

# Tinnitus and Hyperacusis

# 11

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## 11.1 Introduction

Tinnitus is defined as a perception of sound with no external stimulus [1]. It is considered chronic if it lasts more than 3 months. Tinnitus is divided into two entities: **Subjective tinnitus** in which only the patient can hear it, and **Objective tinnitus**, where others can detect it by either a stethoscope or ear canal microphone [2, 3]. Objective tinnitus can be pulsatile or non-pulsatile. Hyperacusis is considered a central phenomenon that is defined as an unusual tolerance to ordinary environmental sounds. Most of the cases of hyperacusis have unknown pathology. Hyperacusis and tinnitus can coexist with each other.

## 11.2 Tinnitus

### 11.2.1 Subjective Non-pulsatile Tinnitus

- Half of the patients have tinnitus in both ears. In those who have it unilateral, it is more common on the left side [3].

- The prevalence increases with age [4].
- Risk factors: age, male sex, lower education and annual income level, more than 15 h per week of noise exposure at work, poor health condition, obesity, hypertension, diabetes, cardiovascular diseases, head trauma, smoking, and alcohol [1, 5].
- Possible etiologies:
  - Certain otologic diseases can present with tinnitus (called syndromic tinnitus). For example, Otosclerosis, Meniere's disease, and vestibular schwannoma [3].
  - Certain medications can cause tinnitus like salicylates, aminoglycosides, quinine, and platinum-based antineoplastic medication [3].
  - Tinnitus is associated with depression and anxiety [6].
  - Look at Table 11.1 for some medical conditions that can lead to tinnitus [7].
- Pathophysiology:
  - Any pathology that can damage the auditory system can lead to tinnitus like:
    - Damage to outer hair cells [8].
    - Disturbance of intracellular calcium level (can be caused by specific medication and noise) [8].
    - Damage to the inner ear can cause the downregulation of the inhibitory pathway leading to spontaneous firing of nerves [9].
- Subtypes:
- Look at Table 11.2 [2].

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**Table 11.1** Some medical conditions that can lead to tinnitus

– Sensorineural hearing loss: Sudden sensorineural hearing loss, Meniere’s disease, vestibular schwannoma, noise-induced hearing loss, and presbycusis.
– Conductive hearing loss: otitis media, ossicular dislocation, and otosclerosis.
– Endocrine: pregnancy and thyroid disease.
– Metabolic: Vitamin deficiencies and hyperlipidemia.
– Medications: salicylates, aminoglycosides, quinine, platinum-based antineoplastic medication, and antihypertensive medication.
– Head trauma.
– Neurological diseases like meningitis, multiple sclerosis, and stroke.
– Temporomandibular joint (TMJ) syndrome.
– Depression and anxiety.

**Table 11.2** Subjective tinnitus subtypes

Hearing loss subtype
Somatic tinnitus subtype
Typewriter tinnitus
Musical tinnitus
Intrusive
Associated with affective disorder

### 11.2.1.1 Hearing Loss Subtype

- Mainly includes noise-induced hearing loss (NIHL) and presbycusis.
- NIHL:
  - The prevalence of tinnitus in NIHL is 50–70%.
  - Intense sound exposure causes a reduction in blood flow to the cochlea leading to reactive oxygen and nitrogen molecules, which have a damaging effect on the cells.
  - Certain medicines like Vitamin E, salicylates, and *N*-acetylcysteine have antioxidant effects and can give some neuroprotection [2].
- Presbycusis:
  - The prevalence of tinnitus in NIHL is 70%.
  - In those patients, hearing loss is not only attributed to the age, but in fact, it is a combination of the cumulative effect of noise-

induced injury to the cochlea, metabolic injury, and vascular injury. Taking in consideration other comorbidities that become more prevalent by aging like diabetes, which can affect the cochlear function [2].

### 11.2.1.2 Somatic Tinnitus Subtype

- It means the tinnitus in which somatic stimulation can modulate the loudness and pitch of the tinnitus [10].
- Examples:
  - The tinnitus that occurs after the removal of vestibular schwannoma. In some of those patients, tinnitus can be modulated by exaggerating eye movement, leg movement, or cutaneous stimulation of the hand [2].
  - Another example is tinnitus that can occur with the temporomandibular joint disorder. Jaw movement and pressure over the joint can modulate the tinnitus in some of these patients [2].
- Somatic tinnitus can be responsive to acupuncture treatment or electrical stimulation of the ear and scalp [2].

