



NOISE-INDUCED HEARING LOSS (NIHL) AND ITS CORRELATION WITH AUDIOMETRIC OBSERVATIONS IN HEAVY VEHICLE OPERATORS SUFFERING WITH METABOLIC DISORDERS

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Abstract- Type II diabetic Mellitus (DM) is a chronic metabolic disease. In 2014, 9% of adults 18 years and older had diabetes. In 2012, diabetes was the direct cause of 1.5 million deaths. More than 80% of diabetes deaths occur in low- and middle-income countries. In India, about 5% populations suffer from diabetes or related complication. DM chronic auditory complications may include spiral ganglia atrophy, degeneration of the vestibulocochlear nerve myelin sheath, reduction of the number of spiral lamina nerve fibers, and thickening of the capillary walls of the stria vascularis and small arteries which lead to hearing loss. *Aim and Objective:* This study aims to know the incidence of hearing loss and to establish correlation with clinical parameters & personal hygiene of individuals. *Materials & Methods:* Sixty-four subjects were diagnosed as type II recruited in this study are heavy vehicle drivers & helpers. Noise-Induced Hearing Loss (NIHL) analysis study featuring hearing impairment in all individuals has been done after interviewed by various sets of questions related to listening ability. All subjects underwent a physical examination, blood investigations to confirm metabolic disorders & audiometric examination to evaluate hearing loss. *Results & Conclusion:* Conductive hearing loss is higher amongst the all three types as compared to sensory neural hearing loss & mixed hearing loss. There is no definite pattern of audiometric results; it could be variation in pre-assessment preparation of individuals subject. Certain medications used may cause damage of hair cells in the inner ear that may be the reason of higher frequency among the study subjects affected by sensory neural hearing loss compared with other two types.

Keywords- NIHL, audiometric observations, metabolic disorder

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Introduction

A large number of world's population suffers from Diabetes mellitus is one of the world's major diseases. It currently 143 million people are affected worldwide and the number is growing rapidly. In the India, about 5% populations suffer from diabetes or related complication like severe inner ear infection. So it is alarm in order to control the disease. Diabetic mellitus is a principal risk factor for cardiovascular disease (CVD). Type II DM also affects the cardiac muscles, causing both systolic and diastolic cardiac failure. Evidence suggests that although hyperglycemia, the hallmark of diabetes, contributes to myocardial damage, it is clearly not the only factor because both pre-diabetes and diabetes increases the risk of CVD [1-4]. Researcher Penido et al. observed that sudden sensorineural hearing loss noted that the worst results in treatment happened to older subjects and those who had associated disorders: systemic hypertension, hyperglycemia and dyslipidemia [5]. Monitoring cardiovascular risk in these patients with diabetes does not overlook the problems. In this review author attempted to provide an explanation of the current scientific knowledge about the large blood vessels (macrovasculature) and the small blood vessels (microvasculature)

to the less well-understood cellular and molecular mechanisms of CVD in subjects of type II diabetes.

Atherosclerosis is the major threat to the macrovasculature for subjects with and without diabetes. The general etiology of atherosclerosis has been reviewed elsewhere by many researchers [6], but several factors relate to diabetic mellitus are not discussed elaborately. In many publication authors dyslipidemia correlated with atherosclerosis, and up to 97% of subjects with diabetes are dyslipidemia [7]. Increased triglycerides and decreased HDL cholesterol found in the plasma of subjects with diabetes, abnormalities are observed in structure of lipoprotein particles [8].

