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Management of Tinnitus
The Enriching Views of Treatment Options

Edited by Tang-Chuan Wang



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Audiological Tinnitus Management: An Essential Audiological Protocol for Elderly Patients with Comorbidity of Hypertension and Tinnitus

Ayo Osisanya

Abstract

Elderly population with comorbidity of hypertension and tinnitus is increasing across the world, and the dilemma in the management of such elderly patients across the neurology and audiology/otology clinics seems enormous due to the attendant effects of such health-related comorbid conditions and ageing. This has been observed to have negative effect on the general well-being of quite a number of the elderly patients identified with the comorbid health conditions. It has also increased the tinnitus severity and related psychosocial reactions of the elderly patients. Worse still, the situation causes undulating increase in the prevalence of the comorbid condition of advanced age both male and female irrespective of cultural differences. Due to the aforementioned, this chapter is written with the aim of highlighting the efficacy of audiological tinnitus management options considered essential in the rehabilitation of individuals with comorbidity of hypertension and tinnitus. The chapter also discusses the benefits of combined therapies in rehabilitating elderly patients with comorbidity of hypertension and tinnitus and concluded with some useful recommendations for effective management of the comorbid condition.

Keywords: ageing, audiological rehabilitation, elderly, hypertension, tinnitus

1. Introduction

The synchronous firing of auditory neurons, which always results in tinnitus, has been clinically observed to have a significant relationship with hypertension—the age-related blood pressure (Bp) elevations as a consequence of changes in the arterial structure and physiological functions accompanying ageing. Although the rise in blood pressure (Bp) is not a normal part of ageing, it often occurs as a result of some underlying conditions such as lifestyle factors, diseases and abnormalities that can aggravate (high) blood pressure, leading to severe complications and increased risk of heart disease, stroke and death. Due to multifactorial relationship between hypertension and tinnitus, the incidence of the comorbid conditions in the elderly population is increasing across the globe, even with increased blood pressure

level as a consequence of damage to inner ear microcirculation, ototoxic effects of antihypertensive drugs and increased/constant perception of noise generated by the blood vessels. Hypertension is the major risk factor for cardiovascular morbidity and mortality in the elderly population [1]. Hypertension alters cognitive functions of motor and visual acuity as well as auditory performance in the elderly population. It also leads to vascular remoulding by narrowing the lumen and wall thickening. This may affect cerebral blood flow and also disturbs cerebral metabolism and structure. The negative effect of high Bp levels on intellectual performance can also be linked to alterations in the cerebral white matter [2].

Hypertension which is one of the most common clinical conditions affecting older people in this contemporary time accounts for the majority of health-related cases with evidence of increased systolic blood pressure due to advancing age. Thus, a positive association has been observed as regards to the relationship between hypertension and tinnitus. This promotes vascular changes, inner ear microcirculation and tinnitus as noticed. It in turn brings about cochlear microcirculation, resulting in hair cell damage and consequently tinnitus, a common pathophysiological scenario to many conditions such as arterial hypertension, dyslipidaemia, diabetes mellitus, smoking and caffeine abuse [3]. The association between hypertension (especially arterial type) and tinnitus is stronger in older patients and cannot be disassociated from the hearing loss, which is endemic among attendant tinnitus patients [4]. Also, the clinical and psychoacoustic characteristics of tinnitus in hypertensive and normotensive patients seem similar, as well as tinnitus-related distress [4]. The comorbidity and characteristics of the conditions in addition to advancing age can be attributed to the increased complications and attendant effects of the conditions on the elderly patients. This is evident in the galloping increase in the prevalence of elderly patients with comorbidity of hypertension and tinnitus attending neurology and audiology clinics in this contemporary time. Tinnitus has also been reported to be associated with the use of diuretics with low systolic blood pressure. Although the prevalence of tinnitus is observed higher in patients with uncontrolled Bp ($\geq 140 \geq 90$ mmHg) than patients with adequate Bp control ($< 140 / < 90$ mmHg) [5], the increased prevalence of tinnitus in elderly patients can be as a result of some factors such as hypertension, vascular disease, diabetes and autoimmune and degenerative disorders.

