

Macrossomia e habilidades auditivas: estudo comparativo*****

Macrosomia and auditory abilities: a comparative study

Luciana de Paula Maximino De Vitto* (lupvitto@fob.usp.br)

Dagma Venturini Marques Abramides**

Carolina Ferreira Campos***

Mariana Sodário Cruz****

Mariza Ribeiro Feniman*****

Antônio Richieri-Costa*****

*Fonoaudióloga. Doutora em Ciências Biológicas pelo Instituto de Biociências da Universidade Estadual Paulista (Unesp) - Botucatu. Docente do Departamento de Fonoaudiologia da Faculdade de Odontologia de Bauri da Universidade de São Paulo (FOB-USP).

**Psicóloga. Doutora em Ciências Biológicas pelo Instituto de Biociências Unesp - Botucatu. Docente do Departamento de Fonoaudiologia FOB-USP.

***Fonoaudióloga. Pesquisadora Voluntária do Setor de Genética Clínica do Hospital de Reabilitação de Anomalias Craniofaciais (HRAC-USP).

****Fonoaudióloga. Pesquisadora Voluntária do Setor de Genética Clínica do HRAC-USP.

*****Docente do Departamento de Fonoaudiologia FOB-USP. Pós-Doutora pela Universidade de Cincinnati - (Ohio) - USA.

*****Médico do Setor de Genética do HRAC-USP. Livre Docente pela USP.

*****Trabalho Realizado na Setor de Genética Clínica do HRAC-USP.

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Abstract

Background: macrosomia is the positive deviation of normal growing standards. **Aim:** due to the lack of studies related to the auditory abilities in macrosomic syndromes, the aim of the present study was to verify and compare the auditory abilities of two patients and to correlate these results with other complementary findings. **Method:** anamneses, hearing, language, psychologic and neuroimage evaluation in two female subjects, eight and seventeen years old. **Results:** subject I - normal; subject II - impaired. **Conclusion:** there is a growing need for more investigations of the neurophysiology of the auditory system in this population. Studies in the area of hearing can favor the early diagnosis and therefore the intervention process.

Key Words: Macrosomia; Central Auditory Disease.

Resumo

Tema: macrossomia é o desvio positivo dos padrões de crescimento normal. **Objetivo:** devido à escassez de estudos das habilidades auditivas nas síndromes macrossômicas, este trabalho objetivou verificar e comparar o desempenho auditivo de dois pacientes e correlacioná-los aos achados complementares. **Método:** anamnese, avaliação audiológica, de linguagem, psicológica e de neuroimagem em dois sujeitos do gênero feminino, de oito e dezessete anos. **Resultados:** sujeito I - normal, sujeito II - alterado. **Conclusão:** há uma crescente necessidade em investigar a neurofisiologia da audição nessa população, visto que estudos fonoaudiológicos poderiam propiciar o diagnóstico precoce, favorecendo o processo de intervenção.

Palavras-Chave: Macrossomia; Doenças Auditivas Centrais.



Introduction

Language development depends on many factors, such as: affective, social, and biological. Among the biological factors, gestational and maturational ones are outstanding. It is important for these factors to be adequate, in order to positively interfere on the neuropsychomotor development and, language acquisition, essential stages that provide children exploration, acknowledgement, and communication with the world. (Lima et al., 2003).

Thus, pathological conditions interfering in the primary process of the child formation during the gestational period must be investigated. Macrosomia is traditionally known as positive deviation of normal growth patterns (Moretti-Ferreira, 1995). It can also be defined as somatic overgrowth at a certain time of development. It is generally present at birth and postnatal life. Weight and height are considered equally important and are associated to physical anomalies (Baujat, et al 2004; Carlo and Dormans, 2004). Mental impairment is another characteristic frequently described and related to the higher incidence of neoplasia (Cohen et al., 2002).

The process of maturation of the central nervous system is another important factor since it is responsible for the global development of the individual and its auditory abilities.

The auditory system allows the individual to identify language phonemes. Thus, if the auditory perception is altered, language and communication problems may occur.

The evaluation of auditory processing through behavioral tests has been a valuable tool for clinical audiology, given that; auditory abilities (localization, memory, discrimination, figure-ground) are significant stages of the oral and written language development. The correlation between the auditory processing and the principles and mechanisms of the central nervous system is extremely important for the etiological basis research in order to obtain a more precise study of the auditory neurophysiology in different affections.

