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Description of interhemispheric disconnection syndrome in a patient with Marchiafava-Bignami disease*

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ABSTRACT

Interhemispheric disconnection syndrome (IDS), described by Sperry, Gazzaniga and Bogen, is characterized by the presence of visual and tactile anomia, absence of interhemispheric transference of unilateral somatosensory stimulation of both hands, hemialexia and unilateral left-side apraxia. Subsequently, changes were also observed in the sensory interhemispheric transfer and in tests of crossed motor control. In Marchiafava-Bignami disease (MBD) there have been descriptions of partial IDS. The aim is to describe the dissociations in IDS that are presented in a patient with MBD, using a specialized assessment methodology. Patient and Method: A 54-year-old patient, right-handed, with 11 years of schooling, presented with antecedent chronic alcoholism. Neuropsychological tests were administered for general assessment along with specific tests of interhemispheric transference. Results: Borderline changes were found in visual memory, visual-constructive abilities and attention and executive functioning. In tasks of interhemispheric transference the patient showed changes in: the imitation of hand poses; inter-manual pressure point localization (tactile stimulation); reading aloud of words by visual hemifield; and movement control. Conclusion: Our patient showed a wide lesion of the Corpus Callosum (CC) with relative preservation of the splenium, accompanied by partial disconnection syndrome in the context of a global cognitive deterioration from his chronic alcoholism.

Keywords: Split-Brain; Marchiafava-Bignami Disease; Hemispheric Specialization; Tachioscopic Assessment; Interhemispheric Disconnection Syndrome

1. INTRODUCTION

Interhemispheric disconnection syndrome (IDS) as a consequence of the sectioning of the Corpus Callosum (CC), described by Sperry, Gazzaniga and Bogen (1987), presents typical functioning in the domains of behavior, personality and intelligence, making it impossible to distinguish between individuals with IDS and healthy controlls [1]. Even so, specialized assessment can reveal that IDS is characterized by the presence of visual and tactile anomia caused by the disconnection of the right hemisphere from the language mechanisms that are dominantly localized in the left hemisphere, the absence of interhemispheric transference of unilateral somatosensory stimulation of both hands, unilateral left-side hemialexia and apraxia. Subsequent changes can also be observed in the interhemispheric transference of sensory information and in tests of crossed motor control [2].

Marchiafava-Bignami disease (MBD) is a rare complication of chronic alcoholism that causes demyelination and necrosis of the CC [3]. In both its acute and sub-acute forms [4], the occurrence of altered consciousness, such as stupor, at the onset of the illness is associated with a worse prognosis and more severe disability. A presentation with no alteration of consciousness is associated with a more favorable prognosis and is characterized by an acute or sub-acute onset that includes cognitive changes, dysarthria, gait disorders and interhemispheric disconnection [5]. Unlike in patients with commissurotomy, partial IDS has been reported in patients with MBD who have extracallosal lesions as a consequence of chronic alcoholism (Wernicke-Korsakoff Syndrome or alcoholic encephalopathy) [5,6].

The illness typically affects the truncus of the CC, followed by the genu and finally the splenium, although it can also affect the entire CC [7,8]. In cases of partial

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lesions various dissociations have been reported. Lhermitte, Marteau, Serdaru & Chedru (1977) described partial IDS in three patients with MBD with tactile agnosia, left-side ideomotor apraxia and left-side agraphia, although they did not specify the nature of the lesions [9]. Lechevalier, Andersson & Morin (1977) report a patient with necrosis of the CC, sparing an area in front of the splenium and of the anterior commissure, unable to grasp objects presented to the right visual half field with the left hand, or to respond to contralateral somaesthetic stimuli with either of the upper limbs [10]. He also has anomia to pictures projected tachitoscopically to the left visual field, disturbances in the transfer of somaesthetic information and left side ideomotor apraxia.

It was reported crossed homonymous hemianopia and crossed left hemispatial neglect in patient with MBD, with lesions of the entire CC except for the extreme anterior portion. He also showed apraxia, agraphia and tactile anomia of the left hand [11].

Berek, Wagner, Chemelli, Aichner & Benke (1994) described partial IDS in a patient with MBD with left-side ideomotor apraxia and left-side hemi-dyslexia with involvement of the genu, splenium and the rostral region of the truncus of the CC [12].