Age-dependent hypertension, with the prolongation of life expectancy, remains one of the major factors causing cardiovascular morbidity, mortality and pulsatile tinnitus. This always affects older people, with the prevalence of 60% among the elderly [5]. Therefore, blood pressure has been observed as an important risk factor in the development of cerebrovascular disease, congestive heart failure and coronary heart disease [6] which is the major cause of continuous ringing in the ear/head of the elderly population. Often, the associated tinnitus, which is not generated by external stimulus, can be classified as auditory and para-auditory tinnitus. The former represents the majority of cases, and the latter is subdivided into muscular tinnitus somatosounds [3]. With the impact of high Bp and the immense amount of blood flowing in and out of the head, tinnitus becomes evident in the humans, causing hearing loss of different degrees and severity, depending on the severity of the blood pressure. This comorbid conditions always make the elderly to experience vascular abnormality, blurred vision, chest pain, reduced anxiety, irritability, reduced cognitive functions, reduced quality of life, depression, poor communication, fatigue, reduced social functions, mood swing, withdrawal syndrome, poor emotional state or health, regular hospital visit and continued use of anti-depressants [7]. Therefore, comprehensive management strategy, involving audiological rehabilitation and blood pressure control mechanisms, might be holistically employed, for it will aid the reduction of hearing-loss-induced deficits of function, activity, participation, quality of life through a combination of sensory

management, perceptual training, counselling [8], as well as drug management, psychotherapy and physical exercises to regulate the blood pressure and its flow in and out of the brain.

2. Tinnitus: meaning and effects on the elderly population

2.1 Tinnitus: a health-related condition

Tinnitus is an observed condition in which people experience different kinds of auditory sensation without any external stimulation. Tinnitus, as a health-related condition, can be described as an evidence of perception of noise or ringing in the ear/head without external influence or generation (propagation) of sound signal(s). Tinnitus is regarded as the sensation of hearing kind(s) such as ringing, buzzing, hissing, chirping, whistling or other sounds without external sound signal; it is rather a symptom of underlying condition(s) such as age-related hearing loss, drug-related conditions, high blood pressure, ear injury, evidence of accumulated ear wax, cardiovascular disorders or metabolic disorder and/or a circulatory system disorder [7].

Tinnitus is derived from the Latin word *tinnire* which means to ring, and as a condition it is being described as a conscious perception of an auditory sensation in the absence of a corresponding external stimulus. Tinnitus can be subjective, when the experience is of the individual alone, or less commonly, and it can be objective, when an observer can hear the tinnitus. The sensation is generally of an elementary nature as descriptions of hissing, sizzling and ringing are common, although, in some cases, more complex sounds such as voices or music are perceived [9].

Scientifically, tinnitus is regarded as a kind of sensation of sound in the absence of overt acoustic stimulation, and it can be classified according to whether the perceived noise has an identifiable source, for example myoclonic contractions of tensor tympani muscle [10]. Tinnitus is a deafferentation-induced phantom phenomenon characterised by abnormal cerebral synchrony and connectivity, as the reduced or absent afferent cochlear input causes a reorganisation of tonotopic cortical maps, where representations of those frequency regions neighbouring the deafferented part become expanded [11]. Also, tinnitus can be described as a constant ringing, buzzing noise or a high-frequency whistling sound affecting all age groups. Tinnitus may be present all the time, or it may be an occasional phenomenon. This deafferentation-induced phantom phenomenon may vary in pitch from low sound to a very high sequel, with attendant capacity towards interfering in one's ability to concentrate or perceive the actual (intended) sounds or messages.

Tinnitus has been identified as a common symptom associated with ageing health-related conditions. Tinnitus is a continuous ringing in the ear or head without any external corresponding sound signal, which features noise in one ear or both ears or in the middle of the head. At times, it is difficult to pinpoint the site of lesion, but it is a manifestation of malfunction in the processing of auditory signals involving perceptual and psychological components. It is the sensation of any sound perceived in the head or in the ears without an evident of external stimulus. Currently, there is no universal agreeable definition of tinnitus; but some definitions state that it is a phantom auditory sensation [12–14].

