Plenary II: How Do We Measure Up?
Quantitation in EDX and Clinical Practice

Peter J. Dyck, MD
Robert D. Rondinelli, MD, PhD
Mark Hallett, MD
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Chair: Holli A. Horak, MD

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Objectives

Objectives - Participants will acquire skills to (1) recognize the clinical, neurophysiological and histo-pathological techniques available for quantifying normality or abnormality in patients with suspected peripheral neuropathy, (2) explain the process for evaluating patients with MSK and NM disorders and determine how impairment is quantified in regards to disability determination, and (3) list the manifestations of non-organic NM and movement disorders and explain the potential neurobiological mechanisms which underlie these disorders.

Target Audience:
• Neurologists, physical medicine and rehabilitation and other physicians interested in neuromuscular and electrodiagnostic medicine
• Health care professionals involved in the management of patients with neuromuscular diseases
• Researchers who are actively involved in the neuromuscular and/or electrodiagnostic research

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2011-2012 AANEM President

John C. Kincaid, MD
Indianapolis, IN
Plenary II: How Do We Measure Up?
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Faculty

Peter James Dyck, MD
Department of Neurology
Mayo Clinic and Mayo Medical School
Rochester, MN

Dr. Dyck is the Roy E. and Merle Meyer Professor of Neuroscience, Professor and Consultant in Neurology, at Mayo Medical School and Mayo Clinic. He heads Mayo’s Peripheral Neuropathy Research Laboratory. Dr. Dyck’s clinical practice and research interests have encompassed most varieties of peripheral neuropathy. He is completing large-scale epidemiology surveys of healthy subjects and patients with diabetes of Caucasian, Hispanic, and Northern Plains Indians origin and recently completed studies on the occurrence of diabetic polyneuropathy in patients with impaired glycemia in Olmsted County, Minnesota. Dr. Dyck’s medical degree was earned at the University of Toronto, and he completed Neurology fellowships at both Mayo and University Hospital-Saskatchewan. Dr. Dyck has been the first editor of 12 volumes of textbooks on various aspects of peripheral nerve biology and its diseases. He received Honorary Membership in the AANEM in 2001.

Mark Hallett, MD
National Institute of Neurological Disorders and Stroke
National Institutes of Health (NIH)
Bethesda, MD

Dr. Hallett is Chief of the Human Motor Control Section of NIH’s Medical Neurology Branch. He completed his medical studies at Harvard University, his residency at Massachusetts General Hospital, and fellowships in neurophysiology at the NIH and in the Department of Neurology, Institute of Psychiatry in London. He serves on the editorial boards of many journals and is past editor-in-chief of Clinical Neurophysiology. Dr. Hallett is author, co-author, or editor of more than 900 articles and books. His work now focuses on principles of human motor control and the pathophysiology of movement disorders. He has had a particular interest in psychogenic movement disorders and been the lead editor for two books on this subject. He is a past-president of the AANEM and the Movement Disorder Society.

Robert D. Rondinelli, MD, PhD
Department of Physical Medicine & Rehabilitation
Iowa Health
Des Moines, IA

Dr. Rondinelli is the Medical Director of Iowa Health Des Moines’ Physical Medicine and Rehabilitation Department. He completed his medical and Ph.D. degrees at the University of Illinois. Dr. Rondinelli is a member of several professional associations, including the American Academy of Physical Medicine and Rehabilitation (AAPMR), Association of Academic Physiatrists (AAP), Sigma Xi Scientific Research Society, and the American Association for the Advancement of Science. He is a past president of the AAP, and also serves as an Associate Editor for the AAPMR journal and has more than 70 publications including editing several textbooks, numerous book chapters, theses, and peer-reviewed articles for several scientific journals.
Proficiency (Accuracy Among Evaluators) of Commonly Used Nerve Tests
INTRODUCTION

This discussion will address the reasons why proficiency (accurate evaluation of neuropathic signs and symptoms and nerve tests among evaluators) is needed for high quality neuromuscular practice, epidemiology surveys, and therapeutic trials. Plus, some insights will be provided on how to perform proficient evaluation of signs and symptoms, nerve conduction studies (NCSs), and quantitative sensation tests (QSTs).

WHY DISCUSS PROFICIENCY OF NERVE TESTS?

Proficiency in the evaluation of nerve tests is important for a variety of reasons, including:

• To allow the United States Congress (through the Centers for Disease Control) to mandate proficient neurologic assessments.
• To detect and characterize unique new syndromes based on their pathophysiologic differences.
• To assess new treatments (e.g., for treatment of transthyretin amyloid polyneuropathy), new anti-infectious agents, and medications for pain modulation.
• To improve specialty training and certification (and recertification).
• To improve epidemiology surveys and therapeutic trials.

CLINICAL PROFICIENCY IN NEUROMUSCULAR MEDICINE HAS NOT BEEN ADEQUATELY ADDRESSED

Based on anecdotal information, when patients report weakness, numbness, or pain in anatomical distributions typical of diabetic sensorimotor polyneuropathy (DSPN), physicians tend to record a degree of weakness, reflex change, or decreased sensation whether or not it is objectively present. In addition, it is important to realize that in tertiary electromyography (EMG) laboratories, the apparent electrophysiologic abnormalities of referred patients may be due to causes other than nerve disease (e.g., low temperature, etc.). Two series of studies to investigate clinical proficiency in neuromuscular medicine have been carried out:

• Expert neuromuscular physicians in the Neurologic Examination vs. Clinical Neurophysiology Tests (Cl vs NPhys) Trial 1 (see below) markedly over reported neurologic signs in comparison to the electrodiagnostic (EDX) results for the diagnosis of DSPN.
• Chaudhry and colleagues’ studies2 (see below) have shown that there is a lack of proficiency among EDX physicians at a single medical center (Johns Hopkins) in measuring the attributes of NCSs.

