Processamento auditivo em criança com doença cerebrovascular*****

Auditory processing in children with cerebrovascular disease

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Abstract
Background: cerebrovascular disease (CVD) during childhood is a rare condition; its short, medium and long-term characteristics deserve further investigation. The application of behavioral techniques may improve clinical characterization, thus rendering more efficient therapeutic planning and control. Aim: to describe the audiological manifestations in a child with CVD in two distinct moments of clinical follow-up. Method: the child, with a confirmed diagnosis of a single and unilateral episode of CVD, presenting satisfactory cognition and language skills, was submitted to a battery of conventional and auditory processing tests, which included a simplified evaluation as well as monotic, dichotic, and temporal processing tests. The obtained data was paired with those of a normal right-handed child, of the same gender, age and socio-cultural level. Results: results indicate impairments in auditory memory as well as in selective attention during binaural separation and integration tasks for verbal and non-verbal stimuli. Conclusion: clinical development, although favorable, was below the average expected for the same age when compared to the control. The prospective evaluation of a child with DCV permitted the characterization of the auditory behavior, the definition of its parameters as well as the development of the audiological characteristics.

Key Words: Cerebrovascular Disease; Stroke; Auditory Perception.

Resumo
Tema: na infância a doença cerebrovascular (DCV) constitui condição rara em que a evolução a curto, médio e longo prazo tem merecido esclarecimentos. Neste sentido, a aplicação de técnicas comportamentais pode possibilitar melhor caracterização clínica, visando o planejamento e controle terapêutico eficientes. Objetivo: descrever em uma criança com DCV as manifestações audiológicas em dois momentos distintos da evolução clínica. Método: a criança, com diagnóstico comprovado de episódio único e unilateral de DCV, apresentando habilidades de linguagem e cognição satisfatórias, foi submetida a conjunto de testes convencionais e de processamento auditivo, incluindo a avaliação simplificada e as categorias de testes monóticos, dicóticos e de processamento temporal. Os dados obtidos foram pareados com criança normal destra, de mesmo sexo, idade e nível sócio-cultural. Resultados: foi constatado comprometimento nas habilidades de memória auditiva e atenção seletiva em tarefas de integração e separação binaural para estímulos verbais e não-verbais. Conclusão: a evolução, embora favorável, se mostrou abaixo do esperado para a idade, quando comparado com seu par. A avaliação prospectiva da criança acometida por DCV possibilitou caracterizar o comportamento auditivo, definir seus parâmetros e a evolução do quadro audiológico.

Palavras-Chave: Doença Cerebrovascular; Acidente Vascular Cerebral; Percepção Auditiva.

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Introduction

In cerebrovascular disease (CVD) there is the development of a critical condition, resultant of ischemic or hemorrhagic vascular alterations in the central nervous system with symptoms and signals that persist for 24 hours or more(1). In adult population it is the second more common cause of mortality in the world and the main responsible for the loss of healthful life. About two thirds of the episodes happen with individuals with age superior to 65 years, being presented an increasing incidence values to each life decade(1). In childhood, the CVD is less common, reaching 2,6 to 3.1/100,000 children each year and, although a rare condition, it is an important cause of mortality and morbidity(2). Studies have proven neurological and pervasive deficits, of varied intensity, in more than two thirds of the cases, contradicting the historical impression of good prognostic attributed to these patients(3,4). This affirmation turns to the pretence for studies concerning the evolution in the medium and long term of the CVD.

In this context, the special hearing tests, widely used in the diagnostic complementation of diverse clinical populations, have contributed in the clarification of the evolution of CVD in adults, adolescents and children(5,6,7). This knowledge is well relevant, particularly in children, given the impact that disorders of this nature can determine in language, not only in acquisition and development, but also in the efficiency and rapidity in daily use and, consequently, in learning. This way, the aim of this study was to investigate the auditory processing information at two distinct evolutionary moments in child with CVD diagnosis.