Tinnitus ranges from high pitch to low pitch with multiple tones or sounds without tonal quality, but it may be perceived as pulsed, intermittent or continuous noise. This debilitating condition may begin suddenly or gradually, as well as being sensed in one ear (or both ears) or in the head. This health-related condition has been observed to affect 10–33% of the aged population, and it is mostly associated with some psychosocial and health conditions such as anxiety, irritation,

annoyance, concentration and insomnia, stroke, rhinosinusitis, diabetes, head injury, hypertension [15] and reduced quality of life [16]. Also, it has been observed that a number of health conditions are capable of causing or worsening tinnitus. The causes include inner ear cell damage, which always affect the random electrical impulses to the brain leading to tinnitus, chronic health conditions/injuries affecting the auditory nerves, exposure to loud noise, age-related hearing loss, head/neck injuries, auditory canal blockage, Meniere's disease, atherosclerosis, malfunction of capillaries (a kind of abnormal connections between arteries and veins) and hypertension as well as other related conditions that can increase blood pressure [7].

Tinnitus noise may be low pitched, mid pitched or high pitched; it may also be one or more components perceived by the patient. Therefore, diagnosis and treatment are majorly based on self-report. It is important to note that tinnitus is neither a disease nor an illness but a symptom to many treatable health conditions. At one time or the other, people may experience ringing in the ears as a result of the usage of certain drugs (antibiotics or aspirin) and/or being exposed to loud noise of 85 dB and above for 8 hours daily and without adequate ear protection and traumatic brain injury, as part of normal ageing process (presbycusis). It can also coexist with some ear problems such as impacted wax, inner ear abnormality, etc. Tinnitus is a prevalent problem and common in all groups, although in the past, it had been considered as a problem of youths, but now it has been discovered that it is more common among the aged [17]. It is estimated that tinnitus affects approximately 50 million people in the United States of America. A similar ratio has been reported in the United Kingdom [18]. In Nigeria, it is mostly associated with treatable health conditions such as otitis media, stroke, rhinosinusitis, diabetes, head injury and hypertension, which affect 10–33% of the population. The association between tinnitus with functional impairment and reduced quality of life highlights the need for its inclusion in any comprehensive medical programme for the elderly, but it cannot be overemphasised [15]. Therefore, people have to be educated on how to take care of their health to prevent any health hazard which can lead to tinnitus and to avoid suffering from ringing in the ear in their old age. People suffering from tinnitus go through tough time as a result of associated psychosocial [emotional and behavioural] problems which include severe headache, negative thoughts, dizziness, hearing problem, anxiety, irritation, annoyance, concentration problem, sleep difficulties, depression and poor attention focus [7]. Studies have shown that the quality of life is reduced in patients suffering from the aforementioned problems [16, 19]. Meanwhile, it is noteworthy that psychoacoustical characterisation of tinnitus cannot fully determine the level of discomfort evoked by this condition. Thus, it has been observed that a person suffering from tinnitus may not be aware of it and may not feel any discomfort occasioned by the affliction, while another person suffering from tinnitus is constantly aware of the difficulty in attention focus, falling asleep, and enjoying life; this is because tinnitus is perceived differently and allows the individual to react to it differently [20].

2.2 Classifications and symptoms of tinnitus

Tinnitus can be classified into four different groups based on its nature and characteristics. Each of these classifications has different characteristics but with similar nature and symptoms. The four classifications would be discussed as follows:

- i. Subjective tinnitus: This is a kind of tinnitus that can only be perceived or heard by the affected person. Scientifically, subjective tinnitus can be defined as an acoustic phantom phenomenon of a perception of sound in the absence of external-physical generated sound signal(s) [7], which is typically

initiated by damage to the peripheral hearing system leading to a sequence of structural and functional changes in the central hearing system [21, 22].

Subjective tinnitus is the most common type of tinnitus, and it always occurs as a result of exposure to excessive noise. Most of the times, this type of tinnitus appears and disappears suddenly and may last for a period of time before it disappears. There are two types of subjective tinnitus, which are:

- a. Non-pulsatile subjective tinnitus: This can be considered as the most common type of tinnitus and is typically caused by damage to the peripheral hearing system due to undetectable sounds within the central nervous system.
- b. Pulsatile subjective tinnitus: This type of subjective tinnitus can also be referred to as vascular or pulse-synchronous tinnitus due to its relationship with disturbances in the blood flow. Pulsatile subjective tinnitus can be explained as a kind of ringing in the ear/head which is perceived as a rhythmic pulsing experience of thumping or whooshing sound due to increased blood flow or narrowing of the opening of the blood vessel.