PROFICIENCY OF ASSESSMENT OF SIGNS AND SYMPTOMS

In two prospective multicenter trials (Cl vs NPhys Trial 13 and Trial 24), the proficiency of neuromuscular experts to assess signs and symptoms has not been adequately addressed.
and symptoms and make a clinical diagnosis of DSPN was tested. In Trial 1, on 2 consecutive days 12 expert neuromuscular physicians, using clinical evaluations, assessed 24 patients with diabetes without and with DSPN. As shown in the Figure, patients were masked by wearing surgical clothing and masks; even their voices were electronically distorted. In Trial 1, physicians markedly over reported clinical signs, but also symptoms and clinical diagnoses. All neuropathic signs (muscle weakness, decrease of muscle stretch reflexes, and sensory loss) were over reported. In Trial 2, when the physicians being tested agreed to only use the term “unequivocally abnormal” for perceived abnormal signs and symptoms, the over reporting of signs, symptoms, and diagnoses was prevented. In Trial 2, as compared to Trial 1, improvement was observed for the evaluation of pinprick sensation (p = 0.03), decreased muscle stretch reflexes (p = 0.06), and touch pressure sensation (p = 0.06). The conclusion in Trial 2 was, “The simple pre-trial decision to use only ‘unequivocally abnormal’ signs and symptoms taking age, gender, and physical variables into account in making clinical judgments (Trial 2) as compared to ‘usual’ (presumably more sensitive) criteria (Trial 1), each compared to confirmed nerve conduction abnormality, improved physician proficiency for diagnosis of diabetic polyneuropathy. These insights might be applied to neurologic instruction, medical practice and therapeutic trials.”

Figure. This image shows the degree of masking that was used so that patients could be assessed on several occasions without being identified by their appearance or voice characteristics. Their voices were electronically distorted. Used with permission from Dyck, Overland, Low, et al.3

PROFICIENCY OF ATTRIBUTES OF NERVE CONDUCTION

Chaudhry and colleagues evaluated intra- and inter-observer agreement of seven Johns Hopkins EDX physicians’ assessments of four other Johns Hopkins EDX physicians assessments of NCS attributes in healthy subjects and in those with DSPN. The study group found that whereas intra-observer variability was not significantly different, inter-observer differences among EDX physicians were significant. This inter-observer variability was attributed to differences in NCS evaluations. The researchers concluded that because of inter-observer variability, a single EDX physician should perform longitudinal studies (e.g., therapeutic trials).

The same issues have been addressed in Ci vs. NPhys Trial 3 (manuscript in preparation). For this trial, experts from four North American medical centers examined on two occasions the same masked cohort of 24 patients as in Trials 1 and 2. In addition to reviewing the intra- and inter-observer agreement, the authors’ assessed the effect of the use of a defined percentile level of abnormality (≤ 2.5th or ≥ 97.5th) and a composite percentile criterion for a composite score abnormality (i.e., ∑ 5 nerve conduction normal deviates ≤ 2.5th). The results will be given at the meeting.

PROFICIENCY OF QUANTITATIVE SENSATION TESTS

On two occasions, technologists from three U.S. medical centers were tested on their proficiency in assessing 12 patients (healthy subjects and patients with DSPN) using quantitative sensory testing (QST). The technologists’ proficiency using highly standardized computer QSTs of vibration, touch-pressure, cool detection, cool discrimination, and heat-as-pain tests was evaluated. The intra- and inter-observer agreement was then reviewed. These studies are being prepared for publication. As compared to confirmed composite and referenced NCS abnormalities, the QSTs results were highly specific, providing good characterizing information regarding sensory deficits in DSPN patients. Additionally, no statistically significant intra- or inter-observer differences were observed in the test results—a remarkable finding.

CONCLUSIONS

Studies of diagnostic proficiency in studied cohorts masked as to their identity and disease condition allows three conclusions:

1. For the assessment of signs and symptoms, use of term “unequivocal abnormality” as a threshold for noting an abnormality appears to prevent the marked over and incorrect reporting of signs and symptoms.

   • Whereas intra-observer assessment of NCSs was not statistically significant, inter-observer differences were found due to differences in the evaluation of NCSs. Greater attention needs to be given to standardizing the performance of NCSs. Use of standard reference values and specific criteria for DSPN should be used.
• The use of highly standardized and referenced computerized assessment of modalities of QST has shown high levels of accuracy and of intra- and inter-observer agreement. These approaches can be recommended for quality medical practice, epidemiology surveys, and therapeutic trials.

REFERENCES


Assessment of Neuromuscular and Musculoskeletal Impairment and Disability
INTRODUCTION

Neurologists, physiatrists, and other physicians dealing with the evaluation and treatment of patients with disabling conditions due to illness or injury can expect to be called upon to perform formal disability assessments from time to time. The purpose of this discussion is to help familiarize participating physicians with the concepts and terminology of disablement and the practices of impairment rating and disability evaluation.

TERMINOLOGY AND DEFINITIONS

The following terms and definitions are frequently applied to the evaluation and reporting of disablement:

**Aggravation:** A circumstance or event that permanently worsens a pre-existing or underlying and susceptible condition.

**Apportionment:** A determination of percentage of impairment directly attributable to pre-existing or resulting conditions and directly contributing to the total impairment rating derived.

