

# Arterial Abnormalities Leading to Tinnitus



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## KEYWORDS

- Tinnitus • Pulsatile tinnitus • Vascular abnormalities • Internal carotid artery variants
- Vascular masses

## KEY POINTS

- Tinnitus is the unwanted perception of sound in the absence of an external stimulus, and is classified by whether the sound is perceived by the patient alone, or also by the clinician (eg, subjective vs objective), and by whether it is continuous, or varies with the patient's pulse (eg, nonpulsatile vs pulsatile).
- Causes of pulsatile tinnitus can broadly be divided into vascular and nonvascular types.
- Vascular causes of pulsatile tinnitus are numerous, and are further characterized by the location of the source of the noise within the cerebral-cervical vasculature: arterial, arteriovenous, and venous.
- Patients with pulsatile tinnitus should first be evaluated with contrast-enhanced CT of the head and temporal bones. When noninvasive imaging studies fail to demonstrate a cause, catheter angiography should be performed to exclude a dural arteriovenous fistula.

## INTRODUCTION

Tinnitus is the unwanted perception of sound that originates, or seems to originate, from one or both ears.<sup>1-4</sup> The word tinnitus is derived from the Latin *tinnire*, meaning “to ring,” although the noise may also be described as buzzing, roaring, whistling, clicking, or musical.<sup>5-8</sup> Chronic, persistent tinnitus may affect up to 10% of adults in the general population, although only a minority of these cases are severe.<sup>4,6,9-11</sup> Tinnitus occurs more frequently in men than women, and increases in prevalence with advancing age, being most common from 40 to 70 years.<sup>2-6,11</sup> However, tinnitus has also been reported in children.<sup>3-6,11,12</sup> The perceived severity of tinnitus may have little correlation with its impact on the patient's life, which may range from negligible to disabling.<sup>3,5-9</sup>

Tinnitus may be classified by whether the sound is perceived by the patient alone, or also by the clinician (eg, subjective vs objective), and by whether it is continuous, or varies with the patient's pulse (eg, nonpulsatile vs pulsatile).<sup>1,2,4-6,8,13</sup> Most cases of tinnitus are subjective and nonpulsatile, with the auditory stimulus being present without an external stimulus.<sup>1,3,8,9,11</sup> In these instances, tinnitus is often associated with some degree of hearing loss and is thought to likely arise from damage to the outer hair cells of the inner ear.<sup>1,3</sup> Imaging typically is unremarkable in these cases.<sup>5</sup> Treatment options for this type of tinnitus primarily consist of patient reassurance, masking devices, and cognitive therapy.<sup>3,11,12</sup> However, nonpulsatile tinnitus can rarely be associated with a treatable condition, such as a tumor compressing the eighth

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cranial nerve or other central nervous system processes, including stroke or demyelinating disease.<sup>5</sup>

In contradistinction, pulsatile tinnitus, where the perceived sound is synchronous with the patient's pulse, is relatively uncommon, accounting for less than 10% of tinnitus cases.<sup>1,6,10,14</sup> Pulsatile tinnitus is often secondary to an identifiable, acquired vascular anomaly or congenital vascular variant, which produces a physical sound that is perceived by the inner ear, and may sometimes be auscultated by the clinician.<sup>4,5,7,8,10,11,14–16</sup> Because the source of the sound is often unilateral, pulsatile tinnitus also typically localizes to one side.<sup>1</sup> However, cases of bilateral pulsatile tinnitus do occur, but are more likely to be nonvascular in origin, and are typically associated with sensorineural hearing loss.<sup>1,17</sup> Imaging plays an important role in the management of pulsatile tinnitus by helping to evaluate for potential causes, which can then facilitate treatment.<sup>1,7,8,18</sup>