Methods

This study it was submitted to the Committee of Ethics in Research of the College of Medical Sciences of the State University of Campinas, FCM-UNICAMP, according to determination of the National Council of Health- Conselho Nacional de Saúde- resolution 196/96, and approved as 642/2005. The parents had signed Term of Free and Clarified Consent.

Subject

Male child that presented a CVD at 4 years and 10 months of age (main child). The patient, previously higid, suffered injury cuts-contuse in soft palate after a bicycle fall with wooden connecting rod. He was admitted in the Emergency Room of this institution, conscientious, presenting orientation and without neurological signals, however, in the following hours, he evolved to clinical worsening characterized by sleepiness, shunting line of looking at and oral rhymes, hemianopsia, hemiplegia and aphasia. Since then, he is observed in the Clinical of Research in CVD in Childhood and Adolescence, Department of Neurology - FCM - UNICAMP.

Thrombosis of left carotid artery was proven by image examinations as computed tomography, arteriography, SPECT and magnetic resonance.

Regarding the Speech- Language and Audiological treatment, the child is on observance since the acute phase and was submitted to the evaluation of the auditory processing (AP at 8 and 11 years of age). The child, native speaker of the Brazilian Portuguese, fulfilled all prerequisite for this evaluation, presenting compatible language, attention and cognitive function compatible to the requirements of the tests, proven by Speech-Language and Psychological evaluation. At the time of evaluation the subject was not under medication.

Before the vascular episode, the child was right handed and did not present historical familiar of sinistrality.

The obtained results were compared to the ones of right-handed child, of same sex, age and social and economical status, with normal development of the neural and psychomotor and academic point of view.

Speech-language and hearing evaluation

The patient was evaluated two times, being the first at 8 years and 2 months, and the second at 11 years and 2 months, therefore with an interval of 3 years; and the normal control child, at 8 years and 7 months and at 11 years and 3 months.

The following procedures were adopted:

. anamneses: approaching clinical history, familiar development and with emphasis in language and experience in different situations of listening.
. language evaluation: by means of half-directed colloquy, using thematic figures.
. audiological evaluation: after meatoscopy, included tonal audiometry; logoaudiometry with attainment of percentile index of speech recognition and of threshold of speech recognition; acoustic immitance tests with timpanometry, threshold of contra-lateral and ipsi-lateral acoustic reflex and immintace decay attainment. For attainment of the percentile index of speech recognition the list of

words in recorder in compact disk was used. The ipsi-lateral acoustic reflex was tested in the frequencies of 1000 and 2000 Hz and the contra-lateral one from 500 to 4000 Hz.

. evaluation of the AP: it included sound localization in five directions, verbal and non-verbal sequential memory, speech in noise (SN), filtered speech (FS), non-verbal dichotic (NVD), consonant-vowel (CV), dichotic digits (DD), staggered spondaic word test (SSW) and pitch pattern sequence test (PPS).

The procedures for language and auditory function evaluation were carried through in acoustic room, in six sessions of fifty minutes each, as proposed by Pereira and Schochat (1997)(8).

AC30 connected to a Sony compact disc player, immitance meter Interacoustics AZ-7, musical instruments and compact discs, understanding the volumes of the evaluation manual and the one of AuditecTM were used.

Results

The main subject child presented evolvement of the cortical and perforating branches of the middle cerebral artery, of ischemic type with hemorrhagic transformation. The cortical and sub-cortical injury in the left hemisphere compromised structures related to the processing of auditory information (Figure 1).

It was detected in the critical stage ample manifestation followed by favorable language evolution and persistence of the motor commitment (Table 1).

At the Speech-Language Pathology interview (age: 8 years and 2 months) behaviors for the inquiry of the AP were identified, as agitation, carelessness, difficulty to tell facts and slowness in school learning, with necessity of help to improve understanding of lesson boarded topics.

