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VERIFICATION OF THE BEHAVIOR OF THE AUDITORY ORGAN TO THE INDUSTRIAL PROFESSIONAL NOISE IN THE BOILER AND FORGING ROOMS AT "NICOLINA MECHANICAL PLANT"

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ABSTRACT: The symptomatology of the professional acoustic trauma varies according to the stage of the clinical observation, even if at the first contacts with the noise the workers signal the sensation of muffled hearing, various ringing sounds, etc. The present study aims at checking the behavior of the auditory organ to the industrial professional noise through experimental research conducted at the boiler and forging rooms of "Nicolina Mechanical Plant". Clinic and experimental: the lot of patients totaled 14 witness subjects, aged between 18 – 25, without hearing disorder history, with normal otoscopic aspect and unimpaired hearing in order to determine the audiometric behavior in relation to the professional noise. The symptoms fade away after work is finished. After 8-10 days there appears a phenomenon of adaptation with disappearance of the symptoms. Deafness occurs silently, varying from one subject to another depending on the individual type, ranging from several months to a couple of years.

Key words: audiogram, noise, auditory analyzer, hearing impairment.

INTRODUCTION

In order to check the behavior of the auditory organ to the industrial professional noise experimental research has been conducted in the boiler and forging rooms of "Nicolina Mechanical Plant". From the research the following aspects were drawn:

This professional environment is characterized by a variable sound spectrum with a maximum frequency between 800-2000 Hz at an average intensity of 109 dB and 102 dB for the 4000 Hz frequencies.

The background noise is doubled in certain areas by the discontinuous and high frequency noise of the pneumatic hammers.

MATERIAL AND METHOD

The research took place as follows:

Clinical and experimental: on 14 witness subjects, aged between 18 – 25, without hearing disorder history, with normal otoscopic aspect and unimpaired hearing in order to determine the audiometric behavior in relation to:

- white audiometric noise of 100 dB;
- a pure sound on various tones at 100 dB;
- the professional noise from the area subject to the research.

Clinical and experimental: on a lot of 112 workers of the boiler and forging section divided on groups of work seniority in order to determine:

- the permanent auditory deficit prior to beginning the shift;
- the reaction of the auditory analyzer to the professional noise of the section after a 5 hours exposure.

The results of the research are as follows:

For the witness subjects exposed to the three situations the audiometric results show:

The monolateral stimulation for 5 minutes of the normal auditory analyzer with white noise determined no modification of the auditory acuity after the stimulation in any of the cases. There results that at the level of the auditory analyzer of normal young people

there developed a process of adaptation which, once the stimulation ended favored the return to the level of the pre-stimulation factor.

A 5 minutes exposure to a continuous pure sound of low-pitched tone (500 Hz) at an intensity of 100 dB, HL acting monolaterally by air transmission, determined a slight decrease of the post-stimulation thresholds of CA and CO for the same homolateral frequency (20 dB, HL post stimulator and returns to the pre-stimulation threshold in 3-4 minutes). This shows that the adaptation occurred at a proper level and that there is a short remanence period after the stimulation ends.

The stimulation with a high-pitched sound (4000Kz) under the same conditions of monolaterality, the duration and intensity determined the constant and relatively strong decrease of the thresholds CA and CO bilateral (of up to 30 dB Hl homolateral and 20 dB controlateral for CA and of 10-15 dB homolateral and 5 dB controlateral for CO). The return of the thresholds occurs after 15-18 minutes for CA and 10-15 minutes for CO, monolateral; after 10-15 minutes for CA and 10-15 minutes for CO, controlateral sometimes beyond the pre-stimulation threshold.

This research confirms the classical opinion of the harmfulness of high-pitched frequencies to which adaptation is more profound and the recovery slower.

For the high-pitched tones the audiometric modifications of the thresholds under the conditions of monolateral stimulation showed constant bilateral modifications.

The exposure of a lot of witness subjects (for 30-60-90 minutes) to the industrial noise determined certain auditory modifications in the area of medium and high frequencies at ¾ of the cases in proportion to the duration of the stimulation.

For ¼ of the cases, the exposure to the noise determined the disproportionate alteration of the post stimulation curves, which raises the problem of individual reaction variability of the constitutional or trained auditory organ.

The research conducted on a lot of 112 workers with 1 to 20 years of work experience, depending on the noise, showed that the audiometric modifications were closely related to the work seniority.

The pure tone audiometric curves of the workers from the group of 1-2 years of work experience in a noisy environment showed a less marked loss in the area of the frequencies of up to 2000 Hz and a decrease at 4000 Hz at the bone level, a curve significantly inferior to the one if medium and low-pitched sounds, with a rising tendency for the frequencies of 2000-4000 Hz.

