Case Report

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Otoneurological aspects in Traumatic Brain Injuries: series of cases

Aspectos otoneurológicos em Traumatismos Cranioencefálicos: série de casos

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ABSTRACT

It is a retrospective, cross-sectional, descriptive, approved by Ethics Research Committee (ERC), under number CAAE 16728013.0.0000.5346. This is a series of cases that aims to investigate the presence of otoneurological symptoms and the postural balance of six patients with dizziness after Traumatic Brain Injury (TBI). Participants were submitted to a clinical anamnesis and the evaluations: Sensory Organization Test through Foam Laser Dynamic Posturography and oculomotor and vestibular tests of Computerized Vectoelectronystamography (VENG). The data were analyzed from the reference values for each evaluation. In posturography, it was observed that the greatest differences between the value obtained and the reference value were in positions VI, V and III, respectively. Sensory analysis indicated alteration mainly in the visual and vestibular preference systems. All the evaluated patients presented at least one alteration in the VENG tests. Five patients had alterations in the caloric test, and none presented alterations to the rotatory chair test (RCT), which evaluates the vestibular compensation. Considering vestibular complaints, four patients were on psychotropic treatment for depression. These results demonstrate the presence of vestibulo-ocular alterations in post-TBI, which should receive special attention due to associated central impairment.

Keywords: Traumatic Brain Injuries; Dizziness; Postural balance; Pathologic nystagmus; Vestibular function tests

RESUMO

Estudo retrospectivo, transversal e descritivo, aprovado pelo Comitê de Ética em Pesquisa (CEP), sob o número CAAE 16728013.0.0000.5346. Trata-se de uma série de casos que tem por objetivo investigar a presença de sintomas otoneurológicos e o equilíbrio postural de seis pacientes com tontura após traumatismo cranioencefálico (TCE). Foram submetidos a uma anamnese clínica e a avaliações: teste de organização sensorial por meio da posturografia dinâmica *foam laser* e provas oculomotoras e vestibulares da vectoeletronistagmografia computadorizada (VENG). Os dados foram analisados a partir dos valores de referência para cada avaliação. Na posturografia, observou-se que as maiores diferenças entre o valor obtido e o valor de referência foram nas posições VI, V e III, respectivamente. A análise sensorial indicou alteração, principalmente, nos sistemas de preferência visual e vestibular. Todos os pacientes avaliados apresentaram ao menos uma alteração nas provas da VENG. Cinco pacientes tiveram alteração na prova calórica e nenhum apresentou alteração na prova rotatória pendular decrescente, que avalia a compensação vestibular. Além das queixas vestibulares, quatro pacientes estavam em tratamento com psicotrópicos para depressão. Tais resultados ratificam a presença de alterações vestíbulo-oculares no pós-TCE, os quais devem receber atenção especial devido ao comprometimento central associado.

Keywords: Lesões encefálicas traumáticas; Tontura; Equilíbrio postural; Nistagmo patológico; Testes de função vestibular

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INTRODUCTION

Traumatic Brain Injury (TBI) is defined as an alteration in brain function caused by an external force, either by closed trauma, explosion or by big acceleration-deceleration[1]. Among the pathophysiological mechanisms of TBI are: concussion, in which there is a temporary loss of consciousness caused probably by transient electrophysiological dysfunction; contusion consisting of varying degrees of petechial hemorrhage, edema and tissue destruction, generally leading to prolonged unconsciousness; skull fractures, when a stroke exceeds the elastic tolerance of the bone; cranial nerve injuries; changes in cortical excitability[2].

There are two main categories of neurobiological mechanisms of traumatic brain injury: focal and diffuse lesion. The focal lesion includes cortical or subcortical contusions and lacerations, as well as intracranial hemorrhages. It occurs due to the direct severe impact on the brain and is seen mainly in severe cases of TBI. Diffuse injury is caused by stretching and shearing of brain tissue independent of skull fracture, direct impact or compression injury on the surface of the brain. The diffuse axonal injury, the main form of this mechanism, results from acceleration/deceleration forces that lead to the rupture of axons[3].

The focal lesion may directly affect the labyrinth, causing perilymphatic fistulas, Benign Paroxysmal Positional Vertigo (BPPV) and unilateral vestibular hypofunction. The diffuse lesions may reach the structures that participate in the vestibular compensation process, namely, cerebellum, cortex, reticular formation, visual and proprioceptive systems and vestibular nuclei, compromising the process of integrating information from the afferent systems[4].