It was evidenced, at the first evaluation, that on the test of sound localization a result adjusted for the age. In the tests of verbal and non-verbal sequential memory, recognition of items was below expectancy. In monotic, SN and FF, the results were adjusted for the age. In the NVD, asymmetry of response between the right and left ears in the attention free stage and difficulty to focus the attention to the stimuli presented in both directed conditions. In the CV inversion of the perceptual asymmetry in favor of left ear was evidenced, and in the subsequent stages, difficulty on the identification of the stimuli presented in the right ear was also evidenced. In test DD, difficulty in reporting the numbers presented to the right ear and in the SSW, in the competitive right condition was presented.

In the second evaluation, altered results in the same tests were obtained. However, in the NVD (right attention), DD and SSW, greater number of correct identification with right ear could be identified and, in the SSW, variation in the type of error, with inversion of presented items and reduction of the amount of omissions in the competitive right condition (Figure 2).

The evaluations of the control child were adjusted for the considered ages, proving in the case-control study the alterations in the main subject (Appendices 1 and 2).

Discussion

TABLE 1. Identification and vascular commitment:

Subject	Age*	Artery	H	Type	Localization	Image	Evolution	
							Acute Stage	Late Stage
Main Child	4y10m	MCA PB	L	I-H	Cortical sub-cortical	LOG FIG PO P TMG TSG PhG I CN NL EC IC	Sleepiness Hemihypoestesia Look deviation and rhyme L Homonym Hemianopsia R Hemiplegia R Aphasia	Hemiparesia

Y: years; m: months; MCA: middle cerebral artery; LB: perforating branch; H: hemisphere; R: right; L: left; I-H: ischemic with hemorrhagic transformation; LOG: lateral obituary gyrus; FIG: frontal inferior gyrus; PO: *pars opercularis*; P: parietal; TMG: temporal medium gyrus; TSG: temporal superior gyrus; PhG: parahippocampal gyrus; I: insula; CN: caudate nucleus; NL: nucleus lenticular; EC: external capsule; IC: internal capsule; *age at the vascular episode.

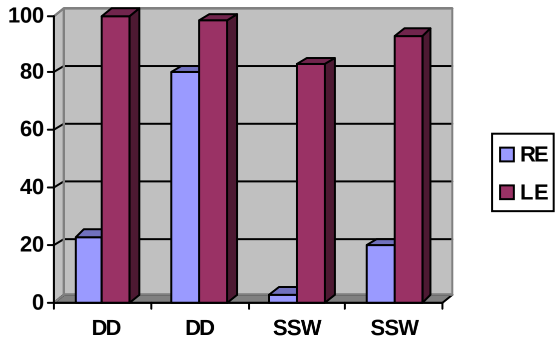
The ability of sound localization is mediated mainly by structures of brainstem; however, in individuals with cerebral injury it has been told presence of difficulty in identifying the source in the injury contra-lateral location (9,10). In these cases, ample injuries are described as involving specially the temporal auditory areas. In our subject, not only the temporal lobe was involved, but also, parietal, insular areas and sub-cortical structures, known to be related to auditory processing, as proven for the neuroimaging studies. However, the related difficulty was not verified, possibly due to the time period between the acute event and the accomplishment of the audiological evaluation, occurring by the use of acoustics tracks in the identification of the sound source(11). The efficient use of the tracks can still, have been facilitated by the environment of the test, more restricted and with sonorous competition control, given the reference of cortical mediation in activities of more complex localization(12). In the sequential memory test, the main subject presented results inferior to the ones of the control subject. In the resolution of the activity, the processes of immediate memory are activated, demanding retention and maintenance of the order presentation of items - abilities of auditory memory and temporal ordinance. These abilities are improved with age advance(13) and with the essentials in the learning processes, because there is the necessity of comparing the perceived stimulation with the previously acquired knowledge, a permanent demand in the daily activities and great relevance in the school environment. The sub-components of the memory system are consisted the areas of the frontal and inferior parietal lobe in the left hemisphere and by parietal-occipital areas in both hemispheres; and even when selective, the evolvement of some component may affect performance(14). In the applied memory tests, the increase of the number of stimulation surpassed the capacity of short-term storage with reduction in the performance in the main subject. These data were emphasized in another study(12). As previously mentioned, in our subject, the parietal lobe was completely involved by the vascular injury.

