action potential matches the partially blocked CMAP, confirming the presence of a focal conduction block.

[1]Rhee, E.K., England, J.D. and Summer, A.J. A computer simulation of conduction block: Effects produced by actual block versus interphase cancellation. Ann Neurol 1990; 28: 146-156.

[2]Lange, D.J., Trojaborg, W., Latov, N. et al. Multifocal motor neuropathy with conduction block: Is it a distinct clinical entity? Neurology 1992; 42: 497-505.

26.

Mononeuritis Multiplex Revisited

R.E. LOVELACE (New York, U.S.A.)

Mononeuritis multiplex (MM), originally described in the vasculitis of polyarteritis nodosa[1] is defined as a neuropathy affecting multiple nerves, usually asymmetrically in anatomical space and at different points in time, giving rise to varying degrees of pathophysiologic and clinical maturity of the lesions. At first, axonal lesions in the collagen vascular diseases were described followed by infective neuritis as in neuropathy of lepromatous leprosy[2] and the mononeuritic form of diabetic neuropathy, when the development of the disorder had also strong demyelinating aspects.

A revised definition of MM incorporated these different pathologies giving it syndrome status.[3] Although neuropraxia is usually thought to describe the temporary disturbance of function seen in nerve pressure lesions, it has been described in the asymmetric vascular occlusive lesions, and we have observed it in the early phases of a sarcoid neuropathy in a patient with rheumatoid arthritis, both eventually developing axonal lesions.

Cases illustrate the use of quantitative methods of following MM in the predominantly demyelinating and reversible conduction block (CB) syndromes of some paraproteinemias (a macroglobulinemia recently reported by Thomas) and of multifocal CB motor neuropathy simulating Amyotrophic Lateral Sclerosis. MM syndrome necessitates exclusion of HIV related neuropathy.

[1]Lovelace, R.E. Mononeuritis Multiplex in polyarteritis nodosa. Neurology 1964; 14: 434-442.

[2]Rosenberg, R.N. and Lovelace, R.E. Mononeuritis Multiplex in lepromatous leprosy. Arch Neurol 1968; 19: 310-314.

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Poster Sessions

A-1

The Integrated EMG Lab

ERIK STÅLBERG, STEFAN STÅLBERG, MATS ÅSTRÖM and PER YTTERBERG (Uppsala, Sweden)

A description of the present configuration of our neurophysiological laboratory is given.

About 35 PCs are connected to a local network (LANtastic). They are used for booking-billing, administrative statistics, EMG-analysis, reporting, word processing, statistical analysis, desktop publishing and program development. The EMG set up will be shown in some detail. Recording and analysis are made in a PC based system. The results are stored in a server and each physician may review and edit EMGs-CVs in his/her office and produce a report.

The network has modem connection to a satellite EMG laboratory with the same type of PC based equipment. All CV and EMG data may be transmitted to our server and the results, although obtained remotely, may be reviewed in the ordinary way after about 90 seconds.

The network has also connections to hospital and university networks, including E-mail service.

Network connection between all PCs in a laboratory has a number of advantages regarding efficiency for daily routines, e.g., for text handling when more than one person is involved, e.g., a physician and a secretary or two or more physicians working on the same manuscript. The connection of EMG systems to the network is of great advantage; review in the office, display of data during rounds of lectures and transmission of data from remote laboratories.

A-2

Recruitment Pattern of MU in Peripheral and Central Paresis

Th. VOGT, W.A. NIX, and C. BEER (Mainz, Germany)

Objective: The goal was to see, if the recruitment pattern of single MUs in altered in lesions of the central or peripheral nervous system.

Background: The recruitment order of MUs during voluntary movement is related to their size (size principle), which is fundamental for fine gradation of force. This ability is disturbed in paresis and spasticity. The role of recruitment disturbance in these conditions is not clear.

Method: We studied the recruitment order in normals, stroke patients and patients with peripheral nerve lesions. In the EDC and TA muscle MU size was estimated by macro emg and related to the units recruitment threshold, measured by strain gauge.

Results: In long standing peripheral lesions MUs were enlarged in regard to their macro potential, their recruitment order according to the size principle was preserved by compared to normals, the thresholds were increased.

In stroke patients this order was disturbed as MU size was only weak correlated to their thresholds. Furthermore less units are activated within the measuring range.

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Conclusion: In chronic neurogenic lesions the peripheral motor system is reorganized according to the size principle whereas in central lesions the disturbed recruitment order seems to contribute to the motor deficiency.

A-3

Electrical, Mechanical Properties and Firing Pattern of Single Motor Units in Amyotrophic Lateral Sclerosis

J. POUGET, A. SCHMIED, B. MORIN, J.P. VEDEL and J.Ph. AZULAY (Marseille, France)

Single motor unit activity was recorded in the extensor carpi radialis muscles of control subjects and 8 patients with amyotrophic lateral sclerosis. Subjects were instructed to keep the same contraction level as regularly as possible using an auditory feedback. Motor unit action potentials were recorded with the macro EMG technique. Amplitude and area of the macro-EMG potentials were taken as a measure of the size of a motor unit. To record twitch force, the forearm was immobilized in a device leaving the wrist joint free and maintaining the back of the hand in contact with an isometric force tranducer. The signal recorded with the single-fibre channel of the macro-EMG electrode was fed into a window discriminator which generated trigger signals to average the macro-EMG potential and the twitch contraction of the same motor unit. Up to 500-1000 sweeps were recorded and the spike-triggered-averaging program included a refractory process which made it possible to trigger muscle force analysis only when the motor unit discharge was lower than 10 Hz. Single motor unit discharge pattern was analyzed from interval histograms and joint interval histograms. Patient with ALS showed motor units with enlarged macro-EMG potentials and increased twitch forces. Discharge pattern analysis revealed a number of double discharges. Irregular joint interval histograms were mainly observed in patients with pronounced upper motor neuron involvement.

A-4

Alteration of Motoneurone Properties in Muscular Dystrophy

MIRLA PIOTRKIEWICZ, MALGORZATA FILIPLUK and IRENA HAUSMANOWA-PETRUSEWICZ (Warsaw, Poland)

Every motor unit potential is a response to the excitation from a motoneurone. Therefore an activity of a motoneurone may be investigated by analyzing of time series of motor unit potentials. With this purpose in mind, we analyzed single motor unit potential trains recorded during isometric muscle contractions at different levels of constant force. Potentials were picked up by bipolar electrodes made from Teflon-coated tungsten wires of 90 μm diameter which were introduced into a muscle by means of a disposable hypodermic needle.

Our results for dystrophic muscle show an increase in motor unit firing rate as well as in rate range corresponding to muscle tension increase from minimum to maximum. Also the dependency of the standard deviation of interspike intervals on their mean value for dystrophic muscle was shifted towards shorter intervals which suggests that in dystrophic motoneurones the afterhyperpolarization is shortened. The observed alterations were more pronounced at the more advanced stages of the disease.

The results indicate that the properties of motoneurones supplying dystropic muslces are altered. Both decrease of afterhyperpolarization duration and enhanced firing rate are characteristic for the motoneurones supplying faster muscles.

A-5

Automatic Analysis of the Electromyographic Interference Pattern (EMG-IP): A Statistical Approach to Discriminate among Controls, Myopathies and Neuropathies

JIE CAO and DONALD B. SANDERS (North Carolina, U.S.A.)

The stepwise multi-group linear discriminant analysis technique was used to develop optimal combinations of features measured from the EMG-IP with the aim of minimizing the misclassification rate in controls while maximizing the correct classification rates in patients with myopathy and neuropathy. This produced two combinations of features that minimized the pooled expected cost of misclassification (PECM). The posterior probability U-method error estimator procedure was used to attain both low variance and almost unbiased estimates of the misclassification rates simultaneously.