**Causality:** An association between a given cause (an event capable of producing an effect) and effect (a condition that can result from a specific cause) within a reasonable degree of medical probability. Causality requires determination that:

- An event took place.
- the claimant experiencing the event has the condition (i.e., pathology/impairment).
- The event could cause the condition (biological plausibility, etc.)
- Within medical probability the event did cause the condition.

**Exacerbation:** A circumstance or event that temporarily worsens a pre-existing or underlying and susceptible condition.

**Impairment:** A significant deviation, loss, or loss of use of any body structure or function in an individual with a health condition, disorder, or disease.

**Independent medical examination (IME):** A (usually) one-time evaluation performed by a physician examiner who is not treating the patient or claimant, in order to answer specific questions posed by the referring party, including MMI determination, impairment rating, and return-to-work restrictions, if applicable.

**Maximum medical improvement (MMI):** The point at which a condition (impairment) has stabilized and is unlikely to change (improve or worsen) substantially in the next year with or without treatment. It is believed to occur when the following criteria have been satisfied:
• A sufficient healing period has transpired (based usually on the analysis that includes consideration of the natural course of disease for the specific pathology which, in some cases, may be days or months or rarely even years).

• the medical condition (impairment) has fully resolved; or it has reached a static and stable status (plateau) after which, in the next 12 months, no further reasonable progress occurs or is expected to occur towards resolution of the pathology.

Maximum medical improvement does not preclude the deterioration of a condition that is expected to occur with the passage of time (i.e., beyond 12 months); neither does it preclude allowances for ongoing followup or maintenance medical care, should such care be indicated based on current evidence-based practice generally accepted by the scientific community.

Medical possibility: Something could occur due to a particular cause (probability less than or equal to 50%).

Medical probability: Something is more likely to occur than not (probability exceeds 50%)

COMPARISON OF MAJOR UNITED STATES DISABILITY SYSTEMS

Workers’ Compensation

Workers’ compensation (WC) law is determined by jurisdictional statutes which vary from state to state, and which may differ in terms of the definition of an employee/employer relationship and the exemptions which may apply. It is a no fault system whereby the injured employee forgoes the right to sue their employer for damages in most cases, in exchange for coverage when eligibility requirements are met. A causality determination must be made that the injury or illness arose out of and in the course of employment, and occurred while the employee was at work and actively participating in work activity (job-related social and recreational activities generally do not qualify). Coverage is established in accordance with jurisdictional statutes, and, in order to qualify for wage-loss benefits, the injured employee’s condition must persist beyond a statutory waiting period typically extending from 0-7 days; the injury or illness must also be reported to the employer within 30 days of onset and a claim filed within 1 year for disability and 2 years for death.6,7

Benefits for WC include survivor benefits (in case of death), medical and rehabilitation expenses, and wage-loss benefits (typically two-thirds weekly wages up to a cap). An employee risks forfeiture of benefits if the claim is due to intoxication or substance abuse at time of injury, for refusal to comply with safety rules and equipment, for incarceration, or for refusal to return to work after being medically cleared to do so.

Disability under WC can be determined to be temporary or permanent and partial or total. Many states have enacted a second injury fund whereby employment of individuals with pre-existing work-related disabilities is encouraged. Such funds can reduce employer risk (hence cost to ensure) for excessive compensation and medical expenses in such cases.

Physician rating schedules vary among WC jurisdictions, the majority of which require or recommend a version of the American Medical Association’s (AMA’s) Guides to the Evaluation of Permanent Impairment (Guides).

Social Security

The Social Security Administration (SSA) comprises the largest U.S. disability system, assisting an estimated one-third to one-half of all persons qualified as disabled. Coverage is typically extended to those persons whose medical disablement renders them unable to engage in any substantial activity by reason of any medically determinable physical or mental impairment that can be expected to result in death or that has lasted or can be expected to last for a continuous period of not less than 12 months.6,9

The SSA offers two separate disability programs. The first, Social Security Disability Insurance (SSDI), extends coverage to disabled workers who have worked in a qualified job for 5 out of the 10 preceding years and who are less than 65 years of age. The Federal Insurance Contribution Act (FICA) payroll tax with deductions covering the Old-Age, Survivors, and Disability Insurance (OASDI) is the funding source for SSDI. Benefits are afforded to those considered totally incapacitated, and their surviving spouse and children, and are provided in the form of a monthly stipend.

The second program, Supplemental Security Income (SSI), provides income for medically indigent persons who suffer from blindness, disability, or old age (~ 65 years of age). Eligibility is determined according to a means test. It also extends to disabled children who demonstrate an inability to function independently and in an age-appropriate fashion. As a federal-state partnership, SSI is funded through general revenue (federal and state income tax) and does not require a work history to be eligible.

A separate physician rating scale is provided by the SSA.12

Department of Veterans Affairs

The Veterans Benefits Administration (VBA) within the Department of Veterans Affairs oversees the Compensation and Pensioning (C&P) Service, and all veterans who have received honorable or general discharge from active military service are eligible for benefits. Entitlement may be service-connected for injuries or disease incurred or aggravated during time of active duty or non–service-connected for conditions determined to be unrelated to active duty. Entitlement is determined by the C&P Service’s Adjudication Division.6,8

Disability compensation for eligible veterans is paid out in monthly pensions not subject to state or federal income tax, is adjusted by Congress to reflect changes in cost of living, and varies according to number of dependents. In the event of death, monthly benefits are payable to the surviving spouse or children. Additional benefits include hospitalization and medical care, orthotic and prosthetic devices, durable medical equipment, and adaptive modifications to home and vehicle.