These curves show that in noisy environment conditions a permanent auditory deficit settles after one year of activity, at the limit of the socially identifiable auditory deficit.

The pure tone curves of the workers group with 5-10 years of work experience were characterized by a moderate deficit in the area of the frequencies of up to 2000 Hz and a decrease or sudden drop of 20-25 dB towards high-pitched tones.

For these workers the bony curve, initially inferior to the airborne curve, became convergent, surpassing it in the area of the 2000-4000 Hz frequencies.

After the pure tone audiometry of the various categories of workers after a 5 hours work period in the industrial environment it was noticed that:

- the post stimulation audiometric curves of the workers with 2 years of work experience resembled the pre-stimulation audiometric curves of the workers with 5 years of work experience in a noisy environment.
- those of the workers with 5-10 years of

work experience resembled those of the workers with 15-20 years of work experience in a noisy environment.

The comparison of the pre and post stimulation audiometric curves of the workers with 5-10 years of work experience show a serious alteration of the function of adaptation for high-pitched frequencies but a conservation of the function for the medium and low-pitched frequencies. This shows a function of accommodation depending on the tone field, being almost null for higher frequencies, where a pure tone hearing loss of 50-70 dB places the auditory level at the limit of social disability.

By comparing the pre and post stimulation curves for all the work groups obtained 35-45 minutes after the separation from the noise, the persistence of an auditory deficit was signaled. This proves that the duration of the 30 minutes rest period appears insufficient for the annihilation of the auditory fatigue which sets in after the first 5 hours of work in a noisy environment.

The permanent auditory deficit identified for the subjects under examination are indicative of the same insufficiency of rest between two days of work.

The total noise acting on the auditory organ of the worker during 8 hours of daily work determine at the level of the organ modifications that cannot be annihilated by auditory rest in the following 16 hours. Thus, the remaining auditory deficit of the previous day is added to the effects of the noise related to the following workday, leading to a progressive and permanent auditory deficit.

Evolution – deafness due to professional noise trauma is of a sensorineural type, the bone curve overlapping the air curve. According to Maduro and Lallement it evolves in 4 stages:

- the period of installation of hypoacusia – the first days of work in a noisy environment determine dizziness, slightly painful sensations, intellectual and physical fatigue; after several weeks the ear adapts to the noise, but there appears an increase of the threshold (bone and air) at the frequency of 4096 to 50 dB, which can be assessed after the workday. After several rest hours the threshold comes back to normal. This is the fatigue stage of hearing. In time, there appear irreversible cochlear lesions which trigger an increase in the threshold for the frequency of 4096 up to 40 dB.
- the period of total latency – once this deficit appears there follows a period of latency. The audiogram shows a "V" shaped decrease around the frequency of 4096 for a distance of 1-2 octaves, but the hearing of the conversational voice is normal.
- the period of subtotal latency – after a period of time that varies from individual to individual and depends on the intensity of the traumatic noise, the hearing loss at 4096 deepens and the neighboring octaves are affected of 2048 and 8192. Conversational voice is still heard normally, but the distance of hearing whispers decreases gradually. Deafness may dwell in this stage without further evolution, even if the exposure to the noise continues.
- the terminal period – after several years of exposure to noise, for the individuals with a particular susceptibility of the auditory organ deafness may aggravate further. The audiometric curves go from low-pitched tones to high-pitched ones.

Conversational voice is heard with difficulty. Intense acouphene may appear at this stage, seldom other than hearing remnants for 90-100 dB for lower frequencies.

The installation of deafness due to sound trauma depends therefore on the particular sensitivity of the auditory organ. Cases when

workers perform 10-15 years of activity in a noisy environment and still possess a normal hearing are common.

The positive diagnosis – the diagnosis of professional deafness must be indicated every time the hypoacusia develops as a result of work performed in a noisy environment.

Apart from this element, the following characteristics should be taken into consideration for professional deafness:

- hypoacusia is mostly bilateral and always starts by a scotoma at the level of 4096 frequency;
- the scotoma tends to enlarge towards the area of high-pitched frequencies 8192, and in a very advanced stage towards the low-pitched tones;
- the auditory acuity for whispering voice is low, the decrease varying in elation to the work seniority;
- Sullivan's index is normal for all individuals suffering from this disorder;
- the phenomenon of recruitment is present;
- hypoacusia is intensified during work.