Applying the two optimal combinations of features to studies performed in the biceps muscle under the assumption of equal a priori probability, 86% of studies in 77 male and female controls were correctly classified. 79% and 68% of studies in 53 male and 56 female patients, respectively, with well-defined nerve or muscle disease were classified correctly, whether or not the tested muscle was clinically involved. When the tested muscle was moderately or severely involved clinically, 90% of studies were classified as being abnormal and 88% were accurately classified by disease type (myopathic or neurogenic).

With this technique we can develop and test the discriminant value of new features and combinations of features of the EMG-IP.

A-6

Decomposition of Multichannel EMG

J.C. SMEREK and H. de BRUIN (Hamilton, Ontario)

A novel method for decomposing multichannel needle EMG is presented. This method separates action potentials (APs) from the interference pattern into action potential trains (APTs) when little if any knowledge about the shape or time of occurrence of an AP is known a priori. Decomposition starts by first adaptively filtering out background noise from the interference pattern. Next, optimal detection of APs is performed by an artificial neural network trained to detect time-frequency patterns characterized by the majority of action potentials located in the recording volume. Once the location of an AP is identified it is extracted from the interference pattern and classified to an APT by using a nearest neighbor criterion. Superpositions are resolved by using extrapolation (with regularization) of AP peaks and detection information from other channels. From both the past firing history and the current level of muscle contraction a maximum

likelihood estimate of the next firing time of that action potential is made. Current APs predicted to occur within this firing time window are first used to classify an unknown AP. If no classification results then that AP either belongs to one of the other APTs not checked or is a new APT. After all classification of APs, the validity of each APT is checked by a clustering algorithm.

This decomposition algorithm was tested on multichannel needle EMG recorded from the first dorsal interosseus. Various contraction protocols involving up to 30% maximum voluntary contraction were done. Ninety per cent of all APs detected were successfully classified.

A-7

Changes in Motor Unit Estimates with Aging

V. GALEA and A.J. McCOMAS (Hamilton, Ontario)

Elderly persons usually exhibit some degree of muscle atrophy, together with a reduction in voluntary strength, but there is still argument concerning the nature of the cellular events involved. We have now re-examined this issue, by estimating the numbers and relative sizes of motor units in four limb muscles, using a fully automated system (Galea et al. 1991).[1] In 161 healthy volunteers, aged 20 to 98 years, estimations of motor unit numbers were performed on the thenar, hypothenar, biceps and extensor digitorum brevis muscles. Motor unit estimates were found to decline significantly with age in the distal muscles, however, motor unit numbers in the biceps muscle appeared to remain constant. The excitable muscle fibre mass, as reflected in the area of the maximum M-wave, was diminished in all four muscles. Take together, the results suggest that the muscle deterioration in the elderly is due to a combination of changes in the muscle fibres and in their nerve supply, and that the emphasis may differ between proximal and distal muscles.

Research supported by: the Muscular Dystrophy Association of Canada and the DeGroote Foundation and approved by the University Ethics Committee.

[1]Galea V, DeBruin H, McComas AJ. The numbers and relative sizes of motor units estimated by computer. Muscle and Nerve 1991; 14: 1123-1130.

A-8

Motor Unit Estimates Through Accelerometry

D. ELEVELD and H. De BRUIN

Accelerometers were used to measure evoked peak limb acceleration (EPLA) for the fourth (index) finger. EPLAs were used to investigate force properties of motor units (MUs) and estimate their numbers in the first dorsal interosseous (FDI) through clustering in the EPLA versus stimulus amplitude relationship. This system was semi-automated using a personal computer with A/D and D/A facilities. Upon repeated excitation, some MUs potentiate and increase their force contribution by 3 to 4 times. It was found that MU number estimation procedures based on force that do not consider twitch potentiation may be underestimating MU numbers. A disadvantage of using EPLA for MU estimation is that sensitivity may vary between subjects due to finger weight and joint dynamics.

A-9

A Method for the Longitudinal Study of Single Human Thenar Motor Units

T.J. DOHERTY and W.F. BROWN (London, Ontario; Boston, U.S.A.)

Methods currently available to study the electrophysiological and contractile properties of single human motor units (MUs) preclude the same MU from being studied on repeated occasions. We have developed a method, described herein, which allows single thenar MUs to be studied longitudinally.

Sites were located along the median nerve where it was possible to selectively stimulate a single motor axon as determined by: a) the presence of an "all-or-nothing" surface-detected motor unit action potential (S-MUAP); b) the presence of F-responses identical in size and shape to the direct S-MUAP; c) excitation thresholds widely separated from the next highest threshold motor axon so as to allow stimulation frequencies as high as 50 Hz.

To ensure that the same single motor axon had indeed been located and stimulated in successive studies, additional criteria included: a) the motor axon was found at approximately the same site along the nerve; b) the threshold for excitation remained widely separate from the next highest threshold motor axon; c) the shape of the S-MUAP and position of the MU were almost identical on repeated studies; d) S-MUAP and F-response latencies were very similar.

This method provides, for the first time, an opportunity to longitudinally study the electrical and contractile properties of single MUs to investigate the effects of training, aging, and various diseases of the motor neuron and motor axon.

A-10

Sources of Error in the Spike-Triggered Technique of Motor Unit Number Estimation (MUNE)

M.B. BROMBERG and J. BROMBERG (Ann Arbor, U.S.A.)

MUNE is an electrophysiologic method to estimate the number of motor units innervating a muscle or group of muscles by determining the ratio of the maximal evoked response amplitude to the average single unit response amplitude. We investigated sources of error in the spike-triggered averaging technique with emphasis on errors encountered in ALS subjects.

The maximal evoked response may be enlarged artificially by volume conduction from muscles innervated by the same nerve or from muscles innervated by nearby nerves to give an over estimate of the MUNE ratio.

Spurious trigger potentials (e.g., fasciculations) contaminate the spike-triggered average. A single spurious potential within 1 order of magnitude of the averaged potential is acceptable, but inclusion of 10 potentials of twice the amplitude or 2 potentials of 5 times the amplitude inflates the average amplitude to > 110%. Spurious potentials are derived from the population of single potentials. Plots of the amplitudes of single averaged potentials for normal and ALS subjects showed the range to span 1 and rarely 2 orders of magnitude, while median and mean amplitudes were within 1 order of magnitude of the highest values.

Shifts in the triggering spike can occur when trigger potentials are complex and unstable, resulting in temporal shifts during averaging. Modeling of temporal shifts revealed that a 2 msec shift was acceptable, but a 4 msec shift reduced the amplitude to < 90%.

Understanding sources of error can improve the accuracy and reproducibility of the spike-triggered averaging technique.

A-11

Long Term Monitoring of Motor Unit Numbers in Uremic Patients on Hemodialysis

J. DELBEKE (Mouscron, Belgium)

Surface electrode investigations have repeatedly been performed in 40 non-diabetic uremic patients on chronic hemodialysis. Each test session included suralis nerve sensory potential amplitude, motor and sensory nerve conduction velocity and latency measurements, estimations of the number of motor units in the EDB and plantar muscles, H reflex analysis as well as skin reflex and EKG R-R variation studies. In accordance with the literature, each of these tests is affected in some of our patients.

In ten cases more than ten examinations have been repeated by the author at a rate of about twice a year. No definite trend appears after years of follow up. Nevertheless, very different numbers of functional motor units are often found in the same patient from one session to the next. These changes can be very quick but do not occur simultaneously in different muscles. Fluctuations in other results do not correlate with the motor unit count. The timing of the dialysis before the examination, however, is a factor to consider.

The motor unit estimation technique evaluates collateral reinnervation through the average size of single motor unit amplitudes. The youngest patients (21 - 51 years) thus show a poor collateral reinnervation as compared to the older half of our population (51 - 82 years). This difference does not correspond the degree of denervation.

These findings are best explained in terms of reversible conduction blocks as would be produced by a reduced safety factor, for example.

