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Tinnitus effects and correlations between CAPD, language processing, and ASD: A Capstone Case Series

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A Capstone Case Series

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Abstract 1

Introduction: Some people with tinnitus have normal audiometric hearing thresholds. Even when hearing is within normal limits, patients can suffer a myriad of symptoms from tinnitus, including depression and other mental health problems. Case Presentation: A male adult presented to the clinic with complaints of *bothersome* tinnitus, asymmetric hearing loss, and a long history of environmental noise exposure, including both occupational and recreational noise. Discussion: Audiologists should determine the primary concerns of their tinnitus patients and how the condition affects their health and wellbeing. To do this, a thorough case history, audiologic assessment, outcome measures, and empathetic listening should be administered to fully understand the extent of disability. Continuous monitoring of the tinnitus patient is recommended with referral for follow up care when their tinnitus produces related depression. Conclusion: Further research is suggested in order to determine clinical protocols and care plans that improve quality of life for patients with asymmetric hearing loss.

Key Words: Tinnitus, hearing loss, occupational noise, bothersome tinnitus, outcome measures.

Case Presentation 1

Effects of Tinnitus with Concomitant Symptoms

Introduction

According to the American Tinnitus Association (ATA), tinnitus is defined as the auditory presence of noise when no sound is present (ATA, 2018). Patients may complain about sounds within their ears or head, and describe this as buzzing, hissing, whistling, roaring, chirping, or clicking. About 50 million Americans report experiencing tinnitus and 20 million report a *bothersome* degree of tinnitus (ATA, 2018).

Literature Review

Not every patient who experiences tinnitus has audiometric threshold hearing loss. Kochkin, Tyler and Born (2011) reported that 43% of Americans with tinnitus do not have concomitant hearing loss but this statistic varies in the literature. Tinnitus patients without hearing loss typically do not pursue audiology services, but every person with tinnitus should be evaluated and counseled. Clinical consultation is recommended, even though, for 80% of patients, tinnitus is classified as *non-bothersome* (Henry et al., 2015).

Exposure to hazardous levels of noise can lead to noise-induced tinnitus (Themann & Masterson, 2019). According to Ralli et al. (2017), 35-77% of people with noise-induced hearing loss report a concomitant symptom of tinnitus. Given the relationship between noise and tinnitus, a thorough case history should be performed by audiologists to identify factors that might have contributed to complaints of tinnitus in noise-exposed patients. To understand the impact of tinnitus on a person's lifestyle, include intake questions about disturbance of sleep, stress, impaired concentration, negative emotional reaction, depression, and suicidal ideation.

According to the ATA, besides noise exposure, causes of tinnitus include excessive cerumen, trauma to the head or neck, traumatic brain injury, ototoxic drugs, and various disorders. Following a thorough case history and audiometric testing, audiologists should provide education, counseling, and audiologic rehabilitation, as needed. Our case study aims to demonstrate the effect that tinnitus can have on an individual and advise clinicians of support techniques and tools, and patient education. Audiologists must be trained to identify, document, and advise patients if there is any appearance of depression that appears associated with the tinnitus.

Case Presentation

An adult male presented to the clinic for complaints of tinnitus and hearing loss. He reported a sudden-onset hearing impairment initiated by a “buzzing” sound and followed by complete loss of hearing in the left ear. His history of occupational and recreational noise exposure was extensive, employed as a train engineer while having previously worked as a machinist for several years. In addition, he reported a history of recreational use of firearms, but reported that hearing protection was worn during that activity.

Tinnitus had reportedly worsened over the past three years. It was characterized as a “constant buzzing sound” in his left ear only that did not change in pitch, but in loudness. His tinnitus was classified as *very bothersome* which made it difficult to hear the phone ring and interfered with obtaining adequate sleep. Due to an asymmetric hearing loss, a CT scan was ordered to rule out an acoustic neuroma, which, according to the patient, was negative. An audiologic evaluation was administered (Figure 1). For the right ear, the results showed normal hearing sloping to moderate sensorineural hearing loss. The left ear revealed a moderately severe to moderate rising pattern that sloped to moderately severe mixed hearing loss. The patient reported a history of vertigo, which caused him to fall three times in the past year, so videonystagmography was administered, which was negative.

