Review

Occupational Noise-induced Hearing Loss

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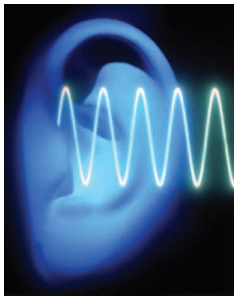

Abstract

Noise-induced hearing loss (NIHL) is a well-known entity in daily practice of otolaryngology. A wide variety of NIHLs are work-related. Occupational noise is the most common cause of NIHL in adults which is up to now considered incurable and the best approach to it is to utilize maximal protection. An effective noise exposure prevention program consists of identification of sources of noise and implementation of controlling measures and regulations at working environments as well as performing periodic audiologic evaluation of those who are working at noisy environments. The present paper, briefly reviews occupational NIHL mainly based on the related data available on *PubMed* up to early 2010.

Keywords: Noise; Hearing Loss, Noise-Induced; Occupational Diseases

Introduction

Noise is considered as an "unwanted sound"[1] with various harmful effects on health. Noise-induced hearing loss (NIHL) is an irreversible damage of the cochlear hair cells of the inner ear. It may present as partial or total hearing loss and its severity depends primarily on duration of noise exposure and sound intensity.

The history of occupational NIHL (ONIHL) probably dates back to many centuries ago, even though as Alberti stated, it only became a major occupational aural disorder after discovery of gunpowder and has increased significantly after the Industrial Revolution. From audiological point of view, for the first time in 1886, Thomas Barr described the "boilermaker's deafness" related to shipbuilding. Then, the histological features of NIHL in the organ of Corti of the inner ear were demonstrated by Haberman in 1890. Afterwards, Fowler described the characteristic noise-induced 4 kHz notch on audiogram and in due course in 1939, Bunch explained broadly the audiometric findings of NIHL.[2]

At global scale, the major cause of NIHL in adults is occupational noise[3] which seems to be currently increasing in developing countries.

Occupations at risk

Noise production has raised parallel with the industrial growth and technologic advancements and presently, many people in the world are exposed to intermittent or continuous hazardous sound levels (>85 dB) at their work environments.

Many workers including those engaged in heavy industry, factories, forge hammering, coal and ore mining, construction, cement plants, gas processing industry and mechanical engineering as well as mill and stationary machine device operators and workers at oil refineries are at risk of occupational NIHL. For instance, in a metalworking company in Brazil, the rate of suggestive cases of NIHL was around

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15.9%.[4] In a similar survey studying NIHL among the US mine workers, the investigators found that certain pieces of equipment in coal primary plants were the loudest sources of noise production.[5] In another investigation performed in Iran, the audiometric assessment of the workers in a textile plant who were occupied in spinning and weaving units confirmed a significant increase in the prevalence of high frequency sensorineural hearing loss (SNHL).[6] In another study on 384 workers at an oil refinery in Taiwan, the researchers showed that those workers who had been exposed to noise for more than 15 years had an increased hearing threshold shifts at high frequencies (*i.e.*, 3, 4, and 6 kHz).[7]

Civilian aviation started in the first decades of the twentieth century.[8] Flight crews, pilots, airline ramp employees, and maintenance workers at airports are all at potential risk of NIHL. In a study performed on full-time male workers working at a large metropolitan airport in Korea, it was shown that occupational noise exposure, other risk factors (*e.g.*, non-occupational noise exposure, history of pervious ear diseases, taking ototoxic drugs, smoking and hypertension), and use of hearing protective devices were significantly associated with hearing status of these workers.[9] In another study conducted in 2007, out of 609 pilots aged between 26 and 68 years, 431 (70.8%) had SNHL.[10]

Military personnel including pilots are exposed potentially to loud sounds. Acoustic trauma may occur during military service due to impulse or blast wave noise exposure.[11] The prevalence of hearing loss in an army aircrew was reported in 1996 by Owen. The study revealed that those aircrew with more than ten years of flying experience had a hearing threshold shift correlated with their age and number of years of flying.[12]

One study showed that 36% of firefighters had a moderate to severe SNHL at 3, 4, or 6 kHz.[13] They were exposed to a harmful level of intermittent noise from sirens, air horns, engines of emergency vehicles and fire trucks.[14]

Railroad service employees including locomotive crew are also exposed to noise and at potential risk of developing ONIHL.[15]

Farmers may face occupational hearing loss for exposure to noise produced by agricultural machineries. Concurrent exposure to chemicals including solvents and pesticides may also potentiate their hearing impairment.[16]

The drivers and operators of heavy trucks would be exposed to noise. In a recent study from Iran, it was shown that in professional drivers hearing impairment appeared earlier at 4 and 8 kHz than lower frequencies.[17]

Hearing status of 200 traffic policemen in Moscow was compared to that of 50 policemen who had been working in offices. The results revealed a higher prevalence of ONIHL in traffic policemen.[18]

