Literature Review

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Use of contralateral masking in air-conduction auditory brainstem response: systematic review

O uso do mascaramento contralateral na pesquisa do potencial evocado auditivo de tronco encefálico por condução aérea: revisão sistemática

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ABSTRACT

Purpose: Critically analyze the need to use contralateral masking in the measurement of Auditory Brainstem Response (ABR) by air conduction on unilateral or bilateral asymmetric sensorineural hearing loss by means of a systematic literature review. **Research strategies:** A search was conducted at the PubMed/MEDLINE, LILACS, ADOLEC, IBECS, SciELO, Web of Science, Scopus and Embase electronic databases, proceedings of the International Meeting of Audiology and the Brazilian Congress of Speech-language Pathology and Audiology, and bases of institutions with Graduate Studies Programs in Speech-language Pathology and Audiology, using the following descriptors: Evoked Potentials, Auditory, Brainstem, Perceptual Masking, Hearing Loss, and Sensorineural. **Selection criteria:** Studies with levels of evidence from 1 to 5 published in Portuguese, English or Spanish until January 2018 were selected. The articles should address the need to use contralateral masking in the measurement of air-conduction ABR in individuals with unilateral or bilateral asymmetric sensorineural hearing loss. **Results:** A total of 334 studies were found, and eight of them met the pre-established criteria. The studies included in the review were controversial as to the need for contralateral masking. **Conclusion:** There is no consensus on the need to use contralateral masking in the measurement of ABR by air conduction in individuals with unilateral sensorineural hearing loss; however, most studies report the use of contralateral masking in the measurement of ABR with click stimulus in individuals with severe and profound unilateral sensorineural hearing loss.

Keywords: Evoked potentials; Auditory; Brain stem; Perceptual masking; Hearing loss; Sensorineural; Electrophysiology; Systematic review

RESUMO

Objetivo: analisar criticamente a necessidade do uso do mascaramento contralateral na pesquisa do potencial evocado auditivo de tronco encefálico (PEATE) por condução aérea, na perda auditiva sensorioneural unilateral ou bilateral assimétrica, por meio de uma revisão sistemática da literatura. **Estratégia de pesquisa:** foram consultadas as bases de dados eletrônicas PubMed/MEDLINE, LILACS, ADOLEC, IBECS, SciELO, *Web of Science*, Scopus e Embase, bem como os anais do Encontro Internacional de Audiologia e do Congresso Brasileiro de Fonoaudiologia, além das bases de instituições com pós-graduação em Fonoaudiologia, utilizando os descritores *Evoked Potentials, Auditory, Brain Stem*, *Perceptual Masking* e *Hearing Loss, Sensorineural*. **Critérios de seleção**: foram selecionados os estudos com níveis de evidência de 1 a 5, publicados em português, inglês ou espanhol, até janeiro de 2018. Os artigos deveriam abordar a necessidade do uso do mascaramento contralateral na pesquisa do PEATE por condução aérea, em indivíduos com perda auditiva sensorioneural unilateral ou bilateral assimétrica. **Resultados:** foram encontrados 334 estudos, sendo que oito artigos contemplaram os critérios preestabelecidos. Os estudos incluídos foram controversos quanto ao uso do mascaramento contralateral. **Conclusão:** não existe um consenso quanto à necessidade do uso do mascaramento contralateral no PEATE por condução aérea, em indivíduos com perda auditiva sensorioneural unilateral. No entanto, a maioria dos estudos direcionou para a sua utilização na pesquisa do PEATE com estímulo clique em indivíduos com perda auditiva sensorioneural unilateral de graus severo e profundo.

Palavras-chave: Potenciais Evocados Auditivos do Tronco Encefálico; Mascaramento perceptivo; Perda auditiva neurossensorial; Eletrofisiologia; Revisão sistemática

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INTRODUCTION

In audiological assessment, contralateral masking is important to avoid the occurrence of cross-hearing - a situation in which the non-tested ear will respond to the stimulus presented on the ear test due to skull vibration[1,2]. Thus, the use of masking noise enables the independent evaluation of the ears, which is fundamental for accurate definition of the audiological diagnosis and, consequently, of the most appropriate intervention.