The monotic tests foresee the application of auditory stimulation in unfavorable listening conditions, either by degradation (SN) or distortion (FF) of the acoustic signals, defying each auditory canal in an independent way. This type of presentation uses the abilities of auditory closing and is moderately sensible in cortical injuries.

In this condition, an expected result would be the reduction of the rightness in the contra-lateral side of the injury(9,10), effect not verified in the child with CVD, possibly because of the fact that the accomplishment depends on brainstem structures(8,9,15), which had remained unaffected after the injury and on cortical areas responsible for the phonological processing(15), that were reorganized in the months that followed to the critical episode; as aphasia recovery. Our results are similar to those by Pereira and Schochat (1997)(8) and Gonçales et al (2002)(16), involving diverse clinical population. The dichotic tests, the ones with increasing linguistic loading, evaluated the ability of selective attention in separation tasks (NVD and CV) and binaural integration (DD and SSW). In the NVD, normal individuals present symmetry between ears in the identification of stimulation in the first and in the subsequent stages, the capacity to repeat the stimuli presented in the solicited ear(17). The main subject presented, in

FIGURE 1. MR- Commitment of the left cerebral parenquimal the territory of the MCA.

FIGURE 2. DD e SSW - Competitive conditions obtained at the first (left) and at the second (right) auditory evaluation.



the stage of free attention, greater number of identification with the ear that had direct access to the unaffected hemisphere. This lateralization can be justified by the unbalance of the hemispheric contribution in the identification of stimuli, which depends on both to be efficiently processed. The errors in the stages of directed attention and the inversions in the right stage evidence the difficulty in directing the attention for the target stimuli.

In CV test, free attention stage, bigger precision in the identification of the stimuli presented to the right ear is expected. The findings of the perceptual asymmetry inversion constitute classic effect in studies with injured patients under dichotic stimulation. Literature has related this asymmetry as resultant of multiple factors, as age, type, localization and extension of the injury, cerebral state prior morbidity, conditions of the neighboring and contra-lateral injury areas, therapies received, among others, acting in a cascade effect on the cerebral reorganization(6,18). In extensive injuries of left hemisphere, the verbal function can be reorganized in the opposing hemisphere, and in a sequence, a new standard is established having the exchange of the advantage direction. In stages of directed attention, the child presented difficulty in focusing the attention for the right ear, presenting omissions, substitutions and inversions, being incapable to use the required canal efficiently and to suppress the information received by the left ear.

In the DD and SSW tests, repetition of all items is requested and in both, the subject presented answers below expectance. The alteration was more accented to the SSW, presumably because the DD is served by familiar stimulation and with limited possibility of combination of few numbers, being able to be more easily compensated by the linguistic ability of the subject, when compared with the second test. Murray et al (1997)(19) using different stimulation than the one used in this study, however with resolution increasing in complexity, verified that the increase of the demand provoked reduction in the efficiency of the individuals with unilateral cerebral injury, contrasting significantly with normal individuals.

The PPS evaluates the abilities of resolution and temporal ordinance of different stimuli in frequency, having involvement of both cerebral hemispheres. This way, the right would be responsible for the global recognition and the left for commanding and nominating the sequence of stimuli(20). In the stage of humming it would have greater participation of the right hemisphere and in the nomination of the left. Individuals with right unilateral injury would present both stages modified, since that this hemisphere would be the responsible for the identification of the acoustic standard. In left injuries, the adequacy in the stage of humming and degradation in the one of nomination of the dependence of this hemisphere for the linguistic labeling would be expected. In our subject adjusted answers in the two stages of the test were evidenced.