This rhythmic tinnitus can be caused by several health conditions such as anaemia or an overactive thyroid gland making the blood to flow rapidly and loudly, hardening of the arteries (atherosclerosis), high blood pressure or irregular blood flow in the brain and around the ear leading to pressure or internal noise generation within the central nervous system. Apart from the common signs and symptoms of tinnitus, afflicted individuals with this type of tinnitus will manifest a health condition referred to as idiopathic intracranial hypertension.

- ii. Objective tinnitus: This is a kind of tinnitus that can be heard by another person, apart from the sufferers. Objective tinnitus is an uncommon type of tinnitus caused by inner ear structural defects such as hair cell damage, vascular anomalies or repetitive middle ear muscle contractions and presence of chronic recurrent rhinosinusitis leading to Eustachian tube dysfunction. This kind of tinnitus can be easily treated through the treatment of the cause(s) or by avoiding the risk factors.
- iii. Neurological tinnitus: Tinnitus can also manifest as a result of neurological disorder(s) which affect the brain auditory functions. This type of tinnitus is rare and can be caused by some neurological diseases such as Meniere's disease.
- iv. Somatic tinnitus: This type of tinnitus is classified in line with the manifestation of ringing in the ear/head due to dysfunction along the sensory system. It is purely the ringing in the ear/head as a result of underlying dysfunction of the sensory system.

3. Hypertension: meaning and effects on the elderly

3.1 What is hypertension?

Hypertension is a condition characterised as an abnormality of high blood pressure (HBp), with an evidence of exerted force by the blood against the walls of the blood vessels. Thus, hypertension as a health-related condition is referred to as high

blood pressure that can lead to severe-to-profound complications and increased risk of coronary artery diseases, cardiovascular diseases, atherosclerosis and dementia [23]. This high blood pressure (Bp) has been observed affecting 25% of the world's population, and it is the largest single contributor to global mortality [24]. It has also been found to be a significant economic burden to public healthcare providers in most countries of the world, even with improved pharmacological and counselling treatment.

Hypertension is an age-dependent health-related condition, as it is common in people aged 65 and older, and a clinical diagnosis is established by demonstrating a systolic Bp of greater than or equal to 140 mmHg and/or diastolic Bp of greater than or equal to 90 mmHg on at least three different Bp measurements [24, 25]. Hypertension can be confirmed with a repeated blood pressure checkups, based on the manifestation of consistently high blood pressure with a force of the blood flowing against the walls of the blood vessels. At this junction, it is medically defined as a blood pressure higher than 130 over 80 millimetres of mercury (mmHg) [26]. Also, it has been determined by the volume of the blood the heart pumps and the amount of resistance to blood flow in the arteries. For instance, the more blood the heart pumps, the narrower the arteries, and then, the higher the blood pressure will be experienced. Therefore, the long the force of the blood exerted on the arteries, this will automatically lead to high blood pressure, which will eventually cause some health problems if the condition is not controlled early. Once the condition is not adequately controlled, it will lead to serious health challenges including heart attacks, stroke and a state of psychological stress. In determining blood pressure, two (2) numbers have been recorded which are the upper and lower numbers. The upper number is referred to as the systolic pressure that is the pressure exerted during the heartbeat, while the lower number is the diastolic pressure—a kind of pressure evident when the heart is relaxing after the heartbeats. This reading is important and encouraged to be taken repeatedly for appropriate decision and management. Hypertension is the major risk factor for some health-related conditions. Most of the times, it allows cognitive functions, motor and visual sensitivity and auditory performance of the elderly populations who experience the condition.

Hypertension has been observed to always aggravate pre-existent tinnitus through two principal mechanisms: damage to the cochlear microcirculation and to ototoxicity caused by diverse antihypertensive drugs, such as furosemide and beta-blockers, as an electron microscope study revealed that the primary site of cochlear involvements in patients with hypertensive is the stria vascularis, followed by the Corti organ [27]. It has also been observed that there is an increase of extracellular volume generally associated with high sodium retention in hypertension [28, 29]. The prevalence of hypertension and its related condition(s) is increasing. Thus, patients who experience tinnitus often report significant associated morbidities, hypertension, lifestyle detriment, emotional difficulties, sleep deprivation, work hindrance, interference with social interaction, depression, anxiety, insomnia and decreased overall health have been attributed to tinnitus, although causative relations are yet unknown. Patients with tinnitus can have risk of depression, anxiety, and insomnia [30].

