NEUROLOGIC CLINICS OF NORTH AMERICA

Neurol Clin N Am 20 (2002) 291–303

The clinical electromyography examination An overview

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Definitions of terms

The term electromyography (EMG) was first coined by Weddell et al., in 1943, who pioneered the clinical use of needle electrode examination of muscles. Since then, the titles EMG or Clinical EMG have been used by physicians to refer to the electrophysiologic examination of peripheral nerve and muscle, which includes nerve conduction studies (NCS) and needle EMG. Unfortunately, this continues to cause confusion among physicians and healthcare workers; some physicians refer the study as EMG/NCS, reserving the name EMG solely to the needle EMG evaluation and adding the term NCS to reflect these studies separately. Others have used the title needle electrode examination (NEE) to reflect the needle evaluation of muscles, while keeping the name EMG to describe the entire evaluation. More recently, a nonspecific term, the electrodiagnostic (EDX) examination, has gained popularity to serve as an umbrella covering both the needle EMG and NCS. Other nomenclature used worldwide includes the electrophysiologic examination (which may be confused with the cardiac electrophysiological studies) and the electroneuromyographic (ENMG) examination (which is, in my opinion, the most accurate, yet not widely used, description of the study). Finally, the physician performing and interpreting these studies is referred to as electromyographer (EMGer), electrodiagnostician, or EDX consultant.

To minimize confusion among physicians and other healthcare providers, the designations, EDX examination, EMG examination or clinical EMG examination, are best used interchangeably to reflect the entire electrophysiological study of nerve and muscle (NCS and needle EMG), while

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PII: S0733-8619(01)00002-0

the names needle EMG or NEE are kept for the specific testing which involve needle electrode evaluation of muscle.

The practice of electrodiagnosis is a practice of medicine. EDX consultants (electromyographers) function in a similar fashion as radiologists by providing diagnostic studies directed by the patient clinical symptoms and working diagnosis. Hence, the EMG study should be as independent as possible, by providing an objective physiological assessment of the neuromuscular system [1].

Scope of electrodiagnostic examination

The EDX examination (EMG examination) comprises a group of tests that are usually complimentary to each other and necessary to make a final diagnosis [1–6]. The EDX examination is composed of several components:

(1) *Nerve conduction studies (NCS)*, which include sensory, motor, and mixed NCS with measurements of response amplitudes, areas, distal and proximal latencies, and conduction velocities. Unfortunately, many physicians continue to refer to this test as nerve conduction velocities (NCV), reflecting the focus on velocities (and latencies) and, thus ignoring the most important data obtained with these studies, namely amplitudes and areas.
(2) *Needle EMG (NEE)*. Sometimes, the terms "conventional or routine" precede needle EMG to distinguish this test from the advanced EMG studies including single fiber EMG and quantitative EMG (see below). At other times, the names "concentric or monopolar" are added to reflect the type of needle electrode used during the needle EMG study. Needle EMG includes evaluation of muscles' spontaneous and insertional activities, and motor unit action potential (MUAP) recruitment, activation and morphology.
(3) Special studies are additional tests, which often supplement the NCSs and needle EMG. Some are administered when specific neuromuscular disorders are suspected. These studies include: (a) *F-waves* are also referred to as F-responses. Because of their utilities and ease, these late responses are often incorporated during performance of the NCSs and have become an integral part of the EDX examination. (b) *H-reflexes* are also labeled as H-responses. As with F-waves, many EMG laboratories have included the tibial H-reflexes routinely when NCSs of the lower extremities are performed. (c) *Blink reflexes* are specialized studies often done in the evaluation of patients with facial nerve, trigeminal nerve, brainstem disorders or added to the armament of studies in patients with suspected peripheral polyneuropathy, particularly the demyelinating type. (d) *Repetitive nerve stimulations* are specialized tests usually done following motor NCSs and indicated in patients with suspected neuromuscular junction disorders, but may be useful in myotonic

and neurogenic disorders. (e) *Single fiber EMG* is a specialized study, which is most useful in the diagnosis and management of patients with neuromuscular junction disorders, particularly myasthenia gravis [7]. EMG is an adjunctive test in the assessment of neurogenic disorders. (f) *Quantitative EMG analyses* are a group of specialized studies usually requiring sophisticated equipment and software, used as a clinical and research tool in the assessment of the microenvironment of the motor unit. These studies include MUAP morphology analysis, turns and amplitudes analysis, macro EMG, and motor unit number estimate (MUNE) [8].

