The Role of Neurophysiological and Neurovisualization Testing Methods in the Diagnosis of Motor Neuron Disease

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ABSTRACT

Motor neuron disease (MND) is a progressive disease of the nervous system that affects the motor (movement) cells of the brain and spinal cord. The disease belongs to the group of neurodegenerative diseases such as Alzheimer's and Parkinson's. The causes of this disease are still being studied. It has been proven that environmental factors also play a significant role in the development of MND. Motor neuron disease is, without a doubt, a disease that causes partial or complete loss of working capacity in people of working age, requiring the organization of a medical and social system.

KEYWORDS

Motor neuron disease, Amyotrophic lateral sclerosis, neurophysiological method, MRI, central motor neuron and peripheral motor neuron.

Relevance: Motor neuron disease is a multifactorial heterogeneous disease, and its pathogenesis involves complex mechanisms of various processes, such as oxidative stress, excitotoxicity, protein aggregate formation, impaired autophagy, neuroinflammation, impaired RNA posttranscriptional modification, axonal transport impairment, and mitochondrial dysfunction.

The diagnosis of MND, according to international diagnostic criteria, is made based on clinical signs (central and peripheral motor neuron damage) at 3 of 4 levels (brainstem, spinal cord-cervical, thoracic and lumbar regions) and on paraclinical examinations (ENMG) in the progressive stage of the disease. During this period, the neurological status of patients is constantly monitored to determine whether symptoms such as muscle weakness, atrophy, fibrillation develop in the disease.

When forming a diagnosis of the disease, it is necessary to conditionally use the results of ENMG confirming damage to the upper and lower motor neurons and the criteria for determining clinical signs (El Escorial criteria 1998, 2005). The diagnosis of MND is considered doubtful if the patient has sensory, pelvic organ function, visual acuity disorders, signs of vegetative dysfunction, Parkinson's or cortical dementia symptoms lasting more than 5 years.

The presence of normal sensory pathways in one or more body parts and the absence of blockades are considered to be supportive features of MND. Laboratory tests also play an important role in the differential diagnosis of the disease. For example, muscle biopsy is performed to differentiate MND from other myopathies. Some viral diseases, such as human immunodeficiency syndrome, Lyme disease, and tick-borne encephalitis, cause symptoms similar to those of MND. In addition, symptoms characteristic of MND are also caused by multiple sclerosis, acute demyelinating polyradiculoneuropathy, multifocal motor neuropathy, Guillain-Barré syndrome, and spinal muscular atrophy. Therefore, it is certainly advisable to conduct a differential diagnosis with these diseases. Despite the fact that the duration of symptoms exceeds 12 months, other causes are excluded, and the clinical course of this disease is diverse, a specific diagnostic test for MND has not yet been developed.

Purpose of the study: to determine the role of a comprehensive approach consisting of clinical-neurological, functional, neuropsychological, neurophysiological, and neurovisualization methods in developing a method for predicting the severity of motor neuron disease.

Materials and methods of research: We studied 80 patients aged 35-65 years, who were divided into 2 groups: main group - 45 patients with various forms of MND; comparison group – 35 patients with CMN and PMN lesion syndrome (G95).

During the study, stimulation electroneuromyography (ENMG) and needle electromyography (EMG) were used to diagnose 29 patients with MND. For the purpose of comparative diagnosis, 17 patients with compression ischemic myelopathy were involved in EMG examination.

Results and discussion: In patients with MND, no statistically significant deviations from the norm of the M-response were observed, in turn, a pronounced amyotrophic decrease in the amplitude of the M-response in a particular muscle was on average 3.4±1.3 mV, which is explained by a decrease in the motor unit (MU) during the exacerbation of the disease. In turn, in 86.2% of patients, the speed of propagation of excitation along the motor and sensory fibers remained almost unchanged.

When studying the F-wave, it was found that in 93.1% of patients (on average 22.0±5%) along with the presence of blocks, its amplitude increased by an average of 1210±140.2 μV (the maximum recorded amplitude of the F-wave in this group of patients was up to 3500 μV). This is probably due to, on the one hand, an increase in the motor unit, and on the other hand, a decrease in the number of unit of motor participating in the implementation of each F-wave.

In the study conducted using rhythmic stimulation, the decrement phenomenon was detected in 34.5% of patients, which was 11–18% (average 14.2±3.6%). The data presented are interpreted as ineffective reinnervation, as in the studies of a number of authors. Needle EMG revealed spontaneous activity in the arms and legs of all patients, including fasciculations, fibrillations, as well as polyphasia and increased potential of the motor unit in the m.lingulais, m.mentalis and intact muscles (100%) (Fig. 1)

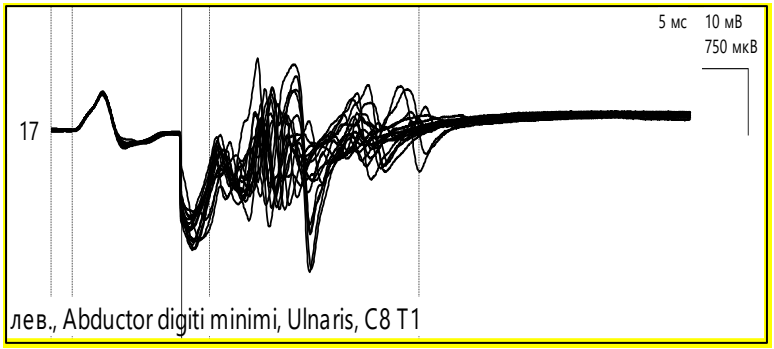

Figure 1. Patient Sh.Z., 34 years old. Left Abductor digiti minimi, Ulnaris C8 T1 conduction velocity (CV) examination (giant F-waves 52.9%).