3.2 Types, symptoms and causes of hypertension

There are two major types of hypertension. These types will be discussed based on the observable symptoms and causes:

1. **Primary hypertension:** Primary hypertension is a kind of high blood pressure characterised by a pressure that is not associated with any identifiable

pathological cause. It is the most common type of hypertension, as it accounts for about 95% of the hypertensive cases, and it is more common among the elderly [31]. This primary type of hypertension has non-universally established or agreed known cause(s) but is observed to occur as a result of various factors including obesity, stress, negative lifestyle and other negative psychosocial-related factors and heredity. The observable symptoms include frequent experience and feeling of headaches, tiredness, dizziness and/or nose bleeds and insomnia.

2. Secondary hypertension: This is a kind of high blood pressure that is less common among the aged population. It accounts for about 5% of the hypertensive cases. Secondary hypertension is an abnormality in the arteries supplying blood to the kidney due to an elevation of blood pressure resulting from the underlying cause(s) such as cardiovascular disorder, uncontrolled primary hypertension, loss of elasticity in the arteries, airway obstruction during sleep, hormone abnormalities, tumour of the adrenal glands and drug-related factors [31]. The symptoms of this secondary type of hypertension include very high blood pressure, systolic blood pressure that is over 180 millimetres of mercury (mmHg) or diastolic blood pressure over 120 mmHg, resistant hypertension, central obesity and palpitation.

Other minor types of hypertension are:

- a. Isolated systolic hypertension: This is a type of hypertension mostly common in elderly as a result of loss of elasticity in the arteries.
- b. Malignant hypertension: This is a type of hypertension common among the younger adults due to prompt and continuous high blood pressure. This comes with evidence of chest pain, regular headache, psychological stress and trauma, blurred vision and numbness in the arms and legs.
- c. Resistant hypertension: This is a type of hypertension as a result of a reaction occasioned by the usage of different types of antihypertensive medications. Resistant hypertension is more common in obese and female gender, with an evidence of diabetes and kidney disease.

4. Effects of comorbidity of hypertension and tinnitus on elderly

- i. Idiopathic intracranial hypertension promotes the scourge of tinnitus, especially pulse-synchronous tinnitus among the elderly.
- ii. The comorbidity of tinnitus and hypertension can promote the complaints of continued whistling, humming or marching noise heard in one ear or both ears that is in synch with a kind of intermittent pulse and clear indication or manifestation of high intracranial pressure compressing the blood vessels. This is always associated with continuous and severe headache and elevated intracranial pressure.
- iii. Comorbidity of hypertension and tinnitus brings about the increase in perilymphatic pressure in the elderly due to the increase of extracellular volume associated with high sodium retention in hypertensive health-related condition(s) [3].

- iv. Unresolved hypertension and the attendant effect on the general well-being of the elderly can influence negative personality conducts, even with the evidence of increased negative psychological condition or mood swing, sleep deprivation, frustration, anger, feelings of hostility, aggressive depositions, depression, irritation and reduced quality of life.
- v. Significant impact on hearing mechanism leading to reduced hearing sensitivity.
- vi. Comorbidity of hypertension and tinnitus significantly impairs the quality of life (health, psychosocial, recreational and work-related) of the affected elderly population.
- vii. The influence of hypertension induces or aggravates the severity of tinnitus and other related psychosocial and other distressing symptoms and conditions in the elderly.
- viii. Hypertension is a major risk factor of tinnitus in the elderly with systemic diseases.
- ix. Comorbidity of hypertension and tinnitus promotes continual and spontaneous firing rate of neurons within the central auditory system leading to increased neural synchrony in the firing pattern across neurons in primary auditory cortex and map reorganisation in the auditory modality. This in turn, due to advanced age, brings about increased systolic blood pressure and cochlear microcirculation, resulting in hair cell damage, cardiovascular morbidity, mortality and pulsatile tinnitus and tinnitus-related distress [3, 4]. Consequently, it has been observed that the prevalence of hypertension and tinnitus-related distress is increasing across the globe, as patients who experience tinnitus often report significant associated morbidities, hypertension, lifestyle detriment, emotional difficult, sleep deprivation, depression, anxiety and decreased in overall health, generally associated with high sodium retention in hypertensive condition [28, 30].

