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A BRAIN QUANTITATIVE REPRESENTATION OF ACOUSTIC NEUROMA: MRI CASE STUDY

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ABSTRACT:

Acoustic neuroma is a slow growth benign tumor in the brain that is usually associated with hearing loss, tinnitus and vertigo. Brain volumetric and structural connectivity analyses provide quantitative representations of the damage may occur in the brain, which may be facilitated as indicators of the progress during the follow-up. A case study of 42 years old women suffering from the acoustic neuroma is presenting in this case study.

INTRODUCTION

Acoustic Neuromas (ANs) is a rare benign brain tumor that is also known as a vestibular Schwannoma. It is usually slow growing in the brain, which expands at its site of origin (1.5 mm/year) and does not spread to other parts of the body.[1]. It grows on the nerves responsible for hearing and balances that can lead to have problems such as hearing loss and unsteadiness.

The prevalence of incidental ANs appears to be approximately 2 in 10,000 people [2]. It accounts for 8-9% of intracranial tumors, and 80% of tumors were found within the cerebellopontine angle [3]. It is uncommon to see bilateral ANs that is typically associated to neurofibromatosis type II (NF2) [3]. ANs are usually associated with some common symptoms such as unilateral progressive hearing loss, tinnitus, vertigo and disequilibrium [2].

Magnetic resonance imaging (MRI) is considered as one of the most accurate method for diagnosing ANs [4]. MRI was found more effective and superior to computer tomography (CT) with iodine injection or combined with gas cisternography [5]. Advance MRI analysis techniques have been used widely to investigate several idiopathic brain disorders such as epilepsy [6], autism [7] and subjective tinnitus [8]. Grey matter (GM) volume and white matter (WM) diffusion metrics have been used widely as indicators of brain changes in many acoustic disorders such as hearing loss [9] and tinnitus [10].

A case study of a 45 years olds women suffering from acoustic neuroma is presenting in this case report. We aim to quantify brain grey matter (GM) volume and white matter (WM) diffusion metrics in a patient with acoustic neuroma that is justifying by estimating the intracranial volume, certain brain grey matter (GM) and white matter (WM) volumes, and diffusion metrics.

CASE REPORT

A 45-year old woman is suffering from an acoustic neuroma (AN) for 2 years. She is having a routinely MRI scan done every year to keep tracking the progression of the AN. She is a right-handed, and the level of anxiety and depression is 14 that was measured using the Hospital Anxiety and Depression Scale (HADS) [11]. The participant has signed the consent form as an agreement to participate in this study.

Pure tone audiogram (PTA) reveals that the patient has a normal hearing threshold in the right ear at all frequencies, while moderately severe hearing loss in the left ear at high frequencies (3-8 kHz) (Figure 1). There was no previous history of excessive noise exposure and family history of hearing loss. She is suffering as well from tinnitus ipsilateral of the AN.

The tinnitus sounds were descried as hissing, whistling and ringing. She has experienced the tinnitus perception for 10 years in the left ear. The effect of tinnitus on the quality of life was examined using Tinnitus Handicap Inventory (THI) [12] and Tinnitus Functional Index (TFI) [13] that were 40 and 53 respectively. The highest impact of tinnitus perception was found on the concentration TFI dominant, while the social activity was found the lowest impact on the TFI dominants. The Visual Analogue Scale (VAS) was used to assess the tinnitus severity, loudness and annoying that were seven, four and seven out of ten respectively. All demographic characteristics are summarized in Table 1.

