

Relationship between Some Cardiovascular Risk Factors (Hypertension and Diabetes) and Hearing Loss: A Review and Critical Appraisal

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ABSTRACT

Cardiovascular disease and its risk factors are no longer only problems in developed countries, they are equally prevalent in developing countries. Cardiovascular risk factors have been hypothesized to play a role in the pathogenesis of hearing loss. Specifically, hypertension and diabetes mellitus can affect the cochlear microvasculature, leading to cochlear atherosclerosis. These atherosclerotic changes may result in impairment of local micro-cochlear circulation, causing ischemia and necrosis of the stria vascularis, hair cells, and the entire organ of Corti, and this may lead to hearing loss. The effect of cardiovascular risk factors on hearing is still under investigation. The aim of this study is to review the relationship between cardiovascular risk factors (hypertension and diabetes) and hearing loss.

KEYWORDS: Hearing loss, cardiovascular risk factors, hypertension, diabetes mellitus, critical appraisal

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INTRODUCTION

Cardiovascular diseases are leading cause of death worldwide, accounting for about 16.7 million deaths annually.ⁱ The mortality associated with cardiovascular diseases increased to about 25 million deaths, if current trends continue, the mortality and morbidity of cardiovascular diseases are expected to increase several folds.ⁱⁱ Current estimates show that the global burden of cardiovascular diseases far exceeds that of their mortality rate, affecting about 128 million people, or nearly 8 times the number of cardiovascular deaths.ⁱⁱⁱ These mortality and morbidity represent only the tip of the iceberg, large proportion of individuals have asymptomatic disease, and target organ

damages, which are secondary to the presence of cardiovascular risk factors.

Hypertension, which was identified in a recent World Health Organization (WHO) report as among the most important preventable causes of cardiovascular death, affected 972 million people worldwide and is predicted to increase by around 60%, to about 1.56 billion people.^{iv} Similarly, diabetes mellitus, which currently affects 151 million people globally, is expected to increase by 46%, to around 221 million individuals.^v Cardiovascular diseases and their risk factors are no longer problems in developed countries. Similar trends are now emerging in developing countries, including Nigeria, where the prevalence of hypertension, diabetes mellitus, and other cardiovascular risk

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factors are rising. The number of individuals with multiple cardiovascular risk factors is increasing at an alarming rate, leading to increased mortality, morbidity, and target organ damages.

The target organ damage associated with cardiovascular disease and its risk factors include; stroke, coronary artery disease, peripheral vascular disease, chronic kidney disease, retinopathy, and hearing loss.^{vi,vii,viii} The relationship between stroke, chronic kidney disease, and coronary artery disease has been well established. However, the relationship between hearing loss and cardiovascular risk factors is still under investigation. The pathological basis of these end-organ damages was reported to be from atherosclerosis and other vascular changes.^{ix} These vascular changes have also been hypothesized to affect the arterial system of the inner ear. The arterial supply of the inner ear comes from the labyrinthine artery, a branch of the vertebrobasilar system. It is an end-artery, and it is very susceptible to vascular insufficiency. Furthermore, any impairment of local micro-cochlear circulation can cause ischemia and necrosis of the stria vascularis, hair cells, and the entire organ of Corti, and this may lead to hearing loss.^x

Hearing loss is a hidden disability affecting about 430 million people worldwide, and the World Health Organization (WHO) estimates that by the year 2050, over 700 million people will have disabling hearing loss.^{xi} In Nigeria, the burden of hearing loss is also high. A study conducted in the Northern part of Nigeria showed a prevalence of 26.2%, while a prevalence of 43.4% was reported in the Southern part. It is reported that 50% of cases of hearing loss are preventable through identification of risk factors, early diagnosis, and prompt treatment.^{xii} The importance of prevention must be emphasized. From an employment perspective, hearing loss can significantly reduce an individual's ability to undertake job tasks that require the use of auditory signals or verbal communication, causing social isolation in the workplace and impacting upon teamwork and group productivity.^{xiii} In most cases of hearing loss, the problem is irreversible, therefore, all efforts should be made to target the primary etiology and risk factors of hearing loss. Hence, it is important and justifiable to review the literature on the relationship between some selected cardiovascular risk factors (hypertension and diabetes) and hearing loss. These cardiovascular risk factors may be amenable to intervention and subsequent prevention of hearing loss.

