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Diagnostic evaluation of neck torsion test in objective examination in patients with vertigo and/or hearing-impairment

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ABSTRACT:

Introduction. The aim of the study was to evaluate the neck torsion test in objective examinations of patients with vertigo and/or hearing loss.

Material and methods. The study was conducted in 100 patients, including 54 women and 46 men aged 17–79 years, who were divided into two groups: I – 50 patients, including 30 women and 20 men aged 17–79 years (mean age 49.92 years) with dizziness and/or hearing impairments, and confirmed asymmetry of intracranial vessels, II – 50 patients – control group, including 24 women and 26 men aged 20–71 years without dizziness and/or hearing disorders and without disturbance in the construction of intracranial vessels. For each patient, the following tests were carried out: subjective, objective otorhinolaryngological, Doppler ultrasound specifying diameter of vertebral and carotid arteries and the velocity of blood flow in these vessels, audiological diagnostics, including the examination of latency of waves I, III, V of the auditory evoked potentials of the brain stem, otoneurological diagnostics with used the neck torsion test.

Results. It appears from the analysis of the material presented that the application of the neck torsion test in the Doppler ultrasound results in the fact that the difference in the mean systolic velocity of blood flow in vertebral artery is higher on the side opposite to the turning of the neck, and the increase in the average diastolic blood flow velocity in the vertebral artery on the side of the test being performed and its reduction on the opposite side in the study group, when compared to the control group. The value of the wave I, II, V latency in the ABR test during the neck torsion test is extended more in the study group than in the controls, on the side of the performed test. The performed neck torsion test in the VNG test increases the occurrence of both, square waves and nystagmus (much higher in the study group than in the controls).

Conclussion. The application of the neck torsion test in the Doppler ultrasound, ABR and VNG test in patients with vertigo and/or hearing loss means that these tests become functional, thereby increasing their diagnostic value and may be used to monitor the rehabilitation of inner ear disorders.

KEYWORDS: neck torsion test, objective examination, vertigo, hearing-impairment

INTRODUCTION

The symptomatology of the anomalies of carotid and vertebral vessels is very diverse and seems to be associated with the kind of anomaly. The presence of anomaly can be clinically silent and be discovered accidentally while performing medical imaging of the circulatory system, cause isolated symptoms or complex syndromes of subjective conditions to the affected person [1].

As it was mentioned above, the character of the reported complaints depends on the kind of the anomaly. It is essential whether a given lesion has influence on vessel capacity in performing its basic function, which is supplying relevant structures in blood, or causes changes in anatomical position resulting from incorrect vascular course or build which can cause negative effects on adjacent structures that in normal conditions have no contact with the vessel affected by anomaly. As the vast majority of information about the anomalies of carotid and vertebral vessels comes from single case reports, finding a syndrome or symptoms which could with great sensitivity and specificity indicate this problem is difficult.

Among the symptoms that are the most often described in global literature, paroxysmal vertigo and dizziness come to

the fore. Other reported complaints which can coexist with them or occur as isolated symptoms or in complexes are gait instability, nausea, double vision, syncope, bilateral tinnitus, decrease of hearing, cervical radiculopathy and headache [2, 3, 4, 5].

A wide and heterogenic set of symptoms caused by the anomalies of carotid and vertebral vessels and the mechanism of their pathogenesis that is not always fully explained as well as coexisting systemic diseases which could cause reported complaints make the diagnostics of these lesions especially challenging. It seems reasonable to search for even more perfect management algorithms allowing at least to select the group of patients in whom the diagnostics will be properly oriented, extended and will allow to make a proper diagnosis.

The aim of this study was to assess the diagnostic value of the neck torsion test in objective studies in patients with vertigo and/or hearing loss.

MATERIAL AND METHODS

The study was conducted in 100 patients, including 54 women and 46 men, in the age of 17-79 years (mean age 47,14), hospitalized in the Otolaryngology, Laryngological Oncology, Audiology and Phoniatry Clinic of the Military Medical Academy University Hospital in Łódź, who were divided into two groups:

I - 50 patients, including 30 women and 20 men aged 17-79 (mean age 49.92) with vertigo and/or hearing loss and confirmed carotid or vertebral vessels anomaly,

II - 50 patients - control group, including 24 women and 26 men aged 20-71 years (mean age 44.36) without vertigo and/or hearing loss and without abnormalities in build of carotid and vertebral vessels (operated on in the Clinic due to nasal septum deviation).