According to World Health Organization guidelines Hearing loss is ability to perceive sounds occurs over a wide spectrum of frequencies. Human ear is sensitive to a frequency band within that spectrum expressed in decibels (dB). Frequencies capable of being heard by humans are called audio sound. The range is in-between 20 Hz and 20,000 Hz (Hertz). Frequency higher than audio frequency is referred as ultrasonic, while frequencies below audio are referred as infrasonic [9]. Loss of the ability to hear sound frequencies in the normal range of hearing is called hearing impair-

ment. The World Health Organization (WHO) defines disabling hearing impairment in adults as a permanent unaided hearing threshold level (average for frequencies 0.5, 1, 2, 4 kHz (kilo Hertz)) for the normal ear of 41 dB or greater [10]. In children below 15 years of age, suffering with hearing impairment is defined as permanent unaided hearing threshold level for the normal ear is 31 dB or greater. A person suffering from hearing impairment has difficulty in perceiving or recognizing sound clearly due to auditory defects. The impairment may be unilateral or bilateral. The degree of hearing impairment can be classified into five levels and ability to perceive sound is as listed below:

Mild: Difficult to identify soft sound such as whispering.

Moderate: Unable to hear clearly what others are saying during conversation. Requirement of Hearing aids.

Moderately severe: Unable to clearly hear loud noises.

Severe: Can only hear very loud noises and sounds.

Profound: Difficult in perceiving any sound.

Depending on the cause, hearing impairment may be temporary or permanent. Temporary hearing impairments are almost always conducted and are far more common than permanent hearing impairments. Permanent hearing impairments are usually sensorineural, but may also be conducted. The type of hearing impairment depends on which part of the ear is affected. If there is defect in ear canal, eardrum, middle ear bones or middle ear space (e.g. Fluid) it may result in a conductive hearing impairment (sometimes called mechanical hearing impairment). Defect in cochlea, auditory, nerve or brain it more commonly results in a sensorineural hearing impairment (also called nerve hearing impairment). When patient has both sensorineural and conductive hearing impairments, it is called a mixed hearing impairment.

Causes of hearing impairment:

Congenital Factors

- Viral infection during pregnancy, e.g. rubella infection
- Heredity
- Congenital defects such as anomalies of the ear, nose or throat
- Premature birth, birth asphyxia, excessive bilirubin, etc.

Acquired Factors

- Eardrum perforation
- Excessive wax
- Middle ear effusion or infection
- Otosclerosis or ear ossicle dislocation
- Sequelae of childhood diseases such as
- Measles and meningitis
- Head or ear trauma
- Prolonged exposure to loud noise
- Medication that may lead to hearing damage

Hearing Impairment Effect on Following Career Development Parameters

- Language: Delayed language development with unclear speech and incorrect pronunciation.
- Emotion and behavior: Easy to have emotional and behavioral

problems as a result of difficulties in verbally expressing himself/herself.

- Self-confidence: Lack of self-confidence with poor self-image for being always mistaken to be slow in response.
- Social interaction: Socially excluded by peers due to poor comprehension and/or actively avoid social contact and communication.
- Academic performance: Academic performance being affected due to difficulty in receiving the correct messages.

Type II diabetic mellitus (DM) is a chronic disease derived from the inadequate production of insulin in the pancreas or from the resistant insulin. It is characterized by hyperglycemia [11] and is a genetically inherited disease [12].

Understanding the differences of symptoms and an etiology is an important in Noise-Induced Hearing Loss (NIHL). In some cases the etiology is unknown. Since hearing is a complex process, the causes of hearing loss are also complex. Hearing loss can occur because of damage to the inner ear. Noise occurs when sound waves reach to the inner ear, where the sound waves are converted into nerve signals that recognize as sound. Ear consists of three major areas: outer ear, middle ear and inner ear. Sound waves pass through the outer ear and cause vibrations at the eardrum. The eardrum and three small bones of the middle ear (the hammer, anvil and stirrup) amplify the vibrations as they travel to the inner ear. The vibrations pass through fluid in the cochlea. Attached to nerve cells in the cochlea are many tiny hairs that translate sound vibrations into electrical signals to brain. Different signals to your brain depend on vibrations of different sounds which brain center distinguishes one sound from another.

