Diagnostic Approaches for Hidden Hearing Loss and Cochlear Synaptopathy: A Systematic Review

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Background

Cochlear synaptopathy, also known as “hidden hearing loss,” is a recently described auditory disorder that is believed to affect auditory neural processing (Kohrman et al., 2020). Subjects with suspected cochlear synaptopathy most frequently complain of degraded hearing sensitivity in noisy situations, tinnitus, and in some cases, hyperacusis. This type of synaptic damage to the inner ear can be caused by noise trauma, ototoxic drugs, and aging. These physiological changes can occur without affecting peripheral hearing sensitivity. Because pure-tone thresholds are not typically affected, hidden hearing loss cannot currently be identified and diagnosed in a standard audiologic hearing evaluation. In fact, most of what is known about cochlear synaptopathy has only been demonstrated in animal models and can only be confirmed in humans through post-mortem temporal bone analysis (Brahmall et al., 2019). Several recent studies have sought to establish non-invasive assessment methods and diagnostic tools to identify hidden hearing loss. Though a variety of measures have been implemented in studies, a consensus has yet to be reached on establishing a clinical gold standard for assessing cochlear synaptopathy.

Clinical Question

In adults with normal hearing thresholds and who report difficulty understanding speech in noise, what tools are available to assess hidden hearing loss?

Methods

Databases Searched:

❖ PubMed and Embase

Key Search Terms:

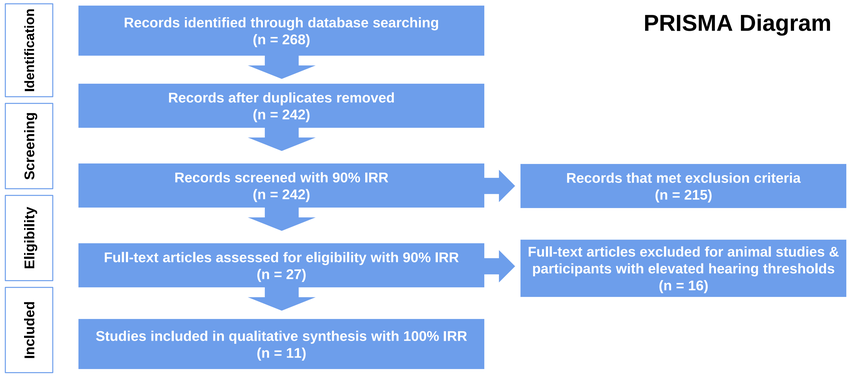
(1) “Cochlear synaptopathy” OR “Hidden Hearing Loss”, (2) Missed hearing loss in adults, and (3) Assessment

Inclusion	Exclusion
Adults (18+ years old)	Children (0-17 years old)
Individuals with normal audiometric thresholds	Individuals with documented hearing loss
Self-reported hearing difficulties or excessive noise exposure or tinnitus	Other comorbidities including middle or inner ear pathologies
Experimental design, cohort design, and case studies	Animal Studies

Review Process Standards & Protocol:

- Independently conducted by the two author's
- Inter-rater reliability (IRR) calculated at all levels of review
- Quality appraisal(s) conducted on all articles eligible for inclusion in the final synthesis
- Data extraction completed on included studies

Results



Question	Article 1	2	3	4	5	6	7	8	9	10	11
Does the study aim/purpose/objective assist in answering your question?	+	+	+	+	+	+	+	+	+	+	+
Were the study methods appropriate for the question?	+	+	+	+	+	+	+	+	+	+	+
Were the methods clearly described?	+	+	+	+	+	+	+	+	+	+	+
Were valid and reliable instruments/methods used to measure the outcome?	+	+	+	+	+	?	+	+	+	+	+
Were all appropriate variables clearly described?	+	+	+	+	+	+	+	+	+	+	+
Were all appropriate outcomes clearly described?	+	+	+	+	+	+	+	+	+	+	+
Were all participants accounted for at the conclusion of the study?	–	–	+	–	–	+	+	–	–	–	–
Was there freedom from conflict of interest?	+	+	+	+	+	+	+	+	+	+	+
Were the statistical analysis methods clearly described and appropriate?	+	+	+	+	+	+	+	+	+	+	+
Were the results statistically significant?	–	–	+	+	–	+	+	+	?	–	+
Were the results clinically significant?	–	–	?	–	–	?	?	–	–	–	?

(1) Bhatt et al., 2019, (2) Bramhall et al., 2017, (3) Dewey et al., 2020, (4) Grinn et al., 2017, (5) Guest et al., 2019, (6) Kikidis et al., 2019, (7) Liberman et al., 2016, (8) Megha et al., 2019, (9) Paul et al., 2017, (10) Prendergast et al., 2017, (11) Ralli et al., 2019

YES = + **NO = –** **UNSURE / NOT ADDRESSED = ?**

Reference	Sample (n)	Age of participants (yrs)	Common measure: PTs	HF PTs	DPOAEs	SPiN	Measure(s) being studied	Relationship found?	Evidence Quality
Bhatt et al. (2019)	32	18 - 35	✓	✓	✓	✓	Dichotic digit test, QuickSIN, & ABR amplitude	X	Good Quality
Bramhall et al. (2017)	64	19 - 35	✓	X	✓	X	Wave I ABR amplitude	✓	Good Quality
Dewey et al. (2020)	62	25 - 40	✓	✓	X	X	Subcortical fMRI, ABR wave I and V amplitude, & ABR I/V amplitude ratio	✓	Good Quality
Grinn et al. (2017)	26	20 - 27	✓	X	✓	✓	Words in noise, AP amplitude, & DPOAEs	X	Good Quality
Guest et al. (2019)	70	18 - 19	✓	X	X	✓	Acoustic middle-ear-muscle reflex	X	Lesser Quality
Kikidis et al. (2019)	48	20 - 35	✓	✓	✓	X	ABR waves I, II, V amplitudes and latencies	✓	Good Quality
Liberman et al. (2016)	34	18 - 41	✓	✓	✓	✓	SP, AP, SP/AP amplitude ratio	✓	Good Quality
Megha et al. (2019)	40	20 - 35	✓	X	✓	X	NB chirps & Tonebursts on ABR wave V latency	✓	Good Quality
Paul et al. (2017)	25	18 - 19	✓	✓	X	X	Subcortical EFR & behavioral amplitude modulation detection	✓	Good Quality
Prendergast et al. (2017)	126	18 - 36	✓	✓	X	X	ABR amplitude & Envelope FFR amplitude	X	Lesser Quality
Ralli et al. (2019)	32	Young ≅ 23.1 Old ≅ 62.4	✓	X	X	X	Tone in noise threshold	✓	Good Quality

Discussion

- A variety of measures were used in the studies across the literature though there has yet to establish a gold standard assessment tool
- Most of the studies implemented electrophysiology measures
- All studies used common measures such as conventional pure tone audiometry to determine normal hearing sensitivity
- Most of the studies measured Distortion Product Otoacoustic Emissions (DPOAEs) to assess outer hair cell integrity
- Studies found conflicting results
- Methodological challenges:
  - Studies reported weak statistical significance in results
  - Researchers were often uncertain regarding clinical significance of their findings
  - Only one study included participants older than 41 which narrowed the focus of the review
  - Results cannot be easily applied to the entire adult population
- Systematic review limitations:
  - Only two research databases were included
  - Search strategy yielded studies with small participant sample sizes
  - Excluded studies with “near-normal” hearing subjects
- There is not a clear consensus on the relationship between any of these test measures and cochlear synaptopathy

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