The most common acute, subacute and chronic disabilities observed after TBI are sensorineural disorders such as cognitive disturbances of sleep and hearing (tinnitus, changes in auditory processing), with significant occurrence of changes in body balance[1].

A common symptom in this population, dizziness is characterized as instability or imbalance, mainly due to neurological damage (cerebellum, cranial nerves related to ocular motricity, among others) or dizziness - rotational dizziness - when the impact reaches the vestibular system. This system is responsible for sending information about the perception of linear and rotational acceleration, positioning and head mobility[5] to the Central Nervous System (CNS).

Changes in body stability may also be after the damage in the relationship among vestibular, somatosensory and visual systems information. The processing of these afferents, resulting in vestibular reflexes, provides stability in the static balance invariably, or proportionally, during dynamic balance. In the absence of functionality of any of the related systems, the CNS will demonstrate impediments to process this information effectively[6].

There is difficulty in the clinical definition of dizziness in the TBI, due to the variability of the symptoms, which have been traditionally attributed to brain lesions, but do not always discriminate objectively. Despite the increasing number of research involving evaluation and rehabilitation strategies for this population, accurate investigations that identify specific deficits in each system, normal situation or sensory overload still lack in the clinical routine. Vestibulometry can provide concrete data on the postural balance and motor coordination of the patient, relating these data to their functional capacity, helping to detect the etiology of the symptoms after the impairment[7].

The objective of this research was to investigate the otolaryngological symptoms and to evaluate the postural balance of six patients after traumatic brain injury.

CLINICAL CASE PRESENTATION

It is a retrospective, cross-sectional, descriptive, approved by Ethics Research Committee (ERC), under number CAAE 16728013.0.0000.5346. All patients signed Informed Consent Form, consenting to the performance and dissemination of the research and its results.

The exams were extracted from a database of patients seen at a University Hospital Equilibrium Outpatient Clinic. All patients answered to an anamnesis to obtain current and past medical history, with questions about the main complaint, presence and characteristics of dizziness, as well as health issues in general.

For the evaluation of the body balance, the Foam-laser Dynamic Posturography[8] was used, with a subsequent analysis of the results of the Sensory Organization Test (SOT). The test consisted of: a) placing the patient in ortostasis, with bipodal support, without shoes, arms extended along the body inside a cabin of $1m^2$, with 2m height, made with detachable iron support, wrapped by tissue with horizontal lists, alternating in light and dark, of 10cm each; b) around the patient´s waist was placed a handmade belt, containing a laser-beam pen, at the level of the 2nd lumbar vertebra. It was directed pointing to a scale in paper millimeter (50cm X 50cm), fixed horizontally in the upper part of the cabin. The anteroposterior displacement of the patient was evaluated through the bundle during the six stages of the SOT, all lasted 20 seconds each (Figure 1).

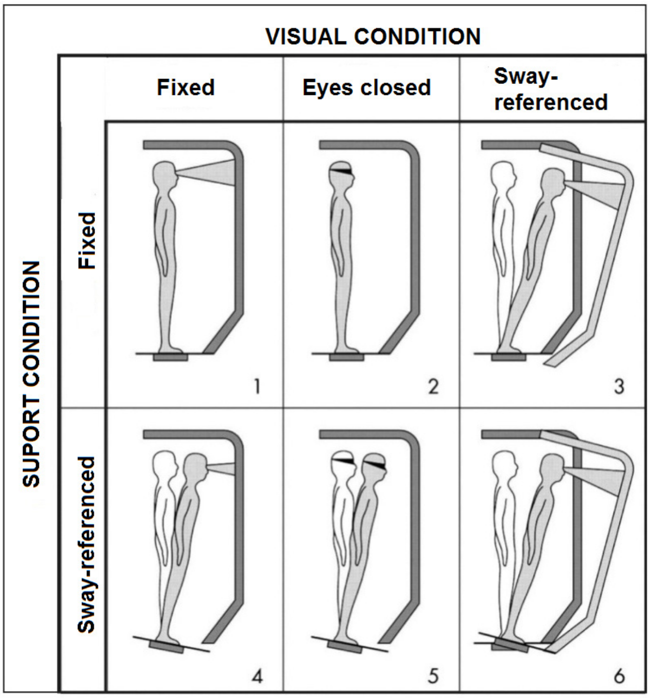

Figure 1. Sensory conditions and positions evaluated in the Foam Laser Dynamic Posturography
Source: adapted from Castagno (1994)

The calculation of the anteroposterior deviations was made through the Excel software; the verification of the preferences of the visual, somatosensory and vestibular functions were analyzed according to the means of the SOT according to the following formulas: Somatosensory function: SOT II/SOT I; Visual function: SOT IV/SOT I; Vestibular function: SOT V/SOT I; Balance index: (SOTIII + SOT VI)/(SOT II + SOT IV). The normal values for SOT: SOT I (90%), SOT II (83%), SOT III (82%), SOT IV (79%), SOT V (60%), SOT VI (54%).