Clinical forms:

1. unilateral form: in opposition to the aspects stated for the symptomatology of professional deafness, namely that it is bilateral; there are cases when the auditory deficit settles only in one ear, even if it was not subject to previous lesion. This fact can be easily explained in the case of workers who stand with only one ear close to the source of the noise.
2. local deficit form : is a form only at the clinical level where the deficit is situated at the level of the 4096 frequency, uni or bilateral, although due to their work experience the workers exhibit a hearing impairment situated at the level of the 4096 frequency, uni or bilateral.
3. atypical local form of deficit: although people work in the same noise conditions, they sometimes exhibit a decrease of the hearing capability at the level of 2048 frequency, uni or bilateral.
4. rapid evolution form: this form is characterized by the rapid evolution of hypoacusia.
5. slow evolution form – this form manifests itself by the absence of important audiometric modifications for workers who work for years in a noisy environment.

Differential diagnosis is done with:

Presbycusis – it is a hypoacusia that appears as a normal biological phenomenon that starts around the age of 30 and becomes embarrassing only around 50.

The evolution of the hypoacusia is slow. The scotoma is localized first at the level of the 2048 frequency. It shows no recruitment.

Otospongiosis is first manifested under the form of a transmission-type hypoacusia that rapidly turns into a mixed type deafness. It is a lot more frequent with women.

It usually starts around puberty, aggravates during pregnancy, breast feeding and menopause. The evolution may settle in a variable period of time, of several years or even decades. It exhibits Willis' paracusia. It shows no recruitment.

Deafness from Meniere's syndrome – is a deafness of pure perception. It appears suddenly and is repeated under the form of crises, being accompanied by dizziness and acouphene.

Deafness by fracture-less cranial trauma: is a deafness of pure perception. It may present itself under various forms, starting from benign hypoacusia to serious deafness.

The air curve in this form of deafness interests all frequencies, predominantly the high-pitched one. The bone curve is parallel with the air one.

Deafness by endo or exogenous intoxications: is a deafness of pure perception and can be uni or bilateral. At first hypoacusia is situated at the level of the 8000 frequency.

Prognosis – the evolution of the morphofunctional disorders takes two stages. The first stage is hypoacusia, the second one, deafness.

In the hypoacusia stage, the degenerative lesions affect the auditory organ only to a small extent.

By taking proper protection measures deafness may be prevented at this stage.

The deafness stage is of a particular importance since it is a social disability. It may be serious, culminating with complete deafness.

Due to the degenerative lesions that irreversibly settled in, the aspect of prevention of professional noise is crucial in order to fight deafness.

RESULTS AND DISCUSSIONS

The prophylaxis of professional deafness

Noise, omnipresent and ever-growing due to technical development, industrialization and urban agglomeration constitutes a problem that needs to be solved urgently. Noise pollution represents one of the most devastating dramas of our environment, since its effects are insidious and undoubtedly cumulative.

Deafness varies from individual to individual, and even for the same individual in relation to certain circumstances, as the time of exposure, moment, and physical characteristics of the noise and resistance of the organism.

With regard to the means of fighting and preventing the effects of noise on the human body in general and on the ear in particular, they constitute the subject of various researches both in the medical and the technical field worldwide.

If the problem of violent noises is currently well known, encompassing both the effects of the hearing and on the organism generally, the study of less high-pitched, irregular noises which make up professional or even social life still constitutes a difficult issue.

The means of prevention are based first of all on the precise knowledge of the noise parameters, its nature, frequency, intensity, and duration of exposure as well as its character of continuity or intermittence.

Once these facts are known, the preventive action comprises a series of medical and technical measures.

The main measures recommended for the fight against professional industrial noise are: the diminution of the noise source; the diminution of noise transmission; the diminution of perception.

The diminution of the noise source: the main sources of industrial noise are represented by machines, equipment, motors, tools, and means of transportation or noisy maneuvers. With regard to the noise sources represented by fixed machines, equipment or motors, these needs to be insulated, and each of them should be studied individually in order to take the best measures. It is advisable to confine them into insulated blocks whose size, elasticity and form will be decided depending on the frequencies of the machine noise they need to absorb. It is recommended that the mechanical part should avoid contact with the ground and rubber fittings should also be used.

Diminution of transmission: the following principles need to be observed in the attempt to diminish the noise transmission within factories:

- the distancing of sound sources one from another or grouping them and totally placing them at a safe distance;
- the deafening of the noises produced by the use of porous, light and phono-absorbent insulation materials;
- the interruption of noise propagation by the use of materials that do not vibrate;
- the annulment of noise propagation by the use of insulated screens.