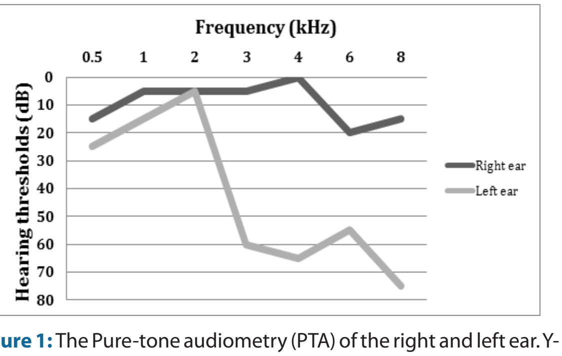

Figure 1: The Pure-tone audiometry (PTA) of the right and left ear. Y-axis is the hearing thresholds (dB) and x-axis is the tested frequencies (kHz)

Table 1: Demographic characteristics for the participant.

	Age	Gender	Handedness	HADS	Onset (Yrs)		Location		THI	TFI		VAS (/10)	
					AN	Tinnitus	AN	Tinnitus			Severity	Loudness	Annoying
Demographic	45	Female	Right	14	2	10	Left side	40	53	7	5	7	

An MRI scan showed a moderate (approximately 1.79 X 1.71 X 1.75 cm) well defined heterogeneously enhancing extra-axial space-occupying lesion is seen in the left c-p angle cistern region with brainstem compression (Figure 2). Lesion is displaying heterogeneously hypointensity signal on the T1-weighted images. Lesion is abutting the tentorium cerebelli and indenting the brainstem.

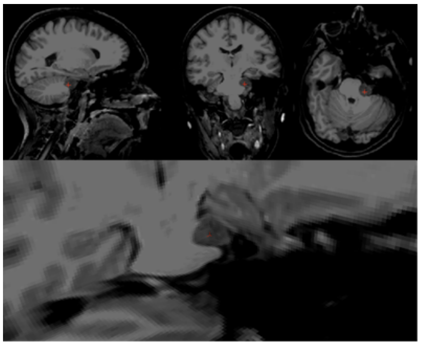

Figure 2: MRI scan shows the lesion in cerebropontine angle.

The total intracranial volume (ICV) and brainstem volume were measured that were 1067.91 cm^3 and 24.41 cm^3 respectively (Table 2). The ratio of brainstem volume and ICV was 2.28 in the AN patient (Figure 3). The total grey matter (GM) volume in the right hemisphere was 210.46 cm^3, left hemisphere was 208.65 cm^3, and the lateralization index (LI) of the GM volume was 0.004 (Table 2). The total white matter (WM) volume in the right hemisphere was 249.09 cm^3, the left hemisphere was 246.93 cm^3 and the LI was 0.004.

The GM volume of the thalamus was found greater in the right hemisphere (8.18 cm^3) compared to the left hemisphere (7.78 cm^3), and the LI of these measurements was 0.01. The volume of the right auditory cortex (AC) (0.97 cm^3) was slightly lower than the volume of the left AC (1.07 cm^3), and the LI of these measurements was -0.05.

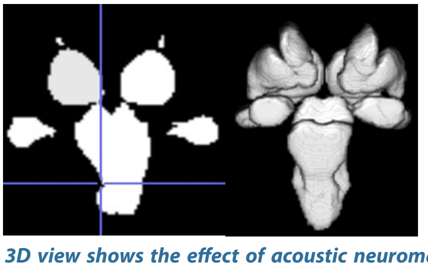

Figure 3: 3D view shows the effect of acoustic neuroma on the shape of brainstem

Table 2: Quantification measurments of brain volume in a patient with acoustic neuroma.

	Side	Volume (in x 10^{-3} cm^3)	Lateralization Index (LI)
Intracranial volume	Whole brain	1067.91	N/A
GM Cortex volume	Right	210.46	0.004
	Left	208.65	
WM Cortical Volume	Right	249.09	0.004
	Left	246.93	
Thalamus	Right	8.184	0.01
	Left	7.886	
Auditory cortex	Right	0.97	-0.05
	Left	1.07	
Brain-Stem	Whole brain	24.413	N/A

The mean fractional anisotropy (FA) of right corticospinal tract (CST) was 0.388 mm^2/s, while left CST was 0.401 mm^2/s, and the LI of FA in CST was -0.01. The mean FA of the right anterior thalamic radiation (ATR) (0.40 mm^2/s) was higher than the FA of left ATR (0.275 mm^2/s), and the LI of ATR was 0.03 (Table 3 and figure 4).