A-12

A Study of Thenar Motor Unit Number Estimates Based on the Analysis of F-Responses

D.W. STASHUK, T.J. DOHERTY, A. KASSAM and W.F. BROWN (Waterloo, Ontario; London, Ontario; Boston, U.S.A.)

Thenar motor unit number estimates (MUNEs), based on an average surface detected motor unit action potential (S-MUAP) calculated from the data point by data point average of a sample of S-MUAPs selected automatically or manually from a population of F-responses or by multiple point stimulation (MPS), were compared. Young (n = 18, aged 31 ± 11 years) and older (n = 15, aged 68 ± 3 years) subjects were studied. MUNEs based on the automated selection of S-MUAPs from the F-responses were similar to estimates obtained using MPS (219 ± 77) and compared well with those derived using a computer assisted manual method for selecting S-MUAPs from the F-response (automated 245 ± 105 vs. manual 241 ± 100, r = 0.93). Similar differences between the MUNEs of young and older subjects were obtained for both the automated F-responses (287 ± 103 vs. 195 ± 34) and MPS (290 ± 94 vs. 172 ± 68) based techniques. Furthermore, the automated F-response based technique had good repeatability (r = 0.71). The advantages of the automated F-response based technique for collecting a sample S-MUAPs for calculating MUNEs include the ready tolerance of the technique by subjects, the minimal amount of operator interaction required, and the additional information relating to the conduction velocities and latencies of single motor axons.

B-13

Is Neuromuscular Transmission Jitter A Non-Linear Dynamical Process?

J.M. GILCHRIST, M. PERRONE and J. ROSS (Providence, Boston, U.S.A.)

Neuromuscular transmission can be viewed as a system definable by dynamical equations. Utilizing prolonged axonal stimulation single fibre EMG, neuromuscular transmission becomes a time-series of interpotential intervals. A linear dynamical explanation is inadequate because jitter, i.e., the variability between consecutive interpotential intervals, exhibits seemingly random behavior. We examined whether the randomness was due to noise in the system (intrinsic or extrinsic), or whether it could be explained by non-linear dynamics, e.g., as deterministic chaos.

The presence of chaos was assessed by analysis of serial IPIs using phase-space plots and Poincare maps in 2 and 3 dimensions, principle components analysis, correlation dimension (using the Grassberger-Procaccia algorithm) and approximate entropy, with little evidence topologically or mathematically for deterministic chaos. IPI histograms exhibited gaussian distributions and power spectrum analysis revealed a power law frequency dependence with exponent of –2 ($P(f) \sim f^{-2}$), strongly suggesting neuromuscular transmission jitter was due to intrinsic noise characteristic of a random walk phenomenon and simple diffusion.

B-14

Extra-Discharges in a Muscle Fibre May be Responsible for Initiating and Maintaining the Complex Repetitive Discharges

JOŽE V. TRONTELJ, ERIK STÅLBERG and ADNAN J. KHURAIBET (Ljubljana, Slovenia; Uppsala, Sweden; Kuwait)

Complex repetitive discharges (CRDs) are an electrophysiological feature of chronic denervation, but are also seen in some other conditions associated with hyperexcitability of muscle fibres, and can be generated in muscle fibres with preserved innervation. The finding of "low" jitter between the individual spike components had led to the assumption that CRDs depend upon ephaptic transmission of excitation between neighbouring hyperexcitable muscle fibres.

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A number of SFEMG recordings containing complex repetitive discharges were reviewed. Using the published criteria (Stålberg and Trontelj 1979), one or several extra-discharges of individual muscle fibres could often be identified within the basic complex. This particularly applied to CRDs in cases of advanced muscular dystrophy. A muscle fibre in a voluntarily firing motor unit could suddenly give rise to one or several extra-discharges; this was followed by a CRD involving the same and occasionally additional muscle fibres. The extra-discharges in this case are believed to have the role of the principal pacemaker. On the other hand, one of the extra-discharges (often the second or the third in a burst) could function as a secondary pacemaker; its disappearance was associated with dropping out of one or a group of other muscle fibres.

It is suggested that extra-discharges may have a role in initiating and maintaining the CRDs, particularly those of the high-frequency type with a closed electrical loop.

B-15

Multiple Innervation of Muscle Fibres – SFEMG Evidence in Myasthenia

JOŽE V. TRONTELJ and ERIK STÅLBERG (Ljubljana, Slovenia; Uppsala, Sweden)

Multiple nerve endings terminating on single muscle fibres can occasionally be inferred from SFEMG recordings during axonal microstimulation.

Bimodal latencies suggestive to two-neurone innervation may be obtained when stimulus strength is varied. The phenomenon can only be identified when the responses at the early latency show intermittent neuromuscular block. It is distinguished from an axon reflex by the fact that the weaker stimulus elicits responses at only one latency and the stronger one at two.

On the other hand, trimodal latency distribution (responses at 2 latencies obtained with the weak stimulus and the appearance of a third latency with the strong stimulus) suggests two NMJs belonging to different branches of a single motor neuron. One of the latencies in this case is due to an axon reflex. Again the phenomenon is only manifested when intermittent blocking occurs at the NMJ giving rise to the earliest responses.

In both kinds of responses, the order of appearance of the early, (intermediate) and late latencies, respectively, with increasing stimulus strength depends on the location of the recording electrode relative to the NMJ responding to the weaker stimulus.

Both kinds of recordings can be seen in patients with myasthenia. Presumably they are due to ectopic NMJs formed at separate points along the muscle fibre following a severe damage to the original NMJ. At a stage in the process, the two NMJs may co-exist and be functional.

B-16

Patterns of Neuromuscular Transmission by Stimulation SFEMG

K. ARIMURA, Y. ARIMURA, S. TAKENAGA, M. OSAME and E. STALBERG (Kagoshima, Japan; Uppsala, Sweden)

Stimulation SFEMG is advantageous because it is less technically difficult and it well differentiates pre- and post-synaptic neuromuscular transmission abnormalities. Stimulation SFEMG at different rates (1, 5, 10, 20 Hz) were performed in patients with Myasthenia Gravis (MG), Botulinum Toxin treatment (BT) and Amyotrophic Lateral Sclerosis (ALS). In BT, the jitter improved from 1 to 5 Hz stimulation confirming a presynaptic abnormality. In MG, the typical increase in jitter of a postsynaptic disorder was noted up to 10 Hz stimulation. At 20 Hz, jitter improved in MG suggesting a presynaptic facilitation. However, some endplates of MG showed improvement of jitter between 5 and 10 Hz, thus suggesting a possible coexisting presynaptic abnormality. Remarkably in ALS, the increased jitter at lower rates even worsened at 20 Hz, thus suggesting some pathophysiological changes at the presynaptic area.

B-17

Influence of Inactivity Atrophy on Macro-EMG

K. BEER, W.A. NIX, and T. VOGT (Mainz, Germany)

The objective of this study was to investigate in which way inactivity atrophy of limb muscle influences macro-EMG parameters. The macro-EMG signal reflects the electrical activity of a motor unit and can be taken to estimate its size. From the single fibre trigger for the macro signal, additional information can be taken to measure the fibre density (FD) of the unit.

We studied patients with unilateral limb immobilization and muscle atrophy. Acute effects were studied after a radial fracture (n = 8) and cast removal in the EDC and chronic effects in the vastus medialis muscle in patients with knee joint instability after cruciate ligament reconstruction (n = 13). Macro-EMG was performed in recording 20 potentials and figuring the median for amplitude and area, also the FD for the whole muscle was calculated.

In healthy volunteers we examined both vastus medialis muscles to look for side dependent difference. The difference was small with 7% for amplitude and 6.3% for area. In patient with ligament reconstruction the immobilized leg had a drop of 12.5% for amplitude and 32.8% for area. In the EDC the atrophy muscle had 21.3% smaller amplitude and 25.8% smaller area macro-values. FD was not changed in the atrophy muscle. This can be explained by the homogeneous reduction of the fibre diameter and the attenuated fibre property as an electrical generator.

