

EARLY DIAGNOSIS AND TREATMENT OF HEARING IMPAIRMENT IN CAROTID ARTERY STENOSIS

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Shodmonkulova G.R.

Phd researcher, Departement of Otorhinolaryngology, TMA.

Khaydarova G.S.

Doctor of medical science, Departement of Otorhinolaryngology, TMA.

Abstract

Carotid artery stenosis (CAS), a condition characterized by the narrowing of the carotid arteries due to atherosclerosis, is a well-known risk factor for stroke. However, its impact on auditory function remains underrecognized. The inner ear relies on a constant blood supply, primarily from the labyrinthine artery, a branch of the anterior inferior cerebellar artery (AICA). Reduced blood flow due to CAS can result in cochlear ischemia, leading to sensorineural hearing loss (SNHL) and other auditory dysfunctions.

Objective:

This article explores the relationship between carotid artery stenosis and hearing impairment, discusses early diagnostic approaches, and reviews current treatment options to prevent permanent auditory dysfunction.

Methods:

A review of recent literature on the pathophysiology of CAS-related hearing loss, available diagnostic methods, and medical and surgical interventions was conducted. Studies on vascular contributions to SNHL, microcirculatory changes, and outcomes of carotid interventions were

Introduction

Carotid artery stenosis is a leading cause of stroke and transient ischemic attacks (TIAs), but its association with hearing loss remains underrecognized. The inner ear requires a constant supply of oxygen-rich blood, primarily delivered by branches of the carotid and vertebrobasilar arteries. Reducing this blood supply due to stenosis can result in sensorineural hearing loss and other auditory dysfunctions [1].

1 Table: Stages of Disease Progression in Carotid Artery Stenosis and Hearing Impairment

Stage	Pathological	Clinical Symptoms
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	Changes	
Early Stage (Mild stenosis: <50%)	<ul style="list-style-type: none"> - Formation of atherosclerotic plaques in the carotid arteries - Slight reduction in blood flow, but compensatory mechanisms are still active 	<ul style="list-style-type: none"> - Often asymptomatic - Occasionally, temporary hearing loss or tinnitus may occur
Intermediate Stage (Moderate stenosis: 50-70%)	<ul style="list-style-type: none"> - Significant reduction in blood flow, leading to initial cochlear and vestibular ischemia - Endothelial dysfunction and increasing inflammation 	<ul style="list-style-type: none"> - Persistent or worsening tinnitus - Progressive sensorineural hearing loss (SNHL) - Dizziness and balance disturbances
Severe Stage (Critical stenosis: >70%)	<ul style="list-style-type: none"> - Serious impairment of cochlear blood supply - Microembolic events blocking small blood vessels in the inner ear - Oxidative stress and mitochondrial dysfunction leading to hair cell apoptosis 	<ul style="list-style-type: none"> - Sudden sensorineural hearing loss (SSNHL) - Persistent balance issues and dizziness - Reduced speech comprehension
Late Stage (Complete arterial occlusion or thrombosis)	<ul style="list-style-type: none"> - Complete ischemia of the labyrinthine artery, leading to auditory nerve damage - Neurovascular atrophic changes 	<ul style="list-style-type: none"> - Irreversible hearing loss - Severe decline in sound perception - Need for hearing aids or cochlear implants

Pathophysiology The labyrinthine artery, a branch of the anterior inferior cerebellar artery (AICA), is responsible for supplying the cochlea and vestibular structures. When blood flow is compromised due to carotid artery stenosis, ischemic damage to these structures may occur, leading to auditory symptoms [2].

This ischemia may present as sudden sensorineural hearing loss (SSNHL) or progressive hearing deterioration.

Pathophysiological Mechanism	Description	Impact on Auditory Function
Reduced Cochlear Blood Flow	Narrowing of the carotid artery leads to decreased blood supply to the labyrinthine artery , which nourishes the cochlea and vestibular structures.	Ischemia and hypoxia impair the function of hair cells and auditory neurons , leading to sensorineural hearing loss (SNHL) .
Oxidative Stress & Mitochondrial Dysfunction	Inadequate blood flow reduces oxygen and nutrient delivery , leading to increased free radical production and mitochondrial damage in cochlear cells.	Hair cell apoptosis and irreversible auditory dysfunction due to oxidative damage.
Microembolic Events	Plaque rupture and embolization from carotid artery stenosis can cause tiny clots to block the microvasculature of the cochlea.	Can result in sudden sensorineural hearing loss (SSNHL) or fluctuating hearing impairment .
Endothelial Dysfunction & Inflammation	Atherosclerosis leads to chronic inflammation , disrupting the blood-labyrinth barrier and impairing vascular function.	Persistent inflammation can cause progressive hearing decline and tinnitus .
Altered Cochlear Microcirculation	Disruptions in vascular autoregulation and capillary damage reduce nutrient and ion exchange in the cochlea.	Leads to electrolyte imbalance , affecting the endocochlear potential and reducing hair cell function.
Neurovascular	Chronic ischemia	May cause auditory