Diffuse thickening of basal membranes, also observed in the vascular endothelium, is most prevalent morphological findings in diabetic microangiopathy. These thickening are more evident on skin capillaries of skeletal muscles, retina, kidney glomeruli, and renal medulla. The pathogenesis of this morphological disorder is unclear, but it is related to higher lipid levels. There are few neurological disorders related to the involvement of lower extremity motor and sensory nerves, characterized by Schwann cells injuries, myelinic degeneration, and damage to axonal. The cause of this neuropathy is still under investigation, but it may be related to diffuse microangiopathy and the consequent malnourishment of peripheral nerves. Arteriosclerosis, frequently seen in conjunction with DM, may also contribute to the onset of neuropathies [13,14].

Malucelli et al [12] that DM may cause hearing impairment, but a firm correlation has not been described yet. It is known that a series of variables may favor the association of both conditions, but more studies are required to establish the role these factors. As seen above, type II diabetic subjects and hearing impairment may be interdependent components, or even components of a genetic syndrome. The association between DM and hearing impairment is being given a lot of attention. Complaints related to the auditory and vestibular systems and metabolic disorders affecting glycosides and lipids have been reported the main etiologic factors related to hearing impairment, tinnitus, and dizziness [16]. Therefore, the diabetic population must be considered at risk for auditory conditions [17].

An audiogram is a graph of audible threshold for standardized frequencies measured by audiometer. On Y axis intensity measured in decibels (db) plotted and the X axis represents frequency measured in Hertz. The threshold of hearing is plotted relative to a standard-

ized curve that represents 'normal' hearing, in dB (HL). They curve representing equal loudness at different levels, as well as at the threshold of hearing. This is not the best threshold found in all subjects, under ideal test conditions & equal-loudness contours, but is standardized in an American National Standards Institute (ANSI) standard at highest 1 kHz level [18].

Material & Methods

Present study is conducted at Department of Shalaky Tantra, D Y Patil University's School of Ayurved, Navi Mumbai. Noise-Induced Hearing Loss (NIHL) of heavy vehicle drivers & conductors attending Shalaky Tantra OPD of D.Y. Patil University's School of Ayurved, Navi Mumbai has been recruited in this study. All ethical guidelines regarding human research are strictly followed. The subjects were recruited after proper information about this project in local as well as in vernacular language, written set of the same instructions has provided to the subject before taking consent. The biochemical parameter include fasting blood sugar measured for screening purpose. Individual subject showing blood sugar level more than 126 mg/dl investigated thoroughly for confirmation of DM. According to WHO guidelines the term diabetes mellitus describes a metabolic disorder with heterogeneous.

Etiologies characterized by chronic hyperglycemia and disturbances of carbohydrate, lipids and amino acids metabolism resulting from defects in insulin action [19]. HbA1C (Glycosylated Hemoglobin) represents average plasma glucose over the previous 60 to 90 days [20]. It can be performed at any time of the day and does not require any special preparation such as fasting or any pre-analytical precautions. Because of this it is the preferred test for assessing glycemic control in diabetes. More recently, there has been substantial interest in using it as a diagnostic test for diabetes and as a screening test for person at high risk of diabetes [21]. In this study subjects blood sample is taken for biochemical investigations. Fasting blood sugar (FBS), post-prandial blood sugar (PPBS) & HbA1C is measured for confirmation of diabetic mellitus & lipids are measured for existence of dyslipidemia. Audiometry of both ears is performed for measurement of hearing ability at 4000Hz by audiologist.

There are validated questionnaire for evaluation of degree hearing loss, subjects are requested to listen & read these questioners in sound proof room & investigator recorded subject response. If subject responded positively for three or more question, subject has eligibility to into this study for audiometry examination. These questionnaires are categorized on the basis of their features. The subject in this study evaluated on the basis of following set of questions.

Common parameters for Evaluation of Hearing Impairment: Smoking, tobacco chewing, alcoholics, damage to the inner ear, buildup of earwax and infections

Clinical parameters for Evaluation of Hearing Impairment: Muffling of speech and other sounds, difficulties in understanding what others speak, especially against background noise or in a crowd of people, frequently asking others to speak more loudly clearly and slowly, needing to turn up the volume of the television or radio, withdrawal from conversations and avoidance of some social enrollments.