The Veterans Administration Schedule for Rating Disabilities (VASRD) is the required physician rating schedule within the VBA.13
The AMA Guides is a standardized, objective reference for this purpose, originally published in 1971 as a compilation of a series of impairment rating articles for different organ systems which were published in the Journal of the American Medical Association (JAMA) from 1958 to 1970. It has periodically been updated and revised to the most current AMA Guides (Sixth Edition), published in 2008.1

The AMA Guides is recognized nationally and globally as the preferred reference for medical impairment ratings. Various editions are required or recommended by statute in the majority of U.S. WC jurisdictions. The AMA Guides (Sixth Edition) has recently been adopted by 15 of these jurisdictions and is the reference mandated by the U.S. Department of Labor in the various disability systems outlined above; it is also adopted and used internationally in WC and personal injury claims including 9 of 10 Canadian provinces and all three Canadian territories, the Netherlands, Australia, New Zealand, Hong Kong, and Korea.

The AMA Guides (Sixth Edition) builds upon the precedent of the previous editions in placing increasing emphasis upon a diagnosis-based approach, with particular emphasis to musculoskeletal impairment ratings of the spine and extremities. Diagnosis-based impairment (DBI) grids are provided for each anatomical region (cervical spine, thoracic spine, lumbar spine, and pelvis for the spine; digits/hand, wrist, elbow, and shoulder for the upper extremity; and foot/ankle and knee/hip for the lower extremity.) Each grid has five potential impairment classes (Class 0-4) consistent with the International Classification of Functioning, Disability, and Health (commonly known as the ICF classification system) and each covers a broad and precise array of diagnoses ranging from soft tissue conditions (nonspecific, chronic or recurrent), to muscle-tendon and/or motion-segment injuries (sprains, strains, tendinopathy), and to ligament, bone, and joint injuries (fractures, dislocations, arthrodesis, etc.) Impairment rating is a two-step process whereby initial assignment to an impairment class requires the rating examiner to identify the most appropriate diagnosis, and each DBI class has an available range of impairment values with an initial “default” mid-range value. The rating is then adjusted within range as a second step, using three separate criteria to validate the diagnosis and severity (functional history, examination findings, and clinical test results) of the condition. A simple triangulation method enables a final numerical adjustment upward for less-favorable outcomes or downward for more optimal outcomes according to the specific result in each case.

THE INDEPENDENT MEDICAL EXAMINATION

Independent medical examinations (IMEs) are usually a one-time evaluation performed by a physician not previously or directly treating a claimant in order to answer specific questions posed by the referring party. The issues specifically addressed can be expected to include:11

- Has appropriate treatment been rendered?
- What additional testing and/or treatment is needed.
- Has MMI been reached? If so, when? If not, what is the anticipated date of MMI?
- What is the medical impairment rating?
- Can the injured worker return to their former job? If so, how soon?
- What permanent return-to-work restrictions are necessary as a result of the medical impairment?

The answers to all queries are expected to be given “within medical probability.”

REFERENCES

SUGGESTED READING

Quantifying and Understanding Deficits in Nonorganic Neuromuscular and Movement Disorders

Mark Hallett, MD
Chief, Human Motor Control Section
National Institute of Neurological Disorders and Stroke
National Institutes of Health
Bethesda, Maryland

INTRODUCTION

Nonorganic disorders have a variety of names, including medically unexplained symptoms. Other common terms are psychogenic and functional. Most are thought to be psychologically based rather than due to an “organic” disorder of the nervous system, but this is not always evident. There are a number of categories of these disorders.\textsuperscript{5,10} The largest category is somatoform disorders which include conversion disorders and somatization. An older term is hysteria. The notion of conversion is Freudian, that a psychological symptom is converted into a somatic symptom as a way of dealing with the distress of the symptom. With the conversion, the distress is ameliorated, and this is considered to be the primary gain. By this logic, if the conversion is successful, the psychological symptom is gone, and this may be the reason that such symptoms may be difficult to identify in some patients. The conversion also has a secondary gain; for example, a spouse might give the patient more attention. Somatization is the situation of many conversions beginning at an early age. A fundamental feature of conversion is that it is an unconscious process.

Two other categories are included in the nonorganic conditions: factitious and malingering. The critical feature of these two entities separating them from conversion is that the symptoms are feigned; they are voluntarily produced. Factitious symptoms arise to satisfy a psychological need; this entity includes Münchausen syndrome. Malingering is the feigning of symptoms without any psychological factor; the patient is seeking a specific goal, such as a financial benefit, the acquisition of drugs, or avoidance of jail. In both factitious and malingering situations, the symptoms may look the same, but the patients are lying. Unfortunately, doctors (and everyone else) are not good at determining whether someone is lying. The lie detector test depends on autonomic responses, but has many false-positive and false-negative results. Secret surveillance has been used to document these disorders, but generally physicians do not hire detectives. These conditions are thought to be rare. When a lawsuit is pending, suspicion is raised about malingering, but this is not definitive.

Another entity sometimes considered within the rubric of nonorganic is dissociation. This has the implication of a disruption of the unity of a person’s consciousness. This would be an alternative etiology to conversion and will not be further considered here.

Nonorganic disorders are extraordinarily common, but have unfortunately been largely neglected by clinicians and researchers. These include irritable bowel syndrome, fibromyalgia, and chronic fatigue syndrome. Neurological conditions include psychogenic non-epileptic seizures, blindness, memory loss, and aphonia. Here, the discussion will focus on weakness, sensory loss, and movement disorders. A study evaluated the cost of somatization in two large healthcare systems over a 1-year period.\textsuperscript{3} Patients with somatization utilized twice the inpatient and outpatient resources than nonsomatizing patients. The authors estimated that on a national level 16\% of healthcare expenditure, or $256 billion per year, can be attributed to the incremental effect of somatization. In general neurology practice, surveys show that 10-15\% of new patients have nonorganic disease.