Kalckreuth, Zimmermann, Preilowski & Wallesch (1994) described the case of a patient with partial lesions of the CC (partial conservation of the splenium) as a consequence of MBD that presented with a partial disconnection syndrome with left-side ideomotor apraxia and altered tactile transference [13].

The aim of the current work is to describe the dissociations found of IDS in a patient with MBD, using an assessment methodology designed specifically for this purpose.

Hirayama *et al*. (2008) describe a patient with MBD, with partial necrosis in genu and splenium, who showed signs of callosal interruption and a form of dyspraxia in response to oral command or imitation, but no when performing voluntary actions [14].

2. METHOD

2.1. Participant

A 54-year-old patient, right-handed, with 11 years of schooling, presented with antecedent chronic alcoholism over a 20-year history. After ingesting alcohol, the patient experienced symptoms of disordered gait and mutism without loss of consciousness, occurring regressively after a period of one week. Six months after the start of the episode the patient received a neurological examination, MRI and Neuropsychological Assessment.

In the neurological examination the patient presented with hypoesthesia of the lower limbs and foot and active reflexes in the upper limbs. A brain MRI was carried out that revealed necrotic lesions located predominantly in the truncus and genu with relative conservation of the splenium of the CC.

On the basis of these data a diagnosis of Marchiafava-Bignami Disease was made.

2.2. General Neuropsychological Assessment and Tests of Interhemispheric Disconnection

General Neuropsychological Battery

The following tests were administered to the patient:

Mini-mental State Examination [15,16]; Clock Test [17]; the following four subtests of the Spanish Neurological Battery: Word Learning, PMR Verbal Fluidity Test, Verbal Attention Forwards and Verbal Attention Backwards [18]; Trail Making Tests A and B [19]; Semantic Verbal Fluency Test [20]; Rey Complex Figure Test [21]; Boston Vocabulary Test [22]; Block Design subtest of the WAIS [23]; Tower of London [24,25]; and The Wisconsin Card Sorting Test [26].

2.3. Assessment of Interhemispheric Transfer

To test specifically for IDS, tasks that differentiated between hemispheres to a statistically significant level ($p \leq 0.05$) were considered to represent evidence of dissociation.

2.3.1. Tactile Object Recognition (Tactile Recognition)

Are presented 46 objects from the objects from the tactile object recognition battery [27], the first 23 for manipulation only with the right hand and the subsequent 23 only for manipulation with the left hand, with no visual access to the objects. The familiarity (high or low) and size (small or large) of each object were controlled for in the distribution of the stimuli.

The 46 objects from the tactile object recognition battery [27] are contained out of sight in a box of 60 cm × 40 cm × 40 cm, with an opening that permits the patient to place one hand and part of his arm inside. The patient manipulates the first 23 stimuli exclusively with the right hand, and the subsequent 23 with the left hand. He is requested to orally indicate the names of the objects that are presented.

2.3.2. Hand Pose Imitation

The examiner places the fingers and wrist of the patient's left hand in 20 different positions, that the patient is required to imitate each time with his right hand, whilst deprived of visual control [1].

2.3.3. Inter-Manual Localization of Pressure Points (Tactile Stimulation)

In the first part of the test (intra-manual), the examiner presses various points (2nd and 3rd phalanges) of the patient's left hand, which the patient is then required to press with his thumb, in the absence of visual access.

In the second part (inter-manual), the examiner presses various points (2nd and 3rd phalanges) of the patient's right hand, which the patient is then required to press but with the thumb of his right hand, without visual control.

2.3.4. Assessment of Praxis

The patient is requested to produce, in order, 28 one-handed transitive and intransitive gestures and to imitate 28 one-handed transitive and intransitive gestures drawn from the battery to assess cognitive praxis [28,29].

2.3.5. Tachioscopic Assessment

The patient was positioned 50 cm in front of a PC monitor. The programme Superlab Pro [30] was used to display a central fixation point with stimuli alongside, one to the left and one to the right. The distance between the stimuli and the central fixation point varied according to the task. For the tests that included tactile recognition of objects and letters, the aforementioned box was used, which allowed the patient to manipulate objects or letters whilst they remained out of sight.