Subsequently, the patients performed the Computerized Vectoelectronystamography (VENG), with the Contronic system, model SCV, version 5.0. The following criteria were adopted: a) oculomotor tests - calibration of regular ocular movements; open eyes spontaneous nystagmus absent and eyes closed with Slow Component Angle Velocity (SCAV) up to 7º/s; absent vertical and horizontal semi-spontaneous nystagmus; horizontal and vertical pendular tracing pattern type I; optokinetic nystagmus considered symmetrical up to 20%; b) vestibular tests - Rotatory Chair Test (RCT), patient with the head at 30 anterior, symmetrical up to 30% and; Caloric test for water at hot temperatures - 44ºC and cold - 30ºC, with absolute valuesbetween 3º/s and 50º/s and relative values up to 30%. For the VENG, all the patients were previously prepared: abstain from the use of labyrinth stimulants, such as coffee, chocolate, alcoholic beverages (24 hours before the exam); suspending CNS depressant medications (48 hours earlier); on the day of the procedure, avoid excessive fatigue, light meals (three hours before), use glasses instead of contact lenses (interference in recording the trace), avoid makeup and facial creams to facilitate electrical conductivity.

Six subjects, three women and three men, aged between 21 and 54 years old, complained of long-term dizziness after TBI due to traffic accidents (three) and occupational accidents (three). The presence of other symptoms of TBI, such as neurovegetative, visual, headache, and psychotropic medications (Table 1) was also observed.

From all the patients evaluated in the posturography, percentages were lower than the reference standards in most positions, with unanimity in positions II, III, and VI of the SOT. The position with the greatest difference between the value obtained and the reference value was III, followed by positions VI and V (Table 2). In this sense, in relation to the sensory analysis, the systems with the worst values obtained on average, relative to the reference standards were visual and vestibular preference, respectively (Table 3).

Regarding the Computerized Vectoelectronystamography, all patients evaluated had at least one alteration. Of these, five presented alterations in the caloric test, indicated by vestibular dysfunction, four hyperreflexia (one bilateral case) and one case with directional predominance of nystagmus. No patient presented alterations in the assessment of vestibular compensation, that is, all cases had RCT within the reference standards (Table 3).

DISCUSSION

The symptoms reported by the patients of this research were previously described in a study with subjects with whiplash. Complaints include headache, instability or dizziness, irritability, inability to concentrate, sweating, depression, other personality changes and also sensory changes such as tinnitus, hearing loss, visual changes, among others. These symptoms occur in different combinations and are related to changes in body balance[9].

Table 1. Clinical characteristics of the subjects collected from the anamnesis (n = 6)

Characteristics	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Gender	F	F	F	M	M	M
Age	21 years	37 years	21 years	46 years	54 years	50 years
Causes of TBI	Traffic accident	Occupational	Traffic accident	Occupational	Traffic accident	Occupational
Type of TBI	Blunt trauma	Non-blunt trauma	Non-blunt trauma	NS	NS	Blunt trauma
Type of lesion	Diffuse	Diffuse	Diffuse e focal	SE	SE	Focal
Time of lesion	1 year	3 years	2 years	8 years	7 years	5 years
Dizziness	Objective vertigo (E) Cinetose	Objective vertigo (SLE)	Imbalance (SE)	Subjective vertigo (E)	Objective vertigo (SLE)	Imbalance (D)
Duration	Minutes	Hours	Hours	Hours	Hours	Hours
Neurovegetative symptoms	Nausea, vomit, sweating	-	Nausea	Nausea, sweating	-	-
Hearing symptoms	Bilateral acute tinnitus	-	Acute tinnitus (RE),	Severe tinnitus (LE)	Hearing Loss	Acute tinnitus (LE)
Visual symptoms	-	Diplopia	Oscillography, darkening of vision	-	Oscillography	-
Others	-	Headache (occipital)	Headache, tingling in the lower body (L)	Feeling of weakness	Pulsatile headache Lack of memory	Headache, neck pain, reading difficulty
Medications:	-	Benz. (Clonazepam); SRI (fluoxetina)	TA (Nortriptilina)	-	SRI (Not specified)	SRI (paroxetina)
Comments:	Worsening of sensory overload symptoms	Worsening of stress symptoms	-	-	Bad adaptation of corrective lenses	Worsening of symptoms to physical effort