Macro-EMG seems to be a valuable tool to estimate the amount of muscle atrophy following motor inactivity.

B-18

Subclinical Diabetic Polyneuropathy: Early Detection of Involvement of Different Nerve Fibre Types

P.L. OEY, P.H. HENDRIKSEN, G.H. WIENEKE, B. BRAVENBOER and A.C. van HUFFELEN (Utrecht, The Netherlands)

The early detection of subclinical nerve involvement in diabetic patients depends on two factors, namely the biological expression

of the disease and the characteristics of the neurophysiological methods used. Diabetic neuropathy involves different nerve fibre types. Therefore, simultaneous assessment of different nerve functions mediated by different nerve fibre types might be of great help to detect selective nerve fibre involvement. Nerve conduction studies, tests of autonomic function (pupillometry) and terminal nerve branches (SFEMG), and soleus muscle H-reflexes were applied to 60 IDDM patients with no clinical symptoms but abnormal vibratory and/or temperature perception thresholds indicating subclinical neuropathy.

In the majority of patients neurophysiological examination yielded a broad spectrum of neural dysfunction. The perception threshold for cold stimuli was sometimes selectively impaired and abnormal pupillometry results were common suggesting that small fibres are vulnerable in the early stage of diabetic neuropathy. The upper extremities were less frequently and less severely affected than the lower extremities, an effect which may be related to nerve length.

The neurophysiological test results did not change in 30 patients examined prospectively over one year.

B-19

Experimental Guillain Barré Syndrome: A Mouse Model

L.H. van den BERG, P.L OEY, G.H. WIENEKE, S.H.W. NOTERMANS and J.H.J. WOKKE (Utrecht, The Netherlands)

Recently, we have found symptoms of paralysis in mice injected with serum from Guillain Barré Syndrome (GBS) patients.[1] An experimental mouse model of GBS is not yet known. The aim of our study was to explore the usefulness of measuring the nerve conduction by means of the Hoffman (H-) reflex in mice, the technique which is commonly used in rats,[2] for the study of GBS.

Four groups of three mice were used: a healthy control group and three groups of mice in which sera from different sequelae (day 6, 10 & 15 of illness) of a GBS patient were injected. H-reflexes were performed every 3 days during a fortnight.

The ratio between CMAP amplitude from proximal (sciatic notch) and distal (ankle) stimulation (P/D) was calculated, as well as the obtainable H reflexes.

On day 5, the decrease in P/D ratio and increase in H-M interval from proximal stimulation were significantly larger in the GBS group injected with serum from day 6 than in the control group.

Clinically, the symptoms resemble human GBS: insufficient respiration resulting in a wasp-like waist and weakness of the legs; these were found most strongly in the GBS group mice injected with serum of day 6 of the illness. The symptoms disappeared after 48 hours.

These findings suggest that this experimental mouse model of GBS may be a useful method to quantify the peripheral nerve disfunction in autoimmune-polyneuropathy.

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[2]Hendriksen PH, Oey PL, et al. Hypoxic neuropathy vs. diabetic neuropathy: an electrophysiological study in rats. J Neurol Sci 1992; 110: 99-106.

B-20

Pain Induced by Electrodiagnostic Tests

DAVID YARNITSKY, ELIOTT SPRECHER, SHALOM SHTAHL and JESAYCHU A. HEMLI (Haifa, Israel)

Aim of study: Assess characteristics of pain induced by electrodiagnostic tests – whether epidemiological data can predict its magnitude, and whether conduction and needle induced pain are different from each other.

Methods: 58 patients filled a questionnaire following the electrodiagnostic test. In addition to epidemiological data, visual analog scales (VAS) were used to assess intensity of pre-test apprehension and level of pain induced by conduction and needle studies.

Results: Age, gender, ethnic origin (Ashkenazi or Sepharadic) and years of education bear no significant correlation to magnitude of pain induced by the test. Mean magnitude of pain induced by conduction and needle were 4.35 and 4.78 on 0-10 scale, respectively, with no significant difference between the two parameters. Conduction and needle pain were significantly correlated ($p = 0.003$, ANOVA). Degree of pre-test apprehension was not correlated to test pains.

Conclusions: 1) Magnitude of pain experienced during electrodiagnositc test cannot be predicted by epidemiological data. 2) Pre-test apprehension does not predict pain during the test. 3) Conduction and needle tests induce similar amounts of pain.

B-21

Predictors of Pain Relief After Electromyography in the Diagnosis of Lumbosacral Radiculopathy

JENNIFER CHU-ANDREWS (Philadelphia, U.S.A.)

Patients with trauma induced low back pain and radicular symptoms had EMG performed at painful myofascial bands from bilateral L2-S1 myotomes with physical examination before and after the EMG. Follow up questionnaires were obtained two weeks after the test. Of the 76 patients that replied, 52 had pain relief (group 1) and 24 had no pain relief (group 2). Diagnosis of radiculopathy was made on presence of increased normal duration, normal amplitude polyphasic MUAPs (> 30%) in a myotomal pattern. The involvement was bilateral in both groups and the L4, L5, S1 nerve roots were commonly involved. Groups 1 and 2 showed no differences in age, number or degree of nerve roots involved. Group 1 had less pain on palpation of different myotomes and shorter duration of symptoms (15.02 ± 16.85 months) than group 2 (26.44 ± 28.34 months). Group 1 showed increase in strength and/or range of motion after the EMG which correlated with percentage of pain relief. Group 2 had less changes in physical improvement and had increased pain for 6.50 ± 6.04 days after the EMG. Group 1 had 49.15 ± 25.83% pain relief for 8.06 ± 7.52 days which occurred within 1.4 ± 2.2 days, with 55.8% obtaining pain relief immediately after the EMG. Painful myofascial bands were found to be motor end-plate zones and adequate desensitization of these areas is probably the cause of pain relief.

B-22

A Multichannel Analog Conditioning System

J.C. SMEREK and H. de BRUIN (Hamilton, Ontario)

A multichannel analog conditioning system (MACS) is presented. This system which incorporates state of the art analog hardware controlled by a graphical user interface is intended to be used as a front end to a multichannel data acquisition system. MACS enables the user to record the best possible biological signals, especially EMG, under all recording conditions. The computer controlled system permits real time control of signal gain, high pass filter cutoff frequency, low pass filter cutoff frequency and offset. MACS has the ability to monitor up to eight signals in real time and alert the user if any channel becomes corrupt. Furthermore, inherent real time error prevention built into MACS prevents real time errors caused by the combined offsets of channel gain and filter amplifiers.

MACS is completely modifiable to the data acquisition problem at hand. To this end both hardware extension devices and software development libraries are provided. With these tools, a hardware break out box and software interface was developed to condition multichannel needle EMG recorded from the first dorsal interosseus under various contraction protocols.

C-23

Accuracy, Reproducibility and Variability of Hand-Held Dynamometry

A. GOONETILLEKE, H. MODARRES-SADEGHI and R.J. GUILOFF (London, England)

A spring-loaded device that "breaks" at preset forces was used to assess readings obtained by hand-held dynamometry by 3 raters with varying experience in the method. Overall accuracy (3%), but not reproducibility or variability, was improved by greater experience. Readings obtained jointly by 3 raters had 53% greater variability than that obtained by a single rater. Nine muscle groups in 19 patients with motorneuron disease were assessed at 10 sessions (3 replications per session) over 6 days by the experienced rater. Muscle force was expressed relative to that of 22 matched normal controls. Reproducibility was good, with mean percentage difference of 13.2 and repeatability coefficient of 2.17 kg-force for readings 6 days apart; overall correlation coefficient was 0.98. Mean coefficient of variation (CV) of 10 readings was 9.9%. The poorer reproducibility and greater variability seen in clinically weaker muscles may account for differences in patients with bulbar palsy and classical ALS; the degree of spasticity had no effect. The rater was estimated to contribute 40% of the total variability when testing patients. Use of a composite score improved mean percentage difference to 6.7 and mean CV to 5.8%. The reproductibility and variability of hand-held dynamometry readings obtained by a single rater compare well with that of fixed devices. Readings from single raters, irrespective of experience, have similar reproducbility and variability. However, if multiple raters are used for individual patients in longitudinal assessments, as in clinical trials, the variability of their combined readings should be calculated for sample size estimations.

