Rheumatol. Forum
2022, vol. 8, No. 4, 163–168

ISSN: 2720-3921, e-ISSN: 2720-3913
DOI: 10.5603/RF.2022.0023

VIA MEDICA
www.journals.viamedica.pl

Przemysław Daroszewski[1], Katarzyna Kaczmarek[2], Włodzimierz Samborski[3], Dorota Sikorska[3], Juliusz Huber[2]

[1]Department of Organization and Management in Health Care, Poznan University of Medical Sciences, Poland
[2]Department of Pathophysiology of Locomotor Organs, Poznan University of Medical Sciences, Poland
[3]Department and Clinic of Rheumatology, Rehabilitation and Internal Medicine, Poznan University of Medical Sciences, Poland

Update on the diagnostic clinical neurophysiology for rheumatology

ABSTRACT

The current concepts on the clinical neurophysiology examinations for the differential diagnosis of rheumatic diseases are presented. The review aims to provide experience and practical guidelines, especially regarding electromyography. More needle than surface electromyography examinations at muscle rest or during its maximal contraction may reveal the characteristic effects of the myogenic injury caused by particular rheumatic diseases. The diagnosis of myopathic disorders, often found in rheumatic diseases is difficult because of the frequent vasculitis coexistence in the patients evoking subsequent changes in nerve fibres leading to degenerative neurogenic changes that may overlap the diagnostic picture of the primary myogenic changes caused by rheumatic diseases. In these cases, the neurophysiological studies of efferent and afferent neural transmission often reveal peripheral neuropathies just at the subclinical level.

Rheumatol. Forum 2022, vol. 8, No. 4: 163–168

KEY WORDS: rheumatic diseases; clinical neurophysiology; electromyography; differential diagnosis

INTRODUCTION

In patients with rheumatic diseases (especially with connective tissue diseases), clinical neurophysiology studies support the clinical evaluation of muscle function and the transmission of neural impulses in nerves and the efferent and afferent pathways of the central nervous system at its various levels. They enable the targeting and dynamic evaluation of the results of pharmacological and rehabilitative treatment [1]. Neurophysiological examinations are usually performed to confirm or exclude the pathological changes in the activity of the muscle motor units (electromyographical examination [EMG]) or changes in the nerve transmission within the motor and sensory nerves (electroneurographical examination [ENG]). Diagnostically these studies are the most frequently used in cases of diseases presumed to be detected in the systemic changes (degenerative, inflammatory or ischaemic) and also coexisting with rheumatic diseases. In the early diagnostic of many muscles and nerves, the ascertained abnormalities may suggest the onset of disease. Needle elementary electromyography recorded at rest and during the attempt of the maximal muscle contraction is most appreciated by rheumatologists who expect the evaluation of different advancement of symptoms of the myopathic changes [2]. Secondary to the consequences of rheumatic diseases, neuropathies detected in electroneurography are usually associated with systemic vasculitis [3, 4]. The sensitivity of neurophysiological tests in detecting pathological changes in adult rheumatoid patients has been ascertained at 89% [5]. Paediatric electromyography is 91% sensitive and 67% specific in confirmation of myopathic disorders [6].

This review presents current concepts on the results of clinical neurophysiology examinations for the differential diagnosis of rheumatic diseases. The authors provide their experience and practical guidelines, especially regarding electromyography.

Address for correspondence:
prof. dr hab. n. med. Juliusz Huber
Department of Pathophysiology
of Locomotor Organs,
Poznan University
of Medical Sciences
ul. 28 Czerwca 1956 roku 135/147,
61–545 Poznań
e-mail: juliusz.huber@ump.edu.pl

SUBJECTS, METHODS AND RESULTS

The neurophysiological examinations are performed according to the commonly known standards; however, they are modified from time to time concerning the diagnosed disease. Obtained results are compared with the expected parameters ascertained every 5 years on the healthy population of volunteers of both sexes with different ages. Every neurophysiological department should create its normative parameters because of the population and evolution variability of afferent and efferent neurophysiological parameters and the evolution of nerve-muscle diseases. Choosing the particular methods from neurophysiological examinations depends on whether the expected results may help in a diagnosis (by their repeatability in prognosis during the disease course), ascertaining the efficiency of applied therapy, or broadening the knowledge about the pathogenesis of the nosological entity. Usually, an electromyography study reveals abnormalities about 2–3 weeks from the onset of the pathogenic process, so in acute myopathies, it is recommended to conduct the study about three weeks from the beginning of symptoms to ensure good EMG recording sensitivity. Clinically weak muscles and upper and lower extremities should be explored [7].

