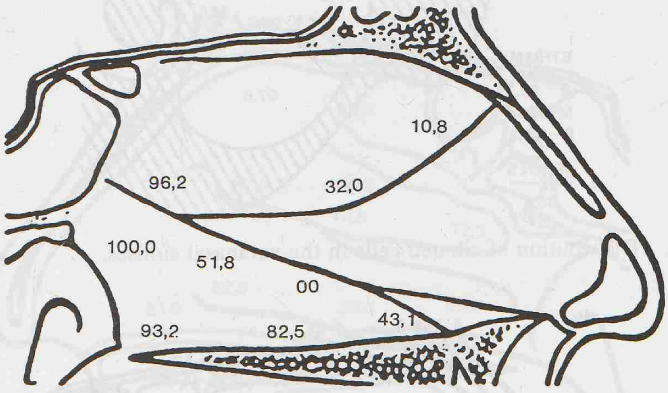

Figure 2. Distribution of ciliated cells in the medial wall and floor of the nasal cavity.

sinuses, the density of ciliated cells was very high, i.e. 91.3% to 97.7%, except near the ostium of the maxillary sinus, where the density was decreased by half (Figure 3).

Non-ciliated epithelial cells were found on the lateral wall in relatively few areas (Figure 4). The lowest density was 9.2% on the medial aspect of the superior turbinate, and the highest was 62% in the anterior 1/3 of the medial turbinate. Similar density values were found in the inferior two thirds of the septum mucosa. In the nasal floor non-ciliated cells were found only in the anterior part where the density was 16.3% (Figure 5). In all paranasal sinuses non-ciliated cells were absent. In the nasal cavity the density of goblet cells varied from 3.8% to 62.8%. However, no specific distribution pattern could be observed (Figures 6 and 7). It was found that the density of goblet cells was lower in the paranasal sinuses than in the nasal cavity. Within the paranasal sinuses the density of goblet

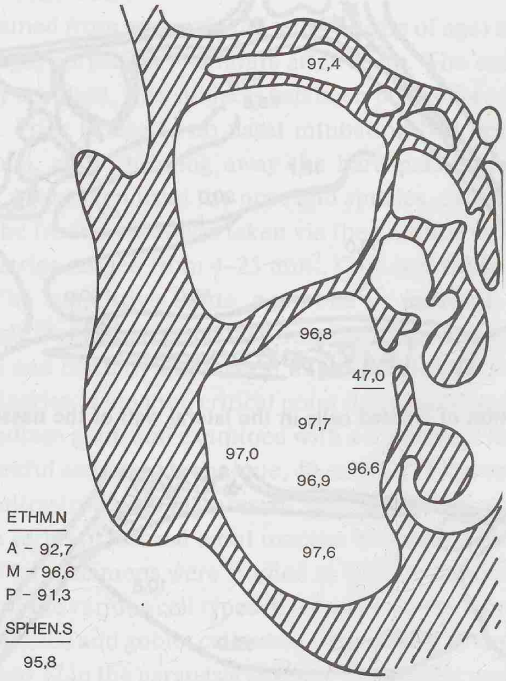

Figure 3. Distribution of ciliated cells in the paranasal sinuses.

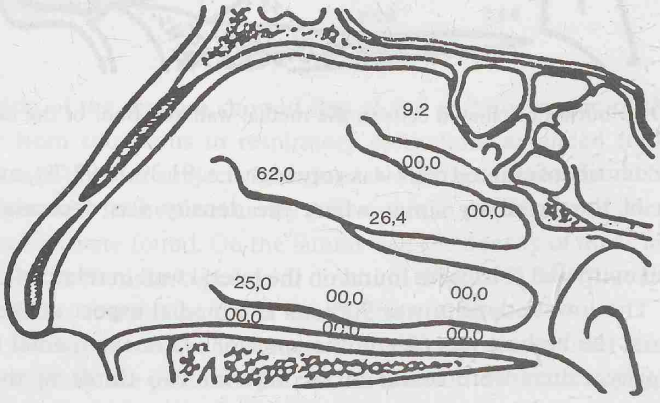

Figure 4. Distribution of non-ciliated cells in the lateral wall of nasal cavity.

cells was essentially very low (approximately 5%), except in one site, i.e. the maxillary ostium where the density of the cells ranged from 51.7% to 54.3% (Figure 8).

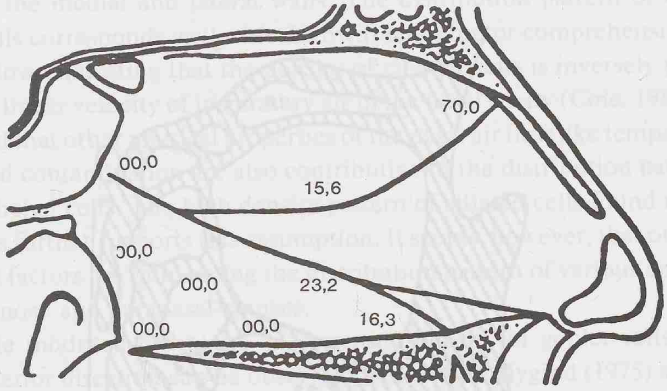

Figure 5. Distribution of non-ciliated cells in the medial wall and floor of the nasal cavity.