### 11.2.1.3 Typewriter Tinnitus

- It is chronic intermittent and has staccato quality [2].
- It is believed that it is caused by vascular compression of the ipsilateral auditory nerve [11].
- It can be misdiagnosed by objective tinnitus caused by muscular origin [2].
- It can be responsive to Carbamazepine therapy [11].
- Other types of subjective tinnitus include musical tinnitus, intrusive, and associated with affective disorder [2].
- Evaluation:
  - Identify the features of the tinnitus from history like:
    - The laterality.
    - Continuous or intermittent.
    - Pulsatile or not, the tone.
    - Is it hissing, humming, sizzling, buzzing, or roaring.

The effect of the surrounding stimuli on the tinnitus; it is exacerbating or inhibiting the tinnitus.

The effect of the tinnitus on the patient like anxiety, depression, or sleep deprivation.

- Different standardized questionnaires can detect tinnitus severity and the disability that can occur on the individual [3].
- Audio tympanogram [3].
- Other tests like:
  - Measurement of loudness and pitch of the tinnitus: it is often not accurate [12].
  - Minimal masking level: the intensity of sound needed to mask the tinnitus [13].
  - Residual inhibition: the length of time where the tinnitus is absent or decreased after being exposed to one minute of masking [14].
- MRI: especially for unilateral tinnitus [3].
- Management:
- Different devices, medications, and psychotherapy techniques were used to treat tinnitus; some of these methods are:
  - Counseling and reassurance which are considered the key step in management [15].
  - Hearing aid: hearing amplification can decrease tinnitus. Patients with associated hearing loss can benefit from hearing aid in treating this condition [16].
  - Sound therapy: by utilizing specific devices, sound can be used for tinnitus masking or distraction [17].
  - Combination treatment modalities (called tinnitus retraining therapy (TRT)), in which combination of counseling and sound therapy is used [18].
  - Cognitive behavioral therapy (CBT) [19].
  - Some other techniques were used to treat tinnitus like relaxation technique, acupuncture, and some herbal medicines [3].
  - Electromagnetic stimulation [20].
  - Certain medications were used like Tricyclic antidepressants, selective serotonin reuptake inhibitors (SSRI), and benzodiazepine. Local anesthesia like lidocaine can suppress tinnitus, but the effect is short term [3].

- Intratympanic injection of steroid or local anesthesia [21, 22].
- Dietary supplements, like vitamins and minerals, were used to treat tinnitus. Vitamin B was found to offer ear protection against noise trauma [3].
- Lasers [3].
- Surgery: stapedectomy was found to treat tinnitus caused by otosclerosis [23]. Also, cochlear implantation was found to improve tinnitus in those patients with profound hearing loss [24].

### 11.2.2 Objective Tinnitus

- It can be pulsatile or non-pulsatile. Look at Table 11.3 [2].

### 11.2.3 Non-pulsatile Objective Tinnitus

- Caused by otoacoustic emission or patulous Eustachian tube.
- Patulous Eustachian tube:

**Table 11.3** Objective tinnitus

Pulsatile		Non-pulsatile
Synchronous	Non-synchronous	
<ul style="list-style-type: none"> <li>- Arteriovenous malformation or fistula</li> <li>- Persistent stapedial artery</li> <li>- Primary vascular abnormality</li> <li>- Carotid artery stenosis</li> <li>- Atherosclerosis of external carotid subclavian artery</li> <li>- Paraganglioma</li> <li>- Hyperdynamic circulation like pregnancy and hyperthyroidism</li> <li>- Pseudotumor cerebri</li> <li>- Jugular bulb anomaly</li> <li>- Venous hum</li> </ul>	<ul style="list-style-type: none"> <li>- Palatal myoclonus</li> <li>- Tensor tympani/ Stapedial myoclonus</li> </ul>	<ul style="list-style-type: none"> <li>- Otoacoustic emission</li> <li>- Patulous Eustachian tube</li> </ul>

- Tuba aperta is another name [3].
- There are two types:
  - Patulous ET: in which the ET remains anatomically open [3].
  - Semi-patulous ET: in which the ET may open at exercise due to low resistance to airflow [3].
- Symptoms: autophony, hearing loss, a sensation of pressure in the ear, and tinnitus synchronized to breathing [7].
- Causes: weight loss (causing loss of Ostmann’s fat pad), radiation, injury to cranial nerve V, or iatrogenic injury to tensor veli palatini muscle during surgery to cleft palate [7].
- Diagnosis: through history and physical examination. Movement of the tympanic membrane with respiration is diagnostic, but it is not always seen. Tympanogram with reflux delay can help in diagnosis but needs an intact TM. Tympanometry can be utilized for diagnosis, and it helps in differentiating between patulous ET and obstructive ET [3].
- Treatment: conservative (it is often self-limited in children). Medical treatment like nasal estrogen drops or oral administration of iodide to induce swelling to the opening of ET [3, 25]. Surgical treatment, for example, grommets insertion was seen to help in alleviating the symptoms [26], and another example is augmentation tympanoplasty with cartilage or tuboplasty [3].

