ORIGINAL ARTICLE

CLINICAL AND NEUROPHYSIOLOGICAL PARALLELS OF THE BRACHIAL PLEXOPATHY IN THE STRUCTURE OF NEUROGENIC THORACIC OUTLET SYNDROME

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ABSTRACT

The aim: Was assessment of the neurophysiological data and features of clinical picture in patients with neurogenic thoracic outlet syndrome (TOS).

Materials and methods: 103 patients with upper extremity pain and/or paresthesia or hypotrophy, or a combination of these symptoms were examined. The examination algorithm included: cervical spine radiography, cervical spine and brachial plexuses magnetic resonance imaging (MRI), upper extremity soft tissues and vessels ultrasonic examination, stimulation electroneuromiography with F-waves registration.

Results: Neurogenic TOS was diagnosed in 29 patients. A significant relationship between the following complaints and neurophysiological parameters was observed: pain, numbness during physical activity and decreased medial anrebrachial cutaneous nerve response amplitude by ≥25% compared to the contralateral side; hypothenar hypotrophy and decrease of ulnar nerve motor/sensory response amplitude; the 4-5th fingers hypoesthesia and decrease of ulnar nerve sensory response amplitude.

Conclusions: Medial antebrachial cutaneous nerve amplitudes asymmetry indices of ≥25% or lack of response may be considered to be a marker of true neurogenic TOS.

KEY WORDS: brachial plexopathy, upper extremity pain, thoracic outlet syndrome, neurophysiological diagnostics

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INTRODUCTION

Thoracic outlet syndrome (TOS) involves compression of the subclavian artery, vein, brachial plexus in one of the following sites: spatium interscalenum, spatium costoclaviculare or the space behind the pectoralis minor muscle tendon to the processus coracoideus fixation site [1-3]. It should be noted that the neurovascular bundle lesion at the scalene triangle level is characterized arterial and neurogenic symptoms, because the subclavian vein joins these structures after leaving the interscalene triangle. The term TOS was introduced by R. M. Peet in 1956 and despite the long history of this nosology, its clear diagnostic criteria are not established till nowadays. This situation has arisen probably due to the presence of non-specific complaints, which may be misinterpreted as traumatic, orthopedic or vertebrogenic pathology.

According to compression of vessels and/or nerve fibers TOS is classified into vascular and neurogenic. The prevalence of neurogenic TOS is about 95% among all TOS forms. Neurogenic TOS is therefore divided into true neurogenic and disputed [3-5].

The true neurogenic TOS etiological factors are classified into congenital and acquired. Congenital anomalies are further divided into bone and fibromuscular anomalies [1-6]. A combination of congenital and acquired anomalies is often observed.

The true neurogenic TOS usually manifests with pain, hypoesthesia, paresthesias of localization, typical for the brachial plexus level involvement, gradually progressive atrophies, and is accompanied by pathological changes in instrumental examination methods findings, and medical history of cervical and thoracic injuries [4, 7-9]. Clinical picture of disputed TOS is similar to the true neurogenic one, but there are no pathognomonic changes found in additional examination methods results.

THE AIM

The aim of study was to analyze the clinical and neurophysiological features of brachial plexopathy in the neurogenic TOS structure in order to formulate the diagnostic algorithm.

MATERIALS AND METHODS

The study was performed on the basis of the neurology and neurosurgery department of Ivano-Frankivsk National Medical University during 2017 and the Research and Practical Center of neurophysiological studies during 2018-2020. Totally there were 103 patients examined with upper extremity pain and/or paresthesia or hypotrophy, or a combination of these symptoms. The patients' mean age of was 37.39±5.17 years, 61 (63%) of them were females.

The algorithm of the planned examination included: cervical spine radiography, cervical spine and brachial plexuses magnetic resonance imaging (MRI) (Siemens 1.5 T), upper extremity soft tissues and vessels ultrasonic examination, stimulation electroneuromiography (ENMG) with F-waves registration (Neurosoft, Neuro EMG-mi-

cro, 2004). Doppler ultrasonography was performed in the position with the upper extremity lowered along the torso and during the Adson's, Eden's, Wright's and EAST provocation tests.

Exclusion criteria:

- cervical spine discoradicular conflict, myelopathy, syringomyelia (verified by MRI);
- tunnel neuropathy, polyneuropathies (diagnosed by ENMG);
- traumatic/orthopedic pathology (verified after orthopedist consultation with the radiological examination (X-ray / MRI and ultrasonic study of the musculoskeletal system);
- upper extremities blood vessels thrombosis (according to ultrasonic examination data);
- neoplastic and postradiation lesion of the chest and upper extremity girdle.

After the examination and data comparison with the inclusion/exclusion criteria 29 patients remained under our supervision. Statistical processing of the study results was performed with the use of computer with a software environment for statistical calculations " R " (R Core Team RR . A language and environment for statistical computing. R Foundation for statistical computing [Internet]. 2018. Available from: URL: https:// www.r-project.org/).

RESULTS

Complaints on pain occurred in 21 (72.4%) cases; pain was localized in the rhomboid muscles, anterior chest surface, neck area, brachioscapular area, forearm, hand.

