

# Typewriter Tinnitus: A Carbamazepine-Responsive Syndrome Related to Auditory Nerve Vascular Compression

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## Key Words

Paroxysmal · Pharmacology · Microvascular · Treatment

## Abstract

Six subjects with similar unilateral tinnitus that was fully suppressed by carbamazepine have been identified. Their ages at the time of the sudden onset of their tinnitus ranged from 39 to 87 years (mean 67). The 3 men had right ear tinnitus. Two of the 3 women had left ear tinnitus. All 6 described a staccato quality of their intermittent tinnitus ('like a typewriter in the background, pop corn, Morse code'). Five of the 6 subjects had no other hearing or vestibular complaints; their audiograms were symmetric and consistent with their ages. Vascular compression of the auditory nerve ipsilateral to the tinnitus was detected in 4 of the 5 subjects imaged. The similarities between typewriter tinnitus and other cranial nerve syndromes associated with vascular compression (trigeminal neuralgia, hemifacial spasm, and glossopharyngeal neuralgia) suggest that surgical decompression of the auditory nerve can relieve medication-refractive cases of typewriter tinnitus.

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## Introduction

When all types of tinnitus are considered, its prevalence is about 10% of all adults. About 1 in 200 of all adults respond that (1) they have tinnitus, and (2) it 'interferes with their ability to lead a normal life'. Pharmacological trials have not revealed any oral medications, including carbamazepine, that consistently suppress tinnitus regardless of the type of tinnitus, but two medications, alprazolam and cyclandelate, have been shown in randomized clinical trials to slightly reduce tinnitus loudness. On the other hand anecdotes describe single individuals in whom a medication has completely suppressed their tinnitus. These medications include carbamazepine, clonazepam, lorazepam, diazepam, scopolamine, risperdal, fluoxetine, and paroxetine, but none of these medications have been shown to suppress tinnitus in multiple individuals with any consistency or for any well-characterized group of tinnitus subjects. Most medication trials have not stratified subjects based on the characteristics of the tinnitus such as tinnitus etiology, quality, location, or whether or how it can be somatically or acoustically modulated.

In our practice we encountered subject AA who presented with right ear tinnitus that she described as 'like a typewriter,' namely staccato and intermittent. Attempts to hear or record an acoustic signal corresponding to her

**Table 1.** Summary of subject characteristics

Subject	Sex	Age at onset	Ear with tinnitus	Duration years	Triggerable	CBZ suppressed	CBZ dose mg	Audiogram symmetry	% Discrimination		IAC loop	
									R	L	R	L
AA	F	76	R	0.25	no	yes	300	S	84	68	yes	yes
BB	F	87	L	0.4	yes	yes	500	S	99	96	no	yes
CC	M	39	R	11	yes	yes	600	S	99	99	no	no
DD	M	54	R	0.3	no	yes	300	R	82	96	yes	no
EE	F	86	L	0.5	yes	yes	400	S	96	96	no	yes
FF	M	59	R	1.5	yes	yes	200	S	96	94	-	-

S = Symmetric; R = right ear; L = left ear; CBZ = carbamazepine; IAC = internal auditory canal. Subjects are ordered by the date of their first visit to the clinic.

tinnitus were unsuccessful. Because the acoustic attributes of her tinnitus were similar to the sensory attributes of trigeminal neuralgia, carbamazepine was initiated and completely suppressed her tinnitus. This report describes our experience using carbamazepine in treating all subsequent subjects with similar tinnitus characteristics.

## Methods and Results

In the past 4 years at the Massachusetts Eye and Ear Infirmary tinnitus clinic we have encountered 6 subjects whose tinnitus is monaural, intermittent and staccato (table 1). Upon initiating carbamazepine the tinnitus of all 6 subjects was fully suppressed. Subject AA has continued on carbamazepine for 4 years. Multiple attempts to withdraw her carbamazepine have led to re-emergence of her tinnitus. Subject BB's tinnitus was completely suppressed with carbamazepine. However after about 2 months of commencing carbamazepine she developed hyponatremia that corrected with carbamazepine withdrawal. She declined other pharmacologic trials. Subjects CC, DD and FF had a similar experience as AA. Subject EE's tinnitus was fully suppressed for over 6 months, but it re-emerged despite maximum doses of carbamazepine. She has recently begun a trial of baclofen.