## PATHOPHYSIOLOGY OF VASCULAR PULSATILE TINNITUS

Pulsatile tinnitus resulting from a vascular cause may be generated by two possible pathophysiologic mechanisms. First, turbulent blood flow at the skull base near the inner ear may generate the noise, which in turn can be generated by a focal vascular stenosis and/or increased blood flow.<sup>1,2,5,6,14,19</sup> Alternatively, pulsatile tinnitus may be generated by amplification of normal blood flow sounds at the skull base.<sup>1</sup> This can occur because of changes in the inner ear that result either in increased bone conduction of sound, or abnormal sound conduction leading to a loss of normal masking of external noise.<sup>1</sup> However, the exact etiologic relationship between these mechanisms and the production of tinnitus needs to be established.<sup>5</sup>

## ETIOLOGIES OF PULSATILE TINNITUS

Numerous causes of pulsatile tinnitus have been described in the literature, the frequency of which have varied considerably between individual reports.<sup>1,6,10</sup> This likely reflects differences in diagnostic work-up and patient selection among the various studies.<sup>1,10</sup> However, the most commonly identified causes of pulsatile tinnitus include benign intracranial hypertension, atherosclerotic disease with associated arterial stenosis, vascular anatomic variants, and vascular tumors at the skull base.<sup>1,3,10,13,19–21</sup> In general, a cause of pulsatile tinnitus is identified in up to 70% of cases.<sup>1,7</sup> An underlying cause of pulsatile tinnitus is more likely to be found when the symptom is unilateral

compared with bilateral, and when the tinnitus is objective.<sup>1,10</sup>

Causes of pulsatile tinnitus can broadly be divided into vascular and nonvascular types.<sup>6</sup> Nonvascular causes include palatal, tensor tympani, and stapedial myoclonus; a patulous Eustachian tube; certain drugs; dehiscence of the semicircular canal; and chronic middle ear disease.<sup>4,6,10,15,17</sup> Vascular etiologies of pulsatile tinnitus are numerous, and are further characterized by the location of the source of the noise within the cerebral-cervical vasculature: arterial, arteriovenous, and venous.<sup>6</sup> This article focuses on arterial and arteriovenous causes of pulsatile tinnitus. For Venous causes, see Reardon M, Raghavan P: Venous Abnormalities Leading to Tinnitus: Imaging Evaluation, in this issue.

## ARTERIAL CAUSES OF PULSATILE TINNITUS

### *Arteriosclerotic Disease*

Arteriosclerotic plaque is one of the most common causes of arterial narrowing in the head and neck, and should be considered in elderly patients presenting with pulsatile tinnitus, particularly in those individuals with a history of hypertension, diabetes, hyperlipidemia, or smoking.<sup>1,6,13,14,17,21</sup> The tinnitus may be generated from turbulent blood flow at the site of arterial narrowing, or conversely from compensatory increased blood flow in a cervical artery secondary to arteriosclerotic occlusion of another vessel.<sup>1,6,13,14,17,21</sup> Tinnitus may occur because of arteriosclerotic plaque arising from any segment of the internal carotid artery (ICA), from the carotid bifurcation to the intracranial carotid siphon, and from plaque involving the subclavian and vertebral-basilar arteries.<sup>5,14</sup> Treatment of the associated arterial stenosis may result in resolution of the tinnitus.<sup>5</sup>

### *Fibromuscular Dysplasia*

Pulsatile tinnitus may also be caused by fibromuscular dysplasia (FMD), a segmental, nonatheromatous vasculopathy affecting medium-size arteries, which typically presents in young to middle-age women.<sup>1,5,7,10,22–25</sup> FMD most commonly involves the renal and cervical ICAs, although the cervical vertebral arteries may also be affected.<sup>17,22,23</sup> These vessels often display a characteristic beaded appearance, with multifocal areas of vessel irregularity and narrowing, separated by segments of variable dilatation (**Fig. 1**).<sup>4,17,22,23</sup> Pulsatile tinnitus is presumably generated by turbulent blood flow arising from the associated arterial stenoses and dilatation.<sup>5,22,23</sup> Many cases of FMD are asymptomatic, although patients may experience pulsatile tinnitus, headache, vertigo, transient ischemic attack, and cerebral infarct.<sup>4,5,22,23</sup> Overall, patients

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