Few studies characterizing the speech, language and hearing development on macrosomic syndrome have been found. Studies mentioning speech, language and hearing alterations described relatives. Other performances in some specific language tests can be found in the compiled literature.

This variability of the clinical phenotypic spectrum opens a perspective to interdisciplinary action on these syndromes (Battaglia, 2003).

In the last few years the speech pathology and genetics have been complementary in order to study

auditory and language alterations that may have fundamental genetic basis.

The role of speech pathology as part of the interdisciplinary team is to characterize the manifestations involving hearing and language from the syntomatological point of view of each syndrome. Other studies on neuroimaging have complemented this clinical speech, language, and hearing evaluation (Senhorini, Busatto Filho, 2002).

Several syndromes may present in their clinical spectrums, different communication disorders correlated with clinical manifestations. Mental impairment and delay in the neuropsychomotor development are clinical evidences that may interfere in the normal process of hearing and language development.

Among the macrosomic syndromes associated with mental impairment and delay in the neuropsychomotor development are the Sotos Syndrome (SS), Weaver Syndrome (SW), Beckwith-Wiedemann Syndrome (SBW), and Proteus Syndrome (SP).

Although the influence of macrosomia on development has been highlighted in this study, other studies related to the auditory system are not frequently found. Many questions about hearing have not yet been answered, specially referring to central dysfunctions in individuals with macrosomic syndromes.

Thus, this study aimed to examine and compare the performance of two patients with macrosomic syndrome in the auditory abilities and correlate them with complementary findings.

Method

Sample

Two patients with macrosomic syndrome, female, aging from 8 to 17 years old were evaluated at the Speech Pathology and Genetics Ambulatory of HRAC-USP and at the Ambulatory of the Genetic Counseling at the IBC-UNESP in Botucatu.

Procedure

The study was authorized by the Ethics and Research Committee from both universities, OF 108/2001-UEP-CEP (08/09/2001) and OF.275/2003-CEP-MACAH/asc (07/07/2003), respectively.

After the approval of the Ethics Committee, the subjects and their parents were invited to participate

in the research. The objectives and methods were verbally explained by the researcher. Subjects received a term of free and clarified consent form that was read and signed by their parents and by the researcher.

Clinical and Genetic evaluation consisted of the characterization of the clinical signals through an investigation and observation of the present signals. They were compared with the tables proposed at the different macrosomic syndromes referred in literature as well as the standard curves of the normal development. The genetic evaluation was performed by a geneticist.

These patients were then assessed by a speech pathologist and focused on hearing. Complementary evaluation consisted of psychological and neuroimaging. The neuroimage study was fundamental for the characterization of the possible alterations of the Central Nervous System correlated to the other clinical findings.

The diagnostic process was performed by speech pathologists and consisted of semi-directed anamnesis with the parents. They answered questions regarding the subjects, clinical history, general development, speech, and language or hearing claims, school performance and, family history.

The investigation of the auditory system was conducted using the conventional clinical audiological evaluation and consisted of the following stages:

- otological Inspection to verify the existence of any prohibition regarding the audiological evaluation;
- imittance measures, in which the conditions of the functioning of the middle ear was observed;
- pure tone audiometry, in order to evaluate the peripheral auditory system through the air and bone thresholds;
- special tests of the auditory processing (AP).

These procedures were performed using a Middle Ear Analyzer SD 30 Siemens, an audiometer SD 50 Siemens. Diotic, monotic and dichotic tests were conducted in order to evaluate the auditory processing (Pereira e Schochat, 1997). They were performed with verbal and non-verbal stimulus sent to the subject through an audiometer of two channels attached to a CD player, utilizing a sound proof booth.

Diotic tests consist of equal stimulus, presented simultaneously for both ears. The auditory fusion test–revised (AFT-R) is a procedure that examines the ability of the temporal

processing; test of sound localization in five directions and memory tests for verbal and instrumental sounds in sequence.

In the monotic tests, different stimulus is presented simultaneously at the same ear, that is, ipsilaterally: evaluate the ability of figure-ground; test of filtered speech: to evaluate the ability of auditory closure.