All subjects described clicking restricted to one ear that is irregular and can occur spontaneously singly or in bursts. In two thirds of the cases the clicks could also be elicited sometimes by various types of external sound. The three subjects over the age of 70 described their tinnitus as 'like a typewriter'. Probably the best description of this type of tinnitus came from CC, a professional musician. He described his right ear tinnitus as follows: 'I can have isolated single clicks that can occur between one every two seconds to one every ten minutes, or I can have isolated "clucks". The isolated clicks merge into a drum roll; the drum roll is a series of single clicks, whereas the clucks occur only singly. I will have periods of two months in which nothing elicits the right ear clicking, and then I will have other periods of two months in which running water will elicit a drum roll for ten seconds and then the drum roll will stop even if the water continues to run'.

Auscultation of the ear canal of all subjects did not detect any sound corresponding to their tinnitus. Two of the first 3 subjects (AA and CC) underwent tympanometry and ear canal acoustic recordings; again nothing was detected corresponding to their tinnitus. Four of the subjects had no other accompanying symptoms. A fifth, BB, described intermittent tickling 'like a needle' of the cheek ipsilateral to her tinnitus occurring about once every 2 weeks for approximately 30 min. Five of the 6 subjects had no other hearing or vestibular complaints; their audiograms were symmetric and consistent with their ages.

DD on the other hand, had a pre-existing asymmetric hearing disorder. His history was that, for 4 years before his right ear clicking tinnitus began, he had been having right-sided hearing loss, tinnitus, and dizziness. His initial audiogram revealed normal pure tone threshold for his left ear but for his right ear between 2 and 8 kHz progressively worsening pure tone thresholds, reaching 90 dB at 8 kHz. His tinnitus was constant and buzzing like a 'zzzzzzzz'. His hearing loss and dizziness would fluctuate. A contrast and CISS MRI scan from 1999 revealed a prominent arterial loop extending into the right internal auditory canal 'which appears to contact the nerves in the mid portion of the canal'. Four years later he developed clicking tinnitus of his right ear, in addition to his constant buzzing which remained unchanged. By the time his clicking developed, his dizziness could be noise induced. Nystagmus was never detected on multiple exams, even with Frenzel lenses and external noise. Like in all subjects, carbamazepine abolished his clicking tinnitus but it had no effect upon his buzzing tinnitus, hearing loss, or dizziness.

Five of the 6 subjects underwent MRI scanning with heavily T<sub>2</sub>-weighted MRI imaging (CISS) and MRA protocols. In all but CC, the subject with the youngest age at onset, arterial loops were detected extending into the internal auditory canal ipsilateral to their tinnitus where they appeared to be compressing the auditory nerve. Only subject AA had bilateral arterial loops.

## Discussion

These tinnitus and subject characteristics bear similarities to other cranial nerve disorders, namely trigeminal neuralgia, hemifacial spasm, and glossopharyngeal neuralgia. All are (a) unilateral; (b) occur predominantly in the elderly; (c) have a staccato character; (d) often are intermittent; (e) can be evoked by a physiological stimulus appropriate for that cranial nerve; (f) respond to medications such as carbamazepine, and (g) frequently have no demonstrable deficit in the function of the associated cranial nerve. These other cranial nerve mononeuropathies have often been associated with vascular compression of the cranial nerve and, when refractory to medications, can frequently be relieved by repositioning the offending blood vessel away from the nerve [1]. As such the similarities suggest that this tinnitus syndrome (1) may also be associated with compression of the auditory nerve by an aberrant blood vessel or mass, and (2) could be relieved by surgical decompression of the auditory nerve.

The detection of auditory nerve arterial compression in all but 1 of our 5 subjects studied with imaging is consistent with this syndrome being caused by auditory nerve demyelination as has been supported by studies of the trigeminal nerve in trigeminal neuralgia [2]. Like trigeminal neuralgia, typewriter tinnitus may be caused by other etiologies which will not be detected with our imaging technique such as venous compression. Such would appear to be the case for CC whose imaging studies detected no arterial compression.