Studies have suggested that the type of recovery after injuries varies over the dependence of the affected hemisphere(6,21). Thus, the right hemisphere, more plastic in the compensation capacity, could carry through its original functions and assume the ones from the opposed hemisphere(22). In recent literature review(23), some recovery phases after-injury were claimed. Immediately after the CVD there would be depression in all neuronal net; after that, the super activation, mainly in areas of the unaffected hemisphere. At a third moment, it would happen a bilateral decline of the activation, in order to finally occur a new inter-hemispheric balancing, with maintenance of the superior activation in the unaffected hemisphere.

When the two moments of evaluation of the subjects are compared, even though the results are kept below of the evidenced ones in normal child of the same age, improvement of the scores is verified. This recovery is more evident to the dichotic. Particularly to the SSW, the subject presented greater processing speed with the left way, verified by means of the inversions, besides better reaching identification of stimulation with the right ear in the competitive condition.

The accompaniment of this child strengthens the necessity of systematic evaluation of individuals considered at risk for the AP disorder(24), and in that it concerns the CVDs, even though it is recognized as an important cause of infantile morbidity(2,4,25), the auditory abilities have not been routinely considered(26,27,28). In the case study stated here, the behavioral tests were sensible to detect dysfunction of specific cerebral regions, useful in characterizing and quantifying the auditory difficulties lived by this child with communication and learning difficulty. Additionally, the auditory function has a long maturational course, reaching adult standard for around the age of 16 years(29) and the capacity of reorganization is kept at the lifespam(30), emphasizing the necessity of continuity of the audiological accompaniment of this child with CVD.

Conclusion

The evolutive study of the AP revealed the importance to characterize the auditory behavior of the child with CVD, when disclosing commitment of the memory abilities and selective attention for verbal and non verbal stimulation, in integration and binaural separation tasks.

This study was also elucidative, explaining the origin of some parental complaints, besides having being configured as an instrument, at the same time, directing therapeutical strategies and monitoring of the recovery mechanisms, demonstrating favorable evolution of the investigated abilities.

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Appendix 1

Audiological evaluations of the child with CVD.

Basic Audiological Evaluation	1st evaluation (8 y 2m)		2nd evaluation (11y 2m)	
Tonal audiometry	Auditory limiar for pure tones above 10 dBNA, from 250 Hz to 8000 Hz		Auditory limiar for pure tones above 10 dBNA, from 250 Hz to 8000 Hz	
SRT	RE: 0 dBNA	LE: 0 dBNA	RE: 0dB	LE: 0dB
PISR	RE: 96%	LE:96%	RE: 84%	LE: 96%
Tympanometry	Curve type A bilateral		Curve type A bilateral	
Contra-lateral acoustic reflex	Present bilaterally		Present bilaterally	
Ipsi-lateral acoustic reflex	Present bilaterally		Present bilaterally	
Immitanciometric Decay	Negative		Negative	
Auditory Processing Evaluation				
Sound localization	5/5: localized in all spatial positions.		5/5: localized in all spatial positions.	
MNVS	3/3 for 3 instruments	0/3 for 4 instruments*	3/3 for 3 instruments	2/3 for 4 instruments
MVS	2/3 for 3 syllables	1/3 for 4 syllables*	3/3 for 3 syllables	1/3 for 4 syllables*
SN	RE:84%	LE: 76%	RE:96%	LE: 92%
FS	RE:76%	LE:84%	RE: 80%	LE:84%
NVD free attention	RE: 7*	LE: 17	RE: 2*	LE: 22
Right attention	RE:6*	LE: 17	RE: 22	LE:1
Left attention	RE:7	LE:15*	RE: 0	LE:24
CV free attention	RE:3*	LE:20	RE: 0*	LE:19
Right attention	RE:1*	LE:19	RE:: 0*	LE:17
Left attention	RE: 1*	LE:16	RE: 0*	LE:21
DD	RE:23%*	LE:100%	RE:80%*	LE:98%
SSW	DNC DC	EC ENC	DNC DC	EC ENC
Combined Total	11 39	7 3	11 32	3 2
	DC: 3%*	EC: 83%	DC: 20%*	EC: 93%
Order effect	0= non significant		+2= non significant	
Auditory effect	0= non significant		0= non significant	
Inversions	1= non significant		8= significant *	
Type A	Absent		Absent	
	Error type: omissions		Error type: omissions and inversions	
PPS	Humming: 83%	Naming: 83%	Humming: 97%	Naming: 100%