In each patient we performed as follows:

- physical examination,
- otorhynolaryngology examination,
- Doppler ultrasound examination with the evaluation of diameter of vertebral and cervical arteries and blood flow velocity in these vessels in the straight head position and afterwards evaluation of blood flow velocity in the vessel of different anatomy with the neck torsion of 60 degrees towards this vessel and evaluation of blood flow velocity in analogous vessel on the opposite site with the neck torsion of 60 degrees towards that vessel,
- audiology diagnostics, including evaluation of wave I, III, V latency of auditory brainstem evoked potentials in the straight head position while stimulating right and left ear and afterwards recording of the potentials while stimulating right ear with the neck torsion of 60 degrees to the right and left ear with the analogous degree of torsion to the left.
- otoneurologic diagnostics, including full VNG examination with the recording of eye movement in the straight head position and with the neck torsion of 60 degrees to the right and to the left, using neck torsion test.

At the beginning of the VNG examination calibration and so called eye detection, which is finding the pupil as a dark spot in the field registered by the camera, were performed. After air caloric test following parameters were analysed:

- vestibular deficit,
- occurrence of square wave jerks and nystagmus,

The study was approved by the Bioethics Committee of Medical University in Łódź no. RNN/90/13/KB from 2013 Feb 19.

The obtained results underwent statistical analysis with following significance tests: Wilcoxon–Mann–Whitney rank-sum test, van Elteren test, $\chi 2$ test, Fisher's exact test, log-linear analysis, generalized linear models with elastic standard errors.

RESULTS

The analyzed mean value of left vertebral artery diameter in research group was 3.27 mm and in control group 3.36 mm (Tab. I). The differences in the value of left vertebral artery diameter between groups were not statistically significant (**p=0.413**).

The mean value of systolic blood flow velocity in right vertebral artery in research group patients in resting phase is 48.00 cm/s and in control group 48.62 cm/s (Tab. II). The differences in systolic blood flow velocity values in right vertebral artery between groups in resting phase were not statistically significant (**p=0.771**).

The assessed mean value of diastolic blood flow velocity in right vertebral artery in research group in resting phase is 14.68 cm/s and in control group 16.12 cm/s (Tab. II). The differences in diastolic blood flow velocity values in right vertebral artery between groups in resting phase were not statistically significant (**p=0.098**).

The mean value of systolic blood flow velocity in right vertebral artery in patients in research group in the right neck torsion phase is 50.77 cm/s and in control group 49.84 cm/s (Tab. III). The differences in systolic blood flow velocity values in right

Tab. I. Descriptive statistics for the age (years) and diameter of the left and right vertebral artery (mm) in the Doppler ultrasound examination in examined patients

EXAMINED FEATURE		STATISTICAL PARAMETER							THE STATISTICAL SIGNIFICANCE LEVEL OF THE DIFFERENCES
		ME	Q_1–Q_3 (IQR)	SD	SE	95% CI	MIN.–MAX.		
Age (years)	Research group	49,92	53,00	38,00–60,00 (22,00)	15,21	2,15	45,60 – 54,24	17 – 79	P=0,063
	Control group	44,36	44,50	32,00–57,00 (24,00)	14,34	2,03	40,28–48,43	20–71	
	Total	47,14	49,00	35,00–58,50 (23,50)	14,97	1,50	44,17 – 50,11	17–79	
Right vertebral artery diameter (mm)	Research group	3,05	2,95	2,50–3,70 (1,20)	0,72	0,10	2,85–3,26	1,90–4,30	P=0,429
	Control group	3,16	3,20	2,80–3,60 (0,80)	0,56	0,08	3,00–3,31	1,50–4,40	
	Total	3,11	3,00	2,65–3,60 (0,95)	0,64	0,06	2,98–3,23	1,50–4,40	
Left vertebral artery diameter (mm)	Research group	3,27	3,30	3,00–3,70 (0,70)	0,64	0,09	3,08–3,45	1,30–4,40	P=0,413
	Control group	3,36	3,40	3,00–3,70 (0,70)	0,46	0,07	3,23–3,49	2,30–4,30	
	Total	3,31	3,30	3,00–3,70 (0,70)	0,56	0,06	3,20–3,42	1,30–4,40	

Tab. II. Descriptive statistics for the value of systolic and diastolic blood flow velocity in right vertebral artery (cm/s) in examined patients in resting phase.

EXAMINED FEATURE		STATISTICAL PARAMETER							THE STATISTICAL SIGNIFICANCE LEVEL OF THE DIFFERENCES
		ME	Q_1–Q_3 (IQR)	SD	SE	95% CI	MIN.–MAX.		
Systolic velocity (cm/s)	Research group	48,00	47,00	42,00–54,00 (12,00)	10,64	1,51	44,97–51,02	30–74	P=0,771
	Control group	48,62	46,50	40,00–57,00 (17,00)	10,62	1,50	45,60–61,64	32–74	
	Total	48,31	47,00	41,00–54,00 (13,00)	10,58	1,06	46,21–50,41	30–74	
Diastolic velocity (cm/s)	Research group	14,68	14,00	12,00–17,00 (5,00)	3,75	0,53	13,61–15,75	8–25	P=0,098
	Control group	16,12	14,00	13,00–18,00 (5,00)	4,79	0,68	14,76–17,48	7–28	
	Total	15,40	14,00	12,50–18,00 (5,50)	4,34	0,43	14,54–16,26	7–28	

vertebral artery between groups in right neck torsion phase were not statistically significant (**p=0.671**).