In the dichotic tests, different stimulus is presented simultaneously for both ears. Test of words and sentences with contralateral competitive message - PSI in Portuguese and test of sentences with contralateral competitive message - SSI in Portuguese: evaluate the ability of the figure-ground; SSW test in Portuguese – dichotic test of alternate disyllables: evaluates the central integrity; dichotic non-verbal test: evaluates not only the perception of the figure-ground, but the ability of association of auditory and visual stimulus; Dichotic Digit Tests: evaluates the auditory ability of perception of the figure ground for words; Test of Binaural Fusion : evaluates the ability of binaural synthesis.

Language assessment consisted of the following aspects: communicative ability and oral and written language being utilized as specific protocol.

In regards to the communicative abilities, the behavior related to the oral communication was characterized by the ability of the individual to answer questions, begin, keep up, and participate in the activity.

Oral language was assessed through the enchainned speech and directed activities including all aspects of the oral language (phonological, semantic, syntactic and pragmatic). It was complemented by the Illinois test of psycholinguistic abilities (ITPA), which evaluates the psycholinguistic abilities based on the communication process.

The psychological evaluation was performed using the Wechsler scale of intelligence - third edition (Wechsler et al., 1991) – brazilian adaptation and standards, and it was performed by a psychologist.

The coronal, axial, and sagittal neuro images were acquired by magnetic resonance imaging of the brain at T1, T2, and flair (fluid attenuated inversion recovery) sequences. This study precisely characterized the alterations of the central nervous system and it was conducted by a neurologist.

Results

Case 1

Identification and anamneses data

K.N.C., born in 16/08/1985, female, white, second daughter of consanguineous parents, mother with 27 years old and father with 36 at the time of birth, without complications during the gestational period. The patient was born in time, through a cesarean with:

- . weight = 2900g (>10°; classification below the average for this age);
- . length = 51 cm (>50°; classification on the average);
- . head circumference (HC) = 35 cm (>50°).

On the third day of life presented ictericia and cyanosis, being hospitalized for 10 days.

As for the development, she firmed the head with 5 months, seated with no support with 8 months, and walked with 1 year and 5 months. It is relevant to mention that the patient had physiotherapy following, helping in the performance, according to the family.

With 1 year and 7 months presented the following anthropometrical data:

- . weight = 11000g (>25°; below the average);
- . height = 90 cm (>95°; above the average);
- . PC = 51 cm (>95°).

When assessed with 11 years old (data obtained at the form) data was:

- . weight = 47800 (>75°; above the average);
- . height = 166 cm (>95°);
- . PC = 57 cm (> 98°).

Regarding the language development, she started to produce the first words with 2 years and 4 months. The family did not remember the first sentences, but highlighted that linguistic productions were induced by speech, language, and hearing therapy.

The patient went to regular school since 2 years old, however, her development was not compatible with the other kids of the same age range, according to the family. She was regularly seen by an interdisciplinary team with speech pathologist, psychologist, educator, and physiotherapist, which permitted integration and development of the oral and written language.

The written language was in time for her age, that is, with 7 years old, she learned how to read and write.

In the last evaluation, the patient was at junior high, with no claims on language and panning to get into a college.

Genetic evaluation

The anthropometrical data obtained on the day of the evaluation, being the patients with 17 years and 11 months were:

- . weight = 58000g (50°);
- . height = 175 cm (between 50 e 75°);
- . PC = 59 cm (>98°).

Table 1 describes the clinical signals present in case 1 and the correlation with the percentage of the frequency referred by literature of the Sotos Syndrome (SS), Weaver Syndrome (SW), Beckwith-Wiedemann Syndrome (SBW), and Proteus Syndrome (SP), which presented correlate signals.

Speech, language, and hearing findings

The audiological evaluation showed normal function of the middle ear, present acoustic reflexes, and air thresholds under the normality patterns at the frequencies from 250 and 8000 Hz in the right ear; from 250 to 4000 Hz in the left ear, with a decrease at the frequencies from 6000 and 8000 Hz, suggesting moderate hearing loss.

Normal outcomes were obtained in the evolution of the central function.

There were no alterations in the oral and written language evolutions. The patient presented good vocabulary, concrete narrative with connection of ideas and thoughts, and organized phonetic-phonological.

In regards to the speech, no alterations were noted.

Psychological findings

In the psychological evaluation, the patient presented verbal intelligence quotient (VIQ) of 101, execution intelligence quotient (XQ) of 85, and a total intelligence quotient (IQ) of 93, that is, in the average.