5. Signs and symptoms of comorbidity of hypertension and tinnitus

- i. Elevation of blood pressure level and regular population of phantom noise (such as ringing, buzzing, hissing, clicking and roaring) in the ear(s)/head. This sound may be constant or intermittent in nature.
- ii. Evidence of hearing loss or complaint of reduced auditory sensitivity and high blood pressure.
- iii. Regular feeling of dull or severe headache.
- iv. Constant pounding in chest, neck and ears.
- v. Irregular heartbeat and difficulty in breathing activity.
- vi. Regular or continual chest pain.

- vii. Vision and visual-related difficulties.
- viii. Constant feeling of depression, insomnia, aggressive dispositions and hostility.
- ix. Evidence of pulse-synchronous tinnitus and negative personality conducts.
- x. Reduced quality of life and feeling of fatigue as well as concentration difficulties.

6. Audiological tinnitus management

6.1 Different audiological tinnitus management (ATM) options for the elderly patients with comorbidity of hypertension and tinnitus

There are several audiological tinnitus management options available towards the rehabilitation of the elderly patients with comorbidity of hypertension and tinnitus. The different ATM options are discussed as follows:

i. Tinnitus retraining therapy (TRT)

Tinnitus retraining therapy is a form of habitual therapy designed to help people who are suffering from tinnitus. TRT is a kind of therapeutic mechanism which is used as a noise generator towards rehabilitating individuals with tinnitus by exposing them to a kind of background noise level towards reducing the negative effect of unwanted sound perception and to also overshadow the perception of the ringing in the ear/head.

Tinnitus retraining therapy is designed to alter the mechanism that transfers the signal from the auditory mechanisms to the limbic and autonomous nervous systems, thereby removing tinnitus-induced reactions [14, 32]. This TRT is a therapeutic mechanism, which always helps an individual with tinnitus to gradually ignore the sound and the associative effects of the tinnitus condition. TRT is used as habitual therapy to give hope to individuals with tinnitus as well as a mechanism of relief to those who are willing to be rehabilitated or adjusted with the condition [33]. Structurally, TRT is designed to help individuals with tinnitus to understand and learn how to stop thinking about the perceived ear/head noise. This therapy makes use of white noise or environmental sounds to block out the tinnitus noise, thereby training the brain to ignore the perception of the negative sound. It is a training or a process of learning how to cope with the perception of the negative sound consciously or subconsciously. As well, TRT is designed to achieve complete habituation of the noise (ringing) perceived in the ear/head practically done through:

- a. Monitoring of the patient's daily living habits.
- b. The use of a device, normally worn behind the ear, with the capacity to generate broadband noise to divert attention of the patient away from the perception of the negative sound (tinnitus).
- c. Introduction of some psychological therapeutic measures for educating the patient to appropriately ignore the tinnitus noise. This is done in addition to some relaxation exercises and giving of stress management counsels, towards eliminating the patient's anxiety and feeling of frustration.

ii. Tinnitus masking therapy (TMT)

Tinnitus masking therapy (TMT) is designed to promote the reduction of audibility of tinnitus by introducing another sound signal through an instrument known as tinnitus masker. The tinnitus masker is used to generate masking noise which can either be applied to the ipsilateral or contralateral ear. The tinnitus masker can also be placed on a bed side for a patient with tinnitus who is experiencing sleeping difficulty [34]. TMT is referred to as sound therapies designed to minimise the contrast between the tinnitus and the surrounding sound, thereby promoting a shift of the patient's focus away from the tinnitus, and to reduce the fatigue and stress occasioned by the tinnitus. TMT involves the use of several devices to produce masking sounds that will interfere with the ringing in the ear. It also means to offer an expected relief to the individuals with severe tinnitus and associated psychosocial reactions.

iii. Cognitive behavioural therapy (CBT)

Cognitive behavioural therapy is another type of audiological rehabilitative mechanism designed to minimise the negative thoughts flowing in the mind of an individual with tinnitus while at the same time changing the person's behaviour towards the tinnitus. CBT is a therapeutic measure to rehabilitate and reduce the effect of tinnitus and its attendant psychosocial reactions by reducing the distress caused by tinnitus. This audiological tinnitus management mechanism makes use of relaxation strategies, cognitive restructuring mechanism of thoughts, reasoning and modified situations to repattern the thoughts and feelings of an individual with tinnitus to acquire essential skills to respond positively to tinnitus and live well-adjusted life, even with the tinnitus condition.

iv. Tinnitus desensitisation therapy (TDT)

Tinnitus desensitisation therapy is a kind of tinnitus therapeutic strategy to desensitise the abnormal processing of negative sound perceived. This is achieved by redirecting the attention (cognitive processing) of the individuals with tinnitus away from the tinnitus-induced signal and enabling the brain to naturally habituate the perceived tinnitus signal.