The assessed mean value of diastolic blood flow velocity in right vertebral artery in research group in right neck torsion phase is 15.33 cm/s and in control group 17.04 cm/s (Tab. III). The differences in diastolic blood flow velocity values in right vertebral artery between groups in right neck torsion phase were not statistically significant (**p=0.064**).

The mean value of systolic blood flow velocity in right vertebral artery in patients in research group in the left neck torsion phase is 50.68 cm/s and in control group 49.08 cm/s (Tab. IV). The differences in systolic blood flow velocity values in right vertebral artery between groups in left neck torsion phase were not statistically significant (**p=0.457**).

The mean value of diastolic blood flow velocity in right vertebral artery in research group in left neck torsion phase is 15.41 cm/s and in control group 19.92 cm/s (Tab. IV). The differences in diastolic blood flow velocity values in right vertebral artery between groups in left neck torsion phase were not statistically significant (**p=0.555**).

The mean value of systolic blood flow velocity in left vertebral artery in patients in research group in resting phase was 47.80 cm/s and in control group 48.12 cm/s (Tab. V). The differences in systolic blood flow velocity values in left vertebral artery between groups in resting phase were not statistically significant (**p=0.882**).

The mean value of diastolic blood flow velocity in left vertebral artery in research group in resting phase was 16.31 cm/s and in control group 16.34 cm/s (Tab. V). The differences in diastolic blood flow velocity values in left vertebral artery between groups in resting phase were not statistically significant (**p=0.974**).

The assessed mean value of systolic blood flow velocity in left vertebral artery in patients in research group in right neck torsion phase was 49.60 cm/s and in control group 48.92 cm/s (Tab. VI). The differences in systolic blood flow velocity values

Tab. III. Descriptive statistics for the value of systolic and diastolic blood flow velocity in right vertebral artery (cm/s) in examined patients in right neck torsion phase

EXAMINED FEATURE		STATISTICAL PARAMETER							THE STATISTICAL SIGNIFICANCE LEVEL OF THE DIFFERENCES
		ME	Q_1–Q_3 (IQR)	SD	SE	95% CI	MIN.–MAX.		
Systolic velocity (cm/s)	Research group	50,77	50,00	43,00–58,00 (15,00)	11,56	1,65	47,45–54,09	29–80	
	Control group	49,84	50,00	43,00–56,00 (13,00)	10,16	1,44	46,95–52,73	33–79	P=0,671
	Total	50,30	50,00	43,00–56,00 (13,00)	10,83	1,09	48,14–52,46	29–80	
Diastolic velocity (cm/s)	Research group	15,33	15,00	12,00–18,00 (6,00)	4,23	0,60	14,11–16,54	9–26	
	Control group	17,04	16,00	13,00–20,00 (7,00)	4,82	0,68	15,67–18,41	10–29	P=0,064
	Total	16,19	16,00	12,00–19,00 (7,00)	4,60	0,46	15,2–17,11	9–29	

Tab. IV. Descriptive statistics for the value of systolic and diastolic blood flow velocity in right vertebral artery (cm/s) in examined patients in respective groups in left neck torsion phase

EXAMINED FEATURE		STATISTICAL PARAMETER							THE STATISTICAL SIGNIFICANCE LEVEL OF THE DIFFERENCES
		ME	Q_1–Q_3 (IQR)	SD	SE	95% CI	MIN.–MAX.		
Systolic velocity (cm/s)	Research group	50,68	51,00	43,00–57,00 (14,00)	10,85	1,53	47,60–53,77	30–79	
	Control group	49,08	49,00	41,00–57,00 (16,00)	10,46	1,49	46,08–52,09	18–68	P=0,457
	Total	49,89	50,00	42,00–57,00 (15,00)	10,64	1,07	47,77–52,01	18–79	
Diastolic velocity (cm/s)	Research group	15,41	15,00	12,00–18,00 (6,00)	4,39	0,62	14,16–16,66	9–29	
	Control group	15,92	15,50	13,00–18,00 (5,00)	4,17	0,59	14,73–17,11	6–28	P=0,555
	Total	15,67	15,00	12,00–18,00 (6,00)	4,27	0,43	14,82–16,51	6–29	

Tab. V. Descriptive statistics for the value of systolic and diastolic blood flow velocity in left vertebral artery (cm/s) in examined patients in resting phase