Among musicians, rock and roll devotees are especially at risk of developing ONIHL. Professional orchestral musicians also run the risk of developing ONIHL.[19] In a study, players of the principal trumpet, first and third horns and principal trombone were at the greatest risk of exposure to excessive continues noise, while the percussion and timpani players were at the maximum exposure to excessive peak noise levels.[20]

In the past few decades, the occurrence of ONIHL in dentists has been discussed in the literature. For instance, Bail and coworkers reported the shifts of hearing thresholds at 4 and 6 kHz in a group of dentists.[21] Other studies also confirmed the problem of early hearing loss among dentists which is caused by high-speed air

TAKE-HOME MESSAGE

- Noise-induced hearing loss is an irreversible damage of the cochlear hair cells of the inner ear.
- Occupational noise is the most common cause of noise-induced hearing lossin adults.
- Tinnitus as an occupational noise-induced symptom should always be considered in those with noise-induced hearing loss.
- Exposure to noise of pregnant women at working places may affect the hearing of their unborn children.

turbines.[22]

In a 12-year prospective study carried out on hearing thresholds of 477 professional divers in Norway, the investigator found a correlation between hearing impairment and diving. In that study, hearing loss was noticed at frequencies of 4 and 8 kHz.[23] Moreover, permanent bilateral SNHL has been demonstrated in professional scuba divers.[24] Barotrauma, decompression sickness and noise are regarded as the main causes of hearing loss among different diving groups.[23]

The problem of noise exposure in employees of a hospital kitchen has been reported in a study; the author recommended metal-to-metal contact must be reduced as much as possible and hearing protectors should be provided to employees working in the dishwashing room until proper control is applied.[25]

The researchers in Denmark assessed the hearing loss among the seafarers and fishermen and reported that hearing loss was a common problem among the workers of the engine rooms of ships.[26]

Rose and colleagues confirmed the popular sport of stock car racing as a potentially significant source of noise exposure. They found that the peak sound level six meters away from the track was 109 dB, which was higher than permissible sound level.[27]

Another study showed that several orthopedic instruments produced sound levels between 95 and 106 dB with potential risk of developing NIHL.[28]

Symptoms

Besides to SNHL which is caused by prolonged noise exposure, the association of NIHL and tinnitus is fully described in the literature and it has been shown that tinnitus would be increased with progression of noise-induced auditory damage. The severity of tinnitus depends on age and duration of noise exposure.[29] In case of occupational noise exposure, many tinnitus sufferers probably remain undetected. Therefore, tinnitus as an occupational noise-induced symptom should always be considered in those with NIHL.[30]

Risk Factors

Rheumatoid arthritis and diabetes mellitus

Employees with rheumatoid arthritis or diabetes mellitus who are working in noisy environments are at a higher risk of developing NIHL.[31]

Chemical substances

Hazardous effect of noise on hearing may be potentiated by concurrent exposure to ototoxic or non-ototoxic chemical substances. For instance, it has been shown that exposure to low to moderate levels of carbon monoxide or hydrogen cyanide can increase the likelihood of developing NIHL.[32] In another study, the role of exposure to organophosphate pesticides as a

risk factor for developing hearing loss in those farmers who were simultaneously exposed to noise has been discussed.[33]

The relationship of toxic solvents in car paints and risk of developing hearing loss associated with occupational exposure to moderate noise intensity has also been reported. The author pointed out the possible synergistic destructive effects on the cochlear hair cells in the inner ear of exposure to toxic solvents in car paints and moderate exposure to occupational noise.[34] The harmful effect of exposure to industrial metals such as mercury on sensory perceptions of workers including their auditory sense has also been reported.[35]

Ototoxic drugs

Taking ototoxic drugs and working simultaneously at the noisy work places would increase the risk of developing NIHL. The synergistic ototoxic effects of concurrent exposure to noise and taking aminoglycosides has been discussed earlier.[36]

Smoking and age

Smoking may enhance the development of ONIHL.[37] The effect of smoking on development of NIHL in 504 workers in a large wagon manufacturing company exposed to risky noise level (>85 dB) was investigated. The results revealed a higher prevalence of hearing loss in smoker workers in comparison to non-smokers.[38]

Researchers showed that after the age of 40 years, there was an additive interaction between smoking and development of NIHL at high frequencies, mostly at 8 kHz.[39] It has been shown that age was an important factor for development of NIHL, particularly among those workers exposed to noise levels below 98 dB.[40]

Heat

In a case-control study in an air conditioning factory in southern China, 2400 workers who were exposed to noise were evaluated. The authors reported that heat exposure may act as a risk factor in development of SNHL.[41]

Hyperlipidemia

Although it is suggested that the serum triglyceride level of workers exposed to high level of noise be meticulously controlled to lessen the risk of NIHL,[42] further large scale studies are needed to make this association more clear.