TABLE 1. Description of the clinical signals of Case 1 and Frequency (F) described these in literature as part of Sotos Syndrome (SS), Weaver Syndrome (WS), Beckwith-Wiedemann Syndrome (BWS), and Proteus Syndrome (PS).

Sinais Clínicos	F	F	F	F
	SS (%)	SW (%)	SBW (%)	SP (%)
crescimento excessivo	100,0	95,5	33,0	-
maturação óssea acelerada	90,0	98,0	21,0	40,0
mãos e pés grandes	88,0	-	-	95,0
atraso no desenvolvimento neuropsicomotor	84,0	95,0	-	-
controle motor fino prejudicado	98,5	-	-	-
dolicocefalia	91,0	-	-	-
macrocrania	100,0	-	-	-
hipertelorismo ocular	91,5	100,0	-	-
estrabismo	-	-	-	-
palato alto e ogival	96,5	-	-	-
erupção dentária prematura	68,5	-	-	-

Legenda: F = frequência.

Neuroimage findings

The magnetic resonance imaging of the brain showed the presence of cavum septum pellucidum and vergae (opening in the middle line of the virtual space of the pellucidum septum), trigono (triangular region between the metopic suture) prominent and discrete ventricular asymmetry (Figures 1 e 2).

Case 2

Identification and anamnesis data

B.L.S.P., born in 12/13/1994, female, white, only daughter of consanguineous parents, mother with 22 years old and father with 27 at the time of birth. The gestation occurred with no interurrences and the patient was born before the time, presenting:

- . weight = 2530 g (>50°);
- . length = 48 cm (>50°);
- . PC= not reported.

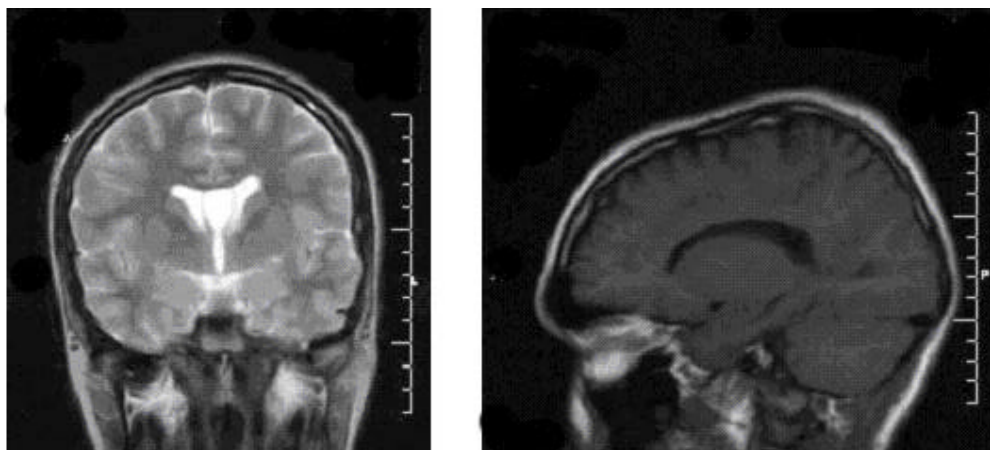
Remained at the hospital for two days, with cyanosis and decreased muscular tonus.

In regards to neuropsychomotor development, she firmmed the head with ten months, seated with support with eleven months, and without any support with 1 year old. She walked with one year and 6 months old with physiotherapy intervention.

When she was examined aging 1 year and 6 months she presented:

- . weight = 13500g (>95°);
- . height = 85,5 cm (95°);
- . PC = 49,5 cm (>95°).

FIGURES 1 AND 2. Magnetic Resonance Imaging (Case 1).



The beginning of the language development was identified by the family when she was 9 months old. With smiles and intentional communicative behavior. The first words happened when she was about 1 year and 6 months old, and sentences with 2 years and 6 months. It is important to note that since she was 1 year old, when the family observed her difficulties, she was seen by a speech pathologist and, until the date of the evaluation was still under assistance.

She started in regular school at 2 years and 6 months old. In the last evaluation, she was on the second grade, which was compatible to her chronological age. The family reported some specific learning problems in Portuguese; however, she was in the same average of her class in the other subjects.

On the day of the last evaluation, the family complained about memory difficulties.

Genetic evaluation

Anthropometrical data on the day of the evaluation, being the patient with 8 years and 6 months were:

- . weight = 31000g (between 75^o e 90^o);
- . height = 139 cm (97^o);
- . PC = 57 cm (>98^o).