The Tinnitus Handicap Inventory indicated that the patient had a moderate severity level of tinnitus with a normal score on the Patient Health Questionnaire-9. A follow-up audiometric test was performed (Figure 2) which demonstrated a consistent pattern in both ears, but improvement of low and mid-frequency thresholds in the left ear. Recommendations included the use of hearing protection when exposed to hazardous noise and otolaryngology consultation for evaluation of his balance problems.

Management

A monaural hearing aid was recommended for the left ear to determine if amplification might improve communication and relieve tinnitus. He was fitted with a receiver-in-the-canal style hearing aid and a Slim-tip earmold. After real ear and speech mapping measures were performed, the patient expressed immediate satisfaction with the sound quality and had favorable relief from the tinnitus. He was advised to return for tinnitus management, hearing aid adjustments, and audiologic monitoring within 30 days. He may have received additional benefit from a binaural hearing-aid fitting but was interested in a monaural hearing aid only for purposes of tinnitus treatment.

Discussion

Audiologists may be the first professionals to identify depression in patients with hearing loss or tinnitus. They should look for markers, such as changes to quality of life, decreased daily activities, signs of depression or problems with sleep, stress, and irritability. When individuals with tinnitus demonstrate signs of depression, audiologists should document this observation and counsel them to seek consultation from mental health. Although our case did not demonstrate signs of depression, he did express lifestyle disturbances due to his tinnitus and hearing loss. From this, it is evident that management of tinnitus-related concerns should be monitored periodically.

Conclusion

A thorough case history, outcome measures, and empathetic listening should aid clinicians in determining the impact of tinnitus on a patient's daily life. If the tinnitus is classified as *bothersome*, the examiner should provide support, educate the patient, and refer for consultation as needed. At this time this report was written, clinical practice guidelines for tinnitus were unavailable, so further research is needed to understand the best methods to manage patients with single-sided tinnitus and associated concomitant issues.

Abstract 2

Introduction: Central auditory processing disorder (CAPD) is a condition seen in children and adults that affects how information is coded, organized, and processed by high-order auditory mechanisms. These patients may become increasingly complex when they present to the clinic with comorbid diagnoses. Case Presentation: An adolescent male was seen for an auditory processing assessment, due to concerns raised by his parents and school educators. He had a history of attention-deficit hyperactivity disorder and autism spectrum disorder (ASD). Results of his audiologic examination revealed normal hearing thresholds bilaterally, with a CAPD that was accompanied by an associative deficit. Discussion: Research has shown a correlation between interhemispheric language problems and handedness. There are data that identify correlations between handedness and ASD. Once CAPD has been diagnosed, clinicians should counsel the patient about home and school recommendations to mitigate educational implications and to avoid social, emotional, and communication problems. Conclusion: Further research should be conducted to examine the co-occurrence of CAPD and comorbidities. Validated treatment strategies and clinical-practice guidelines are needed for pediatric patients who are diagnosed with auditory processing disorders.

Key Words: Autism, handedness, language, central auditory processing disorder, associative deficit.

Case Presentation 2

Correlation between Central Auditory Processing Disorder, Language Processing, and Autism Spectrum Disorder

Introduction

It has been estimated that 3-5% of children are diagnosed with central auditory processing disorder (CAPD; Nagao et. al, 2016), even though this condition may emerge in individuals of all ages. Auditory processing is how the brain receives what is provided by the peripheral auditory system (Katz, 1994). Central auditory processing has been defined as how the brain manages auditory information within the central auditory nervous system (ASHA, n.d.). Auditory processing and central auditory processing terms are used interchangeably in clinics and in the literature. There are many areas of the brain that can be affected by CAPD including the brainstem, auditory cortex, and corpus callosum, along with two secondary subtypes (Bellis, 2002).

A CAPD diagnosis is multifaceted, which demands a diverse team of professionals for full assessment, given the complexity of this condition. Upon diagnosis, CAPD may be interrelated with other co-occurring medical conditions (Brenneman et. al, 2017). When conducting a CAPD differential diagnosis, audiologists should consider the observations from other specialties in addition to the audiologic findings. Furthermore, when autism spectrum disorder (ASD) is diagnosed in conjunction with CAPD, clinicians should be aware that there may be associated problems with handedness that relate to language dominance and processing.