C-24

Reliability of Knee Extension Strength Testing in Elderly Women using a Hand-Held Dynamometer

TARA ROBINSON, DENISE TAYLOR, ANTHONY VANDERVOORT and DENISE CONNELLY (London, Ontario)

Knee extension strength is an important factor for seniors performing activities of daily living such as stair climbing, walking and rising from a chair. The purpose of this study was to evaluate the reliability of a test of KE strength in elderly ambulatory residents at a long-term care facility, using the Microfet hand-held dynamometer. Twenty women with a mean age of 83 years, (range from 68 to 90), were given a brief practice session of about 10 minutes and then tested on two trials by two examiners. On the next day they were retested. Testing position involved sitting upright in an armless, straight-backed wooden chair, with a belt wrapped around the distal thighs. Knee angle was kept at 60 degrees of flexion, using a belt secured around the leg and the chair. There were no significant differences between trials or examiners ($p = .323$ and .698, respectively). The overall mean score for maximum isometric KE strength was 25.7 N.m (SD = 12.1). Variation in the mean values from day to day was less than 5%, resulting in a high Intraclass Correlation Coefficient of .923. It was concluded that this method of knee strength testing had excellent reliability for examining very old women residing in long-term care.

C-25

Delayed Depression of Human Muscle Excitability Following Fatigue

V. GALEA, L. McFADDEN, C. CUPIDO and A.J. McCOMAS (Hamilton, Ontario)

A delayed reduction in muscle fibre excitability has been observed in rat tibialis anterior motor units following severe fatigue (Lannergren et al., 1989).[1] We now report a similar phenomenon in human muscle (biceps brachii) following fatigue induced by continuous supramaximal stimulation at 20 Hz. Muscle excitability as measured by the peak-to-peak amplitude and area of the muscle compound action potential (M-wave) was followed for a maximum of eight hours following fatigue. The volunteers tested fell into two groups. In the first group ($n = 5$), the M-waves potentiated beyond control values within the first 3 min of recovery and then declined for the remainder of the initial 2 hr recovery period; the M-waves recovered to control values within the next 6 hr. The second group ($n = 10$) exhibited a similar pattern of recovery with the exception that their M-waves declined and then normalized within the initial 2 hr recovery period. The cause of this reduction in muscle excitability is presently unclear, though several possibilities exist.

Research supported by: NSERC and the DeGroote Foundation and approved by the University Ethics Committee.

[1]Lannergren J, Larsson L, Westerblad H. A novel type of delayed tension reduction observed in rat motor units after intense activity. J Physiol 1989; 412: 267-276.

C-26

Muscular Fatigue in Duchenne Muscular Dystrophy

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We used a four minute sustained maximum voluntary contraction to investigate anterior tibial muscle fatigability in 8 healthy boys and 11 boys with Duchenne Muscular Dystrophy (DMD) (age 5-10 years). The force generation of dystrophic muscle compared to control (maximum voluntary contraction (MVC) 54.0 ± 6.9 N vs. 126.3 ± 11.6 N, $P < 0.01$, tetanic force (TF) 19.9 ± 3.0 N vs. 58.0 ± 10.9 N, $P < 0.01$; twitch tension (TT) 2.2 ± 0.4 N vs. 6.2 ± 0.7 N, $P < 0.01$) and compound muscle action potential amplitude (CMAP) (2.6 ± 0.3 mV vs. 6.3 ± 0.4 mV, $P < 0.01$) was lower and the half relaxation time of the tetanus in patients compared to control (215 ± 24 MS vs. 138 ± 12 MS, $P < 0.01$) was significantly prolonged. The decline in TF during exercise in both groups (68.1 ± 6.2% vs. 79.6 ± 8.6%, $P = 0.6$) and potentiation in TT (101.8 ± 5.5% vs. 98.1 ± 12.2%, $P = 0.8$) were similar. However, during exercise patients fatigued less compared to controls (decline in MVC 41.4 ± 3.4% vs. 30.0 ± 2.7%, $P < 0.05$) and had less added force (superimposed tetanic stimuli, 15.0 ± 8% vs. 84 ± 12%, $P < 0.01$) suggesting less central fatigue in patients compared to controls. The recovery of muscle force (TT, MVC, TF) during 15 minutes were similar in both groups. There was no significant change in CMAP during exercise and recovery in both groups. These findings suggest that patients with DMD and controls have less intramuscular fatigability and that excitation contraction coupling and central activation pathways are functioning as well as or better than healthy controls.

C-27

Prolonged Exercise Test and Periodic Paralysis

Y. ARIMURA, K. ARIMURA, S. SUWAZONO and M. OSAME (Kagoshima, Japan)

Prolonged exercise test (PET) was performed in 18 cases with clinically suspected periodic paralysis (PP) and compared to 11 healthy controls. Adhering to the procedure of McManis et al. (Muscle & Nerve 1986), the CMAP of ulnar nerve stimulation was compared before and after exercise. In healthy subjects, the CMAP amplitudes showed an initial increase followed by a decline maximally at 16% from pre-exercise values. In PP, 10 cases had positive results showing post-exercise CMAP decline of > 2SD from controls. The positive group were mostly males (9/10) having attacks of muscle weakness of less than 3 days (8/10) and all had history of repeated attacks. Six of these cases had hyperthyroidism and one case had familial hypokalemic PP. The negative group was equally found in both sexes, having only one attack (7/8) which lasted more than 1 week (8/8). Most the cases belonging to the negative group had induced hypokalemia. A positive PET therefore has a predictive value as regards the clinical nature of PP.

C-28

Correlations Between MUP Findings, Histology, Isokinetic Muscle Strength and Imaging Studies

B. FALCK, A. ALANEN, H. KALIMO, R. KARSIKAS, P. HALONEN and K. JOKINEN

MUPs from the anterior tibial and lateral vastus muscles in ten patients with HMSN 1 were compared with ten age and gender matched control subjects. A muscle biopsy was obtained from the vastus lateralis. The isokinetic muscle strength of the knee and ankle flexors and extensors were measured. MR scans were obtained of the thigh and leg.

The amplitude and area discriminated better between the patients and controls than the duration. The amplitude and area of the MUPs was positively correlated with the isokinetic muscle strength in the control subjects. In the patients there was a negative correlation between the amplitude and the strength. The mean diameter of type 1 muscle fibres was correlated with the mean amplitude and the duration of the MUPs in controls and patients. The MUP amplitude was positively correlated with fibre type grouping. The MUP duration was a poor correlation with the other studies.

The MUP amplitude and other MUP parameter related with it were better correlated with the other functional measures of the muscle than the other parameters in healthy and neuropathic muscles.

C-29

Outliers – A Useful Way to Detect Abnormality in Quantitative EMG

CHRISTIAN BISCHOFF, ERIK STÅLBERG and BJÖRN FALCK (Uppsala, Sweden)

Introduction: In quantitative motor unit potential (MUP) analysis at least 20 different MUPs are collected and mean values compared with reference values. Another approach, similar to the visual analysis, is to assess the presence of outliers with abnormal MUP parameters. The aim of the investigation was to compare the diagnostic yield of the method measuring outliers of various parameters with mean values.

Methods: Deltoid, brachial biceps, first dorsal interosseus, anterior tibial, and vastus lateralis muscles of 104 control subjects and 49 patients with various neuro-muscular disorders were studied with a concentric needle electrode using a decomposition method. For each recording of 20 MUPs the third largest and smallest value was defined for each parameter, corresponding to 10 and 90% confidence limits.