It has been proven that such important criteria as spontaneous muscle activity, increased potential of the motor unit and polyphasia are detected not only in patients with MND, but also in patients with myelopathy. The degree of manifestation of these changes depends on the degree of involvement of the lower motor neuron in the pathological process, on the one hand, and on the stage of the pathological process, on the other. In such a situation, the frequency of these changes serves as a differential diagnostic criterion. The absence of motor-sensory disorders in the early stages of MND cannot be a reliable differential diagnostic criterion.

Needle EMG revealed denervative changes consistent with clinical signs of muscle damage. In 58.8% of patients, when examining the state of the muscles, spontaneous activity was observed in muscle groups with fasciculations and fibrillations of various amplitudes. This change was considered a very rare condition. Changes in potential of the motor unit parameters had a positive effect on the denervation-renervation process (Fig. 2).

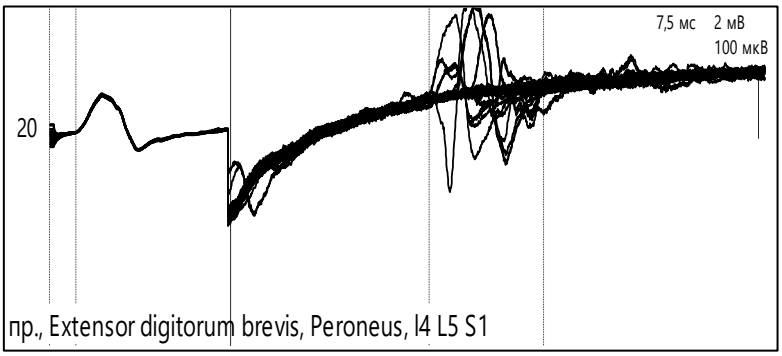

Figure 2. Patient M.I., 65 years old. Signs of damage to the right ulnar nerve of the small tibial nerve of the axonal-demyelinating type at the level of the piriformis muscle and (VL5-S1) roots.

Thus, it was observed that the duration of the action potential of the affected muscles increased by an average of 25.5±2.5%. This, in turn, indicated a change inpotential of motor unit (PMU) in these muscles from 450 to 3500 μV. At the same time, (PMU) in intact muscles remained almost normal. In patients with myelopathy, these indicators in intact muscles retained their basic properties almost normal. However, in the affected muscles, changes characteristic of spontaneous activity, consolidation of (PMU) and an increase in the number of turns were observed. MRI was performed in 32 patients with MND. Similarly, this examination method was also performed in 18 patients in the comparison group. Among the examined patients, all patients with BDS and 12 patients with BDS underwent MRI of the spine and spinal cord to exclude focal changes in the spinal cord of various genesis (vertebral, tumor, demyelinating, neuroinfectious, etc.). In 2 (66.7%) patients with lumbo-sacral form intramedullary high-intensity signals with a clear contour (the "snake eye" sign) were detected in the anterior horn of the spinal cord, at the level of the S5-S7 vertebral segments in the T2 mode. In this case, a decrease in the volume of the spinal cord was observed. It should be noted that this focus had an asymmetric appearance, and in one patient it was detected unilaterally, while in another patient it was detected bilaterally, exceptionally ($p<0.05$).

MRI of the brain showed bilateral hyperintense foci in the frontal part of the subcortical area in 1 patient with cerebral form of disease.

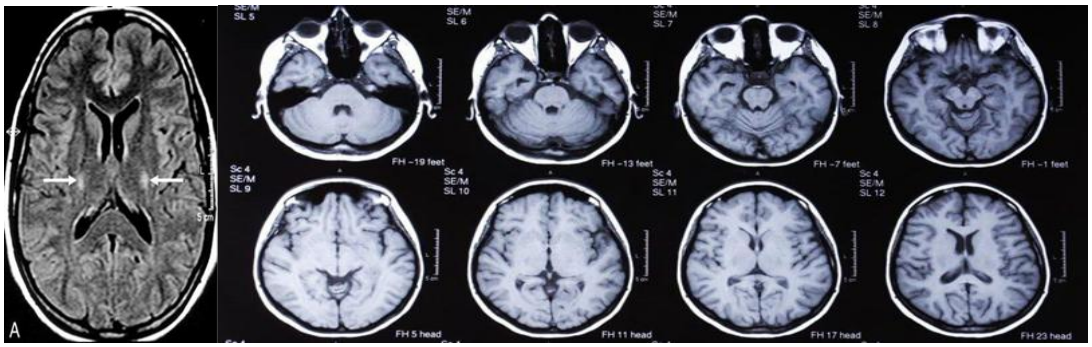

Figure 3. Patient S.F., 43 years old. Brain MRI.

Conclusion: In patients with MND the following specific changes were detected in the EMG examination: "giant" F-waves with blocks, a significant expansion of spontaneous activity and action potential units in all muscles compared with the myelopathy group, and a decrease in the amplitude of the M-response to low-frequency stimulation, which had minimal diagnostic significance in 11–18% of cases.

No correlation was found between changes in the MRI of the brain (hyperintense foci - 9.6%) and the age of the patient at the time of diagnosis, the form of the disease, the region of muscle atrophy and their weakness. At the onset of the disease, a typical lesion of the cervical and lumbar segments of the spinal cord was found in 59–67% of cases.

Thus, our research has shown that in the severe stage of MND, by reducing symptoms, it has a positive effect on the course of the disease and extends life expectancy by 7 months. Medical and socio-psychological measures taken to reduce the affective state led to a decrease in the level of anxiety and depression in them. Palliative care offices have been established in the medical care structure, which allow outpatient monitoring of patients.

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