EXAMINED FEATURE M		STATISTICAL PARAMETER							THE STATISTICAL SIGNIFICANCE LEVEL OF THE DIFFERENCES
		ME	Q_1 – Q_3 (IQR)	SD	SE	95% CI	MIN. – MAX.		
Systolic velocity (cm/s)	Research group	47,80	48,00	42,00 – 53,00 (11,00)	11,60	1,66	44,46 – 51,13	25 – 75	
	Control group	48,12	47,50	43,00 – 53,00 (10,00)	10,09	1,43	45,25 – 50,99	25 – 75	P = 0,882
	Total	47,96	48,00	42,00 – 53,00 (11,00)	10,81	1,09	45,80 – 50,11	25 – 75	
Diastolic velocity (cm/s)	Research group	16,31	16,50	13,00 – 19,00 (6,00)	4,38	0,63	15,04 – 17,58	7 – 27	
	Control group	16,34	16,00	13,00 – 19,00 (6,00)	4,03	0,57	15,19 – 17,49	8 – 28	P = 0,974
	Total	16,33	16,00	13,00 – 19,00 (6,00)	4,18	0,42	15,49 – 17,16	7 – 28	

in left vertebral artery between groups in right neck torsion phase were not statistically significant (**p=0.784**).

The mean value of diastolic blood flow velocity in left vertebral artery in research group in in right neck torsion phase was 17.12 cm/s and in control group 17.38 cm/s (Tab. VI). The differences in diastolic blood flow velocity values in left vertebral artery between groups in right neck torsion phase were not statistically significant (**p=0.791**).

The analyzed mean value of systolic blood flow velocity in left vertebral artery in patients in research group in left neck torsion phase was 49.81 cm/s and in control group 48.30 cm/s (Tab. VII). The differences in systolic blood flow velocity values in left vertebral artery between groups in left neck torsion phase were not statistically significant (**p=0.537**).

The mean value of diastolic blood flow velocity in left vertebral artery in research group in left neck torsion phase was 17.08 cm/s and in control group 16.50 cm/s (Tab. VII). The differences in diastolic blood flow velocity values in left vertebral artery between groups in left neck torsion phase were not statistically significant (**p=0.555**).

Tab. VI. Descriptive statistics for the value of systolic and diastolic blood flow velocity in left vertebral artery (cm/s) in examined patients in right neck torsion phase

EXAMINED FEATURE		STATISTICAL PARAMETER							THE STATISTICAL SIGNIFICANCE LEVEL OF THE DIFFERENCES
		ME	Q_1–Q_3 (IQR)	SD	SE	95% CI	MIN.–MAX.		
Systolic velocity (cm/s)	Research group	49,60	50,00	43,00–56,00 (13,00)	13,17	1,88	45,81–53,38	21–83	
	Control group	48,92	48,00	42,00–56,00 (14,00)	11,32	1,60	45,70 – 52,14	24–80	P=0,784
	Total	49,26	50,00	42,00–56,00 (14,00)	12,22	1,23	46,82–51,69	21–83	
Diastolic velocity (cm/s)	Research group	17,12	17,00	13,00–20,00 (7,00)	4,87	0,70	15,70–18,53	9–29	
	Control group	17,38	16,00	14,00–20,00 (6,00)	4,95	0,70	15,97–18,79	9–29	P=0,791
	Total	17,25	16,50	14,00–20,00 (6,00)	4,89	0,49	16,27–18,23	9–29	

Tab. VII. Descriptive statistics for the value of systolic and diastolic blood flow velocity in left vertebral artery (cm/s) in examined patients in left neck torsion phase

EXAMINED FEATURE		STATISTICAL PARAMETER							THE STATISTICAL SIGNIFICANCE LEVEL OF THE DIFFERENCES
		ME	Q_1–Q_3 (IQR)	SD	SE	95% CI	MIN.–MAX.		
Systolic velocity (cm/s)	Research group	49,81	51,00	45,00–55,00 (10,00)	12,22	1,75	46,30 – 53,32	27–75	
	Control group	48,30	47,50	43,00–55,00 (12,00)	11,97	1,69	44,90 – 51,70	22–81	P=0,537
	Total	49,04	49,00	43,00–55,00 (12,00)	12,06	1,21	46,64 – 51,45	22 – 81	
Diastolic velocity (cm/s)	Research group	17,08	17,50	12,50–20,50 (8,00)	5,26	0,76	15,55–18,60	7–29	
	Control group	16,50	16,00	13,00–19,00 (6,00)	4,32	0,61	15,27 – 17,73	9–27	P=0,555
	Total	16,78	17,00	13,00–29,00 (6,00)	4,79	0,48	15,82–17,74	7–29	

The mean wave I latency in ABR examination of right ear in patients in research group in resting phase was 1.76 ms and in control group 1.71 ms (Tab. VIII). The differences in wave I latency values in ABR examination of right ear between groups in resting phase were not statistically significant (**p=0.324**).