Effect of cardiovascular risk factors on hearing function

Cardiovascular risk factors may reduce blood supply to the cochlea and to the auditory nerve through the production of atherosclerotic plaques in the blood vessels supplying the organs of hearing. This reduction in blood flow may affect the availability of glucose and oxygen to the cochlea, leading to cochlear ischemic changes and dysfunction. Among adults, these changes were found in the

stria vascularis, the organ of Corti, and the auditory nerve. These changes were thought to be the reason for hearing loss.^{xiv} Friedland et al. found a positive correlation between cardiovascular diseases and low-frequency hearing loss. The etiology was attributed to atrophy of the stria vascularis through impaired blood flow to the cochlear apex.^{xv}

Some studies have also explained the possible pathological basis of hearing loss among hypertensive patients as follows: A hypothesis was developed regarding the detrimental effect of hypertension on the cochlear and vestibular systems in humans.^{xvi} The hypothesis explained that the blood supply to the stria vascularis of the cochlear originates from the end-arteries (devoid of collateral circulation), which renders the stria vascularis more vulnerable to circulatory insufficiency. Decreased blood supply in turn leads to reduced oxygen concentration in the cochlea microcirculation, leading to ischemia and possible necrosis.^{9,10,xvii} Additionally, there may be ionic imbalance and abnormal endo-cochlear potential transmission from poor cochlear homeostasis, which can disrupt the exchange of electrolytes in the hair cell milieu and interrupt the transduction of action potential signals across the cochlear nerve endings.^{xviii} Apart from these ionic imbalances, there is an increased formation of free radicals in the inner ear that would impair sensory transduction. All these changes result in cochlear dysfunction, eventual hearing loss, and tinnitus.^{xix}

Diabetes mellitus is one of the most important cardiovascular risk factors. The effect of diabetes on the cochlea and the auditory nerve may occur through the accumulation of sorbitol, which can adversely affect the function of the nerve, leading to hearing loss. Other effects of diabetes mellitus on the cochlear include; angiopathic changes in the stria vascularis, atrophy of the spiral ganglion, and degeneration of the myelin sheath.^{xx} In mice in which diabetes was induced, cochlear blood vessel thickness was found to be increased, as well as changes in the stria vascularis, collapse of Reissner's membrane, and degeneration of the organ of Corti. Additional degenerative changes in the auditory nerve and Scarpa's ganglion were also noted.¹⁴ In human studies, examination of the temporal bones of patients with type 2 diabetes mellitus demonstrated angiopathy and degeneration of the stria vascularis and the hair cells, which may lead to hearing impairment.^{xxi} It was also reported that there was a positive correlation between narrowing of the internal auditory artery diameter and the severity of hearing loss among diabetic patients.¹⁴

Relationship between cardiovascular risk factors and hearing loss

Some cardiovascular risk factors have been associated with hearing loss, such as diabetes mellitus and hypertension. An association between diabetes mellitus and sensorineural hearing impairment has been widely discussed, but despite a large number of studies performed, it remains controversial.^{xxii,xxiii} Hearing loss is very prevalent among the

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elderly population; however, it is almost twice as common in elderly diabetic patients. Several studies also demonstrated a high prevalence of hearing loss among diabetic patients, suggesting that diabetes mellitus may be an independent risk factor for hearing loss.^{xxiv,xxv,xxvi} It is well known that diabetes is associated with many microvascular complications. The human cochlea has an extensive microvasculature, and it is considered vulnerable to the effects of microangiopathy (one of the consequences of hyperglycemia). Hearing loss in diabetics may be a result of microangiopathy.^{xxvii} In a systematic review and meta-analysis, it has been shown that the prevalence of hearing impairment among diabetic patients was 2.1 times higher than in patients without diabetes.^{xxviii}

