THE EFFECTS OF LOW FREQUENCY NOISE ON RAT TRACHEA

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Introduction The clinical consequences of long term (years) exposure to low frequency noise (LFN) (≤ 500 Hz, including infrasound) have been identified and termed vibroacoustic disease (VAD) [1]. Respiratory complaints, among the first to appear (1-4 years of LFN exposure), include bronchitis and repeated oropharynx infections, independent of smoking habits. After 10 years of exposure, light to moderate pulmonary pathology can appear. To further investigate the effects of LFN on the respiratory tract, animal models were used.

Methods *Animals.* Ten age-matche Wistar rats were exposed to LFN in an occupati A L simulated schedule: 8 hrs/day, 5 days/week, weekends in silence. Control rats were kept in equal living conditions, but in continuous silence. All animals were fed standard rat food, had unrestrained access to water, and were treated in accordance with applicable legislation (86/609/CE). *Noise Exposure.* Fig. 1 shows the overall linear and A-weighted noise and spectral analysis collected inside the rat chamber using a digital real time analyzer (B&K 2144). An analog noise generator produced an amplified and frequency filtered acoustic signal so that acoustic energy was highly concentrated in the lower frequency bands, 50 Hz to 500 Hz, exceeding 90dB$_{Lin}$. The overall linear sound pressure level was above 109dB$_{Lin}$, and the A-weighted level was around 98dBA. *Microscopy.* Animals were sacrificed by a lethal intravenous injection of sodium-pentobarbital after a cumulative 1984 hours of LFN exposure. The trachea was divided in two, along the saggital line. Specimens prepared for scanning electron microscopy (SEM) (JEOL JSM-35C) were dehydrated, critical point-dried, coated with gold-palladium and examined with the electron microscope at an accelerating voltage of 15 kV.

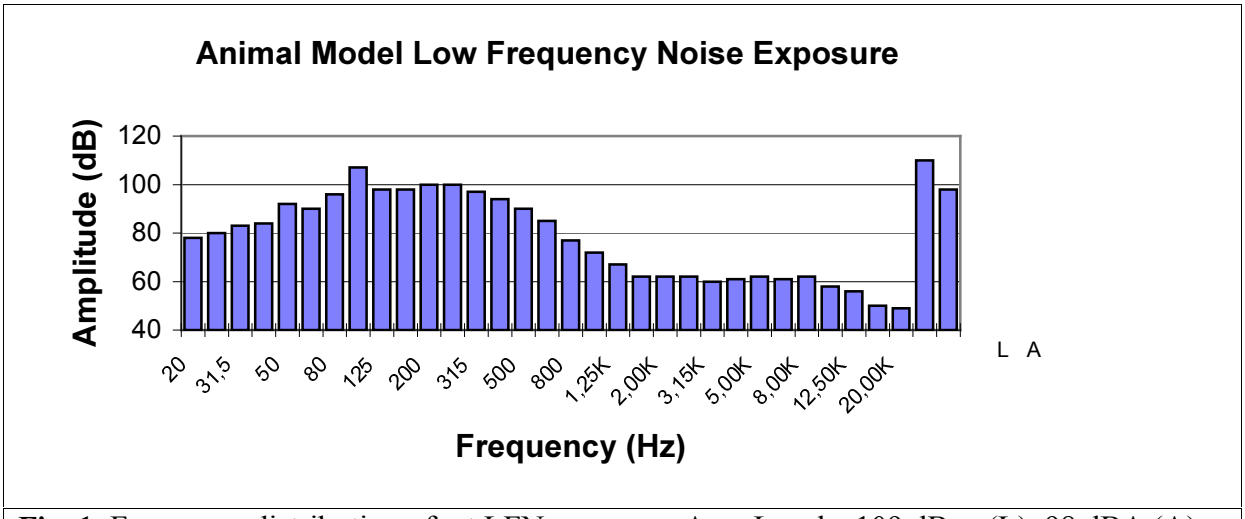

Fig. 1. Frequency distribution of rat LFN exposure. Ave. Levels: 109 dB$_{Lin}$ (L), 98 dBA (A).

Results Epithelial cells are damaged by LFN exposure. Brush cells (BC) always appear at the center of a ring of secretory cells (SC) (Fig. 2). BC microvilli sprout outward into the lumen,

and are regularly distributed over the entire BC surface. SC microvilli are at different lengths (indicating different stages of the cell life-cycle) and carpet the epithelial surface. Ciliary fields are in metachrony coordination and stand upright. Rosetta structures are not changed in the exposed rats (Fig. 3), however individual cell components are dramatically altered. BC microvilli no longer appear uniformly distributed over the BC surface open to the airway and, instead, begin to cluster and fuse among themselves. SC microvilli become short and stubby after 1984 hrs of occupationally-simulated exposure, while cilia appear wilted and sheared. Intercellular junctions become much more visible in exposed rosetta structures.

Fig. 2. SEM – control rat tracheal epithelium of control rat. Two BC (arrows) surrounded by rings of SC. SC microvilli are at different lengths and BC microvilli are uniformely distributed over the surface.

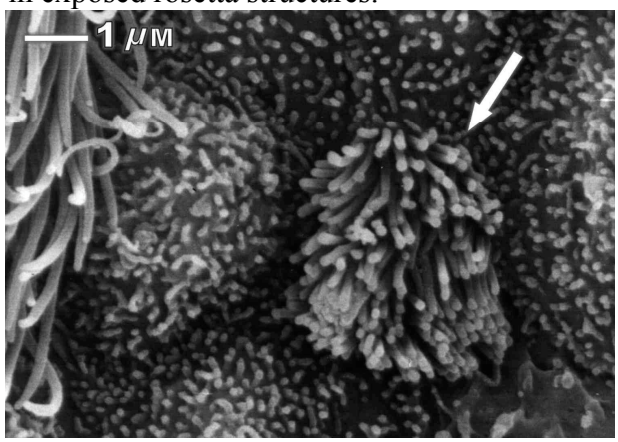

Fig. 3. SEM – exposed rat tracheal epithelium: 1984 hours. Rosetta structure is obvious, centered on a BC (arrow). SC microvilli are short and stubby. BC microvilli are no longer regularly distributed.

Discussion The lack of cilia and the deformation of BC and SC microvilli will certainly have consequences for the respiratory function of LFN-exposed organisms. However, the cellular pathway for this agent of disease is still unclear. The function of BC in the respiratory tract is, as yet, unknown. Occupationally-simulated LFN exposure triggers a number of morphological changes in the cellular landscape of rat respiratory epithelia, including squamous metaplasia. This is not entirely surprising given that LFN has alredy been identified as a genotoxic agent in both human [2] and animal models [3], and all respiratory tract tumors in VAD patients have the peculiarity of being of a single histological type: poorly differentiated squamous cell carcinoma [4]. The results herein demonstrate that ignoring LFN as an agent of disease may have dire consequences to the health of LFN-exposed workers.

Keywords: vibroacoustic disease, cilia, brush cells, microvilli, noise exposure,

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