The mean wave I latency in ABR examination of right ear in patients in research group in right neck torsion phase was 1.88 ms and in control group 1.79 ms (Tab. VIII). The differences in wave I latency values in ABR examination of right ear between groups in right neck torsion phase were not statistically significant (**p=0.012**).

The analyzed mean wave I latency in ABR examination of left ear in patients in research group in resting phase was 1.79 ms and in control group 1.72 ms (Tab. VIII). The differences in wave I latency values in ABR examination of left ear between groups in resting phase were not statistically significant (**p=0.078**).

The assessed mean wave I latency in ABR examination of left ear in patients in research group in left neck torsion phase was 1.88 ms and in control group 1.74 ms (Tab. VIII). The differences in wave I latency values in ABR examination of left ear between groups in left neck torsion phase were statistically significant (**p=0.001**).

In turn, the mean wave III latency in ABR examination of right ear in patients in research group in resting phase was 3.97 ms and in control group 3.88 ms (Tab. IX). The differences in wave III latency values in ABR examination of right ear between groups in resting phase were not statistically significant (**p=0.096**).

The mean wave III latency in ABR examination of right ear in patients in research group in right neck torsion phase was 4.03 ms and in control group 3.94 ms (Tab. IX). The differences in wave III latency values in ABR examination of right ear between groups in right neck torsion phase were not statistically significant (**p=0.171**).

The analyzed mean wave III latency in ABR examination of left ear in patients in research group in resting phase was 4.00 ms and in control group 3.88 ms (Tab. IX). The differences in wave III latency values in ABR examination of left ear between groups in resting phase were not statistically significant (**p=0.033**).

The assessed mean wave III latency in ABR examination of left ear in patients in research group in left neck torsion phase was 4.08 ms and in control group 3.94 ms (Tab. IX). The differences in wave III latency values in ABR examination of left ear between groups in left neck torsion phase were not statistically significant (**p=0.046).**

Tab. VIII. Descriptive statistics for wave I latency of ABR (ms) in examined patients in respective groups

EXAMINED FEATURE		STATISTICAL PARAMETER							THE STATISTICAL SIGNIFICANCE LEVEL OF THE DIFFERENCES
		ME	Q_1–Q_3 (IQR)	SD	SE	95% CI	MIN.–MAX.		
RE, resting	Research group	1,76	1,75	1,65–1,83 (0,18)	0,20	0,03	1,70–1,82	1,20–2,25	P=0,324
	Control group	1,71	1,70	1,60–1,85 (0,25)	0,27	0,04	1,64–1,79	1,02–2,38	
	Total	1,74	1,70	1,63–1,84 (0,21)	0,24	0,02	1,69–1,78	1,02–2,38	
RE, torsion to the right	Research group	1,88	1,83	1,70–1,98 (0,28)	0,30	0,04	1,79–1,96	1,00–2,60	P=0,012
	Control group	1,79	1,77	1,65–1,85 (0,20)	0,46	0,06	1,66–1,92	0,98–4,34	
	Total	1,83	1,80	1,68–1,95 (0,27)	0,39	0,04	1,76–1,91	0,98–4,34	
LE, resting	Research group	1,79	1,75	1,68–1,89 (0,21)	0,22	0,03	1,73–1,85	1,13–2,45	P=0,078
	Control group	1,72	1,73	1,65–1,83 (0,18)	0,21	0,03	1,65–1,78	1,18–2,30	
	Total	1,75	1,75	1,65–1,86 (0,21)	0,22	0,02	1,71–1,80	1,13–2,45	
LE, torsion to the left	Research group	1,94	1,88	1,75–2,03 (0,28)	0,27	0,04	1,86–2,01	1,55–2,58	P<0,001
	Control group	1,74	1,77	1,63–1,90 (0,27)	0,26	0,04	1,66–1,81	1,10–2,30	
	Total	1,84	1,83	1,68–1,97 (0,29)	0,28	0,03	1,78–1,89	1,10–2,58	

Tab. IX. Descriptive statistics for wave III latency of ABR (ms) in examined patients in respective groups