Hypertension is associated with significant complications. One of the complications is hearing loss. Several studies have examined the association between hypertension and hearing loss, but the results have been conflicting. Some of the studies provided evidence of an association between hypertension and hearing loss,^{xxix,xxx,xxxi} while other studies reported contrary opinions.^{xxxii,xxxiii} A study assessing the association between hypertension and hearing reported a positive correlation between the two conditions.^{xxxiv} In concordance with this fact, a cross-sectional study reported an association between hypertension and hearing loss among Korean and Indian participants, respectively.^{xxxv,xxxvi} Similarly, a case-control study in Brazil reported a positive association between hypertension and hearing loss.³⁰ Researchers in Nigeria have also investigated the relationship between hypertension and hearing loss. Yikawe et al. reported that the presence of hypertension was positively associated with hearing loss ($P=0.000$). They further explained that the presence of hypertension in their patients increases the pure tone average by 10 dB.²⁹ In another study, the author examined the relationship between hearing loss and cardiovascular risk factors, and they found that hypertension, was a significant risk factor for hearing loss.^{xxxvii} Similarly, Babarinde et al. investigated the relationship between hypertension and hearing loss and discovered that there was an association between the two conditions, and the prevalence and severity of hearing loss worsened with an increasing degree of hypertension.³¹ Furthermore, Osuji et al. compared hearing thresholds among hypertensive and non-hypertensive diabetic patients, and they discovered that the prevalence of hearing loss among the hypertensive diabetic patients was significantly higher than that of non-hypertensive diabetic patients, and hypertension was responsible for a threefold increase in hearing loss among patients with both hypertensive and diabetic patients compared to those with diabetes only.^{xxxviii}

Prevalence of hearing loss among patients with hypertension

Hearing loss and hypertension are common chronic diseases encountered in clinical practice worldwide. But, few studies have reported the prevalence of hearing loss among

hypertensive patients. A cross-sectional study that investigated the association between hypertension and hearing impairment among Japanese workers showed that subjects with hypertension had a higher prevalence of hearing impairment compared to those without hypertension.^{xxxix} Lim and Stephen reported that the prevalence of hearing loss increases with age and that 50% of the patients with hearing loss had previously unrecognized medical disorders (including hypertension).^{xl} A study in South Africa reported that HIV patients with co-morbid hypertension were 93% more likely to have hearing loss than those without hypertension.^{xli} In Nigeria, a prevalence of hearing loss (38.5%) was reported among hypertensive patients in Sokoto, Northern Nigeria.²⁹ Similarly, Babarinde et al. reported a prevalence of 30% among hypertensive patients in Ibadan, Southern Nigeria.³¹

Factors associated with the development of hearing loss among patients with cardiovascular risk factors

The association between cardiovascular risk factors and hearing impairment may be affected by other cofactors such as age, gender, duration of the risk factor, etc. Several factors have been examined to determine their effect on the development of hearing loss among patients with cardiovascular risk factors. Age may be a factor that determines the development of hearing loss among hypertensive patients. In a study that explored the link between hypertension and hearing loss, the authors reported that age was associated with an increased prevalence of hearing loss, and older individuals had higher prevalence of hearing loss compared to the younger age group.³¹ Similarly, Osuji et al.³⁸ reported that the hearing thresholds among patients with hypertension and diabetes increased with age, and the highest hearing thresholds were seen in the older age group above 70 years. In addition, Mishra et al.^{xlii} reported that elderly individuals were more significantly affected by hearing loss among hypertensive patients. The association between increasing age and hearing loss cannot be discarded, as there is a disease entity called presbycusis, which is a diagnosis of exclusion, and defined as age-related hearing loss in older individuals without any other etiology of hearing loss. Still regarding age, the association between diabetes mellitus and hearing impairment is surprisingly even higher among the younger age group (<60 years of age) than older individuals.⁴²

Gender has also been considered as a possible factor that affects the development of hearing loss among patients with cardiovascular risk factors. Some authors reported that there was no significant difference between males and females in terms of the development of hearing loss among patients with cardiovascular risk factors.^{31,38} However, contrary findings have been documented by other authors, who reported a significant difference between males and females in terms of the development of hearing loss.^{xliii}

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Regarding the duration of cardiovascular risk factors, Vemanna et al.^{xliv} reported that an increase in the duration of hypertension may be associated with hearing loss. Other researchers have also reported a weak correlation between hearing threshold and duration of hypertension in a group of patients.²⁴ Mitchell et al.^{xlv} reported that the risk of having hearing loss increased with the duration of diabetes. It was also reported that diabetes and hypertension have a synergistic effect on the development of hearing impairment among adult patients.^{xlvi}

CONCLUSION

This study examined the relationship between cardiovascular risk factors (hypertension and diabetes) and hearing loss. It is obvious that there is a strong relationship between cardiovascular risk factors and hearing loss. Factors such as age, gender, and duration of cardiovascular risk factors may influence the development of hearing loss. Therefore, these cardiovascular risk factors and some of the associated factors can be amenable to intervention, subsequent prevention of hearing

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