Common Questions to be asked to subject for Hearing Impairment Evaluation:

1. Do you have a problem hearing over the telephone while calling?
2. Do you have trouble in understanding the conversation when two or more people are talking at the same time?
3. Do people complain that you turn the TV volume up too high?
4. Do you take more strain to understand conversation?
5. Do you feel difficulty in hearing in a noisy background?
6. Do you find yourself asking people to repeat their talk?
7. Do many people you talk to seem to mumble or not clear?
8. Do you misread what others are saying and respond inappropriately?
9. Do you have trouble understanding the speech of women and children? and
10. Do people get annoyed because you misunderstand what they say?

Inclusion & Exclusion of the Subjects

Newly diagnosed diabetic subjects, having diabetic prone symptoms & proven metabolic disease were enrolled in this study. Uncontrolled type I&II Diabetes mellitus with more than 3 year of diabetic age, history of consumption of ototoxic, anti-lipoid and antihypertensive drugs in past three months, history of ear surgeries, past ear infections, recent infections in the nose, throat or ear are excluded from this study.

Results and Discussions

Type II diabetic mellitus (DM) is a genetically inherited metabolic disease in which blood glucose and lipid levels are abnormally high due to relative or absolute insulin deficiency, characterized by metabolic disorders (DM & fat accumulation), and vascular and neuropathic complications [22]. Changing pathology of capillary wall thickening, reduced vessel lumen will more intensely affect the internal auditory artery [23]. Researchers states that antipathy is the primary injury connected to hearing loss, while others arguing that vessel wall thickening is non-specific and also found in other diseases too. Human audiology studies indicate that the thresholds of subjects with peripheral neuropathy were always worse than control group individuals in diseases too. Human audiology studies indicate that the thresholds of subjects with peripheral neuropathy were always worse than control group individuals in any frequency [24-26].

In this study 64 subjects recruited working as driver and helper between ages 30-56 years on public transport buses. It is observed from [Table-1] that 21.9 to 43.6% of subjects adapted some habits. Most of these hearing loss symptoms are because of addiction of tobacco (chewing & smoking), alcohol, unawareness of health effects, noise & air pollution. A cross-sectional study published on auto rickshaw drivers of Jaipur, Rajasthan during April-May 2013 with a sample size of 94 with 95% of confidence level and 10% confidence interval. Study finding shows that number of auto rickshaw drivers consumes tobacco or tobacco products were very high (87%). Auto rickshaw drivers were mostly used tobacco in the form of gutkha (72%) and bidi (40%) in comparison to other products. In this study the lowest age of the auto rickshaw drivers were found 18 years and its percentage is 80%. There are restrictions or eligibility of age to drive any vehicle is 18 years and above otherwise author may get this addiction in lower age in Rajasthani population. Awareness level among auto rickshaw driver was high (70%) but still uses

tobacco products because of its addiction (66%) [27]. The German study [28] indicated a limitation to LAmax <45 dB(A), which was documented in WHO document [29]. Unable to protect hazards effects on human health even low frequency truck noise. So it is advised to transport authority to maintain noise of vehicle within permissible limit. Road conditions, urbanization, industrial emission & lack of preventive health awareness are the major causes of noise induced hearing loss & these subjects become symptomatic after exposure to these conditions. It is also observed that 34.9% to 54.7% of subjects complained about accumulation of wax, ear drum repute & ear infection. All these symptoms are severe effects of noise & air pollution. Cross sectional study conducted by TaYuan Chang & co-workers in China states that exposure to road traffic noise at low and hearing-sensitive frequencies may be associated with hypertension and exposure to noise at 125 Hz may have the greatest risk for hypertension [30]. So if proper attention is required to maintain health of transport workers.