Case Presentation

An adolescent male patient was seen for a CAPD assessment. Besides difficulty with reading comprehension, staying on task, and understanding mathematical word problems, his mother reported that he was experiencing problems at school, especially reading, comprehension, following directions, detecting sarcasm, and listening in noisy environments. He was born preterm by emergency Cesarean, was intubated briefly, and admitted to the neonatal intensive care unit for several weeks. After receiving early intervention services for 18 months, he was diagnosed with high functioning autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD) and placed on an individualized education plan (IEP). His IEP consisted of special education, speech therapy, and social skills services, including extended time on tests and modified exams. Speech pathology services targeted semantics and receptive language, and social skills services focused on figurative language, conversational cues, and prosody.

An audiologic evaluation was administered that demonstrated normal hearing sensitivity bilaterally (Figure 1) with normal middle ear function. A CAPD test battery revealed left ear deficits in two areas: dichotic tasks and monaural low-redundancy tasks (CAPD test data have been displayed in Table 1). Both child and family were counseled on the test findings, implications, and recommendations, including the importance of facing communication partners for visual cues, encouraging use of clear speech, obtaining preferential front-of-room seating, and reducing high ambient noise levels in the classroom and other listening situations.

Discussion

According to the Bellis (2002) CAPD model, there are three primary and two secondary subtypes of CAPD. These are, including their region of dysfunction: auditory decoding deficit (primary/left auditory cortex), prosodic deficit (non-primary/right auditory cortex), and integration deficit (corpus callosum). The two secondary subtypes include auditory associative deficit (associative/left cortex) and output-organization deficit (temporal-to-frontal or efferent system; Bellis, 2002). Based on these test results, a diagnosis of CAPD was given, specifically, an auditory associative deficit subtype. The child performed well on dichotic assessments but showed increasing difficulty as the language evaluation component became more complex.

Children with auditory associative deficit exhibit an inability to apply rules of language to an acoustic signal due to poor interhemispheric interaction and an inability to effectively translate and manipulate multiple targets (Ferre, 2019). This observation is consistent with this child's case history. Some of the most common symptoms of auditory associative deficit include reading comprehension and math problem difficulties, semantic and syntactical errors with language, and receptive language deficits. When assessing the test data, clinicians should characterize the collective observations, not just the individual audiologic test findings.

It is common for patients to demonstrate a left hemisphere language dominance; however, the data for this case indicated a right hemisphere language dominance. This patient had a dominant left hand, which suggests that language processing emerges from the right side of his brain. According to Knaus et. al (2016), individuals with right hemisphere dominance have an increased risk of ASD, poor language, and left or mixed handedness. Other research has revealed a correlation between left-handedness and ASD (Kobylinska et. al, 2017). As such, hemispheric dominance and handedness may be markers for language processing disorders.

Conclusion

Central auditory processing disorder is a multifaceted disorder that interferes with the routing of auditory information, especially in complex listening environments (Nagao, 2016). There are several subprofiles of CAPD so test data should be analyzed carefully to determine which segment of the system is being affected. Comorbid disorders may accompany a CAPD diagnosis, including ASD and language disorders (Brenneman et. al, 2017); therefore, children diagnosed with ASD or language disorders should be flagged for immediate evaluation. This should be done for early formulation of a care plan, including family, educational, or home assistance. More research is needed to further delineate the relationship between handedness and language disorders, and the manner in which these conditions intersect with ASD and CAPD.

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Figure 1 (Case 1)