TDT makes use of directional (specific) counselling signal therapy and relaxation exercises to enable the natural habituation processing of the tinnitus-induced signal.

v. Biofeedback therapy

This is a kind of therapeutic programme structurally designed to rehabilitate individuals with pulse-synchronous tinnitus. Biofeedback therapy is a nondrug-based treatment employed to rehabilitate individual with stress and pain health-related conditions towards alleviating the negative feelings and psychosocial effects of the condition on such individual. Biofeedback therapy is designed to rehabilitate stress-induced health conditions through relaxation methods. The therapy is structured to help individuals with tinnitus to control his/her breathing system, heart rate and involuntary functions so as to reduce the effect of hypertension-related conditions. With this therapy, the elderly with comorbidity of hypertension and tinnitus will be remediated towards the control of all the bodily processes, such as heart rate, breathing system and blood pressure. Also, it will help to aid the rehabilitation reduction of elevated blood pressure, increased body temperature and disruption of brain functions through the promotion of mental and

physical-functional activity to even cope with any occasioned stress due to combined effect of hypertension and tinnitus.

vi. Acoustic coordinated reset neuromodulation

The acoustic CR neuromodulation is a well-structured rehabilitative programme based on noninvasive desynchronising stimulation aimed at counteracting a neural synchrony in the individual with pulsatile subjective tinnitus. Acoustic coordinated reset neuromodulation is a kind of rehabilitative mechanism to bring about significant relief of tinnitus symptoms along with a significant decrease of pathological oscillatory activity in a network comprising auditory and nonauditory brain areas which is often accompanied with a significant tinnitus pitch change [34]. The acoustic coordinated reset neuromodulation is used as a therapeutic mechanism towards the reduction in neural synchrony which is considered as a cause of the decrease in the connectivity across the brain areas involved in the larger salience network [35–37]. In essence, this acoustic CR neuromodulation is an essential rehabilitative mechanism for the elderly patients with comorbidity of hypertensive and tinnitus.

vii. Sleep therapy

This is a kind of therapeutic programme which is structured to rehabilitate individuals with sleep disorder. In most cases, tinnitus patients always experience sleep disorder as a result of attendant effect of the health condition on their physical, mental and emotional functioning. The condition may lead to persistent disturbances, depression, anxiety, trauma and sleeplessness.

Sleep disorder often leads to cognitive changes, mental health conditions and daytime distress. As well, tinnitus patient with high blood pressure often experiences poor quality of sleep due to the negative impact of the health condition. This is occasioned by the perception of tinnitus, especially in a quiet environment, and this always affects the sleep patterns and the development of physical discomfort and other related illness. Most of the times, the attendant difficulty often prevents the tinnitus patients from falling asleep. Thus, it is necessary to resolve the sleep difficulty through the development of skills towards the modification of unwanted sleep patterns.

Sleep therapy is a planned psychological treatment to help patients with tinnitus condition to reflect on their beliefs about sleep and negative feeling, as a result of tinnitus and comorbidity of hypertension. Sleep therapy is an effective strategy to resolve sleeping difficulty and attendant anxiety. It is also effective in modifying the emotional responses of patients with tinnitus and comorbidity of hypertension to the health challenges.

viii. Environmental sound enrichment

This is another type of therapeutic programme well structured to rehabilitate individual with tinnitus-related conditions. Environmental sound enrichment is based on the principle of distraction of one sound for the intended sound (message) to be heard or received. This tinnitus management strategy is commonly referred to as sound therapy in the audiology parlance. The sound therapy, which was introduced by Jastreboff and McKinney in 1993, has been an effective mechanism to habituate any disordered auditory system through the use of low-level sounds (sound enrichment) to regulate the auditory functions of any individual with experience of tinnitus. The most effective way for sound therapy is the usage of a kind of

sound enrichment suitable (pleasant and well tolerated) to the patient(s) with tinnitus, although some natural background sounds such as recorded traffic noise or music playing functions (instrumental sounds) and sound generators are well encouraged or advised for effective and prompt result.