Convincing evidence of an association between tinnitus and vascular compression of the auditory nerve has been forthcoming from Ryu and his colleagues. They showed [3], in a study of the tinnitus of hemifacial spasm patients who had undergone vascular decompression surgery of their facial nerve, that (a) all 10 patients who had tinnitus ipsilateral to their hemifacial spasm had neurovascular compression of their eighth nerve (as well as their facial nerve) and (b) 8 of these 10 patients had relief of their tinnitus with neurovascular decompression of the eighth nerve. This finding contrasted with 114 other patients who did not have tinnitus and underwent the same surgery for hemifacial spasm; only 7 of these 114 patients had neurovascular compression of the eighth nerve. A subsequent analysis suggests that both low pitch pulsatile and high pitch continuous tinnitus can be caused by vascular compression and relieved by surgical decompression if hearing is normal [4]. A more recent imaging study is consistent with an association between vascular com-

pression and pulsatile tinnitus [5]. However, neither they nor others have reported an association between vascular compression and cases with tinnitus similar to typewriter tinnitus, i.e. unilateral intermittent staccato tinnitus.

The absence of previous reports of an association between vascular compression and typewriter tinnitus may relate to typewriter tinnitus' relatively infrequent occurrence. Subject DD's high-pitched continuous right-sided tinnitus that preceded his right-sided carbamazepine-responsive typewriter tinnitus is consistent with the analysis of Ryu et al. [3] and supports our vascular compression hypothesis. Furthermore it extends the findings of Ryu et al. [3] by suggesting that the high pitch continuous tinnitus associated with vascular compression is not carbamazepine responsive, whereas, typewriter tinnitus is carbamazepine responsive.

On the other hand, in a 1987 letter to the editor entitled *Ear-clicking 'tinnitus' responding to carbamazepine*, Mardini [6] described his own tinnitus, as virtually identical to our 6 cases. Other studies of 'paroxysmal' unilateral tinnitus have been associated with eighth nerve arterial compression together with hemifacial spasm [7, 8] and synchronous nystagmus [7]. Another case of brief unilateral paroxysmal tinnitus was due to a cerebellopontine angle meningioma. The tinnitus was described as lasting 5–10 s and sounding like 'the screech of brakes'. It was suppressed with carbamazepine [9]. Thus, typewriter tinnitus' paroxysmal property may be the critical feature that accounts for its carbamazepine responsiveness.

With only a total of 6 subjects, our report must be considered preliminary. While our evidence suggests vascular compression as the cause for most, if not all subjects with this syndrome, a larger experience may reveal other etiologies. For instance another report describes 3 subjects with a similar carbamazepine-responsive tinnitus syndrome, one of whom appeared to have had no sound detectable by auscultation. Electromyogram-documented soft palate myoclonus was said to be detected in all 3 subjects [10].

Our report has described a distinct tinnitus syndrome responsive to carbamazepine despite well-designed prior studies showing no benefit of carbamazepine for tinnitus subjects [11–13]. The failure of the prior studies to detect this effect is probably due to its infrequent occurrence. In light of multiple failures to find a 'one-drug for all' tinnitus treatment, our success suggests that efforts might be better spent upon identifying distinct tinnitus syndromes and then testing treatments for such well-defined groups.