Legend: (F) -Female; (M) - Male; (L) - Left; (R) - Right; NS - Not specified; SRI - serotonin reuptake inhibitor; Benz - Benzodiazepine; TA - Tricyclic antidepressant; (-) - absent

Table 2. Mean and differential values obtained in the Sensory Organization Test (SOT) and Sensory Analysis of subjects with dizziness after traumatic brain injury

Sensory Organization Test								
Positions	**Reference value**	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**	**Mean of SOT**
SOT I	90	**77.67**	**81.31**	**84.20**	**86.12**	90.65	**81.43**	**83.56**
SOT II	83	**44.51**	**62.71**	**78.95**	**72.27**	**81.31**	**75.26**	**69.17**
SOT III	82	**17.52**	**26.14**	**73.70**	**31.33**	**81.31**	**69.10**	**49.85**
SOT IV	79	**49.99**	81.31	**78.95**	81.49	**58.08**	81.43	**71.87**
SOT V	60	**-13.71***	**-34.17***	**58.03**	**53.93**	**30.65**	62.96	**26.28**
SOT VI	54	**-18.77***	**-34.17***	**22.12**	**9.23**	**35.18**	**50.73**	**10.72**
Individual mean		26.20	30.52	65.99	55.73	62.86	70.15	
Sensory analysis								
Systems	**Reference value**	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**	**Mean of systems**
SOM	92	**57.31**	**77.12**	93.76	**83.92**	**89.69**	92.42	**82.37**
VIS	88	**64.37**	100	93.76	94.63	**64.07**	100	**86.14**
VEST	67	**17.66**	**-42.03**	68.91	**62.63**	**33.81**	77.31	**36.38**
PREF	95	**-4.07**	**-28.13**	**69.95**	**32.14**	104.04	**86.70**	**43.44**
Individual mean		33.82	26.74	81.59	68.33	72.90	89.11	

Subtitle: [**bold**] = Value below reference standard; (*) = Fall during the Sensory Organization Test

Table 3. Results obtained in the oculomotor and vestibular tests of Computerized Vectoeletronystagmography (n = 6)

Tests	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Calibration-H	Regular	Regular	Regular	Regular	Regular	Regular
Calibration-V	Regular	Regular	Regular	Regular	Irregular	Regular
SN OE	-	-	-	-	-	-
SN EC	-	+ 4º/s L	+ 9º/s L	-	+ 9º/s R	+ vertical 12º/s R
SSN	-	-	-	-	-	-
PT-H	Type I	Type II	Type I	Type II	Type III	Type I
PT-V	Type III	Type II	Type I	Type III	Type III	Type I
ON	Symmetry 5% R	Symmetry 3% L	Assymetry 24% L	Symmetry 7% L	Symmetry 10% R	Symmetry 7% R
RCT	Symmetry 20% CC	Symmetry 15% C	Symmetry 8% C	Symmetry 14% C	Symmetry 15% C	Symmetry 10% CC
Caloric test	Hyperreflexia 59º/s R	Hyperreflexia 71º/s R	Hyperreflexia 55º/s L	Normoreflexia DPN 25% L	DPN 40% R	Hyperreflexia 53º/s bilateral

Subtitle: H = horizontal; V = vertical; SN = spontaneous nystagmus; OE = open eyes abertos; EC = eyes closed; SSN = semi-spontaneous nystagmus semiespontâneo; PT = pendular tracking; ON = optokinetic nystagmus; RCT = rotatory chair test; C = clockwise; CC = counterclockwise; R = right; L = left; DPN = directional preponderancel of nystagmus

Vertigo may persist in 59% of individuals after five years of recovery. Patients with mild TBI, with symptoms of dizziness and imbalance, often experience a slower recovery and are less likely to return to work activity when compared to those without dizziness. In addition, ototoxicity due to medication used to treat conditions associated with head injury may, on rare occasions, affect the vestibular system, causing temporary or permanent changes in the maintenance of body balance(10).