It is advisable to group the noisy machines in sections or workshops and to isolate them from the rest of the building. In a noisy hall of 90 dB less than 10% of the workers work on loud machines, the rest of 90% are disturbed by the noise although their work is a silent one.

Diminution of reception: is done by plugging the workers' ears with more or less sound absorbent materials and individual protection equipment. The following can be used:

- cotton, relatively without effects, it diminishes perception only by 2-3 dB;
- paraffin wax cotton, it diminishes reception by approximately 10 dB but it becomes dirty and irritating;
- glass cotton diminishes reception by 10-15 dB constituting the most practical means, but it has the disadvantage that it irritates and becomes dirty in time;
- earmuffs – under the form of small metal or rubber devices, exhibit a valve for breaking the blast due to the displacement of a small piston at violent noises. They diminish reception by 20 dB and generally yield good results;
- earplugs – are undoubtedly the best means to diminish noise reception. They isolate by 50 dB or more. It is useless for the personnel to wear earplugs that prevent them from hearing commands and impact on the vigilance. The most tolerated and accepted ones are those that absorb on average 15-20 dB and protect the ear against excessive noises (100 dB-15 dB-85 dB, very tolerable area);
- headphones are generally used for noises associated with vibrations, protecting both the ears and the head. Their absorption index is of 30-40 dB, on average and their structure may comprise reception devices that allow communication.

Medical prevention: the medical attempts to solve the problem of professional noise aimed at finding a way to prevent the effects of the noise on the organism and thus professional deafness. This prophylactic side is the only efficient attitude against the harmful action of the noise, as the curative attempts in the presence of already settled lesions failed to provide hope for the future, the lesions being of an irreversible, degenerative nature.

The action of medical prophylaxis comprises several aspects:

1. Selection of employees for labor in noisy areas;
2. Biological protection of the auditory system;
3. Periodical evaluation of hearing, systematic identification and removal of workers with rapid and progressive hypoacusia from the noisy environment.
4. Selection of employees for labor in noisy areas

At the medical examination upon hiring the doctor should identify the cochlear abilities of the new employees within a complex investigation. These characteristics are:

- peripheral tolerance. After a short period of adaptation for labor in a noisy environment the subject presents no subjective symptomatology and hypoacusia is negligible;
- progressiveness. Deafness aggravates usually starting from 4000 Hz and widening in time 2000 Hz and 6000 Hz, later towards the frequencies from the conventional area;
- bilaterality. It is classic but debatable since in numerous cases the curves are parallel but not super opposable.
- individual variability is very large. The classical notion of particular fragility of certain subjects is due to yet unfound causes;
- irreversibility of lesions and absence of any therapy.

The medical examination prior to

employment raises a series of delicate issues for the otologist, who needs to declare the subject able or not to work in noisy environments. This is a difficult decision and implies:

- a precise knowledge of the conditions the subject will work in, especially the noise level he/she will be exposed to;
- the previous professions and their duration as well as the activities performed in a traumatizing noisy environment;
- personal and familiar records of the subject which require a complex interrogation;
- a clinical and audiometric exam to test the individual susceptibility.

Based on these data, the otologist is allowed to forbid prolonged exposure to noise of all subjects who exhibit causes of otic sufferance and who are susceptible of aggravation to: chronic otitis, cranial traumas, toxic deafness, highly evolved professional deafness, otospongiosis, HTA with labyrinth lesions as well as individual susceptibility beside any previous disorder.

The decision is often difficult because the vast majority of the employees fail to show clear cases. That is why two factors need to be considered: the duration of the exposure and the audiometric loss.

Thus, in the event of a boiler worker with a work experience of 5-6 years, his loss represents a satisfactory cochlear resistance and he will be declared able to work because his auditory level is analogous to the average level of the same profession, for the same duration of exposure. If there is the same curve in the case of a subject who worked 1-2 years in a very loud workshop, the subject will be suspected of cochlear fragility and will be declared unable to work in a noisy environment.

The biological protection of the auditory system.

As it is known, the acoustic excitation determines a process of adaptation on the part of the auditory system. If the excitation is within physiological limits, this shows a strictly informative process by which the vibrating waive as physical energy transforms at the level of the neurosensorial structures of the cochlea into sound energy, from where it is transmitted to the cortical centers, fulfilling the neuropsychic phenomenon of integration and auditory sensation.

As soon as the exciting factor, through its intensity and duration, loses the strictly informative, physiological character, the adaptation process may be overcome, determining the phenomenon of fatigue which, unless rest comes in, may gradually transform itself into a traumatism. In the context of the transformation of waive physical energy in neuropsychic sensation, the auditory function implies, beside the morphofunctional integrity of the organism, ways and auditory centers a neurovegetative and biochemical – metabolic interconditioning with the whole organism taken as a whole.