Table 2 describes the clinical signals present in Case 2 and the correlation with the percentage of frequency referred in the literature of Sotos syndrome (SS), Weaver syndrome (WS), Beckwith-Wiedemann syndrome (BWS), and Proteus syndrome (PS), which present correlate signals.

Speech, language, and hearing findings

The audiological exam showed normal functioning of the middle ear and absence of acoustic reflexes, with air thresholds under the normality patterns, for the frequencies from 500 to 8000 Hz in the left ear, and from 1000 to 4000 Hz in the right ear. Moderate neurosensorial hearing loss was noted in the other frequencies. In the central function evaluation the AFT-R tests, dichotic of digits, non-verbal dichotic, SSW, filtered speech in the performance of RE, and PSI showed alterations.

No alterations were noted in the language evaluation. In regards to the oral and written language, the auditory and visual information

TABLE 2. Description of the clinical signals of Case 2 and frequency (F) described these in literature as part of the Sotos syndrome (SS), Weaver syndrome (SW), Beckwith-Wiedemann syndrome (SBW) and Proteus syndrome (SP).

Sinais Clínicos	F	F	F	F
	SS (%)	SW (%)	SBW (%)	SP (%)
peso aumentado ao nascimento	100,0	86,0	39,0	-
crescimento excessivo	100,0	95,5	33,0	-
maturação óssea acelerada	90,0	98,0	21,0	40,0
mãos e pés grandes	88,0	-	-	95,0
atraso no desenvolvimento neuropsicomotor	84,0	95,0	-	-
controle motor fino prejudicado	98,5	-	-	-
macrocrania	100,0	-	-	-
dolicocefalia	91,0	-	-	-
frontal proeminente	93,0	94,0	-	-
abaulamento frontal	-	-	-	-
hipertelorismo ocular	91,5	100,0	-	-
macroglossia	-	-	82,0	-
fissuras palpebrais com inclinação anti-mongolóide	81,5	-	-	-
palato alto e ogival	96,5	-	-	-

Legenda: F = frequência.

processing showed deficits, according to the Illinois test of psycholinguistic abilities (ITPA), which does not determines language disorder.

Psychological findings

In the psychological evaluation, the patient presented intelligence verbal quotient of execution (XQ) of 99, and a classification of total intelligence quotient (IQ) of 104, that is, in the average.

Neuroimaging Findings

The exam of magnetic resonance imaging of brain of the patient revealed. Presence of cavum septum pellucidum and vergae (Figure 3 and 4).

The results obtained in the auditory processing tests are shown on Tables 3, 4, and 5.

Table 6 globally shows the different findings in both cases, from the audiological, cognitive, and, structural point of view of the nervous system.

FIGURES 3 AND 4. Magnetic resonance imaging of brain - Case 2.

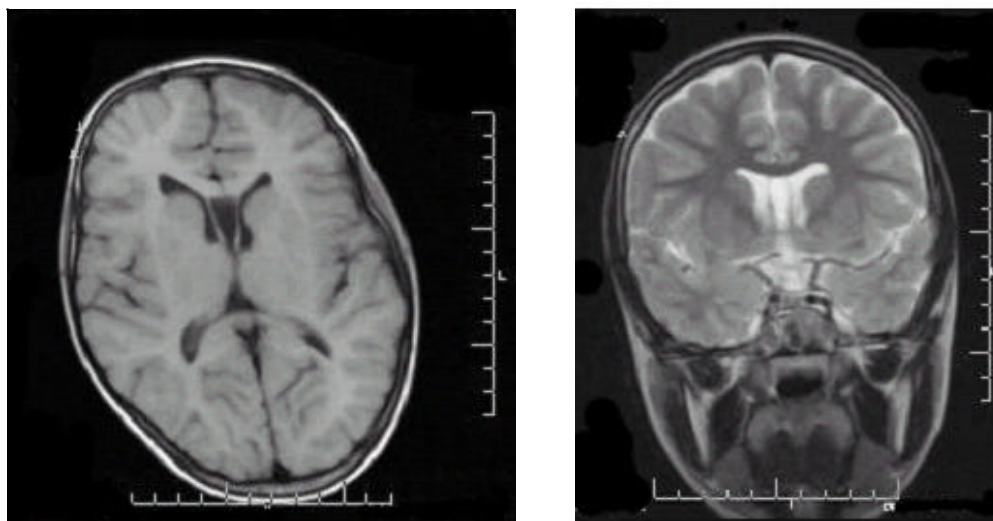


TABLE 3. Scores obtained in the diotic test of the auditory processing and its respective patterns of normality.