The abovementioned complaints mostly corresponded to the dominant arm, which was observed in 17 (80.9%) patients. In addition, the pain which occurred during physical activity, persisted also after the termination of activity.

26 (89.6%) patients complained on numbness, which in 4 (15.4%) cases was permanent, in 4 (15.4%) cases it was positional, in 5 (19.2%) patients numbness occurred during physical activity, 6 (23.1%) patients experienced it during nighttime, and 7 (26.9%) patients noted a combination of complaints on numbness in certain position and during nighttime.

The feeling upper extremity weakness was noted by 17 (58.6%) patients; 7 (41.1%) of them complained on the 4^{th}-5^{th} fingers, 4 (23.5%) patients felt it in the entire hand, in 6 (35.3%) cases it involved all muscles of the upper extremity. In order to objectify the complaints, the muscle strength of the upper extremity was assessed; the strength decrease was detected in 4 (23.5%) cases, namely in m. abductor pollicis brevis and m. interosseus dorsalis I.

Complaints on hand fine motor skills impairment were observed in 13 (44.8%) cases, and were objectively detected in 3 (10.3%) patients. The feeling of hand discomfort bothered 5 (17.2%) patients.

In neurological status hypothenar hypotrophy was observed in 2 (6.8%) cases; in 1 (3.4%) patient thenar, hypothenar and interosseous muscles hypotrophy were observed. Triceps hyporeflexia on the symptomatic side was observed in 1 (3.4%) patient.

Skin hypoesthesia in the 4^{th}-5^{th} fingers along was determined in 4 (13.8%) patients; in 3 (10.3%) cases it included the 4^{th}-5^{th} fingers and the ulnar aspect of forearm.

Supraclavicular region palpation was painful in 5 (17.2%) patients, and in 2 (6.9%) cases it was accompanied by numbness in comparison with the asymptomatic extremity. Intrescalene trigon palpation elicited pain in 4 (13.7%) cases, palpation of the pectoralis minor muscle projection site was painful in 1 (3.4%) patient.

Raynaud's syndrome was observed in 6 (20.6%) cases; it was characterized by presence of symptoms only on the symptomatic side, which differs from the primary Raynaud's syndrome. The majority of authors tend to think that Raynaud's syndrome is a manifestation of the vascular TOS variant [7]. Due to exclusion of the vascular TOS from out study it may be considered to be its secondary variant caused by irritation of the brachial plexus sympathetic fibers. R. T. Alekperov (2014) mentioned the possibility of the primary Raynaud›s syndrome misdiagnosis in case of TOS [10], which leads to inadequate treatment tactics.

Bone abnormalities were radiologically diagnosed. In 3 (10.4%) patients an additional cervical rib was detected; in 2 (6.9%) cases the C7 transverse processus elongation up to 20 mm and 23 mm (N=13-17 mm) was found out; in 1 (3.4%) patient the costoclavicular space narrowing due to the formation excessive osteocallus formation after clavicular injury was detected. Gruber (1869) suggested classification of cervical ribs into 4 groups, where the 3^{rd} and 4^{th} groups includes the cervical rib presence with the fixed fibrous cords, which are radiologically negative.

MRI revealed fibrous cord in the interscalene triangle in 1 (3.4%) person. V. K. Singh (2014) after evaluation of the MRI preoperative findings and postoperative results indicates that the sensitivity of this method is 41%, specificity is 33%.

In order to assess the neurophysiological examination data, the study included 20 apparently healthy individuals.

The neurophysiological investigation results are presented in table I; the parameters of the motor responses, the F - wave latency, the sensory responses amplitude and latency were studied.

The most informative parameters during the neurophysiological data comparison of patients with the upper extremity pain and AHI were the MACN indicators. All patients who were included into the study had unilateral complaints, so we decided to compare the obtained results with the same data of asymptomatic limb (Table II).

During evaluation of the medial antebrachial cutaneous nerve response amplitude in 5 patients the amplitude difference between two sides was ≥25%; in 3 of them the response could not be registered.

Data of significant relation between the complaints and ENMG parameters are presented in Table III.

After assessment of patients' complaints, disease history, neurological status and of instrumental examination methods results, the true neurogenic TOS was diagnosed in 13 (44.8%) patients, the disputed neurogenic TOS was diagnosed in 16 (55.2%) patients. There were no changes detected in ENMG in patients with disputed neurogenic TOS. In our opinion, the lack of neurophysiological changes in patients with disput-

Table I. ENMG parameters of patients with the neurogenic TOS and apparently healthy individuals

	UN		MN		MACN	
ENMG parameters	AHI	TOS	AHI	TOS	AHI	TOS
Motor response amplitude, μV	9.83 ± 2.71	6.48 ± 1.57	10.69 ± 2.64	8.32 ± 2.86	-	-
Sensory response amplitude, μV	7.36 ± 3.04	6.09 ± 3.62	10.53 ± 2.09	8.63 ± 2.47	18.7 ± 4.91	6.52 ± 3.84
Sensory response latency, ms	2.29 ± 0.3 3	2.11 ± 0.67	1.82 ± 0.78	2.05 ± 0.26	2.13 ± 0.28	2 .68 ± 0.48
F-wave latency, ms	28.91 ± 1.32	29.61 ± 4.78	27.01 ± 2.78	28.13 ± 1.64	-	-

Note: UN - ulnar nerve; MN - median nerve; MACN - medial antebrachial cutaneous nerve; AHI - apparently healthy individuals; TOS - patients with TOS.