y: years; m: months; RE: right ear; LE: left ear; SRT: threshold of speech reception thershold; PISR: percentile index of speech recognition; MSNV: memory for non-verbal sequence; MVS: memory for verbal sequence; SN: speech in noise; FS: filtered speech; NVD: non-verbal dichotic; CV: consonant-vowel; DD: dichotic of digits; SSW: staggered spondaic word test; PPS: pitch pattern sequence test. * Results below the expected for the age.

Appendix 2

Audiological evaluations of the control child.

Basic Audiological Evaluation	1st evaluation (8 y 7m)		2nd evaluation (11y 3m)	
Tonal audiometry	Auditory limiar for pure tones above 10 dBNA, from 250 Hz to 8000 Hz		Auditory limiar for pure tones above 10 dBNA, from 250 Hz to 8000 Hz	
SRT	RE: 0 dBNA	LE: 0 dBNA	RE: 0dB	LE: 0dB
PISR	RE: 96%	LE:96%	RE: 100%	LE: 96%
Tympanometry	Curve type A bilateral		Curve type A bilateral	
Contra-lateral acoustic reflex	Present bilaterally		Present bilaterally	
Ipsi-lateral acoustic reflex	Present bilaterally		Present bilaterally	
Immitanciometric decay	Negative		Negative	
Auditory Processing Evaluation				
Sound localization	5/5: localized in all spatial positions.		5/5: localized in all spatial positions.	
MNVS	3/3 for 3 instruments	3/3 for 4 instruments*	3/3 for 3 instruments	3/3 for 4 instruments
MVS	3/3 for 3 syllables	3/3 for 4 syllables*	3/3 for 3 syllables	2/3 for 4 syllables*
SN	RE: 92%	LE: 96%	RE:96%	LE: 96%
FS	RE: 92%	LE: 92%	RE:96%	LE: 92%
NVD free attention	RE:11	LE: 12	RE:12	LE: 11
Right attention	RE:23	LE: 0	RE: 24	LE: 0
Left attention	RE:1	LE: 23	RE: 0	LE: 24
CV free attention	RE:15	LE: 7	RE: 18	LE: 3
Right attention	RE:17	LE: 6	RE:22	LE: 1
Left attention	RE:8	LE: 13	RE:6	LE: 15
DD	RE: 95%	LE: 90%	RE:100%	LE: 98%
SSW	DNC DC	EC ENC	DNC DC	EC ENC
Combined Total	0 3	3 0	0 1	3 0
	DC: 93%	EC: 93%	DC: 98%	EC: 93%
Order effect	3= non significant		0= non significant	
Auditory effect	3= non significant		-2= non significant	
Inversions	0= non significant		0= non significant	
Type A	Absent		Absent	
	Error type: omissions(2) and inversions(4)		Error type: omissions (1) and inversions (3)	
PPS	Humming: 90%	Naming: 97%	Humming: 97%	Naming: 97%

y: years; m: months; RE: right ear; LE: left ear; SRT: speech reception threshold; PISR: percentile index of speech recognition; MSNV: memory for non-verbal sequence; MVS: memory for verbal sequence; SN: speech with noise; FS: filtered speech; NVD: non-verbal dichotic; CV: consonant-vowel; DD: dichotic of digits; SSW: staggered spondaic word test; PPS: pitch pattern sequence test.