Testes Dióticos	Índice Caso 1	Índice Caso 2	Padrão de Normalidade
AFT-R	6,1ms	ausência de limiar descendente	≤ 8ms
localização	80%	100%	≥ 4/5 (80%)
memória para sons verbais	100%	100%	≥ 2/3 (66%) até 8 anos
memória para sons instrumentais	100%	100%	≥ 3/3 (100%) maior que 8 anos
			≥ 2/3 (66,6%)

Legenda: AFT-R = *auditory fusion teste-revised*; ms = milisegundos.

TABLE 4. Scores obtained in the monotic tests of the auditory processing and its respective patterns of normality.

Testes Monóticos	Índice Caso 1	Índice Caso 2	Padrão de Normalidade
fala filtrada	OD = 88%	OD = 60%	OD = OE ≥ 70%
	OE = 88%	OE = 88%	
F/R = 0	OD = 90%	OD = 80%	≥ 80%
	OE = 100%	OE = 100%	
SSI/PSI (ipsilateral)	OD = 70%	OD = 70%	≥ 70%
	OE = 100%	OE = 60%	
F/R = -15	OD = 80%	OD = 40%	≥ 60%
	OE = 70%	OE = ---	

Legenda: OD = orelha direita; OE = orelha esquerda; SSI/PSI: teste de palavras e frases com mensagem competitiva ipsilateral - PSI em Português e teste de frases com mensagem competitiva ipsilateral - SSI em Português.

TABLE 5. Scores obtained in the dichotic tests of the auditory processing and its respective patterns of normality.

Testes Dicóticos		Índice Caso 1	Índice Caso 2	Padrão de Normalidade (\geq 9anos)	Padrão de Normalidade (\leq 8 anos)
SSI/PSI (contralateral)	F/R = 0	OD = 100% OE = 100%	OD = 100% OE = 100%	$\geq 90\%$	$\geq 90\%$
	F/R = -40	OD = 100% OE = 100%	OD = 90% OE = 90%	$\geq 90\%$	$\geq 90\%$
SSW	direita competitiva	97,5%	10%	$\geq 90\%$	$\geq 80\%$
	esquerda competitiva	95%	80%	$\geq 90\%$	$\geq 75\%$
	inversões	0	1	≤ 1	≤ 5
	tipo A	1	15	≤ 3	≤ 3
	efeito auditivo	-3	10	-4 a +4	-6 a +4
	efeito de ordem	1	4	-3 a +3	-4 a +3
dicótico não verbal	atenção livre	OD = 12 OE = 12	OD = 8 OE = 11	OD = OE = 12 (± 1)	OD = OE = 12 (± 1)
	atenção direita	OD = 23 OE = 0	OD = 12 OE = 12	≥ 23	≥ 23
	atenção esquerda	OD = 0 OE = 23	OD = 13 OE = 11	≥ 23	≥ 23
dicótico de dígitos	OD = 100% OE = 100%	OD = 12,5% OE = 85%	OD = OE $\geq 95\%$	OD = OE $\geq 95\%$	
fusão biaural	OD = 92% OE = 96%	OD = 76% OE = 80%	OD = OE $\geq 80\%$	OD = OE $\geq 80\%$	

Legenda: OD = orelha direita; OE = orelha esquerda; SSI/PSI = teste de palavras e frases com mensagem competitiva ipsilateral - PSI em Português e teste de frases com mensagem competitiva ipsilateral - SSI em Português; SSW = teste SSW em Português - teste dicótico de dissílabos alternados; F/R = fala/ruído.

TABLE 6. Results of neuroimaging, psychological and audiological evaluation.

Caso	Alterações Ressonância Magnética	Classificação Intelectual	Diagnóstico Audiológico
01	presença de cavun septo pelúcido	média	normal
02	presença de cavun septo pelúcido ausência de seio transversal	média	alteração do processamento auditivo

Discussion

Case 1 did not show macrosomia at birth. However, developmental data at the first year of life showed higher values about height and head circumference, which characterizes macrosomia. Case 2 presented it at birth. (Cohen *et al.*, 2002).