In clinical practice, the use of contralateral masking in the measurement of auditory brainstem response (ABR)has been widely and comprehensively discussed, even when the sound stimulus is presented through insert earphones, given the scarcity of studies with a high level of scientific evidence, which influences decision making on its necessity and applicability[3,4]. Considering this scenario, professionals sometimes feel insecure about the use of contralateral masking and the results obtained, especially in severe or profound unilateral hearing loss, which justifies the importance and urgency of research in the field.

From this perspective, systematic reviews are crucial for professionals involved in health care decision-making processes[5].

The purpose of the systematic reviews is to identify, evaluate and summarize the findings of all relevant individual studies using well-defined strategies, thereby making the most valid information on a given topic available[6].

PURPOSE

This study aimed to critically analyze the need for the use of contralateral masking in the measurement of ABR by air conduction on unilateral or bilateral asymmetric sensorineural hearing loss by a systematic literature review.

RESEARCH STRATEGIES

This systematic review of the literature, which was based on the methodological recommendations proposed by the Preferred Reporting Items for Systematic Reviews *(*PRISMA)[7], was conducted in four stages: identification, selection, eligibility, and inclusion.

The search strategy was directed through a guiding question formulated based on the PICO (population, intervention, comparison, outcome) acronym as follows: "Is the contralateral masking in the measurement of air-conduction ABR in individuals with unilateral or bilateral asymmetric sensorineural hearing loss necessary due to the possibility of cross-hearing?".

To this end, the search question was structured according to the following concepts: population, as the individuals with unilateral or bilateral asymmetric sensorineural hearing loss; intervention, as the air-conduction ABR with or without a contralateral masking; comparison, a neural response in the absence and presence of masking noise, if employed; outcome, the need for contralateral masking as a result of cross-hearing.

Initially, a literature search was conducted at the Cochrane[8] library at the Virtual Health Library Regional Website (BVS)[9] and the International Prospective Register of Systematic Reviews (PROSPERO)[10], and no systematic review studies addressing the proposed question were found.

In the search for articles, the following descriptors indexed at the Medical Subject Heading (MeSH) and the Health Sciences Descriptors (DecS)[11] were used: "Evoked Potentials, Auditory, Brain Stem", "Perceptual Masking", and "Hearing Loss, Sensorineural", in English, Portuguese and Spanish, combined using the Boolean operator (AND); subsequently, a second search was performed replacing "Perceptual Masking" with "Masking".

The following electronic databases were consulted in the identification stage: PubMed/MEDLINE, LILACS, ADOLEC, IBECS, SciELO, Web of Science, Scopus, and Embase. Additionally, gray literature was verified in the scientific proceedings of two of the main events in the field of Speech, Language and Hearing Sciences: the International Meeting of Audiology[12] and the Brazilian Congress of Speech-language Pathology and Audiology[13], as of 2008 - when they were first made available electronically, as well as in the library databases of higher education institutions that have Graduate Studies Programs in Speech-language Pathology (assessment area - Physical Education) registered at the Sucupira Platform[14] (Table 1).

Searches were delimited by the language of publication: English, Portuguese, and Spanish. In addition, there was no restriction regarding the year of publication, and the search ended in January 2018.

Table 1. Data from graduate studies programs in Speech-language Pathology and Audiology registered at the *Sucupira* Platform (2018)

Graduate studies programs	Institutions
Rehabilitation Sciences	*Universidade de São Paulo*
Speech, Language, and Hearing Sciences	*Universidade Federal de Minas Gerais*
Communication Disorders	*Universidade Tuiuti do Paraná*
Human Communication Disorders	*Universidade Federal de Santa Maria*
Human Communication Disorders	*Universidade Federal de São Paulo*
Speech-language Pathology	*Pontifícia Universidade Católica de São Paulo*
Speech-language Pathology	*Universidade de São Paulo / Faculdade de Odontologia de Bauru*
Speech-language Pathology	*Universidade Federal de Paraíba*
Human Communication Health	*Universidade Federal de Pernambuco*
Human Communication Health	*Faculdade de Ciências Médicas da Santa Casa de São Paulo*

