

Pharmacological treatment for noise induced hearing loss

The simple view has been that high noise levels overstress the cochlea hair cells, causing physical damage, which in turn leads to gradual degeneration of those hair cells. It is now known that high noise levels reduce blood circulation within the cochlear vessels, resulting in excess production of free oxygen radicals, which have a toxic effect on cellular materials in the cochlea. The damage is oxidative in nature, leading to temporary (TTS) or permanent (PTS) threshold shift.

These are gradual noise induced effects, differing from acoustic trauma, which has a sudden onset due to direct physical damage within the ear. There is a “therapeutic window” following excess exposure, probably of about four weeks duration, before permanent damage to hair cells has occurred in the inner ear. To take advantage of this window requires intervention with antioxidants soon after the noise exposure has occurred, in order to help the hair cells repair themselves.

Animal experiments have used chinchilla, with a saline solution applied to the surface of the round window of one ear as a control, and an antioxidant applied to the other ear. After exposure to noise, it was shown that the ears treated with antioxidant had significantly less outer hair cell loss than the control ears. From this it is assumed that enhancement of the anti-oxidant defence system may reduce hearing loss from noise exposure.

A research team at the Naval Medical Centre, San Diego, has been investigating pharmaceutical intervention for noise induced hearing loss, initially supplying medicine to the inner ear via a catheter. Test exposure was to simulated M-16 rifle fire of 150 shots over 75 seconds. It was shown that the antioxidant N-acetylcysteine (NAC) decreased NIHL from these high levels of impulse noise by 70%. One method of delivery has been, as above, use of a micro-catheter to supply

Whilst we all know that high levels of noise are a cause of hearing loss, and have probably seen photos of damaged hair cells, the process by which the damage occurs is not so well known.

Development of understanding has given the potential for some control of noise induced hearing loss, and even shown the way to its reversal.

medication directly to the cochlear fluid by absorption through the round window. Although less convenient than oral administration, this directs the medication to exactly where it is required. A wide range of antioxidants could be produced as similarly effective hearing loss therapies.

Commercial development is licensed to the American Biohealth Group (www.abgpharma.com), which plans to introduce an oral pill as part of a three-pronged therapeutic approach:

- Preventive, by improving the defence methods of the cochlea prior to exposure.
- Rescue, by enhancing the reparative capabilities after acute injury, within the time window before permanent injury is established.
- Building up the cochlea's restorative capabilities in patients with acute hearing loss.

Initial dosage will be a widely available pill to make the ear more resistant to both noise and chemical injury, reducing inner ear damage.

So, in future, it may be a different sort of pill that's handed round at the clubs and discos.

More on the hair cells

The hair cells, to be found deep in the inner ear, are the final mechanical system of the hearing process. Hair cells are at the location where the energy of the sound waves is finally converted into electrical signals to the brain. But to step back a few paces, the complete process can be summarised as:

- Sound is collected by the outer ear and directed down the ear canal where it impinges on the ear drum, causing it to vibrate as a membrane.
- The vibration is transmitted to the bones of the middle ear, the

ossicles (hammer, anvil and stirrup), which are the smallest bones in the body.

- The ossicles connect to the inner ear (cochlea) through the oval window and send vibrations through the cochlear fluid, up one channel and down another, where the vibration is released at the round window.
- The vibrations in the cochlea cause movement of the membrane on which the hair cells are mounted (basilar membrane), causing the hair cells to be stressed against a stiff membrane (tectorial membrane)

The action of the hair cells has been understood only in the last 10 years. The figure shows three rows of outer hair cells and one row of inner hair cells. (The hair cell is the whole body, not just the hair-like elements at the top). The length of the cells varies depending on their position in the cochlea, but the inner hair cells are 30–35 microns in overall length. The cells are topped with bundles of stereocilia, which contact the tectorial membrane. Displacement of the stereocilia opens “gates”, permitting charged chemical ions to flow into the hair cell. These ions stimulate neurotransmitters which flow to the base of the cell and release glutamate into the gap between the base of the hair cell and the auditory nerve. This leads to electrochemical information passing to the brain, where it is interpreted as sound.

The inner and outer hair cells have different functions. It is thought that the single row of inner hair cells are the main transducer of information. The three rows of outer hair cells change length in sympathy with a sound wave, pushing against the tectorial membrane and amplifying the vibration of the basilar membrane, leading to increased stimulation of the inner hair cells.