## References

- 1 Jannetta PJ: Outcome after microvascular decompression for typical trigeminal neuralgia, hemifacial spasm, tinnitus, disabling positional vertigo, and glossopharyngeal neuralgia (honored guest lecture). *Clin Neurosurg* 1997; 44:331–383.
- 2 Love S, Coakham HB: Trigeminal neuralgia: pathology and pathogenesis. *Brain* 2001;124: 2347–2360.
- 3 Ryu H, Yamamoto S, Sugiyama K, Uemura K, Nozue M: Neurovascular decompression of the eighth cranial nerve in patients with hemifacial spasm and incidental tinnitus: an alternative way to study tinnitus. *J Neurosurg* 1998;88:232–236.
- 4 Ryu H, Yamamoto S, Sugiyama K, Nozue M: Neurovascular compression syndrome of the eighth cranial nerve. What are the most reliable diagnostic signs? *Acta Neurochir* 1998;140: 1279–1286.
- 5 Nowe V, De Ridder D, Van de Heyning PH, Wang XL, Gielen J, Van Goethem J, Ozsarlak O, De Schepper AM, Parizel PM: Does the location of a vascular loop in the cerebellopontine angle explain pulsatile and non-pulsatile tinnitus? *Eur Radiol* 2004;14:2282–2289.
- 6 Mardini MK: Ear-clicking ‘tinnitus’ responding to carbamazepine. *N Engl J Med* 1987;317: 1542.
- 7 Isu T, Ito T, Murai H, Yamamoto K: Paroxysmal tinnitus and nystagmus accompanied by facial spasm. *Surg Neurol* 1985;23:183–186.
- 8 Takano S, Maruno T, Shirai S, Nose T: Facial spasm and paroxysmal tinnitus associated with an arachnoid cyst of the cerebellopontine angle – case report. *Neurol Med Chir* 1998;38: 100–103.
- 9 Espir M, Illingworth R, Ceranic B, Luxon L: Paroxysmal tinnitus due to a meningioma in the cerebellopontine angle. *J Neurol Neurosurg Psychiatry* 1997;62:401–403.
- 10 Rahko T, Hakkinen V: Carbamazepine in the treatment of objective myoclonus tinnitus. *J Laryngol Otol* 1979;93:123–127.
- 11 Hulshof JH, Vermeij P: The value of carbamazepine in the treatment of tinnitus. *ORL J Otorhinolaryngol Relat Spec* 1985;47:262–266.
- 12 Donaldson I: Tegretol: a double blind trial in tinnitus. *J Laryngol Otol* 1981;95:947–951.
- 13 Marks NJ, Onisiphorou C, Trounce JR: The effect of single doses of amylobarbitone sodium and carbamazepine in tinnitus. *J Laryngol Otol* 1981;95:941–945.

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## Comments

*D. Alpini (Italy):* The paper describes a particular kind of tinnitus caused by an eighth cranial nerve mononeuropathy due to demyelination probably associated with vascular compression. It underlines diagnostic difficulties in detecting venous rather than arterial compression. In our experience vascular compression of the eighth nerve in the pontocerebellar angle is rarer than arterial loops extending into the internal auditory canal. This kind of compression may be demonstrated only if it is specifically searched during neuroimaging elaboration. Thus, accurate clinical/instrumental investigation of the aspects of tinnitus allows to identify a specific subpopulation of tinnitus patients (unilateral intermittent staccato tinnitus) that could be responsive to carbamazepine. We agree that is not possible (and not correct) try to find a ‘one drug for all’ and that improvement of therapeutic effects is possible only after adequate selection of tinnitus patients. Recognition of the existence of different clinical types of tinnitus has implications for both investigation and identification of underlying mechanisms of tinnitus production, drug development, and treatment.

*D. De Ridder (Belgium):* This is a very important paper for it describes microvascular compression as a cause for tinnitus. Examples of microvascular compression syndromes are trigeminal neuralgia, hemifacial spasms, glossopharyngeal neuralgia as well as a cochleovestibular compression syndrome.

A blood vessel compressing a cranial nerve induces a nerve stimulation leading to a hyperactive cranial nerve syndrome with our without a loss of function. It is diagnosed almost solely based on the history taken, and an MRI is used to exclude other pathology and as a possible confirmation. Treatment consists of carbamazepine,

and in intractable cases surgical microvascular decompression.

Typewriter tinnitus might be the missing link for the clinical diagnosis of vascular compression tinnitus. Based on the analogy with other vascular compression syndromes tinnitus should have the following characteristics: unilateral tinnitus, presenting as short-lasting paroxysms with intermittent tinnitus-free intervals. Tinnitus intervals become progressively shorter and the tinnitus duration longer, ending in constant tinnitus. Tinnitus can be elicited by an auditory trigger. On average the age of the patients is over 50 years old and the tinnitus is associated with a hearing loss. Due to the fact that the cochlear nerve fuses with the vestibular nerve, and is in very close anatomical proximity of the facial and intermediate nerves, a high incidence of associated (cryptogenic) hemifacial spasm (facial nerve), otalgic spells (intermediate nerve) and optokinetic vertigo (vestibular nerve) is expected.