Table 1- Response of subjects for adapted parameters

	Number of subjects responded positively	Percentage of subjects responded positively
1. Smoker	14	21.9
2. Tobacco Chewing	18	28.1
3. Alcoholic	20	31.3
4. Driving a car	19	29.7
5. Damage to inner ear	23	35.9
6. Build-up of wax	28	43.8
7. Infection	26	40.6
8. Treatment taken	35	54.7
9. Repture ear drum	22	34.4

It is observed from [Table-2] that it is very difficult to hear conversation of interest because of background noise; possibility of clear voice is less when background sound is loud. Study published by Sting Arlinger, Department of Audiology, University Hospital London conducted pilot research project on five subjects, four with noise protector & one without. Well tolerable 70 dB noise frequency is used for risk free hearing. It is observed from this study that after wearing ear protector voice recognition is better than without ear protector [31]. It is overall observation that possibility of distractions in voice recognition is more in noise induced hearing subjects than others.

[Table-3] emphasizes on communication or voice transmission through instruments. Subjects are evaluated by various questioner for conversion understanding. Subjects affected by noise induced hearing loss respond these questioners and observations are interesting. 54.7% to 76.6% of subject are unable to understand the conversions clearly. It is also observed from [Table-3] that subjects in this study are under psychological impact of hearing loss. Questioners in [Table-3] is concerned with withdrawal from conversion because of difficulties in recognition of voice, sometime opponent

talk to seem mumble, etc have higher percentage. The prevalence of hearing loss varies with age; approximately 25 percent of patients between 51 and 65 years of age, and more than 50 percent of patients above 80 years of age, have objective evidence of hearing loss [32,33]. Particularly concerning is the increasing prevalence of hearing loss in adolescents and young adults, which affects between 8 and 19 percent of this population [34,35]. According to the National Institutes of Health, an estimated one-third of Americans have some degree of hearing loss and of those, close to one-half are older than 75 years. Medical professionals believe that heredity and chronic exposure to loud noises are the main factors that contribute to hearing loss over time. Other factors, such as earwax obstruction, can prevent your ears from conducting sounds as well as they should. You can't reverse hearing loss. You and your doctor or hearing specialist can take steps to improve what you hear [36].

Audiometry is a relatively simple procedure that can be performed and interpreted by a trained health care professional. Physicians may consider performing audiometry when a patient reports a subjective sense of hearing loss, or patient's decreased conversational interaction with parents [37].

Subjects who are exposed to excessive noise & who have not used adequate hearing protection needs to be investigated thoroughly. Hearing loss is common in hunters and military veterans exposed to acoustic trauma from prolonged use of firearms [38]. When hearing loss is suspected, pure-tone audiometry may be used to evaluate hearing deficits by spot-checking certain frequencies, or to evaluate deficits more completely [39]. Pure-tone audiometry is performed by an audiometer. Handy audiometers have 92 % sensitivity and 94 % specificity in detecting sensorineural hearing impairment [40]. There are several types of audiometers available, model does not matter, all functions similarly. Screening audiometry presents tones across the speech spectrum (500 to 4,000 Hz) at the upper limits of normal hearing (25 to 30 dB for adults, and 15 to 20 dB for children) [41]. Results indicate that the patient's hearing levels are within normal limits, hearing loss is possible or a repeat screening test or a threshold search test is recommended.

Audiometry results may be affected in patients with anatomic birth defects, collapsing ear canals (stenosis of ear canal) which are very common in many older patients whose cartilage has become flaccid, complete occlusion, or absence of an ear canal (atresia). Impacted cerumen can cause a conductive hearing loss. Continuous use of ear headphone over narrow or closed ear canals may add sufficient pressure to collapse, resulting in a false high-frequency hearing loss.

Recent noise exposure audiometry may affect the results of the test. Listening to music through headphones may result in a temporary hearing threshold shift, and may not reflect the patient's true hearing thresholds. Patients should minimize or avoid exposure to loud noise for at least 14 hours before the pure-tone testing [42].

