Changes in Projections to the Inferior Colliculus Following Early Hearing Loss in Rats

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Abstract
Objectives: The purpose was to investigate the effects of early hearing loss on the anatomy of the central auditory system, specifically, the ascending projections to the inferior colliculus (IC).

Study design: We compared normal animals with animals deafened during early development by amikacin, an ototoxic antibiotic that is known to destroy the hair cells in the inner ear.

Methods: Deafness was produced by daily administration of amikacin from postnatal days P7 to P16. A retrograde tract tracer, Fluoro-Gold (FG), was then injected unilaterally into the IC at either P30 or P90. After axonal transport the animals were sacrificed and their brains were prepared for histology. The FG-labeled neurons in the cochlear nucleus (CN) and the dorsal nucleus of lateral lemniscus (DNLL) were counted for each of the animals in the two age groups.

Results: For deaf animals sacrificed at P30 there was a significant reduction in the number of FG-labeled neurons in the ventral CN ipsilateral to the tracer injection. For deaf animals sacrificed at P90, however, there was a significant decrease in the number of labeled cells in both dorsal and ventral CN on both sides of the brain. In DNLL there was no change in the number or pattern of labeled neurons.

Conclusions: Neonatal deafness results in a decrease in the number of neurons projecting from the CN to the IC with the decrease being more apparent during later stages of deafness. In contrast, there are no significant changes in the projection from DNLL to IC.

Materials and Methods
A total of 20 male and female SD rats were used. Newborn rats in the experimental group (n=10) were administered with amikacin (500mg/kg), ototoxic antibiotic drug, on a daily basis over postnatal day 7 to 16.

Auditory function was assessed by recording ABR (auditory brainstem response). FG (Fluoro-Gold) was used as retrograde tracer. A partial craniotomy on the right side was made and caudal pole of the occipital cortex was removed by aspiration to expose right IC. The tracer was injected with a glass micropipette with air-pressure injection system.

After an appropriate interval for the transport of the injected tracers, the animals were sacrificed, and the brains were processed for the analysis. Each brain was cut into two series at P30 or three series at P90 respectively. Deaf rats were compared with the age-matched normal hearing rats (n=10) on each age. The volume of all subdivision of the CN were measured and the number of FG labeled cells in the DNLL and the CN subdivisions were counted at each age.

The IC receives bilateral projections from the DNLL with contra-dominant contribution. Fig. 7 shows the pattern of retrograde labeling in the DNLL of a representative normal hearing rat at P90 with injection of FG in the right IC. We had no significant differences of the number of labeled cells project from the DNLL to the IC between normal and deaf rats in both P30 and P90. The ratio of the number of FG labeled neurons in contralateral / ipsilateral DNLL was computed for each brain and no significant differences of the ratios between normal and deaf rats in both P30 and P90. The ratios were 2.66 and 2.43 respectively in normal and deaf rats at P30, and 2.35 and 2.64 respectively at P90.

Discussion
The projections from the CN to the IC decrease as the duration of deafness increases. The CN might be directly affected by the degeneration of the cochlea because of their direct neural connection. The DNLL receives major ascending projections from all subdivisions of the contralateral CN, the contralateral DNLL, the ipsilateral and contralateral LSO (lateral superior olivary complex), and the ipsilateral MSO (medial superior olive), SPN (superior paraolivary nucleus), INLL, and VNLL (intermediate and ventral nucleus of the lateral lemniscus). Plasticity and neural network remodeling between the upper and the lower auditory nuclei might play important roles after early deafness.

Conclusions
We conclude that neonatal deafness can alter auditory brainstem morphology and connectivity. Prolonged absence of auditory input alters the projection to the IC, especially from the CN. From a clinical standpoint, these results could argue for early cochlear implantation in deaf children.

References