Among the most commonly affected cranial nerves are the optic, oculomotor, trochlear and vestibulocochlear nerves(2). This was confirmed both by the symptoms presented by five patients, who reported visual complaints (diplopia, oscillopsia and reading difficulties), and by the results of the VENG, in which the majority of the individuals presented at least one alteration in the oculomotor tests.

Regarding tinnitus, referred by four patients, it appears concomitantly with other symptoms resulting from cranial and cervical trauma. This symptom is present in about 50% of cases of temporal bone fracture. It may present in a continuous or pulsatile form, being correlated with vascular lesions, whereas that associated with labyrinthine concussion, disarticulation of the ossicular chain, perilymphatic fistula, among others(11).

Post-traumatic headache, reported by four patients, can be caused by functional and/or organic changes housed in the cervical region, called cervicogenic headache. Occurs by events of chest pain, tightening, burning, or pinched in the occipital region and radiating through the temporal, frontal, ocular, pre or retroauricular region. It may or may not be accompanied by craniofacial neurovegetative manifestations such as tearing, ocular erythema, palpebral edema, rhinorrhea and dizziness(12).

For the total cases presented, four were under treatment with psychotropic drugs, three with SSRIs and one with tricyclic antidepressants. SRIs, in terms of their pharmacology, block the presynaptic neuronal membrane receptors maximizing the duration of serotonin (5-HT) action. Nortriptyline hydrochloride inhibits the reuptake of norepinephrine and serotonin in the CNS.

At the starting of treatment, both drugs may have a moderate sedative effect or decrease in motor coordination, resulting in blurred vision and drowsiness. However, the effects tend to subside or disappear after the first few weeks of treatment[13]. Furthermore, the subjects were instructed to discontinue the use of non-vital medications for 48 hours prior to the examination.

Depression cases is common in the first years after injury and some researchers relate psychosocial issues, such as changes in occupational activities, interpersonal relationships, and decreased independence in daily life activities[14]. Acute post-injury screening for the presence of a psychiatric history or current suffering may help identify individuals who require, including vestibular rehabilitation, psychiatric support.

The SN with closed eyes, which may be associated with a peripheral or central labyrinth, was observed in four patients, three with SCAV above 7°/s (two with oscillopsia complaint). However, one patient had SN in the vertical direction, type of nystagmus associated with central etiology. Its pathophysiology reveals asymmetry of central oculomotor tone[6].

In the caloric test, SN with closed eyes can cause directional preponderance to the same stimulated side and lead to directional asymmetry superior to standard of post-caloric nystagmus[6], as can be verified in case 5, or add to the SCAV in absolute values interfering with the caloric test result, as in case 3. In the other cases in which SN was present, its direction was the same as that of hyperreflexia or vertical (case 6), with less interference of SCAV in the post-caloric result.

The results of posturography showed worse values, on average, in SOT V and VI and, consequently, in the vestibular and visual preference systems. In cases 1 and 2, there were alterations in both the oculomotor VENG and caloric tests, a fact corroborated by the sensorial analysis in posturography, in which the systems with the worst values were those mentioned above.

In case 3, there was presence of closed-eyes nystagmus and vestibular dysfunction, including value within the reference standard for the vestibular system in posturography. The values confirm this result where RCT symmetry was observed, indicating vestibular compensation. On the other hand, there was asymmetry in the optokinetic nystagmus test, in accordance with the oscillopsis complaint and the inferior results for the visual preference system in posturography.

In case 4, a lower value can be observed mainly in the visual preference system, corroborating the results of the VENG, namely alteration only in pendular tracing, with normal caloric test. Case 5 presented worse values in the visual and vestibular systems of posturography, in agreement with the alterations in the oculomotor and vestibular tests of the VENG. In spite of the presence of oscillopsia, in this case, highlighting the fact that this patient has reported bad adaptation of the corrective lenses, which may intensify the complaint of dizziness and also make it difficult to perform the visual tests.

Case 6, on the other hand, presented less altered values to posturography, however with vertical spontaneous nystagmus and bilateral hyperreflexia to VENG. The only sensory condition that presented a lag in relation to the others was the visual preference.