Noise intensity and frequency range

In a study carried out on the workers involved in steel mills, lumber mills and marble shops exposing to noise levels >85 dB, the authors concluded that noise intensity, regardless of its frequency range, was a possible independent risk factor for developing hearing loss.[43]

Diagnosis

As ONIHL is incurable, its early detection and rehabilitation are highly recommended. No specific otologic or exclusive audiometric findings can be detected in those with NIHL,[44] thus, accurate history taking and audiometry are of paramount importance in making the correct diagnosis of ONIHL. The earliest audiometric finding is SNHL involving mainly the 4 kHz frequency.[45,46] Differentiating NIHL from other conditions needs a complete otologic evaluation.[47] High frequency audiometric notches may be seen in those who did not have any history of exposure to high level of noise. Therefore, though history of noise exposure is an important clue in the diagnosis of NIHL, all workers, regardless of their exposure history, should undergo regular audiometry to detect NIHL as early as possible.[48]

Prevention

For decades, many controlling legislations on NIHL have been passed worldwide especially in the industrialized countries, nonetheless, as Thorne, *et al*, pointed out despite this endeavor "the current strategies seems to be unsuccessful or insufficiently implemented or both."[47] In order to lower the risk of ONIHL, the following remarks should be considered in a successful hearing conservation program:

- Engineering controlling means should be instituted to decrease the number of sources of noise production[49] and to reduce the level of noise produced.[3]
- Providing free of charge, hearing protective devices for employees working at noisy environments is essential.[49] Training of workers, especially for lower skilled ones, to use these devices correctly is very important.[49] Long-term application of such protective devices depends mostly on comfort of the worker and it plays a major role in its acceptance and effective wearing.[50] Rosborg showed that permanent use of hearing protective devices was associated with good preservation of hearing,[51] nevertheless, the efficacy of these devices mostly depends on their proper use.[52] It is also reported that 68% of workers did not utilize any hearing protective devices in noisy working places.[53]
- The health care authorities should make an effort to reduce noise production in industry to the permissible exposure level (*i.e.*, <85 dB).[54] In addition, the recommended work schedule for those working in noisy environments is working a 12-hour shift followed by a day off.[55]
- In order to implement the hearing conservation measures as well as specialist technical knowledge of noise and the related legislation, headship of the senior manager and the capability of middle managers (chiefly in production and engineering sectors) are required.[56]
- The level of noise exposure over specific time periods should be measured by dosimeters.[57]
- Performing periodic hearing appraisal in those who are exposed to excessive sounds is crucial for early detection and prevention of ONIHL.[58]
- Exposure to noise of pregnant women at working places may affect the hearing of their unborn children. The low frequencies of hearing of unborn children are more affected.[59]

As the ONIHL seems to be a prevalent occupational disorder in Iran due to industrial growth and technologic advancements during the last few decades, the following major points should be considered.

Further detailed studies on various aspects of ONIHL are required at national level. To the best of my knowledge, the information on the level of occupational noise exposure and statistics of the associated hearing impairment in Iran are scarce which warrants conduction of further scientific studies on this issue. Furthermore, employees and workers should be given adequate training in noise, its dangers and preventive measures.

Implementation of proper rules and regulations by responsible health authorities is mandatory. Historically, the activity pertaining to the safety of workers and the occupational health standards has been started in Iran since 1946. Then, some rules and regulations were approved and the Labor Inquiry General Administration (*Edareh-e Koll-e Bazrasi-e Kar*) became in charge of safety measures at work. Afterwards, in 1984, the Ministry of Health took this duty over. Finally, the agenda was revised in 1991 and the Ministry of Health and Medical Education became the

responsible body for the occupational and industrial health in Iran.

The problem of ONIHL may also occur in oil refinery,[7] therefore, the National Iranian Oil Company Health Organization seems to be the best authority for controlling and prevention of ONIHL among the noise exposed workers and employees.

Future Steps

In the past 20 years, the pharmacological prevention and treatment of NIHL have been explored but as yet no promising treatment has been found.[60]

Individual susceptibility to NIHL varies greatly. Therefore, the genetic basis of the disease should be investigated. Formerly, most studies have been carried out in mice model, but more recently, extensive genetic studies have been performed on human deafness including NIHL.[61]

The assessment and diagnosis of NIHL for purposes of compensation may be a challenging issue for otolaryngologists, because the industrial managers, labor unions and workers may have different requests.[62]

As ONIHL is an irreversible widespread work-related hearing handicap in adults, the best approach is prevention through identification of noise production sources, implementing standard rules and regulations, expansion of training programs and performing periodic hearing evaluation of those who are exposed to excessive sound levels. An effective occupational hearing conservation program particularly in developing countries is highly recommended.

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