Patients with conversion have a high frequency of comorbid psychiatric conditions, mostly anxiety and depression.\textsuperscript{14} The patients have significant disability and poor quality of life. In a study comparing patients with psychogenic movement disorders to those with Parkinson disease, there were similar levels of disability, but worse
mental health quality of life and higher levels of distress, anxiety, and depression. One interesting feature is that patients, when they have a conversion, tend to mimic disorders that they have seen or experienced. When there are numbers of susceptible individuals, the disorder may appear contagious or like a common outbreak. This is mass hysteria. Additionally, when a patient has an organic disease, they may extend the symptoms with this mechanism. Hence, many persons with psychogenic seizures have organic seizures too. Patients with multiple sclerosis also seem prone to psychogenic symptoms.

While little is really known about the etiology of conversion, the idea is emerging that it can only be understood with a biopsychosocial model. Individuals may be predisposed genetically with diminished ability to deal with stress, but they may have increased stress, particularly in childhood. Some studies show an increase in physical, sexual, or emotional trauma, both in childhood and contemporary with the disorder. It is crucial to understand that these are “real” disorders. The symptoms are apparent and disabling, and the prognosis is not good.

GENERAL CLINICAL FEATURES

While no rules are absolute, there are some features that are suggestive of a psychogenic disorder. The problem might have had an abrupt onset or have had multiple remissions. There is inconsistency in the disorder and mixtures of symptoms that do not ordinarily go together. Symptoms may disappear with distraction. There might be substantial improvement with placebo or suggestion. Patients may have marked fatigue and disability out of proportion to the signs. Another feature is that the disorder is bizarre looking. In regard to this point, a physician has to be very careful. Merely because the physician has not seen it before, does not automatically make it psychogenic.

This is a session on quantification. Quantification of these disorders can be on several levels. Each symptom can be quantified on traditional scales for the parallel organic condition. For example, strength can be rated on the standard Medical Research Council 0-5 scale, seizures can be quantified with a diary, and tremor can be rated with clinical scales such as the Fahn-Tolosa-Marin scale or instrumental methods such as spiral drawing on a digitizing tablet. Underlying psychiatric conditions can be rated with standard scales as well such as the Hamilton Rating Scale for depression (HAM-D), the Beck Depression Inventory (BDI), the Beck Anxiety Inventory (BAI), and the Spielberger state-trait anxiety inventory (STAI) for anxiety. A scale has been proposed for the severity of psychogenic movement disorders, attempting to encompass all disorders into a single scale. The author’s group has tried to use this scale, but not found it reliable.

Quality of life scales, such as the Short Form (36) Health Survey (SF-36), might well be the best as an overall rating, despite their obvious weaknesses in being influenced by many factors in addition to the target symptoms. As these patients may go from symptom to symptom, it is the overall quality of life that is most critical.

PSYCHOGENIC WEAKNESS AND PARALYSIS

Patients can present with weakness in almost any distribution, some nonanatomical. For example, certain patterns are expected with weakness, such as proximal with myopathies or distal with neuropathies, or “pyramidal” with a stroke. Uniform weakness within a limb is not common. There are also tricks to demonstrate strength where it is appears to be lost. For example, Hoover’s sign is good for detecting hip extension strength. When lifting one leg, the other leg extends, and the presence of leg extension can be demonstrated in this way.

Clinical Neurophysiology

In the face of weakness, routine nerve conduction studies are normal. In the needle electromyography (EMG) examination, there is no spontaneous activity and motor units are normal. The interference pattern, however, is reduced. There is no clear separation of a reduced interference pattern from decreased effort and from a central nervous system (CNS) lesion. In both circumstances there is reduced CNS drive.

A method that can separate a CNS lesion and reduced effort is transcranial magnetic stimulation (TMS) of the motor cortex. It will produce a normal motor evoked potential (MEP) with normal latency in the setting of psychogenic weakness, where it could be abnormal with lesions anywhere along the corticospinal tract from motor cortex to spinal cord. With severe lesions, the MEP will be absent. With compressive lesions, such as cervical spondylosis, or demyelinating disorders, such as multiple sclerosis, the central motor conduction time will be prolonged. Interestingly, not only can a normal MEP be diagnostic, it can also be therapeutic. Patients have been described who improve after normal motor responses are produced by stimulation.

PSYCHOGENIC SENSORY LOSS

Patients may complain of total or partial loss of sensation. In psychogenic sensory loss, the pattern of loss may be nonanatomical or have a severity out of proportion to other features of the neurologic examination. There are tricks to identify psychogenic loss, such as using repeated sensory stimuli (with eyes closed) and asking the patient to say “yes” if they are touched and “no” if they are not. Another commonly used method is vibration on the forehead, which should be felt on both sides even with hemianesthesia. Sometimes, with the tuning fork in the midline of the forehead, a patient will “feel” it when tilted to the good side and not when tilted to the anesthetic side.

Clinical Neurophysiology

Somatosensory evoked potentials (SEPs) are good probes for the large fiber, dorsal column, primary sensory cortex pathway. The presence of good potentials documents that this pathway is intact and is not compatible with total anesthesia. On the other hand, if the symptom is restricted to loss of pain or small fiber sensation, the ordinary SEP would not be a good test.

