Surface ultrastructure of human ependyma

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Specimens of human ependyma obtained immediately after death were immersion-fixed and studied with a scanning electron microscope. Human ependyma is nearly identical in its surface ultrastructural features to the ependyma of other mammals.

KEY WORDS • human ependyma • cilia, ependymal • scanning electron microscope • cerebrospinal fluid

CURRENT reexamination of cerebrospinal fluid dynamics in normal and hydrocephalic states has generated new interest in the ultrastructure of human ependyma. In this paper we depict for the first time the ciliated appearance of human lateral ventricles as delineated by scanning electron microscopy (SEM).

Materials and Methods

An 8-year-old boy with sepsis and pneumonia suffered a respiratory arrest and died. Within 2 hours of death, multiple 2 × 2 mm sections were taken at autopsy from the lateral ventricular walls and immersed for 12 hours in 3% glutaraldehyde, buffered to pH 7.4 with 0.1 M cacodylate buffer at 4°C; specimens were then dehydrated in graded ethanol and placed in amyl acetate for critical point drying with CO2. The ependymal surfaces were plated with palladium and gold and studied in a Cambridge stereoscan, model S4.*

Results

The surface features of all sections were identical in appearance and resembled the ependymal surfaces of other mammals.2,8,11 The uniform lush appearance of the ciliary coat can best be appreciated at a magnification of ×2300 (Fig. 1 upper). Views at a magnification of ×3100 demonstrate clearly the central position of the ciliary tufts as they emerge from neighboring ependymal cells (Fig. 1 lower).

Magnifications of ×7500 provide close-up views of individual ependymal cells (Fig. 2).

Fig. 1. Scanning electron microscope (SEM) studies of human ependyma from the lateral ventricle. Upper: Low power, × 2300. Lower: Medium power, × 3100. Note the troughs marking the ependymal cell borders and the central position of the ciliary tufts.
The demarcation between individual cells is a good index of the quality of tissue preservation; cell borders in these specimens are remarkably sharp despite the 2-hour delay in fixation. Measurements of 25 such ependymal cells yielded an average cell diameter of 9.0 \( \mu \). The cilia, which emerge in a central tuft averaging 16 cilia per cell with little variation, ranged from 0.18 to 0.19 \( \mu \) in thickness. Human cilia do not appear to taper and averaged 13 \( \mu \) in length, with a range of 11 to 14 \( \mu \). Thus, human ependymal cilia are nearly identical in their ultrastructure to the cilia of other mammals.\(^{11,12}\)

**Discussion**

Descriptions of the ciliated surface of human ependyma date from the turn of the century.\(^8\) The autolysis that accompanies the delayed fixation of material from routine autopsies and the limitations of light microscopy resulted in the impression that cilia occurred in scattered patches, if at all. Modern neuroanatomy texts perpetuate this idea: "In man cilia are observed only in embryological stages and are not observed in the adult,"\(^{14}\) and "The embryonic ependyma is ciliated and in some parts of the ventricular lining the cilia may persist in adult life."\(^{13}\)

Worthington and Cathcart\(^{15}\) corrected this impression in 1963 through studies of nine human brains removed within 2 to 6 hours of death. Specimens were immersed in mammalian Ringer's solution as soon as possible after removal, and then examined with water immersion lenses. Their study demonstrated a fully ciliated covering over all ventricular surfaces; some areas showed widespread coordinated ciliary motion capable of generating strong currents.

Both the internal anatomy of human ependymal cells and the relationship of cilia to blepharoplasts have been elucidated in both normal\(^{10}\) and neoplastic tissue\(^*\) by transmission electron microscopy. Studies of human ependyma by SEM have been restricted to a single report of the appearance of the infundibular recess.\(^8\) However, if human material proves analogous to that of other mammals,\(^6\)
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this is one of the few areas within the ventricles where cilia would be expected to be absent or scanty. In other mammals studied so far, including primates, cilia cover the entire ventricular surface with the exception of the recesses and floor of the third ventricle, the subcommissural organ in the roof of the aqueduct, and the area postrema. While it has been shown that ependymal cilia move the cerebrospinal fluid (CSF), the extent to which this contributes to CSF circulation is unknown. Further studies on the distribution and activity of human ependymal cilia are warranted.

References


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