SELECTION CRITERIA

The selection stage was conducted independently by two speech-language pathologists with experience in hearing electrophysiology according to the following inclusion criteria: (I) Types of study: the classification proposed by Cox[15] was used to determine the level of evidence (Chart 1). Articles with levels of scientific evidence from 1 to 5 were chosen to minimize possible losses because, in the field of Audiology, few studies present the designs recommended for a systematic review (levels 1 and 2); (II) Methodology: individuals with unilateral or bilateral asymmetrical sensorineural hearing loss participated and the use of contralateral masking in the measurement of air-conduction ABR was analyzed regardless of the type of earphone and acoustic stimulus used, as well as of the type of masking noise, when employed.

DATA ANALYSIS

In the eligibility stage, the titles of the studies were initially analyzed aiming to exclude those that, despite containing the pre-defined descriptors, did not address the assessed theme. Subsequently, the abstracts of all selected studies were read so potentially eligible texts could be identified.

In the inclusion stage, the selected texts were read in full. A pre-defined protocol form was used. This protocol included the study reference, level of scientific evidence, sample, type of earphone, ABR sound stimulus, neural response in the absence and presence of contralateral masking, when used, and the intensity level of masking noise with the calibration unit, value of interaural attenuation, if any, and conclusion of the research.

Thereby, aiming to find other unidentified studies, the bibliographic references of the selected articles were consulted for reading in full.

There was no need to include a third reviewer because there were no cases of disagreement regarding the studies to be pre-selected and later incorporated into the systematic review.

RESULTS

Twenty the 334 studies identified (Table 2) were considered for full analysis. Twelve of them were excluded for not addressing the guiding question and/or meeting the inclusion criteria. For instance, studies using ipsilateral or binaural masking noise, conducted with normal-hearing individuals or individuals with conductive or mixed hearing loss, animal studies, and those analyzing the use of contralateral masking in other procedures or bone-conduction ABR. The use of the descriptor "masking" resulted in the identification of studies that included tinnitus, possibly considering its therapeutic correlation. Additionally, three other studies were excluded: two that addressed the proposed theme but were published in other languages and one to which full access was not possible. Thus, eight articles were included in the review[16-23] (Figure 1).

After analysis of all the studies included in the systematic review, seven (87.5%) were case studies or case series (level of evidence 5)[16-22] and one (12.5%) was an uncontrolled clinical trial with level of evidence 4[23]. In addition to presenting low level of scientific evidence, were controversial to their recommendations regarding the need to use contralateral masking and the sufficient intensity level of masking noise to eliminate the participation of the non-test ear in the measurement of air-conduction ABR in individuals with unilateral sensorineural hearing loss[16-23].

Chart 2 shows a list of the studies included in this systematic literature review.

Chart 1. Levels of scientific evidence proposed and adapted by Cox[15]

Level of evidence	Type of study
1	Systematic reviews and meta-analyses of randomized clinical trials or other qualitative studies.
2	Randomized controlled trials.
3	Non-randomized intervention studies.
4	Descriptive studies (cross-sectional surveys, cohort studies, case-control designs) and uncontrolled experiments.
5	Case studies.
6	Expert opinion.

Source: COX[15]

Table 2. Distribution of the studies identified in the consulted electronic databases

Electronic database	Total of articles found
LILACS	203
PubMed/MEDLINE	44
Scopus	42
Embase	14
Web of Science	12
SciELO	1
IBECS	0
ADOLEC	0
Proceedings of the IMA	1
Proceedings of the BCSPA	1
Theses and dissertations	11
Bibliographic references	5
Total	**334**

Captions: IMA = International Meeting of Audiology; BCSPA = Brazilian Congress of Speech-language Pathology and Audiology