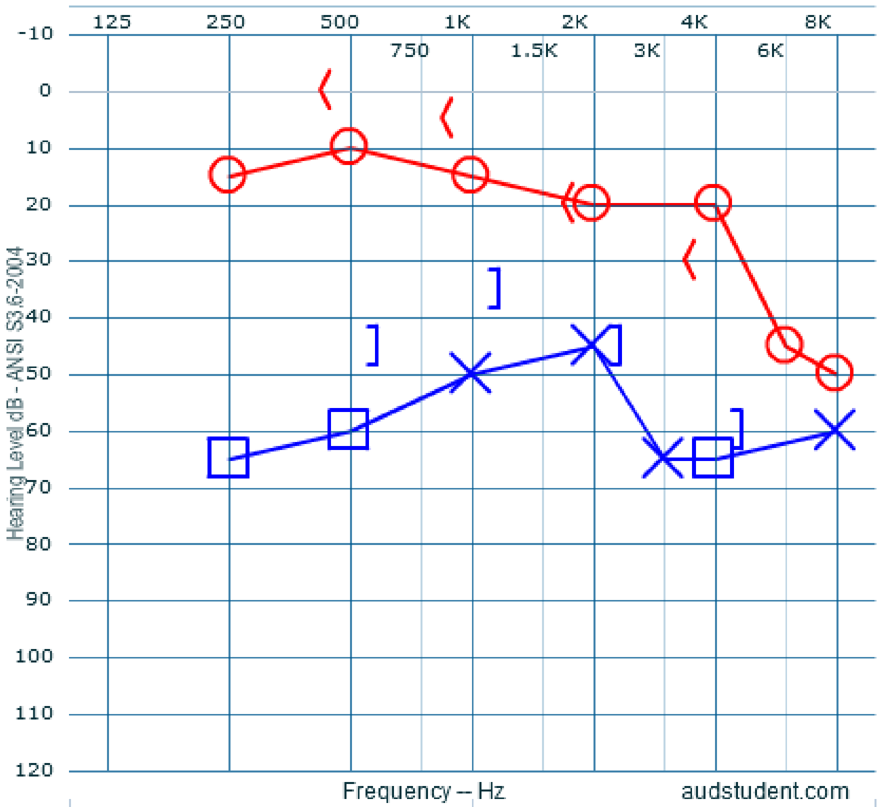

Figure 1. Audiometric data for left and right ear, including air and bone conduction thresholds from 250 to 8,000 Hz.

Figure 2 (Case 1)

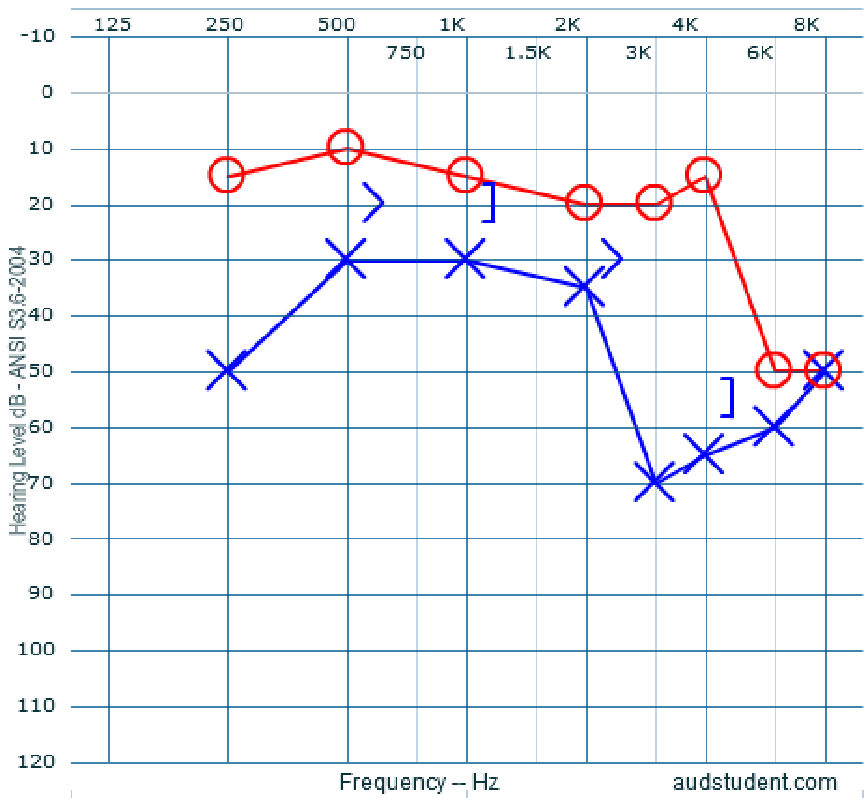

Figure 2. Audiometric data for left and right ear, including air and bone conduction thresholds from 250 to 8,000 Hz.