#### 11.2.4 Pulsatile Tinnitus

- It can be divided into synchronous and non-synchronous [3].

##### 11.2.4.1 Synchronous Pulsatile Tinnitus

- It means it synchronizes with the patient’s heartbeats.
- Etiology [2].
  - *Arterial causes:*  
Arteriovenous malformation or fistula.  
Persistent stapedial artery.

- Primary vascular abnormality.  
Carotid artery stenosis.  
Atherosclerosis of external carotid subclavian artery.  
Paraganglioma.  
Hyperdynamic circulation like pregnancy and hyperthyroidism.
- *Venous causes:*  
Pseudotumor cerebri.  
Jugular bulb anomaly.  
Venous hum.

- Investigation:
  - If retrotympanic mass is found during otoscopy, then order CT temporal bone [27].
  - If atherosclerosis of the carotid is suspected, then ask for duplex carotid US [3].
  - If idiopathic intracranial hypertension is suspected, then referral to ophthalmology should be done along with LP for the measurement of CSF pressure [3].
- Treatment:
  - If no pathology is found, then reassurance is recommended.
  - If pathology is found, treat the underlying condition [3].

##### 11.2.4.2 Non-synchronous Pulsatile Tinnitus

- It is not synchronized with the patient’s heartbeat.
- Causes:
  - Palatal myoclonus: it is caused by myoclonus of the palate leading to rapid clicking tinnitus [28].
  - Tensor tympani/Stapedial myoclonus: leading to low-frequency tinnitus exacerbated by external sound [29].
- It is essential to differentiate between middle ear myoclonus and palatal muscle myoclonus, with the latter presenting with involuntary movement of the soft palate and suprahyoid muscles. Palatal myoclonus is often associated with CNS lesions so that brain MRI should be done [30].
- Treatment: first conservative and supportive therapy should be tried like relaxation therapy, biofeedback, and tinnitus masking. Certain medications can be used like carba-

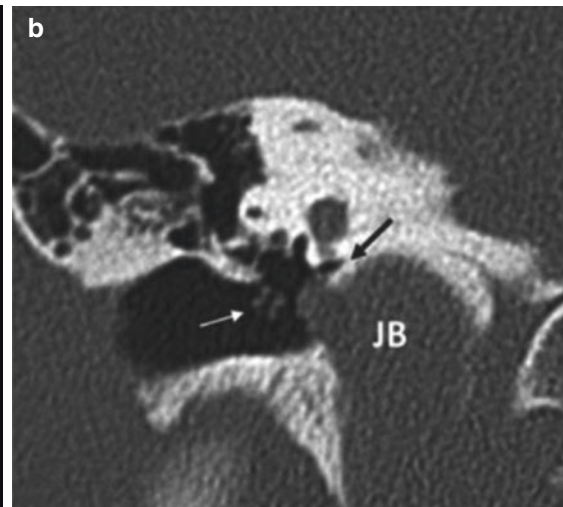
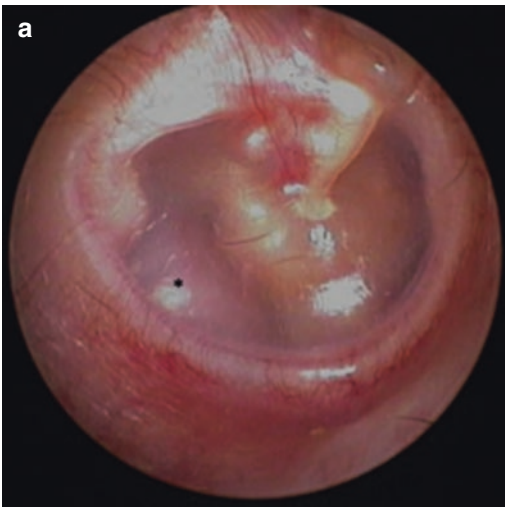
mazepine and benzodiazepine. If these trials failed, then surgical therapy can be offered, which includes the division of both tensor tympani and stapedial muscles [3] (Figs. 11.1 and 11.2).