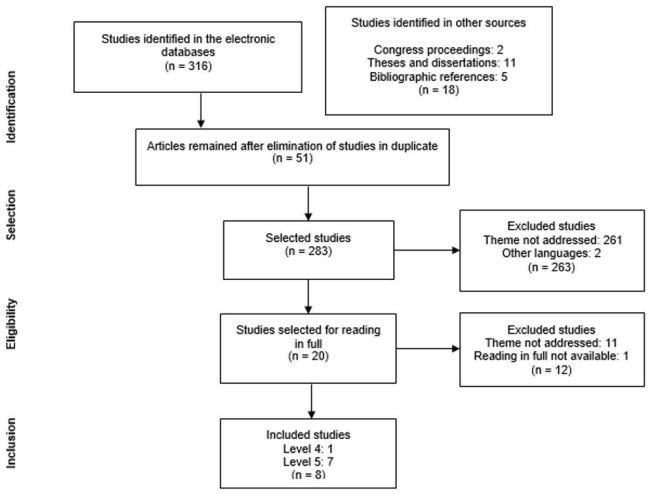

Figure 1. Summary of the steps of this systematic literature review
Captions: n = number of studies

Chart 2. Description of the studies included in this systematic literature review

Reference	LE	Sample	Earphone (model)	ABR stimulus	Response (without masking)	Response (with masking)	IA	Conclusion
Chiappa et al.[16]	5	Two adult individuals with profound unilateral hearing loss	Supra-aural (not mentioned)	Click	Wave V at 60 dB SPL	Absent with white noise at 60 dB SPL	-	Use of masking is required
Finitzo-Hieber et al.[17]	5	Two adult individuals (mean age of 42 years) with profound unilateral hearing loss	Supra-aural (TDH-39)	Click	Absent at 117 dB SPL	-	-	Use of masking is required
Ozdamar and Stein[18]	5	Seven individuals divided into two groups: G1 (three individuals with profound unilateral hearing loss) and G2 (four individuals with suspicion of profound unilateral hearing loss)	Supra-aural (TDH-39)	Click	Wave V at 60 dB HL	Absent with white noise at 30 dB HL below click stimulus intensity on the test ear (i.e., click at 60 dB HL and contralateral masking at 30 dB HL)	60 to 70 dB	Use of masking is required
Humes and Ochs[19]	5	Four individuals (mean age of 16 years) with profound unilateral sensorineural hearing loss	Supra-aural (TDH-39)	Click	Wave V at 135 dB SPL	Absent with white noise at 40 dB SPL	70 to 73 dB	Use of masking is required
Smyth[20]	5	Five individuals with different audiological profiles: (I) normal hearing, (II) severe unilateral conductive hearing loss, (III) moderate-to-severe sensorineural hearing loss, (IV) sensorineural hearing loss with severe recruitment, and (V) profound sensorineural hearing loss with no recruitment	Supra-aural (TDH-49)	Click	Wave V at 60 dB HL in individuals with severe or profound sensorineural hearing loss	Absent with white noise at 60 dB HL	50 dB	Masking is required in individuals with severe or profound unilateral sensorineural hearing loss
Hatanaka et al.[21]	5	One child with profound unilateral hearing loss	Supra-aural (DR-531)	Click	Wave V at 85 dB HL	Absent with white noise at 45 dB HL	-	Use of masking is required
Van Campen et al.[22]	5	Two adult individuals (mean age of 30.5 years) with profound unilateral hearing loss	Supra-aural (TDH-39P and TDH-49P) and insert (ER-3A)	Click	Wave V at 65 dB HL	Absent with white noise at 35 dB HL	75 to 83 dB (ER-3A) 70 to 80 dB (THD-39P) 70 to 75 dB (TDH-49P)	Masking is required even with the use of insert earphones
Toma and Mata[23]	4	22 adult individuals (mean age of 23.5 years) with profound unilateral sensorineural hearing loss	Supra-aural (TDH 39)	Click	Wave V at 70 dB HL (4.5%), 80 dB HL (18%), 85 dB HL (54.5%), and 90 dB HL (23%)	Absent with white noise at 25 to 35 dB HL	65 to 75 dB	Use of masking is required

Captions: LE = level of evidence; ABR = auditory brainstem response; IA = interaural attenuation

DISCUSSION

The use of contralateral masking in the measurement of ABR is a controversial topic in the specialized literature and clinical practice given the lack of studies in the area and the existence of several questions about the need and applicability of masking noise to eliminate the occurrence of cross-hearing, demonstrating the importance and necessity for further research on this theme.