The electroneurographical examination describes the neural transmission in nerve fibres by ascertaining their excitability state or their conduction velocity and has a primary meaning in diagnosing neuropathies. Results of examinations make it possible to find out what type of fibres are injured by the disease (motor, efferent — M and F waves studies; sensory, afferent — SCV studies and partially with H-reflex study), describe a type of changes (axonal, demyelinating, mixed) and a range of the pathological process (mononeuropathy, multiple and multifocal neuropathies of several nerves in different extremities, polyradiculoneuropathy, a general polyneuropathy) or objectively ascertain the influence of therapy or changes in the course of disease (acute or subacute) [8].

The afferent and efferent transmission examinations at different levels of peripheral and central nervous systems include the methods of recordings of the somatosensory (SEP), and motor (MEP) evoked potentials (the latter is induced with the magnetic field). The efficiency in afferent transmission from the level of receptor to the area of the contralateral sensory cortex can also be indirectly characterized in examinations of sensory excitability curves (IC-SD studies). Because many of the demyelinating or rheumatic diseases evoke changes in the transmission of fibres within visual and auditory tracts, diagnostic examinations of visual (VEP) and auditory brainstem (BEAP) evoked potentials are of particular interest [1, 2].

The activity of the motor units (MUs) during muscle relaxation and its voluntary contraction is assessed with EMG, which is methodically divided into nEMG (recorded with the bipolar concentric needle, elementary) and sEMG (recorded with pair of electrodes placed over the surface of muscle's belly and its distal tendon). sEMG is useful for initial screening tests before the application of nEMG, it enables the most accurate selection of a muscle with indications of MUs dysfunction. Non-invasive sEMG is considered more beneficial for studies in children aged below five years; nEMG recording is usually in these patients greatly influenced by the movement artefacts. Non-invasive sEMG recorded from specific muscle groups on both sides of the body may be helpful in confirmation of myopathies in children by evaluating the high-frequency pattern during an attempt of maximal contraction lasting 5 seconds [2, 9].

In each EMG recording during a maximal contraction lasting 5 seconds, the amplitude (in μV) and frequency (in Hz) parameters are evaluated (Figure 1A). In these recordings, an increase in recruitment of single (nEMG) or total (sEMG) motor units action potentials (MUAPs) frequencies above 100 Hz indicates the primary muscular pathology (Figure 1Ae), while a decrease of this parameter in the range of 60–10 Hz (Figure 1Ab and 1Ac) describes the advancement of neurogenic pathology with varying degrees of severity [10]. Due to the lateralization of the motor function, only the difference in the decrease of the amplitude in bilateral sEMG recordings from homonymous muscle groups of more than 20% determines the paresis symptom. In nEMG recording during the muscle relaxation (at rest), the presence of fibrillation potentials (Figure 1C) or the positive sharp waves (Figure 1D) confirm denervation and the neurogenic changes in muscle; pseudomyotonic discharges (Figure 1E) — the myogenic pathological process. The diagnostically useful parameters (during the analysis of usually 20 recorded MUAPs), which help in the differentiation between the muscles diseases of neurogenic or myogenic origin, are