Damage	affects the auditory nerve and brainstem pathways , impairing signal transmission to the auditory cortex.	processing deficits , speech discrimination issues, and increased risk of cognitive decline .
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Carotid artery stenosis leads to hypoperfusion in critical regions of the inner ear, disrupting the metabolic balance required for proper auditory function. The cochlea is highly susceptible to ischemia due to its dependence on a single arterial supply, primarily from the labyrinthine artery. Reduced oxygenation and nutrient deprivation result in oxidative stress and mitochondrial dysfunction, which can contribute to hair cell apoptosis and irreversible hearing loss [3]. Additionally, embolic events from unstable carotid plaques can lead to microvascular occlusions within the inner ear, further compromising auditory function [4]. These embolic phenomena can result in transient ischemic symptoms or permanent damage, depending on the extent and frequency of vascular insults. Furthermore, endothelial dysfunction associated with atherosclerosis exacerbates inflammatory responses, leading to further deterioration of cochlear microcirculation [5]. Studies indicate that patients with carotid stenosis may experience auditory symptoms before the onset of major cerebrovascular events, making hearing loss a potential early indicator of broader vascular pathology [1]. This highlights the need for increased vigilance in screening patients with unexplained sensorineural hearing loss for underlying vascular conditions.

Clinical Manifestations

Patients with carotid artery stenosis may present with:

- Sudden or progressive sensorineural hearing loss
- Tinnitus (ringing in the ears)
- Dizziness and balance disturbances
- Transient ischemic attacks (TIAs) with auditory symptoms

Diagnosis

Early diagnosis involves a combination of audiometric and vascular assessments. Key diagnostic tools include:

- Pure-tone audiometry: assesses hearing thresholds and sensorineural deficits[6].
- Otoacoustic emissions (OAE) and Auditory Brainstem Response (ABR): Evaluate cochlear and neural function [4].
- Carotid Doppler Ultrasound: Detects stenosis severity and evaluates blood flow [7].

- Magnetic Resonance Angiography (MRA) and Computed Tomography Angiography (CTA): Provide detailed imaging of vascular structures [8].

Treatment Options Management strategies focus on restoring proper blood flow and mitigating hearing impairment.

- Medical Therapy: Use of antiplatelet agents, statins, and antihypertensive drugs to manage atherosclerosis and prevent further vascular compromise [5].

- Surgical Interventions: Carotid endarterectomy (CEA) and carotid artery stenting (CAS) can significantly improve circulation and auditory function in severe cases[9].

- Hearing Rehabilitation: Hearing aids and cochlear implants may be beneficial for patients with irreversible hearing loss [10].

Discussion

The association between carotid artery stenosis and hearing impairment raises important considerations for both audiologists and vascular specialists. While the exact prevalence of hearing loss due to carotid stenosis is not well-documented, studies indicate that vascular insufficiency can lead to significant auditory dysfunction. Identifying at-risk patients through routine vascular screenings may improve early detection rates. One challenge in diagnosing hearing loss linked to carotid artery stenosis is differentiating it from other causes of sensorineural hearing loss, such as age-related hearing loss (presbycusis) or noise-induced damage. More research is needed to establish clear clinical guidelines for evaluating patients with unexplained hearing loss for underlying vascular conditions.

Additionally, treatment outcomes vary based on the severity of stenosis and the degree of hearing loss. While surgical interventions like CEA and CAS have shown promise in improving auditory function, more longitudinal studies are required to confirm their long-term efficacy in hearing restoration. Further interdisciplinary collaboration between otolaryngologists, neurologists, and vascular specialists is essential in improving patient outcomes.

Conclusion

Early detection and treatment of hearing impairment due to carotid artery stenosis are essential in preventing permanent auditory dysfunction. Healthcare providers should consider vascular causes in patients presenting with unexplained hearing loss. Further research is needed to refine diagnostic criteria and optimize treatment strategies.

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