Most of the articles included in this systematic review are descriptive observational studies[16-22], which hindered the analysis on the risk of bias using specific instruments directed to observational analytical studies, and only one survey presented level of scientific evidence 4 (uncontrolled clinical trial)[23]. Despite these limitations, the inclusion of these studies in this systematic review is justified considering that no studies with a level of evidence from 1 to 3 were found; this is still a reality in the field of speech-language pathology. Thus, it was not possible to perform a meta-analysis due to the design heterogeneity of the included surveys[24].

In all studies analyzed, ABR was measured using the click acoustic stimulus[16-23]. It is worth emphasizing that most studies were published between the 1970s to the 1990s, which may justify, among other reasons, the exclusive use of this stimulus. Therefore, it was not possible to evaluate the need of contralateral masking by specific frequency, obtained, for example, through the use of ABR with the tone-burst stimulus, which is crucial especially in child audiological evaluation by the importance of electrophysiology thresholds in the prediction of psychoacoustic thresholds to the correct definition of audiological diagnosis.

In most of the studies assessed (87.5%)[16-21,23], supra-aural earphones were used, with only one survey[22] conducted with the use of insert earphones. The benefits of insert earphones over supra-aural earphones have been previously reported, and it involves greater comfort to patients and reduced electrical artifacts, as well as higher interaural attenuation values[25], which are factors that have expanded the use of the insert earphones in clinical practice over the years. Results of the studies analyzed in the present review showed that insert earphones do not eliminate the need for contralateral masking in individuals with profound unilateral sensorineural hearing loss, although the values of interaural attenuation are higher compared with those of supra-aural earphones, which reduces the need or intensity level of the masking noise. Therefore, this finding reinforces the importance of using contralateral masking in the measurement of air-conduction ABR regardless of the type of earphone used.

Analysis of the degree of hearing loss showed that at least one individual in every study had a profound hearing impairment[16-23], except for one survey (12.5%) that reported severe hearing loss[20], demonstrating the possibility of cross-hearing in both situations. No studies conducted with individuals with bilateral asymmetric sensorineural hearing loss were found.

Regarding the type of masking noise, the use of white noise was observed in all studies in which contralateral masking was necessary[16,18-23], that is, the use of broad-spectrum noise was consensually reported.

In contrast, there was no consensus on the need for contralateral masking in the measurement of ABR by air conduction[16-23]. Nevertheless, most studies (87.5%) recommended the use of contralateral masking in individuals with severe and profound unilateral sensorineural hearing loss[16,18-23]. Furthermore, no agreement was observed between the studies assessed for the sufficient intensity level of masking noise to eliminate the participation of the non-test ear, with values ranging from 25 to 60 dB, as well as to the methodology used to employ contralateral masking[16,18-23].

Masking noise was measured in dB HL in six (75%) studies[18,20,22,23] and in dB SPL in two (25%) surveys[16-19]. Previous studies have presented a variation of hearing sensitivity by frequency[26], which originated the standardization of the 0 dB HL[27] aiming to simplify the hearing measurement when considering the level of the sensation of individuals before a sound stimulus.

When comparing the types of earphone and the masking intensity levels, most studies conducted with supra-aural earphones[16,18-21] required stronger masking noise intensity levels than those performed with insert earphones[22], except for one research[23]. Such difference can be justified by the interaural attenuation values, which may differ between the transducers used and the individuals assessed.

These results underscore the need for further research with higher levels of scientific evidence, considering that the applicability of air-conduction ABR in clinical practice is undisputed. The importance of early diagnosis in unilateral and bilateral asymmetrical hearing loss is also highlighted, given the impact of sensory deprivation on the maturation of the auditory cortex[28].

CONCLUSION

There is no consensus on the need to use contralateral masking in the measurement of ABR by air conduction in individuals with unilateral sensorineural hearing loss; however, most studies report the use of contralateral masking in the measurement of ABR with click stimulus in individuals with severe and profound unilateral sensorineural hearing loss.

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