Results: The mean values and the outliers showed no significant age dependency. The sensitivity to detect abnormality was nearly the same for both methods in neurogenic diseases. The number of outliers showed a good correlation to mean values. The outlier technique showed abnormal values for amplitude in 2 and for duration in 3 cases that were missed by mean values. In 3 and 4 cases respectively the findings were reversed. The abnormalities were easier to detect in the neurogenic group than in the myopathic with both methods. However, outliers of amplitude were better correlated with the diagnosis of a myopathy

than mean values; outliers alone showed pathology in 5 cases whereas the mean value alone was never abnormal. The number of acquired MUPs necessary to obtain the 3rd outlier ranged from 3 to 20. On average, 10 MUPs gave 3 outliers for amplitudes and duration measurements.

Summary: Outlier estimation is nearly as good as measurements of mean values in neurogenic conditions and somewhat better in myopathies. If the only aim of the MUP analysis is the characterization of a pathologic condition and not quantitation of the severity it is sufficient to look for the third outlier that clearly indicates pathology as it reduces the investigation time.

C-30

Automated Method for the Evaluation of MUAP Shape Irregularity

EWA ZALEWSKA and IRENA HAUSMANOWA-PETRUSEWICZ (Warsaw, Poland)

The motor unit action potential (MUAP) waveform depends on the motor unit architecture, i.e., on the number of fibres, their sizes and density, hence the analysis of MUAP shape provides information about the MU structure and its changes. These changes may manifest as polyphasic potentials characterized by an increased number of peaks and/or turns, i.e., as signals of a more complicated shape than the normal MUAP.

Complex MUAP signals are difficult to quantify unambiguously with the conventionally used parameters, e.g., the amplitudes, durations, number of peaks and turns, because these parameters characterize the global features of the waveform and are not sensitive to the details of the signal shape. The variations of the shape which may be called the signal's irregularity, are commonly estimated visually. A method for the quantitative evaluation of the MUAP irregularity by means of an appropriately defined coefficient has been developed.

The irregularity coefficient is defined as the "length" of MUAP curve normalized by the singal's amplitude. This coefficient is a generalization of the concept of the number of peak's parameter. It gives an information about the irregularity of potential complementary to the potential characteristic provided by the set of conventional parameters.

The mathematical definition and the properties of the irregularity coefficient are discussed and its application for the quantification and comparison of real signals is presented.

C-31

Characteristics of Single Thenar Motor Units in the F-Response of Young and Older Adults

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The purpose of this study was to characterize the properties of single thenar motor units in the F-response of healthy young (n = 15; age 33 yrs ± 11) and older subjects (n = 15; 68 yrs ± 3). Trains of 300 stimuli at intensities evoking M-potentials 10, 20 and 30% of the peak to peak amplitude of the maximum M-potential, were delivered to the median nerve. In the young, observed firing probabilities of surface-detected motor unit action potentials (S-MUAP) extracted from the F-response, ranged from less than 1 to 10%, varied in size from 0.02% - 5.3% of the maximum M-potential negative peak area, and were similar in size to the population of S-MUAPs collected by Multiple Point Stimulation of the nerve. The range in latencies in individual young subjects were between 8 and 20% which translated to conduction velocities (CVs) of 48 - 68 $m \cdot s^{-1}$ (mean 59 ± 4). The preceding were all independent of stimulus intensity. The S-MUAP sizes were significantly larger in older subjects, and the range and distribution of axonal CVs (38 - 61 $m \cdot s^{-1}$; mean 52 ± 3) were markedly shifted to reflect a slower population of motor fibres and suggest that age-related axonal slowing may uniformly affect all median motor fibres.

C-32

The Ability of MUP Parameters to Discriminate Between Normal and Neurogenic MUPS in Concentric EMG

MASAHIRO SONOO and ERIK STÅLBERG (Tokyo, Japan; Uppsala, Sweden)

The ability of a motor unit potential (MUP) parameter or a set of parameters to discriminate between control MUPs and MUPs from muscles with severe to moderate inactive neurogenic changes was investigated using discriminant analysis. As a single parameter, area gave rather good discrimination, while amplitude, duration and area/amplitude did not give good discrimination. Only 15 - 30% of MUPs from neurogenic muscles were judged to be abnormal by duration alone. The combination of amplitude and the area/amplitude ratio (Area/amp; MUP thickness) improved discrimination considerably and around 70% of neurogenic MUPs were judged to be abnormal. An assigned discriminant function with simple integer coefficients gave similar good results, which was named as "Size Index". The experiment of manual scanning of an MUP revealed that AREA/amp increases, that is, the MUP becomes thicker as the amplitude decreases with increasing recording distance, while the size index remains almost constant for each MUP throughout the needle movement. The new parameter, size index, is promising because (1) its value is stable and resistant to somewhat uncertain duration setting, (2) its value remains almost constant irrespective of the needle position, (3) it gives much better discrimination results than duration.

C-33

Does Human Skin Contain a Battery?

R.W. EINHORN, T. BLOGG, J. BUTLER and A.J. McCOMAS (Hamilton, Ontario)

The use of SSRs (sympathetic skin responses) to investigate function in the autonomic nervous system has prompted further consideration of their mechanism. While it is firmly established that SSRs reflect acetylcholine-induced activity in sweat glands, it is not clear whether the latter generate the potentials directly or whether they modulate a standing (d.c.) potential across the skin. We explored the possible existence of such a d.c. potential

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by introducing a chlorided silver wire, or NaCl-filled tubing, subcutaneously; on the surface of the skin EKG stick-on electrodes were used initially, but in later experiments we replaced these with a AgCl:NaCl system. With the approval of the University Ethics Committee, we studied 4 subjects repeatedly and found that d.c. potentials could indeed be recorded across the skin. The surface of the skin was always negative to the interior of the body and the potentials were especially large across the palm and the undersurfaces of the fingers (e.g. - 80 mV); hairy skin yielded the smallest potentials. The skin potentials varied from moment to moment, and from one subject to another; they also seemed to depend on the hydration of the skin. For various reasons it seems unlikely that the d.c. potentials are due to electrogenic ion transport either in the sweat glands or in the epidermal cells.

C-34

Neurophysiological Monitoring of Sensory and Motor Function during Acetabular Fracture Surgery: Preliminary Results

KENNETH A. KLETTKE, DAVID A. HOULDEN, ALBERT SCHOPFER and JAMES N. POWELL (North York, Ontario)

Post-operative neurological complications in patients undergoing acetabular fracture surgery occur in up to 13% of patients. Intraoperative irritation to the sciatic nerve or femoral nerve is thought to be related to unsuitable retraction of these nerves during fracture fixation.

Presently, the only reported neural monitoring is somatosensory evoked potentials (SSEP's). We have additionally monitored motor nerve function in 8 patients undergoing acetabular fracture surgery.

In our series, posterior tibial nerve SSEP's were continuously monitored and motor evoked potentials (MEP's) were intermittently recorded from selected muscles (predominantly tibialis anterior, gastrocnemius and quadriceps) following electrical stimulation at the thoracolumbar junction using two interspinous ligament needle electrodes placed percutaneously.

In contrast to the SSEP, which requires averaging, only one stimulation is generally necessary to obtain an MEP which provides more rapid feedback to the surgeon.

In one patient, the MEP significantly deteriorated during surgery but returned to baseline once nerve retraction was altered. None of our 8 patients developed a permanent deterioration in evoked responses and none developed new post-operative deficits.