There are now methods coming into more routine use to look at SEPs from heat stimuli, which would evaluate the spinothalamic tract. One method for doing this is the “contact heat-evoked potentials.” Test-retest reliability for this technique has been demonstrated, but this has not been applied to the study of psychogenic patients as yet.

PSYCHOGENIC MYOCLONUS

Myoclonus should be a simple, quick movement. Psychogenic myoclonus may also have this appearance, but many times the movement is a bit more complex, with multiple components over time.
Psychogenic myoclonus, like organic myoclonus, may be present spontaneously, may be action induced, and may be reflex produced. One type of myoclonus is increased startle, and increased startle or startle-like movements are frequent in psychogenic states.

The latency of reflex myoclonus should be very short, so a long latency would be indicative of psychogenicity. Latencies are often difficult to tell by eye, and physiology might be useful. Another clue that reflex myoclonus would be psychogenic is getting a reflex when stopping the tendon hammer just short of the tendon (without actually hitting it). Just the visual stimulus provokes the psychogenic movement.

**Clinical Neurophysiology**

The methods for analysis of myoclonus and for psychogenic myoclonus in particular have been described in detail, and will only be summarized here. There are three steps in the evaluation of myoclonus. First, the analysis of the surface EMG underlying the movement, generally with at least the simultaneous recording of both muscles of an antagonist pair. Second, to record the electroencephalogram (EEG) simultaneously with the surface EMG to look at their correlation. Third, to analyze reflex myoclonus, if present, for surface EMG latencies and EEG evoked responses.

In myoclonus that is a fragment of epilepsy, the surface EMG burst length is generally 30-50 ms and antagonist muscles are always synchronous. In other forms of myoclonus, the surface EMG burst length is longer and antagonist muscle relationships are variable. Psychogenic myoclonus falls into this latter category. Hence, epileptic myoclonus can be ruled out with this method, but non-epileptic myoclonus cannot be. Additionally, some forms of non-epileptic myoclonus have characteristic surface EMG patterns, and this would help identify them as such. For example, in startle, orbicularis oculi is the first and most consistent muscle, sometimes with apparent double burst. This is followed by activity in lower cranial nerve muscles and subsequently by upper cranial nerve muscles and limb muscles. Psychogenic myoclonus may well show highly variable patterns.

The EEG correlate is obtained by backaveraging the EEG using the onset of surface EMG (or movement) as the fiducial point. Each type of epileptic myoclonus has a characteristic EEG correlate. The best well known is the potential associated with cortical myoclonus, a brief negative-positive potential about 20 ms prior to the surface EMG. In non-epileptic myoclonus, generally a potential is not identified. In psychogenic myoclonus, very frequently a normal looking Bereitschaftspotential can be identified. This indicates activity in the premotor cortex.

The physiological correlate of reflex myoclonus is called the C reflex. In organic myoclonus syndromes, the C reflex comes from hyperexcitability of one of several long-latency reflex pathways. All of these pathways produce shorter latencies than the fastest voluntary reaction times, about 40-50 ms. In psychogenic reflex myoclonus, the latencies are variable and similar to, and never faster, than the fastest voluntary reaction time, 100 ms or longer depending on the type of sensory stimulus.

**PSYCHOGENIC TREMOR**

Psychogenic tremor is often highly variable both in frequency and amplitude. It may be present in rest, posture, and kinetic action, and finger tremor is unusual. The tremor may vary or cease with distraction. The most useful clinical test (which can be performed with physiology) is the entrainment test. In this test, the patient is asked to tap voluntarily at various frequencies with a body part unaffected by the tremor. If all body parts show tremor, this still can be performed, with voluntary tapping of one body part while monitoring the response of the “involuntary” tremor in another body part. The tremor is entrained if the tremor takes up the frequency of the voluntary tapping. Another clue of psychogenicity is that the patient might have considerable difficulty in doing the voluntary tapping at the requested rate.

**Clinical Neurophysiology**

As with psychogenic myoclonus, the testing for psychogenic tremor is very good, and it should be able to support the diagnosis. Tremor can be measured with surface EMG and/or with accelerometer, or both. Psychogenic tremor may show marked variation in frequency and amplitude. Additionally, psychogenic tremor is typically exactly the same frequency and in phase in different limbs; this virtually never happens in organic tremors. This can be formally assessed with coherence analysis.

As noted earlier, entrainment can be investigated physiologically. Most commonly this is carried out by measuring tremor of one hand and performing voluntary tapping with the other hand at a series of different frequencies. The different frequencies can be demonstrated for the subject with a metronome. The tremor might stop completely, change its frequency, or will take up the frequency of the voluntary tapping. Coherence analysis can quantify this. While this is a very good test, there are some psychogenic tremors that do not entrain. The ballistic movement test is a variation on entrainment. Here, patients are asked to make a quick movement with one limb. In psychogenic tremor, there might be a pause in the tremor during the movement.

**PSYCHOGENIC DYSTONIA**

Psychogenic dystonia can be difficult. In fact, it was not very long ago that even some types of organic dystonia were thought to be psychogenic. Organic dystonic movements may look like voluntary movements, and features such as sensory tricks and task specificity may strike the physician as psychological in nature. Moreover, authorities still argue about the nature of certain types of dystonia, such as that seen in the setting of complex regional pain syndrome. Fixed dystonia, particularly if it has an abrupt onset, is one type that is frequently psychogenic. There is a good deal known about the physiology of dystonia, and, therefore, clinical neurophysiology should be of great help, but it has not been. For some reason, not yet fully understood, psychogenic dystonia and organic dystonia often show the same findings.

**Clinical Neurophysiology**

Dystonia movement is usually characterized by co-contraction of antagonist muscles, but this is not always the case. Hence, while
lack of co-contraction might suggest psychogenicity, this is not a definitive observation.