Table 3: Quantification measurments of WM integrity in a patient with acoustic neuroma

WM tracts	Side	FA (mm^2/s)	LI
ATR	Right	0.40	0.03
	Left	0.375	
CST	Right	0.388	-0.01
	Left	0.401	

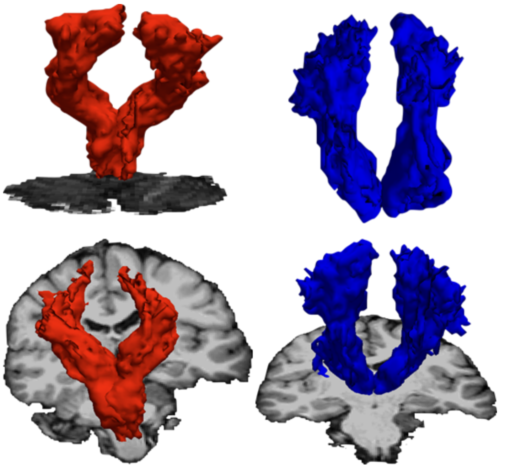

Figure 4: 3D view of WM tracts (anterior thalamus radiation (Blue) and corticospinal tract (Red)) of the patient with acoustic neuroma.

DISCUSSION

We presented a case in which hearing loss and tinnitus are symptoms in a patient had AN for 2 years. The AN is a benign tumor of the eight cranial nerve, which is allocated in the cerebellopontine angle and internal auditory canal. Symptoms duration is not strictly related to the tumor size [14]. The size of the AN in this case report (<18 mm) that is considered as a medium size (11-20 mm) [15].

Acoustic neuroma affects the hearing acuity, and was found associated with tinnitus and vertigo. Hearing loss in AN cases are usually unilateral and progressive [16]. In this case report, hearing loss was found ipsilateral to the AN side, and progressive at higher frequencies (3-8 kHz). According to the THI and TFI scores level of the patient, tinnitus could be noticed in the presence of environmental background, and daily activities can be performed. In addition, the level of anxiety and depression (HADS=14) is an abnormal, which may reflect the impact of acoustic neuroma and tinnitus on the level of anxiety and depression in our patient. Tinnitus perception could be an early symptom of acoustic neuroma. The patient claimed that she had started the tinnitus experience eight years before she was diagnosed with AN.

It was found that AN is compressing the brainstem (figure 3). Also, it is observed that the brainstem is enlarged in the AN patient as the brainstem volume (24.42 x 10^{-3} cm^3) was found higher than the brainstem volume in healthy population in an another study (male 22.05 ± 4.01 x 10^{-3} cm^3 and female 18.99±2.36 x 10^{-3} cm^3) [17].

Thalamus has an extensive nerve connection to relay motor and sensory signals to the cerebral cortex. Auditory cortex (AC) is the last station in the auditory pathway where the incoming sound is processed. At the thalamic level, the volumetric and diffusion measurements show the asymmetries toward to the right side. However, lateralization index (LI) of auditory cortex volume was found asymmetries toward the left side.

Brain morphometric and structural connectivity status in our patient could be a marker for further studies. Although automatic brain analysis in a single clinical case may not be accurate for practical diagnosis purposes, this will undoubtedly change the consent development of technology, and encourage more studies on this interesting topic.

Conflict of Interest

The author declares that there is no conflict of interest.

Learning Points

- Brain volumetric and structural connectivity analyses provide quantitative representations of the damage may occur in the brain, which may be facilitated as indicators of the progress during the follow-up.

- Hearing loss could be found ipsilateral to the Acoustic Neuroma (AN) side, and progressive at higher frequencies.
- The MRI volumetric and diffusion measurements could assess the asymmetric pattern in the brain.

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