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Why electromyoneurography instead of electromyography and electroneurography? Electroneurography is essential for interpretation of electromyographic results!

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Abstract

The author suggests revival and further development of old method who had proven to be of significant benefit in differential dignostics of nerve lesions and displayed significant research possibilities. The basic idea is the unification of electromyographic results with neural stimulation. Therefore the author suggests again, to use new name - Electromyoneurography for the old methods.

Introduction

George Bernard Shaw once wrote: „The single biggest problem in communication is the illusion that it has taken place". I hope this introductory part will make possible, among nowadays achieved scientific circumstances, usage and further development of methods differentiated some decades ago in Centre /Institute for neuromuscular disease, of University Hospital Clinic Zagreb, which I have founded, 1973. The purpose of this review is to shed the light on the old methods who had proven to be of significant benefit in differential dignosis of nerve lesions and possible basis for further scientific research.

Thanks to A.von Humboldt Foundation's scholarship, I spent 1965/1966 in Münich, at the Laboratory for Electromyography and Clinical Neurophysiology, headed by Albrecht Struppler. He was the collaborator of Fritz Buchthal who is considered a founder of Electromyography. The collaboration Münich - Zagreb- Münich persisted for decades, until mine retirement during the begin of the war in Croatia, 1991.

On the global level the criteria for differential diagnostic of normal and pathological changes in electromyography, as well as the techniques of improving them, were changing. Very much was expected from quantitative EMG or later on from simultaneous surface multielectrodes derivations. The suface electrodes were for years officially preferred to concentric needle electrodes. The old concentric needle electrode technique I met defined in Munich's laboratory, some decades ago, slowelly proved to be better. You analyse only few muscles, selected according the logics of neurological finding. By slightly moving the concentric electrode you try to approach to the middle of the motor unit, until the potentials amplitude does not anymore increase.

The novel insight and better understanding of EMG signal was made possible by analysis, with the same recording electrode position, of the effect of corresponding nerve stimulation and this way evoked primary and secondary muscle potential.

Therefore, I proposed to call the method: Electromyoneurography. The stimulation should be done by bipolar uninsulated stimulation electrodes as I learned at Albrecht Struppler's laboratory. The stimulation may be done with surface electrodes also, but the reliability, constancy and reproducibility of the results, with such technique, decreases significantly. With needle electrodes, by simple switching of the polarity, besides the efferent motor conduction velocity the additional afferent conduction velocity measurements can be done. If necessary, the ribbon electrodes for percutaneous evocation of sensory potentials may be involved.

Analyses of evoked muscle or nerve potentials clarifyes so many problems connected with motor unit changes origin. The most of ours very interesting results were published already, the decades ago, most of them as preliminary communications. Its further elaboration was stopped by very complex psychosocial situation and existantial problems in Croatia during the war. To adopt this method you must have additional skills, and develop sensibility for distinguishing the real phenomena from artefacts.

The already reached results I would like to present in nine research chapters.

1. Differential diagnostics of canallicular syndromes
2. New sensory potentials evoking techniques
3. Distal compressive syndromes
4. Physiologic variations in muscle innervation pattern.
5. Evoked secondary muscle potentials analyses
6. Neuromuscular synapse testing

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7. Urethral and anal sphincter analysis

8. Facial nerve examinations

9. Trophic disorders and sympathetic skin response.

Differential diagnostics of canallicular syndromes

I elaborated further the principles I learned at Albrecht Struppler's laboratory. My first articles, after I came back home from the scholarship, were about evaluation of localised slowing in elbow region with plurisegmental application. It involves, first of all the cubital tunnel syndrome [1,2]. Plurisegmental nerve analysis proved to be of value, especially in identification of the acquiered localised comppressive factor resulting in neurological changes [3]. In my handbook (with introduction chapter by Albrecht Struppler), I described for didactic purposes the most common compressive syndromes and their electromyoneurographic and clinical differential diagnostics, with casuistic descriptions and more than 107 original pictures [4]. The new neurological sign "reversible flexion contracture" was described there, as well. In the development of those methods, particularly important was the use of special long needle electrodes for more proximal stimulation points. The length of electrodes was adapted to nerve stimulation point location, longer if a deeply localised nerve was in question. On that way, we succeeded in better differentiation of the upper thoracic aperture syndromes [5]. This way we found the isolated slowing of conduction velocity in proximal neural segments, in polyradiculitis for instance [6]. The method was useful in differential diagnostic of hand amyotrophy [7] where normal conduction velocities in all segments and the greatest amplitude of nerve potential in most proximal , confirmed the spinal origin. In most of the cases the features of evoked direct muscle response were of benefit also, as shown on Figures 1 and 2.