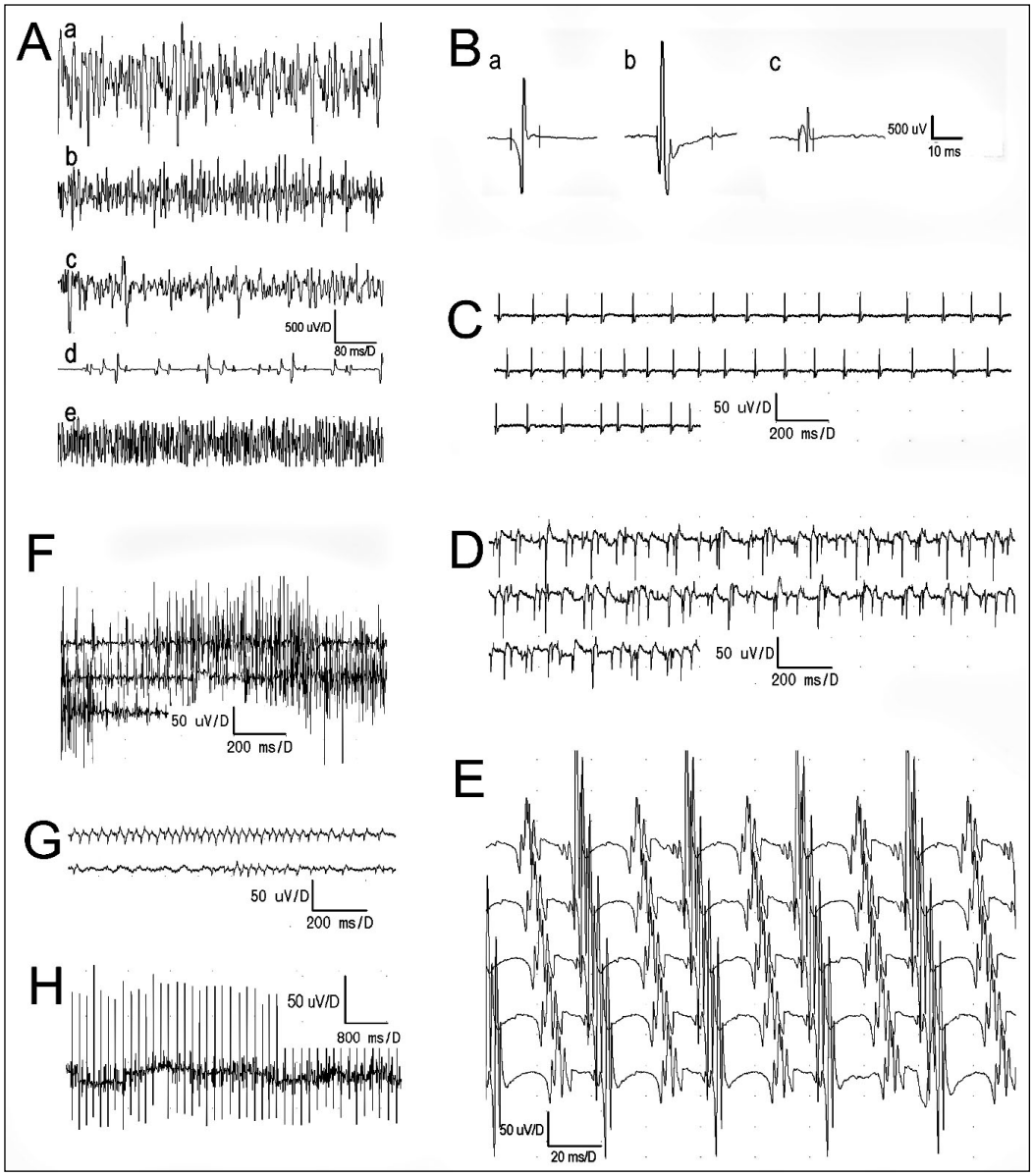

Figure 1. Examples of the needle electromyography recordings recorded in the healthy volunteers (**Aa, Ab, Ba**) and the patients with neurogenic (**Ac, Ad, Bb, C, D, G**) or myogenic disorders (**Ae, Bc, C–F, H**). During the attempt of maximal voluntary muscle contraction lasting five seconds, the normal, high-frequency discharges of the single motor units action potentials (MUAP) at 90–70 Hz should be recorded (**Aa** — with higher amplitude in large muscle groups, **Ab** — with lower amplitude in small muscle groups). The frequency of MUAPs discharges decreases in cases of the moderate (**Ac**, 60–40 Hz) or severe (**Ad**, 30–10 Hz) advancement of neurogenic muscle pathology. In the case of myogenic disease (**Ae**), the recording during the maximal contraction is characterized by the low amplitude and the high-frequency parameters of MUAPs firings rates; **B.** Examples of single MUAPs recorded in (**a**) a healthy subject, (**b**) the patient with the muscle's neurogenic disorder and (**c**) the patient with the muscle's myogenic disorder during the voluntary contractions. The spontaneous potentials recorded at muscle's rest shown in **C** are called fibrillation, the positive sharp waves in **D** and the pseudomyotonic discharges in **E**. **C–D** examples are recorded in patients with rheumatoid disorders and should not be missed with typical trains of the myotonic dischargers (**F**, recorded in the patient with Thomsen's disease), „bizarre" high-frequency discharges recorded in the patient with the clinically recognized spinal muscle atrophy (**G**), the asynchronous trains of discharges recorded from active trigger points in the patients with fibromyalgia (**H**)

mainly the amplitude, the duration of the potential and its area. Under normal conditions, these parameters are different with recordings from different muscles, but usually, their values are in the range respectively 300–1000 μV, 8–12 ms and 350–950 μV/ms [11]. A difference for each of these parameters of more than 25% in comparison to the expected values can indicate pathology in the activity of motor units within the examined muscle. During the voluntary muscle contraction, an analysis of more than 20 single MUAPs in nEMG recordings determining the average amplitude, the duration and the surface area (SI index) increase