Test 1: Visuo-tactile pairing of successive letters

Were presented 20 letters, in succession, to both visual hemifields alternatively, for 125 msec. The letters were sized 30 × 30 pixels (approximately 1 cm × 1 cm). The distance between the centre point of the stimulus and the central fixation point was 300 pixels (approximately 9.5 cm). The familiarity and nature of the letter (consonant or vowel) was controlled for in the distribution of the stimuli to both hemispheres and for both hands. The patient was required to choose the letter from a display of four distracter items that were selected for their morphological similarity to the target letter, located within the box. Recognition was conducted by the right hand during the first 10 trials and the left hand during the remaining 10 trials. After selection, the patient was requested to verbalize the letter that he had seen onscreen.

Test 2: Visuo-tactile pairing of simultaneous letters (extinction)

Were presented 10 pairs of letters to both visual hemifields simultaneously, for 125 msec. The letters were sized 30 × 30 pixels (approximately 1 cm × 1 cm), each situated 300 pixels (approximately 9.5 cm) from the central fixation point. The patient was required to choose the letters that were shown onscreen from a pool of other letters that work as distracters items and were selected for their morphological similarity to the target letters, located out of site. Recognition was conducted by the right hand in the first five trials and with the left hand in the remaining five. Once the choice had been made, the patient was requested to name the letters presented onscreen.

Test 3: Reading words aloud

Were presented 60 words randomly to both visual hemifields alternatively. The stimuli corresponded to those used in the reading test of the Batería para el Análisis de los Déficit Afásicos—BADA [31,32]. The exposure time for each word was 175 msec. The words were 5 cm in height and varied between 2.5 cm and 7 cm in length. The distance between the central point of the stimulus and the central fixation point was 250 pixels (approximately 8 cm). The length (short or medium) of the words was controlled for in the distribution of the stimuli to both hemispheres and for both hands. The patient was asked to read each word aloud.

Test 4: Word reading with tactile recognition of objects

Were presented 44 words to both visual hemifields alternatively, randomly and successively, which corresponded to the stimuli of the battery of tactile object recognition [27]. The words were 5 cm in height and a maximum of 10 cm in length. The distance between the centre point of the stimulus and the central fixation point was 250 pixels (approximately 8 cm). The length (short, medium or large) of the words was controlled for in the distribution of the stimuli to both hemispheres and for both hands. The patient was required to recognize the object that corresponded to the word he read from amongst three distracters, by feeling it with one hand, either the right or the left, according to a pre-established order, according to the procedure for each of four conditions: right visual hemifield (VHF) presentation, recognition with the right hand; right VHF presentation, recognition with the left hand; left VHF presentation, recognition with the right hand; left VHF recognition, recognition with the left hand.

Test 5: Oral naming of visual presentation

Were presented 60 drawings successively and randomly to both visual hemifields alternatively, which corresponded to the stimuli from the Boston Vocabulary Test [22]. The exposure time was 125 msec. The size of the objects was approximately 7 × 9 cm. The distance from the centre point of the stimuli and the central fixation point was 250 pixels (approximately 8 cm). The familiarity (high or low) of the drawings was controlled for in the distribution of the stimuli to both hemispheres. The patient was asked to name each drawing orally.

Test 6: Written naming of visual presentation

The 60 drawings that corresponded to the stimuli from the Boston Vocabulary Test [22], of equal size, positioning and exposure time as in the previous test, were presented in random order to both visual hemifields alternatively. The familiarity (high or low) of the drawings was controlled for in the distribution of the stimuli to both hemispheres. The patient was asked to name each drawing that was shown in writing.

Test 7: Presentation of drawings with tactile object recognition

Were presented successively 20 drawings derived from the Boston Vocabulary Test [22] to both visual hemifields alternatively. The exposition time was 125 msec. The objects were approximately 7 × 9 cm in size. The distance between the central point of the stimulus and the central fixation point was 250 pixels (approximately 8 cm). The familiarity (high or low) of the drawings was controlled for in the distribution of the stimuli to both hands. The patient was asked to attempt to recognize the object that corresponded to the drawing displayed from amongst three distracters, feeling it with one hand, the right or the left.

3. RESULTS

3.1. General Neuropsychological Assessment

Changes in visual memory consistent with a pattern of recuperation; Borderline changes in visuo-constructive, attentional and executive abilities (see **Table 1**).

3.2. Assessment of Interhemispheric Transference

3.2.1. Non-Tachioscopic Tests

In the non-tachioscopic tests, which assessed interhemispheric transference, the patient demonstrated the following results:

Tactile object recognition: adequate transference of a similar level with both hands (no statistically significant differences) (see **Table 2**).