Although each organ has its own neurovegetative potential determined by own anatomo-physiological constants, it cannot ensure its integrity unless conditioned by the neurovegetative and metabolic system in general. Conversely, a balanced organism from a neurovegetative and endocrine-metabolic point of view will react better to the same aggressive factor than an organism that exhibits a neuro-hormonal disorder.

Starting from general elements in the attempt to prevent deafness through noise, the most important factor is the prevention of the auditory fatigue based on the reversibility in time and of the morphofunctional rebalancing of the auditory system prior to exposure to a noisy environment.

The effect of the acoustic pressure exercised on the cochlea results in cochlear adaptation, with the role of preventing the

auditory function.

If the pressure is high or frequently repeated, adaptation may be overcome and the fatigue sets in. If of a permanent nature, this changes gradually into an acoustic trauma.

Beside the constitutional congenital element, the ear may also be the recipient of the action of certain factors of metabolic, circulatory, accidental, inflammatory or toxic order etc., which proves the complexity of the individual biological fund and justifies the reaction variability towards the sound exciting factor.

It was also assessed that in the event of the exposure to professional noise of a subject with endo-labyrinth disorders due to the endogenous professional modifications may trigger serious endocochlear malfunctions with the early installation of degenerative phenomena that lead to serious irreversible deafness.

This is due to the summing up of factors with the same action at the level of the cochlea and to the frailty of the organ towards a new labyrinth hypertension. From the syndromes which exhibit labyrinth hypertension we can count: HTA, Meniere syndrome, labyrinth intoxication, labyrinth commotion.

Thus, the subject that exhibits a Meniere disease in latent stage may go deaf at the moment he/she starts a profession with a noise risk factor.

The patient with tuberculosis treated with streptomycin or its derivates has sensitized (fragilized) his cochlea through ototoxic drugs and the work in a noisy industrial environment may cause deafness due to this sensitivity, while a subject with no fragility may bear without any consequences the sound aggression.

The patient with high blood pressure will bear with more difficulty the action of the noise in professional conditions.

Under these circumstances, deafness is due either to the summing up of factors on the endolabyrinth pressure, as is the case of HTA, Meniere syndrome or commotion or to the cochlear fragility to sound aggression as is the case of the patients treated with ototoxic substances.

Knowing as well as tracing these aspects by the doctor prevents a series of cases that may lead to professional deafness.

CONCLUSIONS

The multitude of testing means of the auditory susceptibility prior to employment and all the organizational or educational measures cannot be deemed as sufficient for the prophylaxis of the traumatic lesions determined by industrial noise. Multiple researches, clinical and experimental, have been conducted in order to increase the auricular resistance to the sound aggression at the workplace.

Thus, it was assessed that one of the conditions of a good cochlear functioning studied in an experimental framework is the value of the endocochlear potentials. Determined by the ionic exchanges, they occur with a great energy consumption resulting from the oxidative processes of glycogenesis. Based on the observation that the cochlea shows great resistance to the diminution of glycemic concentration but exhibits great sensibility within the hypoglycemia of labyrinth liquids, authors have attempted to administer glucides to workers exposed to professional noise. From an experimental point of view though, it yielded little practical results.

An important role in the endocochlear metabolic phenomena is played by the oxidative phenomena under the dependency of the endocochlear oxygen. Starting from the manifestations of electrical potentials in hypoxia, authors thought that by inhaling pure oxygen in hypertension during work it

would be possible to increase cochlear resistance, but these experiments also failed to produce positive results.

The research continued and vitamin medication, enzymes and neuro and epithelic trophic substances were tried to the same purpose.

Among these the most used and with certain results was vitamin A. Vitamin medication plays a debatable role in the increase of cochlear resistance towards various pollutants, by diminishing the intensity of the lesions, but is not enough for the full prevention of the perturbing action of the harmful factor.

The summing up of vitamin medication and auditory rest has a better effect in achieving less extended lesions as compared to the isolated action of the two factors. It needs to be outlined here that neither the complementary action can prevent the harmful effects of the various factors when their aggression overcomes, in duration or intensity, the physiological limits of natural resistance of the auditory system.

Under the conditions of a good selection for working in noisy environments doubled by a technical preventive action and the use of collective and individual protection devices, as well as by an attempt to increase the resistance of the auditory organ of the workers and by the rationalization of the labor-auditory rest factor, the problem of professional deafness can be partially solved.

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