Table 2- Response of subjects depends on frequency of vehicle noise

	Number of subjects responded positively	Percentage of subjects responded positively
1. Muffling of speech and other sounds	43	67.2
2. Difficulty in understanding words especially against background noise or in the crowd of people	48	75
3. Frequently asking to others to speak slowly, clearly and loudly	49	76.6
4. Needing to turn-up the volume of the TV or radio	49	76.6
5. Withdrawal from conversion	39	60.9
6. Evidence of some social settings	35	54.7

Table 3- Response of subjects to clinical evaluation

	Number of subjected respond- ed positively	Percentage of subject recruit- ed in study
1. Do you have problem in hearing over the telephone?	49	76.6
2. Do you have trouble following the conversation when two or more people are talking simultaneously?	50	78.1
3. Do people complain about you to turn up TV volume too high?	42	65.6
4. Do you have to strain to understand conversation?	44	68.8
5. Do you have trouble hearing in a noisy background?	42	65.6
6. Do you find yourself asking people to repeat themselves?	41	64.1
7. Do many people you talk to seem to mumble?	37	57.8
8. Do you misunderstand what others are saying and respond inappropriately?	42	65.6
9. Do you have difficulties in understanding the speech of women and children?	38	59.4
10. Do people get annoyed because you misunderstand what they say?	37	57.8

Table 4- Audiometric reports analysis for RE HL, LE HL & B/L HL in Noise Induced Hearing Loss (NIHL) subjects

Type of Hearing Loss	Percentage of Conductive Hearing Loss	Percentage of Sensory Neural Hearing Loss	Percentage of mixed Hearing Loss
Right Ear Hearing Loss (RE HL)	Mild	3.1	1.6
	Moderate	6.3	9.4
	Severe	4.7	15.6
Left Ear Hearing Loss (LE HL)	Mild	9.4	10.9
	Moderate	6.3	6.3
	Severe	1.6	12.5
Bilateral Hearing Loss (B/L HL)	Mild	3.1	4.7
	Moderate	3.1	3.1
	Severe	0	12.5

Conductive hearing loss is due to defective outer or middle ear that prevents sound from being conducted. It is usually mild or moderate, ranging from 25 to 65 dB. Sensorineural hearing loss also called nerve deafness, results from missing or damaged sensory cells (hair cells) in the cochlea and is usually permanent. It can be mild, moderate, severe or profound. A mixed hearing loss is a combination of both. It occurs due to problems in both the inner and outer or middle ear. According to the "Update on 2004 Background Paper, BP 6.21 Hearing Loss (WHO Report)" about 269.1 millions of world population is suffering by hearing loss. Categorically it is distributed in children (both sex), male adults and female adult. The estimated figures in children of both sex is 31.9, males 183 million & 145 million female. The percentage of population of children is 1.7%, 7.5% male and 5.9 % female [43].

It is observed from [Table-4] that percentage of conductive hearing loss is higher in all three types as compared to sensory neural hearing loss & mixed hearing loss. There is no fix pattern of audiometry results; it could be variation in symptoms presentation of individual subject. Certain medications are considered ototoxic as they may cause damage of hair cells in the inner ear [44-49] that could be reason for higher population is affected by sensory neural hearing loss compared with other two types.

Conclusion

The deficiencies in a comprehensive health care, poor personal hygiene, overcrowding, professional stress, sound pollution, toxic elements mixed in environment, poor accessibility to medications and other interventions, lacks primary, secondary and tertiary prevention interventions are the common reasons for increasing incidences of hearing loss. Hearing loss is a major health problem in transport workers and according to audiometry results percent-

age of population is suffering by sensory neural hearing loss. The major causes for sensory neural hearing loss is damage to sensory cells, ultimate reason may be sound pollution, environment toxic hazards, poor hygiene, imbalanced food & low economic status, etc. Middle-aged diabetes subjects with hearing loss may inquire about family history of diabetes. These affected subjects are advised to take efforts to maintain blood glucose level in normal range so as gravity of hearing loss can be minimized.

Future Prospective

Urbanization, industrial growth close to residential area and modernization has generated a noisier environment. Loud concerts, use of headphones, road traffic contribute to the hearing impairment in many young adults. According the World Health Organization (WHO) exposure to high frequency noise longer time is the major avoidable cause of permanent hearing impairment worldwide [50]. WHO recommends for implementation of National Programs for the Prevention of noise-induced hearing loss [50].

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