EXAMINED FEATURE M		STATISTICAL PARAMETER							THE STATISTICAL SIGNIFICANCE LEVEL OF THE DIFFERENCES
		ME	Q_1 – Q_3 (IQR)	SD	SE	95% CI	MIN. – MAX.		
RE, resting	Research group	3,97	3,98	3,85 – 4,09 (0,24)	0,22	0,03	3,90 – 4,03	3,28 – 4,63	P = 0,096
	Control group	3,88	3,90	3,75 – 4,05 (0,30)	0,29	0,04	3,80 – 3,96	3,08 – 4,70	
	Total	3,92	3,92	3,82 – 4,07 (0,25)	0,26	0,03	3,87 – 3,98	3,08 – 4,70	
RE, torsion to the right	Research group	4,03	3,98	3,90 – 4,13 (0,23)	0,39	0,05	3,92 – 4,14	2,93 – 5,93	P = 0,171
	Control group	3,94	3,96	3,78 – 4,10 (0,32)	0,30	0,04	3,85 – 4,02	3,18 – 4,80	
	Total	3,98	3,98	3,82 – 4,13 (0,31)	0,35	0,03	3,91 – 4,05	2,93 – 5,93	
LE, resting	Research group	4,00	3,98	3,83 – 4,11 (0,28)	0,26	0,04	3,93 – 4,08	3,55 – 4,95	P = 0,033
	Control group	3,88	3,96	3,75 – 4,06 (0,31)	0,33	0,05	3,79 – 3,97	3,08 – 4,50	
	Total	3,94	3,98	3,78 – 4,10 (0,32)	0,30	0,03	3,88 – 4,00	3,08 – 4,95	
LE, torsion to the left	Research group	4,08	4,03	3,90 – 4,18 (0,28)	0,32	0,05	3,99 – 4,17	3,63 – 5,28	P = 0,046
	Control group	3,94	3,98	3,78 – 4,13 (0,35)	0,37	0,05	3,84 – 4,04	3,10 – 4,88	
	Total	4,01	3,99	3,80 – 4,16 (0,36)	0,35	0,04	3,94 – 4,08	3,10 – 5,28	

The analyzed mean wave V latency in ABR examination of left ear in patients in research group in resting phase was 5.91 ms and in control group 5.83 ms (Tab. X). The differences in wave V latency values in ABR examination of left ear between groups in resting phase were not statistically significant (**p=0.300**).

The assessed mean wave V latency in ABR examination of left ear in patients in research group in left neck torsion phase was 5.99 ms and in control group 5.78 ms (Tab. X). The differences in wave V latency values in ABR examination of left ear between groups in left neck torsion phase were not statistically significant (**p=0.006).**

The mean value of vestibular deficit in VNG examination in patients in research group is 23.78% and in control group 14.86% (Tab. XI). The differences between the values of vestibular deficit were not statistically significant (**p=0.030**).

The mean value of vestibular deficit in VNG examination in patients in research group on the left site is 30.28% and in con-

Tab. X. Descriptive statistics for wave V latency of ABR (ms) in examined patients in respective groups

EXAMINED FEATURE		STATISTICAL PARAMETER							THE STATISTICAL SIGNIFICANCE LEVEL OF THE DIFFERENCES
		ME	Q_1-Q_3 (IQR)	SD	SE	95% CI	MIN.–MAX.		
RE, resting	Research group	5,85	5,83	5,62–6,00 (0,38)	0,42	0,06	5,73–5,96	4,50–7,55	P=0,481
	Control group	5,79	5,87	5,53–6,00 (0,47)	0,39	0,05	5,68–5,90	4,80–6,70	
	Total	5,82	5,85	5,59–6,00 (0,41)	0,40	0,04	5,74–5,90	4,50–7,55	
RE, torsion to the right	Research group	5,95	5,98	5,70–6,08 (0,38)	0,45	0,06	5,82–6,07	4,63–7,75	P=0,204
	Control group	5,84	5,85	5,65–6,10 (0,45)	0,38	0,05	5,73–5,95	4,95–6,80	
	Total	5,89	5,89	5,65–6,09 (0,44)	0,42	0,04	5,81–5,98	4,63–7,75	
LE, resting	Research group	5,91	5,83	5,70–6,00 (0,30)	0,38	0,05	5,80–6,02	5,43–7,88	P=0,300
	Control group	5,83	5,84	5,58–6,07 (0,49)	0,37	0,05	5,73–5,94	4,88–6,83	
	Total	5,87	5,84	5,64–6,02 (0,38)	0,38	0,04	5,80–5,95	4,88–7,88	
LE, torsion to the left	Research group	5,99	5,93	5,73–6,20 (0,47)	0,36	0,05	5,89–6,09	5,45–7,13	P=0,006
	Control group	5,78	5,79	5,58–6,00 (0,42)	0,38	0,05	5,68–5,89	4,98–6,90	
	Total	5,89	5,90	5,64–6,09 (0,45)	0,39	0,04	5,81–5,96	4,98–7,13	

Tab. XI. Descriptive statistics for vestibular deficit (%) in examined patients depending on the side of the deficit