There are a large number of physiological abnormalities in organic dystonia, most relating to the loss of inhibition. These abnormalities can be seen at the spinal level, such as reciprocal inhibition, and the cortical level such as short intracortical inhibition assessed with TMS. Most of these abnormalities are shared with psychogenic dystonia.26

One physiological difference might be a measure of CNS plasticity called paired-associative stimulation. This method repetitively pairs a shock to the median nerve with a TMS to the motor cortex. Similar to long-term potentiation, this repetitive pairing leads to an increase in excitability of the motor cortex as assessed by the amplitude of the MEPs in muscles innervated by the median nerve and adjacent muscles. While organic dystonia shows an increased plasticity with this method, psychogenic dystonia does not show this abnormality.26

OTHER PSYCHOGENIC MOVEMENT DISORDERS

Psychogenic gait disorders are common, but there are no physiological studies. Gaits are sometimes rather bizarre and easy to diagnose. Most of these patients complain of poor balance, but it is clear from observing the gait that balance is very good. A biomechanical gait study might not add much to the clinical observation, but quantitative balance testing might be helpful in some circumstances.

Psychogenic parkinsonism is not common, and again there have not been any physiological investigations. These patients often have extreme slowness, marked fatigue, and psychogenic tremors.

UNDERLYING PHYSIOLOGY

The physiology of conversion is not well understood, and motor disorders should be particularly helpful in studying this phenomenon since movement is measurable. Physicians are still fixed in Freudian thinking, even with the name of the disorder. There are now beginning to be investigations of conversion, frequently utilizing functional magnetic resonance imaging (fMRI). A fascinating question is how can the movements look so voluntary, share voluntary mechanisms, and yet felt by the patient as being involuntary. The work of the author and his colleagues gives evidence of increased influence of the limbic system in driving movement,24 and deficient parietal activation, the region thought to give rise to the sense of agency.23 More work needs to be done.

FINAL NOTE

Patients with nonorganic disorders are common and have significant disability. Like any other condition, they need to have the right diagnosis. Therapy is not easy, and there have been few clinical trials. It appears that a multidisciplinary approach is needed, including help from psychiatry, physical therapy, and social work.

REFERENCES


1. What is the preferred term for the cutoff point used to determine whether someone is MORE LIKELY to have come from the healthy or the disease group?
   A. Normal value.
   B. Normal limit.
   C. Reference value.
   D. Control point.
   E. Range.

2. Which of the following is MOST LIKELY to influence results on nerve conduction studies (NCSs)?
   A. Gender.
   B. Temperature.
   C. Body mass index.
   D. Finger circumference.
   E. State in which the patient lives.

3. Which of the following would be MOST affected by display sensitivity?
   A. Peak latency.
   B. Onset latency.
   C. Base-to-peak amplitude.
   D. Peak-to-peak amplitude.
   E. Number of phases.

4. Which of the following is the MOST APPROPRIATE reference value for latencies in NCSs, based on studies of a group of healthy people?
   A. The highest value recorded.
   B. The mean value.
   C. The mean plus 1 standard deviation.
   D. The 5th percentile value.
   E. The 97th percentile value.

5. If you perform three NCSs in a healthy person, what is the approximate likelihood that at least one will be “abnormal”?
   A. 0.5%.
   B. 1%.
   C. 3%.
   D. 7%.
   E. 10%.

6. Why is the differential diagnosis for polyneuropathies divided into axonal and demyelinating neuropathies?
   A. Demyelinating neuropathies are very common while axonal neuropathies are very rare.
   B. Axonal neuropathies are more commonly due to genetic factors.
   C. Most of the axonal neuropathies are treatable by immune modulation.
   D. Demyelinating neuropathies have a higher likelihood of being directly treatable.

7. Which of the following NCS parameters supports the presence of peripheral nerve demyelination?
   A. Sensory potential amplitude change of less than 20% between distal and proximal sites.
   B. Distal motor compound motor action potential (CMAP) amplitude of greater than 80% of the lower limit of normal (LLN).
   C. Segmental motor conduction velocity of less than 70% of the LLN.
   D. CMAP amplitude change of less than 20% between distal and proximal stimulus sites.
   E. The presence of axon reflexes during F-wave tests.

8. In motor nerves with reduced CMAP amplitudes due to axonal neuropathy, which of the following is CORRECT?
   A. Distal latency is usually > 125% of the upper limit of normal (ULN).
   B. Distal latency is usually < 125% of the ULN.
   C. Distal latency is 125% of the ULN.
   D. None of the above.

9. In motor nerves with reduced CMAP amplitudes due to demyelinating neuropathy, which of the following is CORRECT?
   A. Conduction velocity is usually > 80% of the LLN.
   B. Conduction velocity is usually < 80% of the LLN.
   C. Conduction velocity is 80% of the LLN.
   D. None of the above.

10. In motor nerves with reduced CMAP amplitudes due to axonal disease, which of the following is CORRECT?
    A. F-wave latency is usually < 125% of the ULN.
    B. F-wave latency is usually > 125% of the ULN.
    C. F-wave latency is 125% of the ULN.
    D. None of the above.
11. Which is the MAIN reason for polyphasicity in myopathy?
   A. Loss of muscle fibers.
   B. Aberrant motor end plates.
   C. Increased variation in muscle fiber diameters.
   D. Muscle fiber splitting.

12. Which trick is recommended to see motor unit potential (MUP) shape instability?
   A. Trigger and changing the low cutoff filters (high pass filter) to 500 Hz.
   B. Average triggered MUPs.
   C. Use of macro electromyography (EMG).
   D. Perform a study during strong contraction.