Hand pose imitation: presented with difficulties (7/20 correct) compared with a group of five healthy controls (mean 19/20) (see **Table 2**).

Inter-manual localization of pressure points: presented with statistically significant differences in performance between the two hands (see **Table 2**).

Assessment of praxis: presented with statistically significant differences in performance between the two hands (see **Table 2**).

3.2.2. In the Tachioscopic Tasks

To analyze tests 1, 4, 6 and 7, the results were collated to allow the comparison of two conditions: that in which the visual stimuli and the hand used corresponded with the same hemisphere (intra-hemispheric) and that in which the visual and hand corresponded with different hemispheres (inter-hemispheric refers to right visual hemifield-right hand + left visual hemifield-left hand).

Test 1: Visuo-tactile pairing of successive letters

Good transference was shown, with no statistically significant differences between the tasks (see **Table 3**).

Test 2: Visuo-tactile pairing of simultaneous letters (extinction)

Table 1. General neuropsychological assessments.

Mini-Mental State Examination		28
Clock Drawing Test		13
CVLT	First List	−1.1
	Immediate Recall	−1.6
	Delayed Recall	−0.7
	Recognition	−0.9
PMR Verbal Fluidity Test		−1.7
Verbal Attention Forwards		−1.4
Verbal Attention Backwards		−0.3
Trail Making Test A		−9.6
Trail Making Test B		−7.9
Semantic Verbal Fluency Test		−1.3
Rey Complex Figure Test	Copy	−2.5
	Immediate Recall	−2.85
	Delayed Recall	−1.88
	Recognition	−0.87
Boston Vocabulary Test		−1.27
Block Design		−2.0
Tower of London	Moves	−0.8
	Problems Resolved	0.0
	Rule Violation	0.3
	Time Violations	−1.5
Wisconsin Card Sorting Test	Perseverative Response	−1.1
	Conceptual Level Response	−2.1

Except Mini-mental State Examination and Clock Drawing Test, all results on Z score.

Table 2. Non-tachioscopic tasks.

		Correct responses	Errors	Statistical result
Tactile object recognition				
	Left hand	21	2	Fisher test: p 0.489
	Right hand	23	0	
Hand pose imitation				
	Right hand	7	13	
Inter-manual localization of pressure points				
	Intra-manual	7	1	Fisher test: p 0.01
	Inter-manual	1	7	
Assessment of praxis				
	Left hand	14	14	$X^2 = 8.187$; p 0.004
	Right hand	24	4	

No differences were shown in the tasks of visuo-tactile pairing of simultaneous letters (in one trial only he did not find either of the two letters, in the rest of the trials he identified one letter only and showed equal performance with both hands) (see **Table 3**).

Test 3: Reading words aloud

A notable difference in performance was shown between the hemifields in reading words aloud in favor of the left side (see **Table 3**) but this difference did not reach statistical significance.

Test 4: Word reading with tactile recognition of objects

No differences in performance were shown between conditions in word reading and tactile recognition of objects (see **Table 3**).

Test 5: Oral naming of visual presentation

No differences in performance were shown between the visual hemifields (see **Table 3**).

Test 6: Written naming of visual presentation

No differences in performance were shown between the conditions (see **Table 3**).

Test 7: Presentation of drawings with tactile recognition of objects

No differences in performance were shown between the conditions (see **Table 3**).

4. DISCUSSION

In summary, the patient showed no hemispheric differences on the following tests: word reading with tactile recognition of objects; oral naming of visual presentation; written naming of visual presentation; presentation of drawings with tactile recognition of objects; tactile naming (tactile object recognition); pairing of successive letters and pairing of simultaneous letters (extinction).

Otherwise, the patient showed hemispheric differences on the following tests: hand pose imitation; inter-manual localization of pressure points (tactile stimulation); reading words aloud by hemifield and praxis.

IDS-typed dissociations have been described in patients with MBD [33-35] plus a presentation of chronic, alcohol-related encephalopathy with various cognitive changes, dysarthria, visuo-constructive changes, dysexecutive features and memory difficulties.

Our patient showed a wide lesion of the CC with relative conservation of the splenium, accompanied by a partial disconnection syndrome in the context of global cognitive deterioration as a result of chronic alcoholism.

The general assessment showed: changes in visual episodic memory, changes in attention, dysexecutive features and changes in visuo-constructive abilities. In the specialized assessment of interhemispheric disconnection, the patient showed left-side hemi-dyslexia and ideomotor apraxia of the left hand, along with poor performance on hand pose imitation tasks and inter-manual localization of pressure points.