**Fig. 11.1** Otoscopic view of aberrant carotid artery

### 11.3 Hyperacusis

- Defined as unusual tolerance to ordinary environmental sounds [7].
- It is considered a central phenomenon and should be distinguished from recruitment, which is a peripheral phenomenon. Recruitment is not considered part of hyperacusis as the patients will experience rapid growth of loudness upon increasing the tone level [2].
- Prevalence: 8–15% [3].
- Both hyperacusis and tinnitus often occur together [3].
- Most of the cases of hyperacusis have no known pathology. There are some medical conditions that can lead to hyperacusis: look at Table 11.4 [7].
- Pathophysiology is thought to be by GABA central pathways as patients with Benzodiazepine withdrawal experience this phenomenon [31].
- In hyperacusis, patients experience physical discomfort upon exposure to moderate or weak sound stimuli, which generally will not cause any discomfort in a normal person.



**Fig. 11.2** (a) Right ear otoscopic image of the typical bluish appearance of the prominent high jugular bulb (asterisk) visible through the tympanic membrane (b) coronal CT-reconstruction of a right ear, showing a promi-

nent jugular bulb (JB), protruding in into the hypotympanic cavity up to the level of the round window recess (black arrow). Tympanic aerator (white arrow) inserted through a thin tympanic membrane

**Table 11.4** Medical conditions that can lead to hyperacusis

Tinnitus
Bell's palsy
Ramsay hunt syndrome
Lyme disease
Stapedectomy
Perilymphatic fistula
Translabyrinthine excision of a vestibular schwannoma
Head injury
Migraine
Depression
Addison disease
Williams syndrome

- Hyperacusis can have a negative psychological impact on patients. It can lead to misophonia (which means the patient will dislike sounds) or phonophobia (in which patients will have fear from exposure to sounds). In severe cases, patients can become housebound [7].
- Investigation: hyperacusis questionnaires can be utilized. Measurement of loudness discomfort level can be used, but some claim that it is not reliable [3].
- Treatment: Gradual desensitization can be used to treat this condition. Tinnitus retraining therapy (TRT) and cognitive behavioral therapy (CBT) can also be used [32, 33]. It is important to note that in those patients, they may use earplugs as a defense from their increased perception of loudness. However, these earplugs can aggravate the hyperacusis by increasing the central nervous system gain [34].

#### Take-Home Messages

- Tinnitus is divided into subjective and objective.
- Subjective has different subtypes. Examples are hearing loss subtype, somatic tinnitus, typewriter tinnitus, musical tinnitus, intrusive, and associated with affective disorder.

- Hearing loss subtype includes noise-induced hearing loss and presbycusis. The somatic subtype is modulated through physical stimulation like eye movements, leg movement, and pressure on the temporomandibular joint. Usually, they respond to acupuncture therapy. Typewriter tinnitus has staccato quality and can respond to Carbamazepine therapy.
- History is vital during the evaluation of patients with tinnitus. An audio tympanogram can be ordered. Ask for MRI in cases of unilateral tinnitus.
- Counseling and reassurance are an essential step while managing patients with tinnitus. Different methods were used to treat the condition like hearing aid, sound therapy, tinnitus retraining therapy, and cognitive behavioral therapy.
- Objective tinnitus can be pulsatile or non-pulsatile.
- Non-pulsatile tinnitus includes otoacoustic emission and Patulous Eustachian tube.
- Patulous Eustachian tube can be caused by weight loss, radiotherapy, and injury to CN V and tensor veli palatini muscle. It presents with autophony, hearing loss, a sensation of pressure in the ear, and tinnitus that is synchronized to breathing.
- Objective non-pulsatile tinnitus can be synchronous or non-synchronous to the patient's heartbeat.
- Synchronous pulsatile objective tinnitus has different etiologies and is usually caused by vascular pathology.
- Non-synchronous pulsatile objective tinnitus is caused by either palatal myoclonus or tensor tympani/stapedial muscle myoclonus. Palatal myoclonus is often associated with CNS lesions so that brain MRI should be done.

- Hyperacusis is a different pathology in which the patient has unusual tolerance to ordinary environmental sounds. It is believed that a central phenomenon causes it.
- Hyperacusis usually coincides with tinnitus. It usually results in a negative psychological effect on the patients. Tinnitus retraining therapy (TRT) and cognitive behavioral therapy (CBT) can be used in treating this condition.

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