In all cases vestibular compensation was observed. It is known that this is a sequence of events that occur shortly after an injury to the vestibular system and the patients of the present study, in turn, had injuries considered chronic (from 12 months to eight years). In addition, in cases 1, 2 and 3, absolute values of RCT were lower than the absolute values of the caloric test, as well as in case 6, but with more discrete values in this case (Figure 2). Despite the divergence in the literature, this phenomenon, characterized as decoupling, refers to the inversion of what is expected in normal individuals, in which the RCT values are more intense than the values obtained to the caloric test, being more frequent in alterations[15].

Although the most frequently mentioned regions are brainstem and cerebellum[15], it is questioned the involvement of supratentorial lesions among the alterations in the ability to inhibit low-frequency stimuli (caloric test) in contrast to the more intense stimulus of RCT, especially in cases of diffuse

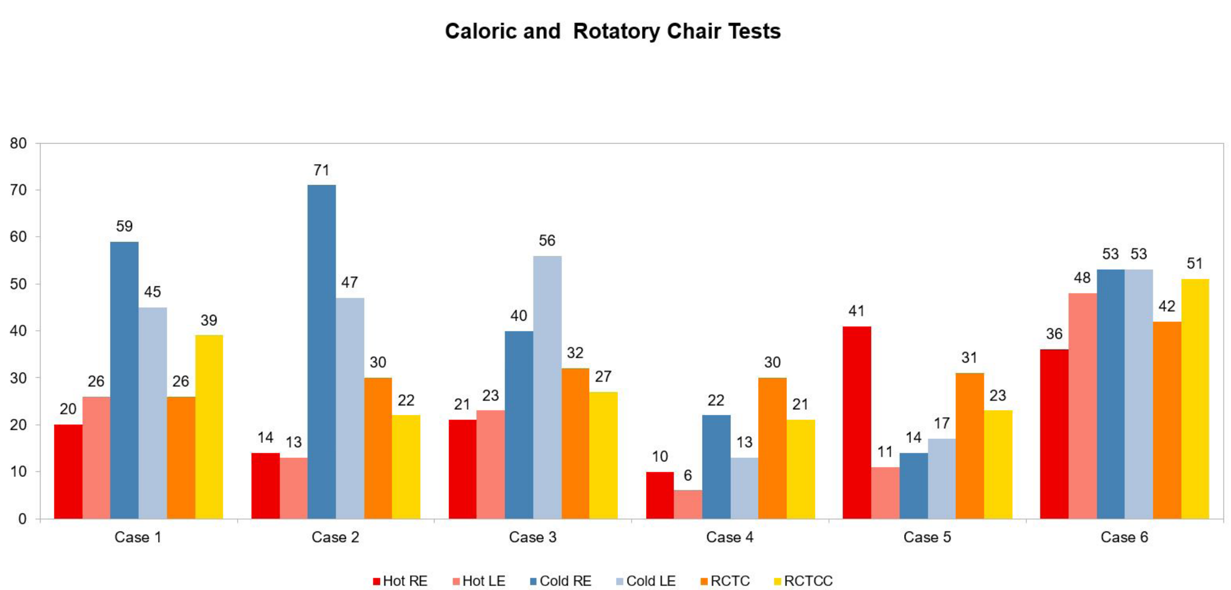

Figure 2. Comparison between the absolute values, in degrees per second, obtained in the Rotatory Chair Test (RCT) and in the Caloric Test, by subject (n = 6)
Subtitle: RE - Right ear; LE - Left ear; RCTC - clockwise; RCTCC - counterclockwise

lesion, which may not be easily identified in macroscopic examinations.

This study has limitations: it was not possible to detail some specificities of the subjects' hospitalization, such as the degree of severity of TBI (commonly verified by the Glasgow scale), as well as possible surgical procedures. Therefore, a better definition of the lesions among other characteristics in the acute phase of the trauma should be considered in future studies on the issue.

FINAL COMMENTS

The patients presented otoneurological symptoms resulting from the TBI, such as neurovegetative and vestibular-ocular. Psychotropic medications were also observed. The results of the foam laser dynamic posturography and computerized vectoelectronystagmography indicated changes due to traumatic brain injury justifying the complaint of dizziness. There were alterations indicative of central lesion: vertical nystagmus, irregular calibration and more intense responses to the caloric test in relation to the rotatory test. In addition, the presence of oculomotor changes may be an alert for interferences in the interpretation of the vestibular exam and, in this sense, posturography represents an important tool to aid in the diagnosis and therapeutic follow-up.

This scenario assumes a relevant aspect in the early otoneurological diagnosis of patients after TBI, since it can influence the conduct of the therapeutic process and thus the affected individuals' quality of life.

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