The most frequent signals in both cases were: overgrowth, accelerate bone maturation, neuropsychomotor delay and, craniofacial alterations.

The psychological assessment showed intelligence quotient in the average for both cases. The oral and written language evaluation did not find any alterations about the processing of syntactic, semantic, pragmatic and phonological information.

The audiological conventional evaluation in Case 1 showed air thresholds in the normal patterns of normality at frequencies from 250 and 4000 Hz in the left ear, with decreases of frequency from 6000 to 8000 Hz. It suggested moderate sensorineural hearing loss. Case 2 presented normal air thresholds in the left ear. While in the right ear there was moderate neurosensorial hearing loss, except at the frequencies from 1000 to 4000 Hz.

The incompatibility between the absence of acoustic reflexes (ipsi and contralateral) and the other conventional finding regarding the audiological assessment (tympanometry, audiometry, and logaudiometry) was observed only in Case 2. In Case 1, the acoustic reflexes were present.

Although the evaluation of the central auditory function was not altered, it is important to mention that, according to the behavioral tests of the auditory processing, in the research of the acoustic reflexes, the functional measure of the structures in the brain stem were obtained. The involvement of the arch reflex with the neural activities of the auditory nucleus was observed. Thus, a possible dysfunction in some of them may result in alterations of the acoustic reflex and, flaws in the abilities involved in the auditory processing (Marotta *et al.*, 2002).

Regarding the evaluation of the central auditory function, Case 1 did not show any alterations in none of the tests performed. However, Case 2 presented alterations in the auditory processing tests, revealing difficulties in the abilities of temporal resolution, perception of the auditory figure-ground, association of auditory and visual stimulus, selective attention, memory for verbal sounds and auditory closure, compatible findings

with the alterations found by the speech, language and hearing evaluation through the ITPA test.

The ventricular asymmetry and the prominent trigono, found in Case 1, were differential findings among the cases evaluated from the point of view of neuroimaging. Several studies have demonstrated that ventricular asymmetry, in isolated occurs in 1:1500 of the newborn alive and generally have no effects on the child development (Kinzler *et al.*, 2001). This data agrees with the satisfactory performance of Case 1, in the different evaluations performed.

The presence of cavum septum pellucidum and vergae was concomitant in both cases, regarding structures anomalies of the central nervous system. These two findings have been described in many conditions the course with cognitive, behavioral and language alterations. They refer in a general way, to the more complex conditions, such as dyslexia, unspecific mental impairment (Soto-Ares *et al.*, 2003), Sotos syndrome (Chen *et al.*, 2002) and others. Paradoxally, the patients of the sample showed satisfactory performance in the cognitive and language abilities, not existing cause-effect relation with such anomalies of the central nervous system. It is important to consider that, in the developmental history, both had alterations in the motor, language and learning areas. However, no alterations were noted at the moment of the last evaluation.

It is clear that early alterations in the development of the cavum septum pellucidum and/or related structures – cross pathways, septal, nucleus or limbic system – may determine the significant damage to the vital functions, such as: memory, emotional stimulus and, stimulus decodification.

These evidences justify the alterations found in the auditory central function of Case 2 (difficulties of temporal resolution, perception of the auditory figure-ground, association with auditory and visual stimulus, selective attention, memory for verbal sounds, and auditory closure).

Another relevant factor in both cases was the frequent interdisciplinary therapeutical approaches since the day of birth. This favorable prognostic has been reported in some studies in literature, with individuals with SS (Moretti-Ferreira, 1995; Rubino, 2003; Passos, 2003), because the early intervention may reflect on the neuronal plasticity, favorably answering with stimulus in supplementary areas (Kandel *et al.*, 2003).

Conclusion

According to the outcomes patients showed similar performance about language and cognition. However, the results on the auditory processing and neuroimaging findings were different.

The correlation between the neuroimaging findings, macrosomic syndromes, and the auditory processing is not clear. New studies on these aspects are still needed.

Investigating macrosomic syndromes, and its manifestations may solve the questions that remain without answers about the process of interdisciplinary diagnostic. This way, speech pathology may provide favorable data for the intervention process. It can bring new findings on the neurophysiology hearing, since auditory abilities have proved to be an area of great interest for research recently.

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Endereço para correspondência:
Luciana de Paula Maximino De Vitto
R. São Gonçalo, 6-73, apto. 101 - Bauru - SP - CEP:17043-170.