13. Which combination of findings is typical of ongoing collateral reinnervation?
   A. Small nascent MUPs.
   B. Increased amplitude and unstable MUPs.
   C. Prolonged duration and stable MUPs.
   D. Low irregular firing rate.

14. When can one see a high amplitude short duration MUP?
   A. In early collateral reinnervation.
   B. In chronic neurogenic conditions.
   C. In recent denervation and the muscle at rest.
   D. In myopathy.

15. Which of the following parameters cannot be quantitated automatically?
   A. Interference pattern at strong effort.
   B. Spontaneous activity.
   C. MUP area.
   D. Number of phases in a MUP.

16. Proficiency of clinical evaluations of signs, symptoms, and clinical diagnosis refers to which of the following?
   A. Ability to do the examination quickly and at low cost.
   B. Ability to do the examination without discomfort or pain.
   C. Ability to do evaluations reproducibly and accurately among examiners.
   D. None of the above.

17. Proficiency of the assessment of signs, symptoms, and clinical diagnosis of diabetic sensorimotor polyneuropathy in the Neurologic Examination vs. Clinical Neurophysiology Tests (CI vs NPhys) Trial 2 was improved by which of the following?
   A. Advising investigators to record as “abnormal” only unequivocal abnormality, taking age, gender, physical fitness, and physical variables into account.
   B. Emphasizing sensitivity over specificity.
   C. Grading abnormality not taking age and gender into account.
   D. By simply accepting judgments of expert neuromuscular physicians.

18. For proficient (accurate and reproducible evaluations among physicians) evaluation of nerve conduction, which of the following statements is MOST CORRECT?
   A. Test fibular F wave latency attributes.
   B. Test fibular motor nerve conduction velocity or sural sensory nerve action potential.
   C. It depends on many factors, including adequacy of patient conditions, good quality instruments, use of appropriate neurophysiologic techniques, and adequate reference values corrected for applicable variables.
   D. It is simply the judgment of an expert clinical neurophysiologist.

19. Accurate and reproducible quantitative sensation testing is dependent on which of the following?
   A. Use of quantified stimuli of known waveform and magnitude given over a broad range of stimulus magnitudes.
   B. Use of adequate algorithm of testing, which should avoid anticipation of results and should include null stimuli.
   C. Use of adequate reference values corrected for sensation tested and corrected for anatomical site and for demographic and anthropomorphic variables.
   D. All of the above.

20. In 2001, the WHO adopted the International Classification of Functioning, Disabilities, and Health (ICF) to replace the earlier International Classification of Impairments, Disabilities, and Handicaps (ICIDH). One of the key improvements of the newer ICF system is which of the following?
   A. The ICF demonstrates the causal link between impairment and disability.
   B. The importance of environmental modifiers to functional outcome is emphasized.
   C. The ICIDH is a classification system whereas ICF is a model of disablement.
   D. Personal choice can be controlled for.
   E. All of the above.

21. Which of the following is the KEY difference between an impairment rating and a disability rating?
   A. An impairment rating excludes activities of daily living (ADL) losses whereas a disability rating takes ADL losses into account.
   B. Impairment is typically expressed as a percentage of the monetary worth of the “whole person.”
   C. Disability is typically expressed in regional terms as a percent loss to the body as a whole.
   D. Impairment rating takes into account functional loss at an organ-system level whereas disability rating takes into account functional losses at a personal and societal level.
22. Maximum medical improvement requires that:
   A. Further medical treatment is not expected to improve the underlying impairment.
   B. Symptoms have completely resolved
   C. Palliative care for symptom relief is no longer needed.
   D. The impairment will not worsen with the effect of aging.

23. Medical “probability” requires that:
   A. Statistical probability (less than or equal to 0.05) has been demonstrated.
   B. Likelihood of causation exceeds 50%.
   C. Possibility of causation has been demonstrated with scientific certainty.
   D. A causal event has probably occurred.

24. Which of the following is CORRECT?
   A. Exacerbation is a temporary worsening of disability, which subsequently returns to baseline.
   B. Aggravation is a temporary worsening of disability, which subsequently returns to baseline.
   C. Exacerbation is a temporary worsening of impairment, which subsequently returns to baseline.
   D. Exacerbation is a permanent worsening of pre-existing and underlying impairment.

25. Which of the following is NOT considered a psychiatric disorder?
   A. Somatization disorder.
   B. Conversion disorder.
   C. Factitious disorder.
   D. Malingering.

26. Patients with somatization disorders, compared to the normal population, have a greater amount of which of the following?
   A. Anxiety.
   B. Depression.
   C. Childhood abuse.
   D. All of the above.

27. Transcranial magnetic stimulation of the motor cortex in a patient with psychogenic weakness will show which of the following?
   A. Normal motor evoked potential (MEP).
   B. Low amplitude MEP.
   C. Prolonged latency of the MEP.
   D. Dispersed MEP.

28. Back averaging the electroencephalogram prior to a psychogenic myoclonus will show which of the following?
   A. No potential.
   B. A sharp negative-positive wave about 20 ms prior to the myoclonus
   C. A normal appearing Bereitshaftpotential.
   D. A bifrontal positive slow wave beginning about 300 ms prior to the myoclonus.

29. When voluntarily tapping the right hand, a psychogenic tremor in the left hand will often show which of the following?
   A. No change.
   B. A similar frequency as the voluntary tapping, but out of phase..
   C. A similar frequency and phase with the voluntary tapping.
   D. A moderate increase in amplitude without change in frequency or phase.