Table 1. Characteristics of electromyographic recordings observed in patients with some rheumatic diseases

Disease or syndrome	EMG recording characteristics	
	At rest (spontaneous activity)	During voluntary contraction (pattern of discharge)
Rheumatoid arthritis	Fibrillation* **(Fig. 1C)**	Neurogenic rather than myogenic
Systemic lupus erythematosus	Pseudomyotonic discharges Fibrillation*	Myogenic*
Lupus with Sjögren's syndrome, Lupus with antiphospholipid syndrome	Pseudomyotonic discharges	Myogenic*
Polymyositis	Fibrillation Positive sharp potentials* **(Fig. 1D)**	Myogenic rather than neurogenic*
Inclusion myositis	Fibrillation	Myogenic
Dermatomyositis	Pseudomyotonic discharges Fibrillation* Positive sharp potentials*	Myogenic, rarely neurogenic*
Gout Systemic scleroderma	Pseudomyotonic discharges	Myogenic, rarely neurogenic*
Rheumatic polymyalgia sarcoidosis	Fibrillation Pseudomyotonic discharges **(Fig. 1 E)**	Myogenic
Fibromyalgia	Asynchronous trains of discharges recorded from active trigger points (mean frequency at 28 Hz, mean amplitude at 362 μV) **(Fig. 1H)**	Normal or slightly myogenic

*Depending on the disease advancement

in comparison to the values of the normative parameters (Figure 1Ba) confirms neurogenic disorder (Figure 1Bb), while their decrease — myogenic disorder (Figure 1Bc). Polyphasic potentials (with more than 3 phases) may occur in both types of muscle disorders [12]. sEMG recording with a mean amplitude of more than 25 μV at rest neurophysiologically defines normal muscle tension [13, 14].

Examples of the nEMG recordings in patients with rheumatoid-related disorders are shown in Figure 1, while descriptions of their characteristics are presented in Table 1.

Contemporary, there is a common agreement that the pathological spontaneous activity nEMG recorded at rest in patients with some rheumatic diseases may be represented by the two main types; fibrillations and positive sharp waves or the high-frequency discharges (called pseudomyotnic or complex repetitive discharges).

The fibrillations and positive waves are the low-amplitude potentials, which always discharge rhythmically due to the generation of action potentials in isolated muscle fibres. They are typical for denervation but can also be detected in myopathies with severe necrosis or inflammation. The high-frequency discharges are characterized by the abrupt onset and cessation and a rhythmic sound like an engine in a loudspeaker connected to an electromyographic device. The myotonic bursts are the representation of the difficulty for relaxation following voluntary or induced muscle contraction, usually after percussion, known as myotonia. They are due to the transient hyperexcitability of the muscle fibre membrane. It reflects the temporary activity of individual muscle fibres that discharge spontaneously and repetitively. They are described by a distinctive sound like a falling plane. Myotonic discharges are typical for myotonic dystrophy but occasionally appear in muscles undergoing inflammatory myopathy.

Too high or too low temperature influences the conditions for adequately recording the electrical MUs activity; the cooling can be used as an inductor in examinations of the myotonic syndromes. Recordings should be performed in the EMG laboratory room at about 22°C. Some pharmacotherapies influencing blood coagulation, psychotropic drugs

or drugs affecting the acetylcholine release (used in cases of treating patients with disturbances at the level of the neuromuscular junction) should be considered in the decision and evaluation of EMG examination [1].

The "immature" EMG recording observed during the maximal contraction test in children up to 14 years of age is characterized by a change in amplitude rather than frequency. After the age of 40, motor units undergo a natural ageing process with a shift in MUAPs parameters in the direction characteristic for the neurogenic pathology. Due to the tendency to a sedentary lifestyle, a functional involution of muscles is observed, and a trend of the variability of the neuromuscular diseases themselves is also described [2].