These characteristics fit in with Levine’s description of the clinical characteristics of typewriter tinnitus, but few of his patients present with any of these associated symptoms. A possible explanation could be found in his radiological description: all patients demonstrate a vascular loop inside the internal auditory canal. Recently, it has been suggested that especially the CNS segment of the vestibulocochlear nerve is sensitive to microvascular compressions and the intrameatal part resistant [1]. The intrameatal part is more likely to be related to pulsatile tinnitus [2], caused by a noncompressive pathophysiology [3]. Typewriter tinnitus might therefore be relatively rare, and associated symptoms as well. It would be interesting to verify whether a compression of the intrameatal compression-resistant PNS segment might also lead to a different clinical evolution in his patients, and not present with the typical evolu-

lution (progressively shorter tinnitus-free intervals and longer tinnitus spells).

Judging from the results of the studies performed up to date, microvascular decompression for tinnitus can cure 30% of the patients, improving another 30%. For a neurosurgeon, these poor results are frustrating and are in sharp contrast with surgical results of other pathologies due to microvascular compression, i.e. trigeminal neuralgia, hemifacial spasm, disabling positional vertigo, and glossopharyngeal neuralgia, where long-term results average at around 85% long-term cure rate [4, 5]. Defining the clinical characteristics of tinnitus due to microvascular compression might possibly improve surgical results, and hopefully bring them to the 'expected' 85% range, similar to outcomes obtained for the other microvascular compression syndromes.

I fully agree with the author's conclusion that tinnitus research could greatly benefit from classifying different subgroups of tinnitus, each with a different pathophysiology, clinical picture and associated treatment. It can only be hoped that the author continues to describe different subgroups and a possible suggestion could be to analyze the clinical difference between typewriter tinnitus and tinnitus related to a vascular compression of the cisternal (CNS) segment of the vestibulocochlear nerve.

#### References

- 1 De Ridder D, Moller A, Verlooy J, Cornelissen M, De Ridder L: Is the root entry/exit zone important in microvascular compression syndromes? *Neurosurgery* 2002;51:427-433; discussion 433-434.
- 2 Nowe V, De Ridder D, Van de Heyning PH, Wang XL, Gielen J, Van Goethem J, Ozsarlak O, De Schepper AM, Parizel PM: Does the location of a vascular loop in the cerebellopontine angle explain pulsatile and non-pulsatile tinnitus? *Eur Radiol* 2004;14:2282-2289.
- 3 De Ridder D, De Ridder L, Thierens H, Nowé V, Van de Heyning P, Verlooy J, Moller A: Pulsatile tinnitus and the intrameatal vascular loop. *Neurosurgery* 2005, in press.
- 4 Moller AR: The cranial nerve vascular compression syndrome. I. A review of treatment. *Acta Neurochir (Wien)* 1991;113:18-23.
- 5 Jannetta P: Outcome after microvascular decompression for typical trigeminal neuralgia, hemifacial spasm, tinnitus, disabling positional vertigo, and glossopharyngeal neuralgia; in Grady S (ed): *Clinical Neurosurgery*. Baltimore, Williams and Wilkins, 1997, vol 44, pp 331-384.

*P. and M. Jastreboff (USA):* The preliminary results presented in this paper point out the need to align pharmacotherapy with an etiology of tinnitus. Carbamazepine is not effective for general population of tinnitus patients, while it appears to be very helpful for a specific, atypical type of tinnitus. The potential link with vascular compression of the auditory nerve creates challenging questions as to what are physiological mechanisms linking vascular compression with this specific perception and how carbamazepine interferes with these mechanisms. While only a very small proportion of tinnitus patients experience 'typewriter-like' tinnitus, answering these questions should provide better insight into processes responsible for initiating the tinnitus signal within the auditory pathways.