The clinical meaning of slowing of conduction velocities, accompanied by clinically perfect motoric activities, in ten cases, was raised [8].

In two qualification publications, in healthy subjects, multisegmental efferent and afferent conduction values of femoral and radial nerves were identified [9,10].

New sensory potentials evoking techniques

At first, we used to evoke sensory potentials on fingers, by the ring-electrodes (brought from Münich), and later on by ribbon electrodes. Interesting were the preliminary results in finger amputation [11].

On the feet, the transferring Buchthal's method of evoking sensory nerve potentials by surface stimulation of the big toe, failed. We tried

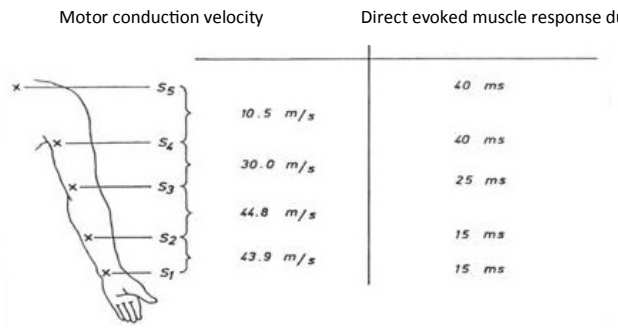

Figure 1. Distal plexus brachialis compression by anomalous muscle. The slowest conduction velocity was obtained in the nerve segment through axilla. The widest evoked muscle potential was obtained through the most proximal stimulation point.

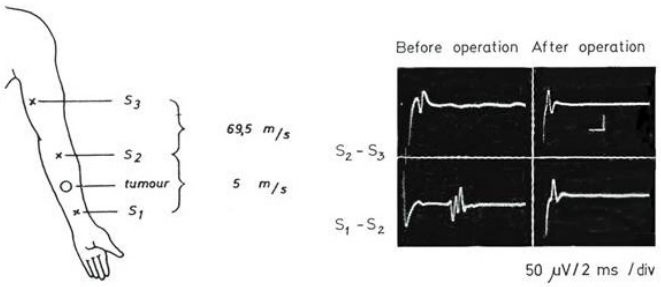

Figure 2. Very small tumour on the median nerve in the lower arm caused slight thenar atrophy and sensibility lesion. Tektronix-565. In afferent fibres of S1-S2 segment nerve conduction velocity was highly reduced: 5 m/s. Motor conduction velocity in the same nerve segment was only slightly reduced and proximally normal.Nerve potential evoked in S2-S3 segment is normal and in S1-S2 (over the tumour side) wide, polyphasic and with prolonged latency . A month after the operation, in the same region, evoked nerve potential with entirely normal features.

therefore to develop our own method [12]. In order to include as much of sensory receptors as possible, we stimulated with the large ribbon electrodes the sensory innervation territory on the feet, of peroneus superficialis , tibialis and suralis nerves. Recording was done by bipolar, needle-electrodes, proximally on the nerve trunk. The subcutaneous stimulation with uninsulated, bipolar needle-electrodes, in patients with even minor skin pathology, evoked the missing, on percutaneus stimulation, sensory potentials in 43,90%, 40,22% and 51,72% of patients [13].

Distal compressive syndromes in the hands

A definition of final latency of median and ulnar nerve as the quotient of "distance through time" enhanced the diagnostic precision [14]. The features of evoked direct muscle response were of benefit as well [15,16] especially in diagnostics of "deep palmar branch" syndrome [17].

Physiologic variations in muscle innervation pattern

Interesting was the registration of physiologic variations in hand innervation territories, an idea that I brought from Münich, and developed it further [18].

The possibility of sensory innervation variations we noticed first time, by chance, during the analysis of sensory changes in SMA/ALS patients [19,20].

The variations in innervation territories, motor as well as sensory, are often found in the same person, in the arms and in the legs. Therefore, we started to speak about congenital diathesis [21]. In a doctoral thesis, in healthy examinees, in the supposed innervation territory of radial nerve, numerous variations in innervation pattern were differentiated, on account of ulnar and median nerve territory [22].