GENERAL REMARKS

Using electromyograms and nerve conduction studies is essential to exclude alternative diagnoses and confirm muscle disease when evaluating patients with suspected myopathic disorders. The usefulness of neurophysiological studies lies in their high sensitivity and specificity for diagnosing myopathies and the ability to exclude other causes of muscle weakness such as neuropathy with motor involvement, myasthenic syndromes or motor neuron disease.

The diagnosis of myopathic manifestations in rheumatic diseases, is difficult because of the frequent vasculitis coexistence in the patients, evoking subsequent changes in nerve fibres leading to degenerative neurogenic changes. The latter may overlap the diagnostic picture of the primary myogenic changes caused by rheumatic diseases. In these cases, the neurophysiological studies of efferent and afferent transmission often reveal peripheral neuropathies at the subclinical level. In cases of patients with chronic nephritis and diabetes, systemic diseases such as generalized amyloidosis, lupus erythematosus, or systemic vasculitis may themselves induce polyneuropathies by the metabolic system change or the induction of immunological factors.

The characteristics of the electromyography recordings may change following the pharmacological treatment, so the relationships between the patterns described in Table 1 and the particular disease of the rheumatoid origin during the differential diagnosis should be ascertained mainly before its application. Needle electromyography shows increased spontaneous activity with fibrillations, complex repetitive discharges, and positive sharp waves in the inflammatory myopathies. The voluntary motor unit activity consists of low-amplitude polyphasic potentials of short duration [15]. Although not disease-specific, these findings help to confirm the active myopathy. Spontaneous nEMG recorded activity can help distinguish the active disease from steroid-induced myopathy, except if the two coexist [16].

The pictures of idiopathic inflammatory myopathies (dermatomyositis, polymyositis, inclusion body myositis, anti-synthetase syndrome and immune-mediated necrotizing myopathy) in differential diagnosis with nEMG recordings are various in particularities, although the myogenic component is common in their early onset [17–20]. There is no evidence of a neurogenic component in inclusion body myositis if quantitative nEMG is used for the differential diagnosis [21].

"Pseudopolymyositis", often called false inflammatory myopathies, among others fibromyalgia, polymyalgia rheumatica, granulomatous myositis, myopathies due to hypothyroidism, metabolic myopathies, McArdle's disease and Pompe's disease, hereditary myopathies, dystrofinopathies, dysferlinopathies, girdle dystrophy and pharmacologic myopathies do not provide the clear cut electromyographic images to the end like polymyositis and dermatomyositis [22].

AUTHORS' CONTRIBUTION

PD, KK, WS, DS and JH provided the concept, PD and JH provided the design, PD, KK, WS, DS and JH collected and interpreted data, PD, KK and JH wrote the manuscript.

FUNDING

This research received no external funding.

ETHICS

The study was conducted according to the guidelines of the Declaration of Helsinki. Approval was also received from the Bioethical Committee of University of Medical Sciences in Poznań, Poland (including studies on healthy people) No 942/21.

DATA AVAILABILITY STATEMENT

All data generated or analyzed during this study are included in this published article.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