EXAMINED FEATURE		STATISTICAL PARAMETER							THE STATISTICAL SIGNIFICANCE LEVEL OF THE DIFFERENCES
		ME	Q_1-Q_3 (IQR)	SD	SE	95% CI	MIN.–MAX.		
Vestibular deficit (%)	Research group	23,78	14,00	7,00–34,00 (27,00)	23,40	3,31	17,13–30,43	0,00–89,00	P=0,030
	Control group	14,86	9,50	4,00–16,00 (12,00)	17,48	2,47	9,89–19,83	0,00–77,00	
	Total	19,32	12,00	6,00–23,00 (17,00)	21,03	2,10	15,15–23,49	0,00–89,00	
Vestibular deficit – LE (%)	Research group	30,28	23,00	13,00–43,00 (30,00)	24,48	4,54	20,9 – 39,59	1,00–89,00	P = 0,186
	Control group	20,79	11,00	4,00–29,00 (25,00)	24,67	5,66	8,90 – 32,68	1,00–77,00	
	Total	26,52	14,00	8,00–38,00 (30,00)	24,74	3,57	19,34–33,70	1,00–89,00	
Vestibular deficit – RE (%)	Research group	14,81	8,00	4,00–14,00 (10,00)	18,91	4,13	6,20–23,42	0,00–68,00	P=0,419
	Control group	11,23	9,00	4,00–14,00 (10,00)	9,89	1,78	7,60 – 14,85	0,00 – 43,00	
	Total	12,67	8,00	4,00–14,00 (10,00)	14,17	1,97	8,73–16,62	0,00–68,00	

trol group 20.79% (Tab. XI). The differences between the values of vestibular deficit on the left site were not statistically significant (**p=0.186**).

The mean value of vestibular deficit in VNG examination in patients in research group on the right site is 14.81% and in control group 11.23% (Tab. XI). The differences between the values of vestibular deficit on the left site were not statistically significant (**p=0.419**).

In VNG examination in research group square wave jerks in resting phase occurred in 48.00% patients and in control group in 32.00% and lack of square wave jerks was noted in 52.00% and 68.00%, accordingly. The differences in the occurrence of square wave jerks in VNG examination between groups were not statistically significant **(p=0.102)**.

In patients in research group in VNG examination square wave jerks in right neck torsion phase occurred in 60.47% patients and in control group in 32.61% and lack of square wave jerks was described in 39.53% and 67.39%, accordingly. The differences in the occurrence of square wave jerks in VNG examination between groups were not statistically significant **(p=0.008)**.

In patients in research group in VNG examination square wave jerks in left neck torsion phase occurred in 58.54% patients and in control group in 38.30% and lack of square wave jerks was described in 41.46% and 61.70%, accordingly. The differences in the occurrence of square wave jerks in VNG examination between groups in left neck torsion phase were not statistically significant **(p=0.046)**.

In turn, in VNG examination in research group nystagmus occurred during right neck torsion in 14.00% patients and in control group in 8.00% and lack of nystagmus was described in 86.00% and 92.00%, accordingly. The differences in the occurrence of nystagmus in VNG examination between groups were not statistically significant (**p=0.525)**.

In turn, in VNG examination in research group nystagmus occurred during left neck torsion in 18.00% patients and in control group in 10.00% and lack of nystagmus was described in 82.00% and 90.00%, accordingly. The differences in the occurrence of nystagmus in VNG examination between groups in left neck torsion phase were not statistically significant (**p=0.388)**.

DISCUSSION

In the analyzed material in Doppler ultrasound examination the differences in values of the diameter of right and left vertebral artery were not statistically significant. Obtained mean values of the diameters of vertebral arteries are similar to the results obtained by other authors examining these vessels in patients both with non-specific neurological symptoms as well as patients without symptoms who underwent routine examination [6, 7]. At the same time it has to be noted that according to the study of Mysior et al. [8] the asymmetry of vertebral arteries of ≤0.5 mm, and that is what was noted in authors' own research, does not cause significant differences in measurable hemodynamic blood flow parameters.

On the other hand in the authors' own research mean value of systolic blood flow velocity in right vertebral artery in patients in research group in resting phase was lower than in control group, similarly to mean value of diastolic velocity.

Obtained lower values of blood flow velocity in vertebral arteries in patients with symptoms of vertebrobasilar insufficiency are reflected in the research conducted by other authors [9, 10].

The use of right neck torsion caused an increase of mean diastolic blood flow velocity in right vertebral artery in patients in research group in comparison to control group, but a decrease of mean value of diastolic velocity.

Also after performing neck torsion test to the left an increase of the mean systolic blood flow velocity in right vertebral artery occurred in research group in comparison to control group as well as a decrease of mean value of diastolic velocity.

The analyzed mean value of systolic blood flow velocity in left vertebral artery in patients in research group in resting phase was lower than in control group and mean value of diastolic blood flow velocity in this artery was also lower. Lower value of resting velocity in research group, similarly as it was shown in examination of right vertebral artery, echoes the results of the studies cited above [11, 12].