Evoked secondary muscle potentials

Quite early in my career as neurologist, I became interested in the meaning of secondary muscle potential and the factors of its variability. The preliminary results were published [23]. The conclusion was that the qualitative analysis of secondary potentials can be useful in differentiating the peripheral, from the central nervous system lesions.

In 1969 [24] our results were unexpected - we found F-type secondary potentials in triceps surae muscle of the patient with extreme brain dammage. The revision of the hypothesis started with the analysis of secondary potentials, in three parts of triceps surae muscle, in

healthy subjects. The first results of further analysis were published in 1986 [25]. The conclusion was, that H-reflex features were not a sign of changes in central motor neurons.

The secondary potentials features changes are depending on muscle analysed, therefore they should be linked with normal structure and function of the motor unit [26-28]. There is no correlation with livelihood of myotatic reflexes as well. The same results were obtained in children [29].

The analysis of F- and H- wave distribution features, point to the hypothesis that they are connected with the muscle function or structure. A comprehensive analysis of proximal and distal legs and arms muscles shows relatively consistent findings. The H-potentials are found in muscles important for jumping and climbing. Hypothesis was defined that secondary potentials features may be phillogenetically determined [30].

The secondary evoked muscle potentials may reflect the cramps [31] or myotonic discharges also.

Neuromuscular synapse testing

A detailed description of the neuromuscular junction testing on the small hand muscles, with figures of the results in myasthenia gravis and Lambert-Eaton syndrome, is given in my handbook [4].

In the charge of Environmental Protection Agency (USA) research project on the influence of pesticides on human health, the neuromuscular synapse testing was considered as examination of choice. At that time official hypothesis was, that pesticide intoxication is first of all, involving neuromuscular junction. Our analysis on healthy subjects demonstrated, that even with the highest level of care, if surface electrodes are used, more or less significant artefacts of evoked muscle potentials occur [32]. Meanwhile in two cases of suicidal intoxication on repetitive stimulation, no decrease of amplitudes was observed [33] only clinically abundant cramps and fasciculations and significante increase of cholin- estherase levels. In 1988, I received the letter by Sir John Walton, President of the Research group of neuromuscular diseases (WFN), informing me of my inclusion into the group. He sent me a short new classification of neuromuscular diseases also. In my answer I pointed out, that cholinergic crisis was included in this new issue again, under the diseases of neuromuscular junction, the fact which is not in accordance with our experience.

Urethral and anal sphincter electrophysiologic analysis

We developed and published the EMG analysis [34]. Electroneurography of pudendal nerve was done with two stimulation points, in order to differentiate the level of neural lesion [35]. We used uninsulated bipolar needle-electrodes, the same ones we used in proximal nerves segments analysis on limbs, only longer.

Facial nerve analysis

The examinations were started already within the group of Albrecht Struppler [36]. In Zagreb, the patients with facial nerve lesion were frequent. The examination was focused on the primary and secondary muscle response of regenerating nerve, with following up to the opposite side reinnervation pattern. Hemispasmus facialis was stopped for several weeks, by Xylocain, 1- 2 ccm, with injection needle as stimulating electrode. The injection was performed, only after the direct muscle response appearance, on very low stimulus intensity.

Trophic disorders and sympathetic skin response

Throughout the years, I followed up motor and sensory signs and symptoms in trophic changes. We started stressing the neurogenic origin of many trophic changes [37]. One hereditary case was examined comprehensivelly [38]. The systematic development of electric sympathetic skin responses was started also [39,40].

Conclusions

The methods of neural electrostimulation, as described, significantly increase the precision of electrophysiologic neuromuscular differential diagnostics. Although in primary implementation, they take time and ask for examiner's special skills, at the end, they save time and money. The percentage of diagnostic errors are this way significantly diminished also.

The imaging differential diagnostic methods: CT, MR or ultrasound muscle examinations are developed, pretending to be better. Their difference in precision and reproducibility against the electrophysiology is for discussion. It is the pitty, that there are still so many preferences of surface electrodes to needle electrodes, even for detection EMG. Actually, analgesia and sterility should be a minor problem. With needle electrodes usage the possiblity of precise and constant identification of efferent and afferent conduction velocities and evoked nerve and muscle potentials, even in very proximal nerve segments, is giving far reaching advantages. The great number of artefacts is avoided this way.

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