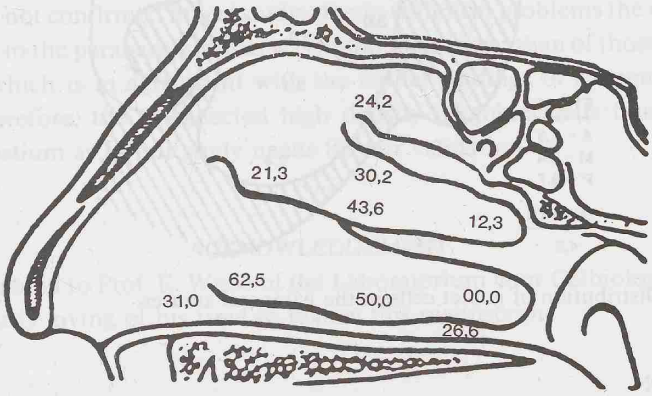

Figure 6. Distribution of goblet cells in the lateral wall of the nasal cavity.

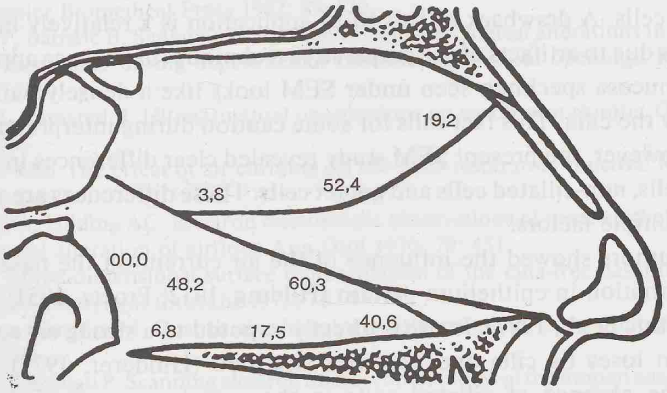

Figure 7. Distribution of goblet cells in the medial wall and floor of the nasal cavity.

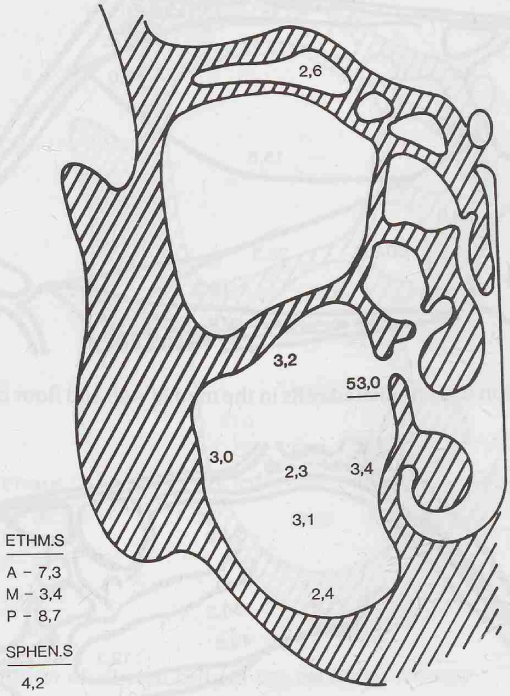

Figure 8. Distribution of goblet cells in the paranasal sinuses.

DISCUSSION

It has been shown by Lenz (1973) that SEM is a useful technique to distinguish different species of epithelial cells in human nasal mucosa, with the exception of the basal cells. A drawback of this SEM application is a relatively high loss of specimens due to artifacts of the preparative technique (in our case approx. 20%). A nasal mucosa specimen seen under SEM looks like a densely haired carpet formed by the cilia. This fact calls for some caution during interpretation of the image. However, the present SEM study revealed clear differences in density of ciliated cells, non-ciliated cells and goblet cells. These differences are apparently due to multiple factors.

Several authors showed the influence of the air current on the nasal mucosa, causing variation in epithelium pattern (Hilding, 1932; Proetz, 1951; Hinderer, 1977; Cvetnic et al., 1987). In areas directly exposed to a strong air current, the epithelium loses its cilia and becomes stratified (Hinderer, 1977). This can explain the absence of ciliated cells in the anterior aspect of the inferior turbinate, but also the increased density of those cells in the anterior-posterior

direction in the medial and lateral walls. The distribution pattern of ciliated epithelial cells corresponds well with the Swift and Proctor comprehensive map of nasal airflow, indicating that the density of ciliated cells is inversely proportional to the linear velocity of inspiratory air in the nasal cavity (Cole, 1982). It is also assumed that other physical properties of the nasal air flow like temperature, humidity and contamination are also contributive to the distribution pattern of various epithelial cells. The high density pattern of ciliated cells found in paranasal sinuses further supports this assumption. It seems, however, that other not well defined factors are influencing the distribution pattern of various epithelial cells in the nose and paranasal sinuses.

In the whole mounted technique an increased density of goblet cells in the anterio-posterior direction can be observed (Tos, 1982). Mygind (1975) suggests that the denseness and length of cilia (approx. 100/cell) may obscure the presence of single goblet cells in SEM preparations. This probably explains why this pattern was not confirmed in our study; due to technical problems the density of goblet cells in the paranasal sinuses was found to be lower than of those found in the nose, which is in agreement with the earlier findings of Mogensen et al. (1977). Therefore, the unexpected high density of goblet cells found in the maxillary ostium as in our study needs further validation.

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