D-35

Apraxia in Congenital Brachial Palsy

A.J. McCOMAS, KAREN PAPE and SUSAN KIRSCH (Hamilton, Ontario; North York, Ontario)

Arm weakness following trauma to the brachial plexus during delivery remains a significant cause of infantile morbidity. While many children appear to recover fully there remain those in whom disability persists, particularly for muscles of the upper arm and shoulder. Both the clinical and EMG examinations frequently demonstrate the presence of denervation in the territories of one or more trunks of the brachial plexus. We are currently including automated motor unit estimation (AMUE) as part of the EMG investigation of such cases. In one 3-year-old boy, presenting with generalized "weakness" and "clumsiness" of the right arm following complete paralysis of the arm at birth, AMUE revealed that the number of motor units in the biceps brachii was within the normal range, despite impaired elbow flexion and supination. Again, although digital movements were impaired, there was an adequate, though reduced, number of thenar motor units, with evidence of considerable collateral reinnervation.

We interpret these findings as evidence of an apraxic component in this type of brachial palsy, presumably due to the motor cortex not having had the opportunity to construct the motor programs associated with exploratory movements of the arm in early infancy.

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D-36

CTSS Version 2.0: A Computer Program for the Clinical Screening of Carpal Tunnel Syndrome

STEPHAN M. RUDOLFER (Manchester, England)

CTSS version 1.0, a microcomputer program for the clinical screening of carpal tunnel syndrome (CTS), was described in a talk by the present author at the Third International Conference on Computerized and Single Fibre EMG, Larnaca, Cyprus, June 1988, and subsequently in the literature (EMG & Clin Neurophysiology 28 (1988), 259-262, and 32 (1992), 483-489). It involved the use of logistic regression, an important statistical technique, to obtain the chance or probability of CTS in a patient whose nerve conduction measurements are input to the program.

This poster will describe a substantial refinement of CTSS version 1.0, in which the differential diagnosis is extended from CTS versus NAD (no electrodiagnostic abnormality detected) to NAD versus mild CTS versus moderate CTS versus severe CTS versus non-CTS abnormality. In addition to the nerve conduction measurements, the patient's anamnesis and clinical signs are incorporated into the diagnostic algorithm, which is based on an extended logistic regression together with expert system methodology for the handling of non-response in the nerve conduction studies. The input of patients' data and output of the results, on screen and from an attached printer, are organized in a user-friendly way. If an IBM-compatible computer is available, the program can also be demonstrated.

D-37

Reaction Time Assessment in Parkinson's Disease

MARTIN SEGURA, JOSE BUERI and ROBERTO E.P. SICA (Buenos Aires, Argentina)

Premotor reaction time (PRT) is considered as representative of the central process related to programming of movements and

proved to be prolonged in Parkinson's disease (PD) patients with prominent bradykinesia. However, PRT includes the time elapsed for the arrival of the warning signal (WS) to the cortex and that employed by the motor volley (MV) from the cortex to the target muscle. The aim of this paper has been to study more precisely the central process by substracting from the PRT both WS and MV times; what was left was considered to be the actual central process which was designed movement activation time (MAT). 17 right handed, no demented, PD patients were studied; 7 age matched healthy subjects served as controls. All of them were instructed to make a sudden lift of the right (r) forefinger immediately after feeling an electrical shock applied to the r Vth finger. EMG was recorded from the r extensor indices (EI) muscle. Immediately before the experiment all subjects had a short training session. Cortical somatosensory evoked potentials (SSEP) from r Vth finger stimulation were recorded at P3 (Fz reference). Motor evoked potentials (MEP) to monopolar transcranial electrical stimulation were recorded at the r EI. MAT was calculated in each subject by substracting SSEP and MEP latencies from PRT. On separated experiments, MAT was estimated in other 9 PD patients while they were on L-Dopa treatment and after 12 hours of drug withdrawal. Cognitive P300 potential was also studied in 7 out of these 9 patients in both conditions.

It was found that PD patients had significantly prolonged PRT ($p < 0.01$) and MAT ($p < 0.02$), while no significant differences in SSEPs and MEPs latencies were found when compared with controls. MAT duration significantly increased ($p < 0.01$) when patients were deprived of L-Dopa. P300 latency and duration did not change in patients on or off treatment. No correlations were found between MAT and duration of the disease (r: 0.45, p ns) or age of patients (r: 0.13, p ns).

These findings have shown that increased PRT found in PD patients is due to MAT enhancement. In these experimental conditions MAT may represent the delay to initiate the running of the motor program and proved to be impaired in PD. The improved performance of patients on L-Dopa treatment suggest a role for dopaminergic mechanisms in the initiation of movement. The P300 characteristics, which did not change when the patients were on off or on conditions, suggest that neither the cognitive nor the arousal states play a role in the MAT observed changes.

D-38

H-Reflex Recovery Curve Conditioned by Transcranial Stimulation

MARTIN SEGURA, CLAUDIA GANDOLFO, FERNANDO CACERES and ROBERTO E.P. SICA (Buenos Aires, Argentina)

Long latency effects to transcranial (TC) stimulation on spinal alpha motoneurone (amn) excitability lasting about 20 ms have been reported (Cowan et al., 1986). The aim of the present paper has been to study long-latency changes (more than 20 ms) on amn excitability by employing TC electrical stimulation in 12 healthy men and 4 patients with upper motorneurone lesions.

Amn excitability was assessed recording the H-Reflex (HR) from the soleus muscle by stimulating the posterior tibial nerve at the popliteal fossa, both in basal conditions and conditioned by a preceding subthreshold TC stimulus at different time intervals (TI). TIs are defined as the time difference with which both volleys reach the amn and they ranged from 0 to 250 ms by steps of 50 ms. To assess the possible role of the gamma fibres, they were blocked, in 2 normal subjects, in the studied lower limb following Holmes (1963) procedure.

At 0 TI when both, the peripheral and the central volleys, reached simultaneously the amns, the HR amplitude exhibited a slight enhancement not significantly different from basal conditions. With longer TIs, conditioned HRs amplitudes showed a larger increment which was maximal ($p < 0.01$) when the descending volley reached the amns 100 ms before the incoming peripheral volley. Thereafter, this effect progressively waned. Blocking the gamma fibres did not change much this behaviour. Conversely, patients exhibited a significantly ($p < 0.01$) lower enhancement of conditioned HR, when compared with controls, at the 100 ms TI.

This study suggests that TC stimulation-conditioned-HR has a recovery curve with maximal facilitation when the preceding descending volley reaches the amn 100 ms before the signal travelling in Ia fibres, probably due to the activation of very slow central motor pathways.

D-39

A General Structure for the Representation of EMG Data

B. JOHNSEN, A. FUGLSANG-FREDERIKSEN, S. VINGTOFT, P. FAWCETT, I. SCHOFIELD, R. LIGUORI, W. NIX, G. OTTE, G. SIEBEN, M. VELOSO and A. VILA (Copenhagen; Newcastle, U.K.; Bologna, Italy; Mainz, Germany; Gent; Lisbon, Portugal; Grenoble, France)

Existing expert systems (ES) for EMG are often customized to their developing laboratory, are technically cumbersome to use and do not meet varying needs of different "EMG Schools". If ES shall gain more footing in the clinical routine it is required that the systems allow for methodological and epidemiological differences in the handling of the EMG examination and the systems are integrated with EMG equipment.

A general structure for the representation of EMG data has been constructed in an European multicentre project ESTEEM (European Standardized Telematic tool to Evaluate EMG knowledge-based systems and Methods). This structure allows for the storage of data from all examination techniques used routinely at seven European EMG laboratories. Inferred information are included in a diagnostic hierarchy by the use of intermediate pathophysiological states providing possibilities for the evaluation of the diagnostic process performed by ES or physicians. The data structure has been implemented in a computer program that is used at seven EMG laboratories to build a common European database of patient cases. The cases in this database go through a procedure where nine neurophysiologists seek consensus on the inferred information. The database will serve as a reference for the evaluation of ES and can give information about diagnostic criteria used.

D-40

Recording Territory of the Surface Electrode

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We assessed the recording territory of surface EMG electrodes. Spike triggered averaging was used to record surface MUAPs (SMUAPs) in the biceps muscle (10 healthy subjects). Each SMUAP was marked as to whether the trigger was "superficial" or "deep" (< 10 mm or > 20 mm from skin, respectively). The 10 mm value was selected as representative of smaller muscles. The CMAP, arm circumference and skin thickness were also measured.