Figure 1 (Case 2)

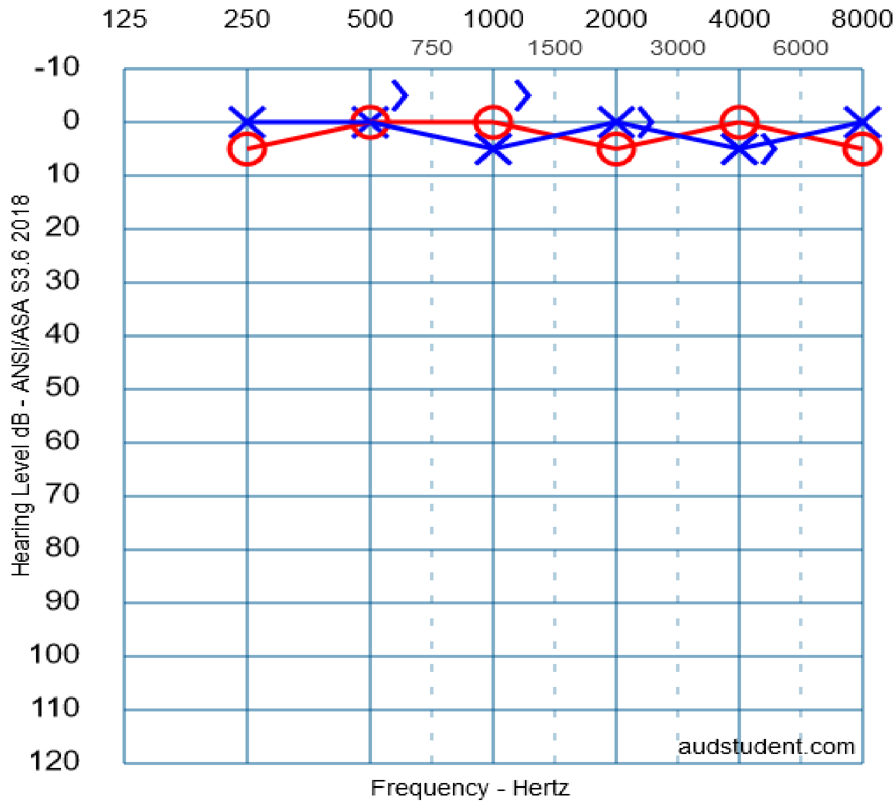

Figure 2. Audiometric data for left and right ear, including air and bone conduction thresholds from 250 to 8,000 Hz.

Table 1 (Case 2)

Competing Sentences Test

Ear	Normal Limits	Patient's Score	
Right	90%	5%	ONL
Left	90%	77.5%	ONL

Dichotic Digits

Ear	Normal Limits	Patient's Score	
Right	90%	90%	ONL
Left	88%	85%	ONL

Ear Advantage (+ or - value) Summary

Test	RE Score	-	LE Score	=	EA	Typical	Cumulative Prevalence		
AFG 0	12	-	15	=	-3	N	If No,	2	%
AFG+8	18	-	19	=	-1	N	If No,	15	%
TCS	23	-	24	=	-1	Y	If No,		%

Pitch Pattern Sequence (PPS)

Ear	Normal Limits	Verbal Response		Hummed Response
Binaural	78%	93%	WNL	

Gaps in Noise (GIN)

Ear	Normal Limits	Patient's Score	
Binaural	52%	88%	WNL
Gap Threshold	8	3	WNL

NU-6 Low Pass Filtered Speech

Ear	Normal Limits	Patient's Score	
Right	75%	92%	WNL
Left	75%	92%	ONL

Staggered Spondaic Words (SSW)

Test Condition	Normal Limits for Age	Patient's Score	
Right Non-Competing	1	2	ONL
Right Competing	3	28	ONL
Left Competing	6	16	ONL
Left Non-Competing	2	2	WNL
Total Errors	12	48	ONL
Ear Effect	-7+3	-8	ONL
Order Effect	-4+4	8	ONL
Reversals	2	0	WNL
Type A Pattern	3	-2	ONL

SCAN-3 for Children

Test	Raw Score	Scaled Score	Scaled Score Points +/-	Confidence Interval Level (%): 95	Percentile Rank	
AFG+8	37	8	4	4 to 12	25	WNL

SCAN-3: C Supplementary Score Summary

Test	Raw Score	Scaled Score	Scaled Score Points +/-	Confidence Interval Level (%): 95	Percentile Rank	
AFG 0	27	8	3	5 to 11	25	WNL
TCS	47	4	3	1 to 7	2	ONL

Table 1. Central auditory processing test data.
WNL = Within Normal Limits; ONL = Outside Normal Limits