Table II. ENMG parameters of medial antebrachial cutaneous nerve of symptomatic and asymptomatic upper extremity

N patient	Sensory response amplitude (μV)		Sensory response latency, ms	
	Symptomatic arm	Asymptomatic arm	Symptomatic arm	Asymptomatic arm
1	14	30	3.1	2.8
2	0	18	-	2.2
3	0	21	-	1.8
4	11	24	2.2	2.1
5	5	19	2.9	1.6
6	0	14	-	1.9
7	8	31	3.0	2.9
8	17	35	2.4	2.4

Table III. Significance of relation between the complaints and ENMG parameters

		Q	X^2	P
1.	**Pain intensification/occurrence after physical activity** the difference of the MACN response amplitudes D/S ≥ 25 %	0.54	2.8	<0.05
2.	**Hypoesthesia of the 4-5 fingers** the amplitude of the UN sensory response	0.54	2.8	<0.05
3.	**Numbness intensification/occurrence after physical activity** the difference of the MACN response amplitudes D/S ≥ 25 %	-0.71	3.0	<0.05
4.	**Hypothenar hypotrophy** the amplitude of the UN motor response	-0.71	3.0	<0.05
5.	**Hypothenar hypotrophy** the amplitude of the UN sensory response	-0.53	1.1	<0.05
6.	**Paresthesia of the ulnar aspect of forearm and hand** the difference of the MACN response amplitudes D/S ≥ 25 %	-0.51	3.8	<0.05

Note: UN - ulnar nerve; MACN - medial antebrachial cutaneous nerve.

ed neurogenic TOS may be associated with technical difficulties in the brachial plexus stimulation in the supraclavicular area, which leads to difficulties in diagnosing local demyelination / conduction block, especially in case of excessive body weight and / or Kovtunovych's pseudotumor. In some patients with controversial neurogenic TOS complaints occurred only at a certain limb position or at certain movements and regressed after position changing, so apparently they were accompanied by a short-term nerve fiber compression and therefore absence of neurophysiological abnormalities.

Neurophysiological changes in patients with true neurogenic TOS were observed in 8 (61.5%) cases. A significant difference of the medial antebrachial cutaneous nerve sensory response between the symptomatic and asymptomatic extremities was observed in 87.8% cases; decrease by ≥25% compared to the asymptomatic limb or lack of response were considered to be pathological.

DISCUSSION

Serror (2002) was the first to suggest that the difference of the medial antebrachial cutaneous nerve amplitude response of more than 50% should be considered abnormal [12]. B. E Tsao et al. (2014) provided data of a retrospective review of the neurophysiological parameters in patients with surgically verified true neurogenic TOS, where the difference of the sensory response amplitude was assessed, and amplitude of less than 50% compared to the contralateral limb was regarded as abnormal [11].

The role of neurophysiological studies in the diagnosis of neurogenic TOS is quite controversial. R. Rous-

seff et al. (2005) describe 20 surgically verified cases of neurovascular compression in the thoracic aperture, but differences from the normal neurophysiological parameters were determined in only 2 patients. B. Machanic (2008) described his own observation where 41 patients with neurogenic TOS were undergoing the ENMG examination and in 40 of them deviations from the normal parameters were observed; the latency, the medial antebrachial cutaneous nerve amplitude asymmetry of more than 50%, stimulation of C8 spinal root were assessed. Later all these patients underwent surgical treatment of the compression at the interscalene trigon level; diagnosis was confirmed intraoperatively in all patients. After surgery regression of all symptoms, increase of amplitude and decrease of latency of the medial antebrachial cutaneous nerve were observed in all of the patients.

The sensitivity of determination of the medial antebrachial cutaneous nerve amplitudes asymmetries in patients with true neurogenic TOS of ≥25% or lack of response, which we obtained in our study, is 33.33%; its specificity is 83.33%, test accuracy is 64.86%, the prognostic value of a positive test result (PVP) is 66.66%, and the prognostic value of a negative test result (PVN) is 64%.

CONCLUSIONS

According to the literature data and the results of our study, the most sensitive neurophysiological parameters in the diagnosis of the true neurogenic TOS are the medial antebrachial cutaneous nerve amplitude with the following results evaluation in comparison with the asymptomatic limb. During assessment of the medial antebrachial cutaneous nerve amplitudes asymmetry the difference of ≥25% or lack of response should be taken into account. According to the results of our study, the sensitivity of determination of the medial antebrachial cutaneous nerve amplitudes asymmetries in patients with the true neurogenic TOS of ≥25% or lack of response, which we obtained in our study, is 33.33%; its specificity is 83.33%, test accuracy is 64.86%, which demonstrates the feasibility of the study in patients with possible neurogenic TOS.

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Conflict of interest:
The Authors declare no conflict of interest.

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