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Hearing Loss in the Workplace: Noise and Something Else?

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Abstract
It is a common knowledge that hearing loss is the result of exposure to high noise levels for extended periods of time. In most situations this is the case; however, there are other agents that also can affect hearing, by themselves or in combination with noise. This paper examines the effects of one of them: chemicals in isolation or in combination with noise.

"Ototoxicity is the property of being toxic to the ear (oto-), specifically the cochlea or auditory nerve and sometimes the vestibular system, for example, as a side effect of a drug" [1]. In practical terms, ototoxicity deals with chemical agents that may affect not only hearing but also the body equilibrium.

The effects from high noise levels can be enhanced by the presence of ototoxic agents, therefore increasing the risk of hearing loss. This has been noted by both the American Congress of Governmental Industrial Hygienists (ACGIH) [2] and by the Occupational Safety and Health Administration (OSHA) [3]. They both recommend actions to be taken when chemicals are present in the workplace. Several European countries as well as Australia recommend that when ototoxic agents are present in the workplace, the daily noise exposure level should be reduced [4].

The situation is quite complex, since ototoxic chemicals are often found in the workplace. They are present in activities as diverse as painting, printing, boat building, construction, furniture making, manufacturing of metal and fiberglass, leather and petroleum products, aircraft maintenance, radiator repair, fire-fighting, pesticide spraying, weapons firing, etc. Therefore, it is possible that a detected hearing loss may not be solely due to excessive noise, but also to the presence of ototoxic substances [5].

Noise is a single physical agent affecting the cochlea, with the external ear canal as the main port of entry. In general, the progression of noise induced hearing loss ceases when the noise is eliminated. However, some data suggest a progression of cochlear and possibly neural dysfunction even after the noise exposure is terminated [6].

In contrast, there are not one, but three routes of entry for the chemical agents: ingestion, inhalation and skin penetration. Their effects occur not only in the cochlea and the semicircular canals, but in the central nervous system as well. They can go well beyond hearing acuity, resulting in compressed loudness, reduced frequency, and temporal resolution and diminished spatial resolution, as well as dizziness and tinnitus. The effects of ototoxic chemicals (alone or in combination with noise) continue even after the cause is removed: The mechanism is most likely a combination of cochlear and neural involvement.

Unlike noise induced hearing loss, the auditory effects of chemical exposure may not be bilateral or even symmetrical. As with the noise induced hearing loss, it occurs first in the high frequency region. Effects are also related to the individuals' exposure history: the longer and the higher the exposure, the greater the effects.

Synergetic and additive effects may occur when chemical ototoxic agents and noise are both present. Those effects can be larger than if the two were acting separately. The additive effect occurs when the effect of both participants is equal to the sum of the individual effects. The most studied combination is that of noise and solvents.

The list of recognized and suspected ototoxic substances is quite extensive, especially when considering that they may also be a part of a complex compound. Also, the exact knowledge of their "safe" limits (TLV or similar) is scarce. Studies in toxicity involving humans are very few and far between. There are many animal studies, but questions remain of how their results can be applied to humans [7].

In general, ototoxic substances are grouped into:

- Pharmaceuticals drugs
- Aromatic solvents
- Asphyxiate gases
- Metals and compounds

Substances from the first group (ototoxic pharmaceutical drugs) are probably the best known. Despite the risk of hearing disorders, they are used to treat serious health conditions for which they may be the only remedy [8,9].

Among the solvents, the main culprits are styrene, toluene, xylene and trichloroethylene. All of these solvents are extensively used in many industries. The combined exposure of solvents and noise increases the risk of occupational hearing loss in a synergistic (more than

additive) manner, especially if the noise is impulsive in nature.

Among the gases, those most often cited are the asphyxiants that interfere with cell respiration. In animal models, they are not toxic when acting alone, but can become ototoxic when combined with high levels of noise. The only exception appears to be CO from smoking, which presumably is implicated in hearing loss, even in the absence of noise exposure.

The list of metals includes lead, cadmium, arsenic and manganese, cobalt, tin, platinum and copper.

To complete the list, we should also add some pesticides and PCBs; most studies of their behavior are based on animal models only.

The main question is what can be done to reduce/eliminate the effects of ototoxic substances. The answer lies in the implementation of a hearing conservation program, including:

a) Determining if the substance(s) is (are) present in the workplace. If that is the case, the measurement of the exposure of the workers will indicate the degree of the hazard.
b) Limiting the exposure by implementing engineering measures or through the compulsory use of personal protective equipment. Exposures should be reduced to “safe” levels, lower than the maximum permissible levels for only noise or only ototoxic chemical.
c) Introducing thorough audiometric tests with follow-up.

Finally, it is fundamental to have management and workers aware of the combined effects of noise and chemicals.

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