The relationship of left-side ideomotor apraxia with the CC was early identified by Liepmann & Mass (1908) and appears to be the symptom that is most commonly reported [1,9,12,13,36-38]. The CC is critical to the left-hand responses to verbal instructions. Limb apraxia can be attributed to simultaneous presence of two deficits: poor understanding of the right hemisphere, which has good control of the left hand; and poor control left-hemisphere ipsilateral, that comprising the orders. However, callous apraxia it seems subject to large individual differences [37].

Another commonly cited finding is agraphia, which was absent in our patient. Hand pose imitation and inter-manual localization of pressure points are classic tests in the assessment of IDS [1], but they are not administered in the majority of the cases reported. There is no consensus in the literature as to the origin of constructive apraxia, which was presented by our patient and is frequently described in those with similar pathology, explainable as much as a consequence of the encephalopathy as of the IDS [13,39].

Table 3. Tachioscopic tasks.

		Correct responses	Errors	Statistical result
Visuotactile pairing of successive letters				
	Inter-hemispheric	8	2	Fisher test: p 0.17
	Intra-hemispheric	4	6	
Visuotactile pairing of simultaneous letters				
	Left hand	0	5	
	Right hand	1	4	
Reading words aloud by hemifield				
	RVHF	7	23	Fisher test: p 0.052
	LVHF	1	29	
Word reading with tactile recognition of objects				
	Intra-hemispheric	8	14	
	Inter-hemispheric	10	12	
Oral naming of visual presentation				
	RVHF	12	18	
	LVHF	12	18	
Written naming of visual presentation				
	Intra-hemispheric	8	22	
	Inter-hemispheric	9	21	
Presentation of drawings with tactile recognition of objects				
	Intra-hemispheric	7	3	Fisher test: p 0.37
	Extra-hemispheric	4	6	

References: RVHF: Right visual hemifield; LVHF: Left visual hemifield.

Overall, most symptoms of IDS, both acute and chronic, are not presented if the splenium is preserved [40,41]. However, certain sections may lead to partial deficits [42, 43].

In this patient, the relative conservation of the splenium allows interhemispheric connections between temporal cortex, occipital cortex and parietal cortex, while the body and knee injuries would result in a interhemispheric connections deficit of sensorimotor cortex, prefrontal cortex and cingulate. This configuration is consistent with the patient's performance on various tests of neuropsychological assessment.

The left frontal lobe plays an important role in controlling movements in relation to language [44]. Altered sensorimotor connections affect the implementation and control of voluntary actions, processing of motion visual information and control of complex movements [36-38].

Somatosensory transfer deficits were not detected in most cases with lesion in the CC body. However, in a complex task (where even normal subjects can make mistakes), a deficit compared with normal subjects could be presented [45,46].

There are two types of hemialexia: the inability of matching written words with objects, and the inability to read words or letters out loud [47]. Lesions in the CC splenium and posterior trunk may cause alterations in the reading of words presented in the left hemifield, with preserved ability to naming pictures presented in both hemifields [48].

When the region of the splenium is preserved, there is a normal transfer of visual information between the two cerebral hemispheres. However, these patients do not transfer stereognostic information [49]. This particular case showed alterations in interhemispheric transfer tasks with verbal input and verbal output (word reading), whereas no abnormalities showed in interhemispheric transfer tasks with non verbal input, or also, in task with verbal input and tactile output (tactile recognition of simultaneous or successive letters). The dissociation between the interhemispheric transmission of verbal and nonverbal information had been previously reported [50, 51].

One problem that we encounter in reviewing the literature is the disparity amongst the neuropsychological assessments of IDS. This makes it difficult both to compare the findings of the neuropsychological assessments themselves and to correlate their findings with neurological lesions. Another obstacle that we have encountered is that, in general, dissociations are not established using statistical criteria. This fact complicates comparisons between patients on account of the lack of shared criteria. We therefore believe that it is very important in the use of the single case study methodology, to determine dissociations on the basis of statistical criteria and the most comprehensive neuropsychological assessment possible, including tachioscopic tests and tests of interhemispheric disconnection. This allows better comparison between patients and probably facilitates the possibility of establishing clearer correlations between the findings of the assessment and lesions, thereby improving our understanding of this pathology and the impact of extracallosal lesions of the CC in themselves.

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