ix. Relaxation therapeutic exercise

Relaxation therapy is a kind of stress management mechanism to consciously relax the body and mind of any individual with health-related conditions and stress either directly or through guided assistance by initiating calmness into the lives of those who are exposed to it. This therapeutic exercise is aimed at reducing stress symptoms and enables the elderly patients with comorbidity of hypertension and tinnitus enjoy better quality of life and, at the same time, reduce the effect of tinnitus and hypertension.

Relaxation therapy is a designed process to reduce the effects of noise in the ears/head and psychosocial reactions occasioned by the comorbidity of hypertension and tinnitus-related patient cope with everyday stress. For this therapy would help to boost the confidence level of the patients to handle the condition, maintaining normal blood sugar levels and increasing blood flow to the muscles, reducing tension and chronic pain, slowing down the heart rate and breathing rate and lowering the blood pressure, as well as reducing anger and frustration. Relaxation therapy can be achieved through regular deep breathing exercises, relaxing music, mediation and mindfulness exercises.

7. Recommendations

Due to the attendant effects of comorbidity of hypertension and tinnitus on the elderly population, it is noteworthy to make the following recommendations in order to holistically rehabilitate elderly patients with such comorbid health-related condition:

1. Proper screening and diagnosis of the elderly patients with high blood pressure, with the aim of identifying those with comorbid conditions.
2. Hypertensive condition should be properly managed, so as to prevent the development of pulse-synchronous tinnitus and its attendant effect on the general well-being of the elderly population.
3. Behavioural control mechanisms towards the reduction of body mass index and raised blood glucose, alcoholic consumption and poor diet (especially food with high sodium and low in fruit and grains). At the same time, the improvement in physical activity and better lifestyle changes can help to enhance the quality of life.
4. Reduction in the level of exposure to environmental noise and air pollution, as well as other related causative or risk factors of tinnitus and high blood pressure.
5. Combined audiological tinnitus management protocols should be adopted rather than a single therapeutic protocol in managing elderly patients with hypertension-induced tinnitus and other tinnitus severity reactions.

6. Concerted effort should be geared towards prompt and effective treatment as well as the management of tinnitus-induced conditions, high blood pressure, diabetes and noise-induced and ototoxic hearing loss.
7. Noninvasive acoustic coordinated reset (CR) stimulation (neuromodulation) should be employed as a means to replace electrical stimulation bursts, which might be occasioned due to high blood pressure.
8. Proper sound stimulation, counselling and stress reduction strategies should be adopted in suppressing tinnitus and its attendant effect on the elderly who presents with comorbidity of hypertension and tinnitus.
9. The usage of combined devices which includes amplification and sound generator capable of producing relaxing fractal tones should be entrenched in the management profile of the elderly patients with comorbid conditions of hypertension and tinnitus.
10. Constant monitoring of the blood pressure level of the elderly population is advocated, and regular audiological assessment is also encouraged.

8. Conclusion

Audiological tinnitus management with the aim of providing appropriate treatment and adjustment for the individual with hearing loss and other conditions occasioned due to the attendant effects of such condition or associated health challenges remains the essential audiological management protocol for the elderly patients with comorbidity of hypertension and tinnitus. Also, it has been established that there is no single therapeutic programme capable of resolving attendant effects occasioned due to comorbidity of hypertension and tinnitus. Therefore, this chapter recommends combined audiological therapies, several psychological measures and regular physical activity in addition to behavioural modification and changes in life styles among the elderly patients with comorbidity of hypertension and tinnitus. Prompt attention must be paid to health conditions relating to unresolved hypertensive condition and its attendant effect on the general well-being of the elderly. Importantly, regular audiological cum and psychological checkups are well encouraged. The mechanism of aural rehabilitation must also be integrated into the audiological tinnitus management for the elderly patients with comorbidity of hypertension and tinnitus. This will promote sensory management towards enhancing auditory functions as well as increase the probability of positive outcomes, which will enable the elderly patients enjoy good quality of life even with the comorbid health-related conditions.

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Conflict of interest

The author declares no conflict of interest.

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