References

1. Huber J. Diagnostyka neurofizjologiczna. In: Zimmermann-Górska I. ed. Reumatologia kliniczna. PZWL, Warszawa 2008: 247–260.
2. Huber J. Badania neurofizjologiczne. In: Szczeklik A, Gajewski P. ed. Interna Szczeklika. Medycyna Praktyczna, Kraków 2022.
3. Bhattacharyya S, Helfgott SM. Neurologic complications of systemic lupus erythematosus, sjögren syndrome, and rheumatoid arthritis. Semin Neurol. 2014; 34(4): 425–436, doi: 10.1055/s-0034-1390391, indexed in Pubmed: 25369438.
4. Graf J, Imboden J. Vasculitis and peripheral neuropathy. Curr Opin Rheumatol. 2019; 31(1): 40–45, doi: 10.1097/BOR.0000000000000559, indexed in Pubmed: 30461543.
5. Bohan A, Peter JB, Bowman RL, et al. Computer-assisted analysis of 153 patients with polymyositis and dermatomyositis. Medicine (Baltimore). 1977; 56(4): 255–286, doi: 10.1097/00005792-197707000-00001, indexed in Pubmed: 327194.
6. Ghosh PS, Sorenson EJ. Diagnostic yield of electromyography in children with myopathic disorders. Pediatr Neurol. 2014; 51(2): 215–219, doi: 10.1016/j.pediatrneurol.2014.04.013, indexed in Pubmed: 24950662.
7. Wu Y, Martnez MM, Balaguer PO. Overview of the application of EMG recording in the diagnosis and approach of neurological disorders. Electrodiagnosis in New Frontiers of Clinical Research. 2013, doi: 10.5772/56030.
8. Falck B, Stålberg E. Motor nerve conduction studies: measurement principles and interpretation of findings. J Clin Neurophysiol. 1995; 12(3): 254–279, indexed in Pubmed: 11221785.
9. Hellmann M, von Kleist-Retzow JC, Haupt WF, et al. Diagnostic value of electromyography in children and adolescents. J Clin Neurophysiol. 2005; 22(1): 43–48, doi: 10.1097/01.wnp.0000151146.91147.a1, indexed in Pubmed: 15689712.
10. Sanders DB, Stålberg E, Nandedkar S. Analysis of the electromyographic interference pattern. J Clin Neurophysiol. 1996; 13(5): 385–400, doi: 10.1097/00004691-199609000-00003, indexed in Pubmed: 8897205.
11. Stålberg E, Erdem H. Quantitative motor unit potential analysis in routine. Electromyogr Clin Neurophysiol. 2002; 42(7): 433–442, indexed in Pubmed: 12395618.
12. Thornton RC, Michell AW. Techniques and applications of EMG: measuring motor units from structure to function. J Neurol. 2012; 259(3): 585–594, doi: 10.1007/s00415-011-6350-0, indexed in Pubmed: 22274786.
13. Wytrazek M, Huber J, Lisinski P. Changes in muscle activity determine progression of clinical symptoms in patients with chronic spine-related muscle pain. A complex clinical and neurophysiological approach. Funct Neurol. 2011; 26(3): 141–149, indexed in Pubmed: 22152435.
14. Huber J, Lisiński P. Early results of supervised versus unsupervised rehabilitation of patients with cervical pain. Int J Artif Organs. 2019; 42(12): 695–703, doi: 10.1177/0391398819853296, indexed in Pubmed: 31177899.
15. Barkhaus PE, Nandedkar SD, Sanders DB. Quantitative EMG in inflammatory myopathy. Muscle Nerve. 1990; 13(3): 247–253, doi: 10.1002/mus.880130312, indexed in Pubmed: 2320046.
16. Uncini A, Lange DJ, Lovelace RE, et al. Long-duration polyphasic motor unit potentials in myopathies: a quantitative study with pathological correlation. Muscle Nerve. 1990; 13(3): 263–267, doi: 10.1002/mus.880130315, indexed in Pubmed: 2320048.
17. Marvi U, Chung L, Fiorentino DF. Clinical presentation and evaluation of dermatomyositis. Indian J Dermatol. 2012; 57(5): 375–381, doi: 10.4103/0019-5154.100486, indexed in Pubmed: 23112358.
18. Dalakas MC, Hohlfeld R. Polymyositis and dermatomyositis. Lancet. 2003; 362(9388): 971–982, doi: 10.1016/s0140-6736(03)14368-1, indexed in Pubmed: 14511932.
19. Briani C, Doria A, Sarzi-Puttini P, et al. Update on idiopathic inflammatory myopathies. Autoimmunity. 2006; 39(3): 161–170, doi: 10.1080/08916930600622132, indexed in Pubmed: 16769649.
20. Blijham PJ, Hengstman GJD, Hama-Amin AD, et al. Needle electromyographic findings in 98 patients with myositis. Eur Neurol. 2006; 55(4): 183–188, doi: 10.1159/000093866, indexed in Pubmed: 16772711.
21. Brannagan TH, Hays AP, Lange DJ, et al. The role of quantitative electromyography in inclusion body myositis. J Neurol Neurosurg Psychiatry. 1997; 63(6): 776–779, doi: 10.1136/jnnp.63.6.776, indexed in Pubmed: 9416815.
22. Gutiérrez-Gutiérrez G, Barbosa López C, Navacerrada F, et al. Use of electromyography in the diagnosis of inflammatory myopathies. Reumatol Clin. 2012; 8(4): 195–200, doi: 10.1016/j.reuma.2011.10.012, indexed in Pubmed: 22196960.