After performing neck torsion to the right an increase of the mean systolic blood flow velocity in left vertebral artery occurred in patients in research group in comparison to control group, but a decrease of mean value of diastolic velocity.

On the other hand, also after performing neck torsion to the left an increase of the mean systolic blood flow velocity in left vertebral artery occurred in patients in research group in comparison to control group and an increase of mean value of diastolic velocity.

The data from global literature on the blood flow changes in vertebral arteries caused by neck torsion are not clear.

Simon et al. [13] and Haynes et al. [14] in their research excluded the influence of head rotation on blood flow in vertebral arteries which contradicts the results of the authors' own research.

While examining blood flow velocities in vertebral arteries during maximum head rotation Yi-Kai et al. [15] noted a decrease of both systolic and diastolic velocity independently of the direction of rotation. The decrease was more marked in the artery contralateral to the direction of the test performed.

The results of the study of Zmysłowska-Szmytke et al. [16] examining mean blood flow velocity in vertebral arteries in three patients with vertigo are equivocally consistent with the authors' own research. The former noted a decrease of blood flow velocity during neck torsion test performed in the direction of the examined vessel in two patients and an increase of the velocity in one of the patient. During torsion test in the direction contralateral to the examined vessel the blood flow velocity decreased in two participants and in one participant there was an increase of the mean value of velocity [16].

In the authors' own research the obtained mean value of wave I latency in ABR examination of the right ear in research

group in resting phase was higher than in control group and after performing right neck torsion test it increased both in research and in control group.

In turn, the analyzed mean value of wave I latency in ABR examination of the left ear in research group in resting phase was also higher than in control group and after performing left neck torsion test its increase was noted.

The described mean value of wave III latency in ABR examination of the right ear in research group in resting phase was higher than in control group and in right neck torsion phase it increased.

The analyzed mean value of wave III latency in ABR examination of the left ear in research group in resting phase was higher than in control group and also became longer in left neck torsion phase.

The mean value of wave V latency in ABR examination of the right ear in research group in resting phase was higher than in control group and in right neck torsion phase it was lengthened.

The described mean value of wave V latency in ABR examination of the left ear in research group in resting phase was higher and in neck torsion phase it was lengthened.

The lengthened latencies of all ABR waves in patients with vertigo including patients with vertigo caused by marked asymmetry of the vertebral arteries are consistent with the results shown by Zhang et al. [17] and Munaro et al. [18].

Moreover, Olszewski et al. [19] indicate a marked lengthening of wave I latency of auditory brainstem responses in neck torsion test which correlate with the presence of degenerative changes of the cervical spine which was not considered in the authors' own research.

In VNG examination in patients in research group nystagmus during right neck torsion phase occurred in 14.00% of patients and in control group in 8.00% and in left neck torsion phase in 18.00% and 10.00% of patients, accordingly.

Karlberg et al. [20], while examining healthy subjects, showed a constant correlation between the neck torsion test and an increase of induced nystagmus which is to indicate that the information from the neck deep sensation receptors is convergent with the other parts of the balance system and allow its proper functioning. Thereby the changes of this convergence may lead to vertigo or dizziness.

The conducted own research showed usefulness of the neck torsion test in revealing cervical nystagmus.

It is confirmed by Olszewski et al. [21] who additionally indicate the advantage of neck torsion test over the examination of positional nystagmus according to Nylen in the diagnostics of cervical vertigo.

The percentage of the nystagmus revealed in neck torsion test in the carried out studies is slightly lower in comparison to the results obtained by other authors [22, 23] but it most probably results from the differences in the research group structure which in this study consisted only of the patients with cervical vertigo.

CONCLUSIONS

1. In the Doppler ultrasound examination the mean value of diameters of right and left vertebral artery was lower and was 3.05 mm and 3.27 mm in research group and 3.16 mm and 3.36 mm in control group, accordingly, which undoubtedly has influence on the evaluation of neck torsion test in the objective examination in patients with vertigo and/or hearing loss.

2. As the analysis of the shown material revealed, the use of neck torsion test in the Doppler ultrasound examination causes an increase of mean systolic blood flow velocity in the vertebral artery contralateral to the neck torsion in research group and an increase of the mean diastolic blood flow velocity in the vertebral artery ipsilateral to the neck torsion test as well as its decrease on the contralateral side in comparison to control group.

3. The value of wave I, III, V latencies in ABR examination in neck torsion phase is more markedly lengthened in research group than in control group on the ipsilateral side to the test.

4. The performed neck torsion test in VNG examination causes an increase in the occurrence of both square wave jerks and nystagmus (markedly higher in research group than in control group).

5. The use of neck torsion test in the Doppler ultrasound, ABR and VNG examination in patients with vertigo and/or hearing loss makes the abovementioned functional examinations and with that increases their diagnostic value. The neck torsion test may be used in monitoring of the rehabilitation of internal ear disorders.

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