Mean SMUAP amplitude decreased from 41.2 μV, i.e., in the "superficial" MUs to 11.03 μV in the "deep" MUs. Skin thickness increased with arm circumference. CMAP amplitude decreased with increased skin thickness ($r = -0.87$, $p < .005$) but did not correlate with arm circumference. Mean "superficial" SMUAP amplitude correlated with skin thickness ($r = -.615$, $p < .05$) but "deep" SMUAP amplitude did not. With "deep" triggers, a SMUAP was not always recorded.

We estimate that the principle uptake territory of the surface electrode is between 10 to 20 mm which is adequate for MU estimation in small muscles. In large muscles such as the biceps, it may result in significant variability of estimates due to sampling techniques. It may also explain why small and large muscles appear to have similar CMAP amplitudes on nerve conduction studies.

D-41

Comparison of CNE and SF Macro Signals Using A Combined CN/SF Electrode

P.R.W. FAWCETT, W.A. NIX, I.S. SCOFIELD and S. CONNOLLY (Newcastle upon Tyne, U.K.; Mainz, Germany)

Background. In conventional Macro EMG, a single fibre (SF) recording surface placed 5 mm behind the electrode tip is used to trigger on the motor unit. In another electrode, a concentric needle (CN) recording surface at the tip acts as trigger.

Methods. We have examined the relationship between the two techniques using a combined CN/SF electrode, where the CN surface was situated in the bevel and the SF surface 5 mm behind the tip. Macro EMG signals were recorded from the uninsulated shaft with reference to a distant surface electrode. A separate SF electrode was used to trigger on the motor unit and the CN/SF needle was inserted 1-2 cm distally in the same longitudinal axis of the muscle. Two separate Macro recordings were made from the motor unit: (1) when a synchronous CN signal was obtained, and (2) when a synchronous SF signal was obtained, along the same electrode track.

Results. In 11 recordings from biceps brachii, the CN-triggered Macro MUP amplitudes were consistently smaller than those obtained with the SF trigger (mean 30%; range 7-56%). The most likely explanation is that the proportion of the Macro recording surface (cannula) within the motor unit is significantly less for the CN- than for the SF-triggered potentials.

D-42

Needle EMG Electrodes

W.T. van der RIJT, D.F. STEGEMAN and B.K. van VEEN (Nijmegen, The Netherlands)

One of the relevant aspects in needle EMG is knowledge of the pick-up characteristic of different types of needle electrodes. This pick-up area dominates the relation between waveshape of motor unit action potentials (MUAPs) and the structure of the motor unit. Although simulation models always represent a simplification of the real physiological system, in clinical neurophysiological research such models have proven to be powerful tools in the interpretation of signals.* The results of a volume conductor study will be presented in which various aspects of EMG needle pick-up area are investigated. In summary: (1) For a single fibre (SF) electrode the pick-up area is exclusively determined by the "spread-out" of extracellular ionic current (volume conduction). For a macro-electrode the dimensions of the electrode completely dominate the pick-up range. A concentric needle (CN) electrode shows a remarkable balance between both aspects. (2) The usual setting for high-pass filtering in SFEMG governs the pick-up area in SFEMG. The difference in physical size between the active surfaces of a CN electrode and a SF electrode then appears secondary. (3) Apart from the above factors, the pick-up range also depends on the structural parameters of the motor units as fibre density, spread of end-plates and fibre diameter range. (4) In the contribution of a single fibre action potential to the MUAP so-called phase cancellation occurs. This cancellation is most pregnant for fibres close to the needle and is almost absent for intermediate distances. It increases again for fibres towards the edge of the motor unit.

*E.g., Nandedkar, Sanders, Stålberg, Andreassen, Muscle Nerve 1988; 11: 151-159.

D-43

Single Fibre Potential Changes Caused by the Presence of the Needle Electrode

D.G. STEGEMAN, M.M.H.J. THEEUWEN, T.H.J.M. GOOTZEN and S.L.H. NOTERMANS (Nijmegen, The Netherlands)

A comprehensive volume conductor study of a single fibre needle EMG (SFEMG) recording has been made.* The electrode shaft is described as a passive inhomogeneity in the volume conductor. The so-called electric double layer formed on the needle shaft surface acts like a high impedance insulating sheet. An important observation is a substantial increase in single fibre action potential (SFAP) amplitude (up to 70%) for muscle fibres observed from a short distance. For SFAPs from muscle fibres located on the back of the SF electrode a shadow effect occurs which can result in a maximal amplitude decrease of 50%. Waveform changes are observed only in situations which are of limited practical interest. The presence of the needle shaft causes an anisotropy-like behaviour of the relation between leading-off point to muscle fibre distance. The observed amplification due to the presence of the needle cannula decreases faster in the

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direction parallel to the cannula than in the direction normal to the cannula. Due to the amplification of SFAPs from muscle fibres observed from a short distance, the maximal distance from which SFAPs are included in fibre density measurements (amplitude greater than 0.2 mV) is raised from 380 μm to 460 μm. Besides this phenomenon, also the consequences of the formation of an edematous layer around the needle cannula have been studied. The effect of a high conductive fluid around the needle electrode counteracts the effects caused by the presence of the high impedance electrical double layer.

*Theeuwen, Gootzen, Stegeman, Ann Biomed Engng (1993, in press).

D-44

Quantitation of the Effect of Botox on Laryngeal Spasmodic Dysphonia with the Turns Analysis Method

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LARYNGEAL ELECTROMYOGRAPHY[1] is technically a difficult procedure and although the percutaneous method appears to be the most easily tolerated, the recording electrode (or needle) can only usually be left in place for a few minutes. Earlier studies have indicated that the normal motor unit potentials are relatively simple and with amplitude range 100 to 400 μV and duration 3-6 msec, and classical single motor unit analysis[2] have shown the marked increase in amplitude with a lesser increase in duration in the chronic reinnervation conditions of motor neuron disease (Bulbar Palsy), traumatic laryngeal nerve lesions and in the over-use situation of spastic dysphonia. This last is now called more correctly spasmodic dysphonia or laryngeal dystonia[3] with earlier results suggesting motor unit amplitude changes in less than 20%, but current results indicating nearly 50% have very large units: up to 10,000 μV in one case.

As TURNS ANALYSIS gives the maximum amount of motor unit information in the shortest time it was selected to monitor the use of BOTOX in treating this disorder. All patients in the study had three electrodiagnostic studies with a blinded injection of BOTOX after the first. Many values of motor unit potentials (MUPs) were collected, the most useful being the "clouds" analysis; plotting amplitude/turn ratio against turns/second. The extremely high (mid and late graph) amplitude cluster was confirmed in the initial study and in the first 38 trial patients denervation and improvement was consistently related to a very low flat "cloud" so that administration of BOTOX could be well predicted. The third follow-up study of three months gave good evidence for either a normal reinnervation pattern or a recurrent high amplitude "cloud" needing more therapy. The amplitude of the MUPs mirrored these findings.

[1]Lovelace RE, Blitzer A, Ludlow CL. Clinical laryngeal electromyography. *In*: Blitzer A, Brin MF, Sasaki CT, Fahn S and Harris KS, eds. Neurologic disorders of the larynx. New York, Thieme, 1991; 66-81.

[2]Lovelace RE, Blitzer A, Szmidt-Salkowska E. Percutaneous laryngeal electromyography for evaluation of neurologic disorders, myopathies and spastic dysphonia. Electroenceph Clin Neurophysiol 1985; 61: S76.

[3]Blitzer A, Brin MF, Fabn S, Lowlace RE. Clinical and laboratory characteristics of focal laryngeal dystonia: Study of 110 cases. Laryngoscope 1988; 98: 636-640.