The referral process to the EMG laboratory

Patients are referred to the EMG laboratory for EDX studies following a clinical assessment by a physician who suspects a disorder of the peripheral nervous system. For example, a patient with intermittent hand paresthesias and positive Phalen's signs may be referred to the EMG laboratory to evaluate a possible carpal tunnel syndrome. The background and specialty of the referring physician plays a significant role in the planning and execution of the EDX study. This usually follows one of these three scenario:

(1) The referring physician is well versed with the anatomy and disorders of the peripheral nervous system and the EDX examination. The referring physician is often a neurologist or physiatrist but, occasionally, a neurosurgeon or an orthopedist. In this situation, the referral information often includes a brief, yet focused, clinical information, and a limited differential diagnosis. In these situations, the EDX consultant performs an EDX study on the symptomatic limb(s) to confirm or exclude the suspected diagnosis or, sometimes, make an alternative diagnosis, which may have not been considered by the referring physician.
(2) The referring physician is also the EDX consultant (electromyographer). In other words, the patient is examined first by the EDX consultant (usually a neurologist or physiatrist) who, then, performs and interprets the EDX study. The advantage of this situation is that the neurological examination is often thorough and the differential diagnosis is limited. Hence, the selection of NCSs and the choice of sampled muscles on needle EMG are well guided by the neurological findings. Though this scenario is ideal, it is not practical in a busy EMG laboratory. A pitfall of this approach is that some electromyographers may perform a very limited and suboptimal study, or become bias by the clinical information, resulting in a significant number of diagnostic errors. Another hazard is that some EDX consultants may change the interpretation of similar findings among different studies to suit and support the clinical diagnosis. For example, a diabetic patient with denervation of quadriceps, iliacus, thigh adductors, and lumbar paraspinal muscles may be diagnosed in the EMG laboratory as consistent with lumbar radiculopathy or dia-

betic amyotrophy depending on the temporal course of the symptoms, pain characteristics, status of diabetic control, or findings on imaging of the spine.

(3) The referring physician is not well versed with disorders of the peripheral nervous system. Often, the referral working diagnoses in these patients are vague, nonspecific or extensive. Since the EDX study has limitations related to patient discomfort, expense, and time constraints, a directed neurological history and a brief neurological examination is often mandatory before planning and executing the EDX study. Unfortunately, contacting the referring physician to extract more specific information is often, in my experience, not fruitful.

Patients referred to the EMG laboratory should have a referral from completed by the referring physician with relevant clinical information and differential diagnosis (Fig. 1). Referring physicians should describe the EDX study to their patients, particularly in regard the discomfort associated with it, without creating a significant anxiety. If unclear about the technical details of the procedure, they should encourage their patients to contact the EMG laboratory to get a verbal or written description of the procedure (Fig. 2). Such written descriptions should be widely available in all referring physicians offices.

EMG laboratory procedures

Upon arrival to the EMG laboratory for testing, the patient should be informed in details of the procedures planned based on the referral information and clinical manifestations. Reading a written description is useful, but a verbal description of the procedure by the EDX technologist and electromyographer are usually more comforting and reassuring to the patient.

EDX consultants must have a good fund of knowledge pertinent to the anatomy, physiology, and disorders of the peripheral nervous system. They must be familiar with the anatomy necessary for performing the NCSs and needle EMG. Although a formal training in clinical EMG is necessary, the EDX consultant skills is usually based on the number and type of patients studied.

Nerve conduction studies and repetitive nerve stimulations may be performed by the electromyographer, EDX technologist, or both (Table 1). Well-trained, preferably certified, EDX technologists should work under close supervision of the electromyographer. The EDX consultant should view all NCSs and RNS before proceeding with the needle EMG. Additional NCS may be added pending the needle EMG findings. For example, the median sensory NCS, recording the index and thumb, should be added to the routine NCS if the needle EMG examination reveals denervation in C6 innervated muscles, to confirm the presence of a C6 radiculopathy (intraspinal canal lesion) and exclude an upper brachial plexopathy.

EMG Laboratory Referral Form

Patient Name:_____ Hospital Number _____

Patient Telephone (Home):_____ Work_____

Appt. Date:_____ Time:_____ a.m./p.m.

Reason for EMG (indicate symptoms, findings, working diagnosis and/or check appropriate box below):

Referring Physician Name:_____

FOCAL PROBLEMS (SELECT LIMB - RIGHT OR LEFT - IF BOTH, INDICATE WORSE SYMPTOMATIC SIDE)					
UPPER EXTREMITY	*Right*	*Left*	*LOWER EXTREMITY*	*Right*	*Left*
Cervical Radiculopathy			Lumbosacral Radiculopathy		
Carpal Tunnel Syndrome (CTS)			Lumbar Canal Stenosis		
Median Neuropathy (except CTS)			Femoral Neuropathy		
Ulnar Neuropathy			Peroneal Neuropathy		
Radial Neuropathy			Sciatic Neuropathy		
Brachial Plexopathy			Tarsal Tunnel Syndrome (TTS)		
Thoracic Outlet Syndrome (TOS)			Lumbosacral Plexopathy		
Axillary Neuropathy			*OTHER*		
Musculocutaneous Neuropathy			Facial Neuropathy (Bell's Palsy)		
Suprascapular Neuropathy			Vagal Neuropathy (Laryngeal Palsy)		
			Phrenic Neuropathy		
			Thoracic Radiculopathy		
GENERALIZED PROBLEMS (SELECT RIGHT OR LEFT - BOTH UPPER & LOWER EXTREMITIES WILL BE EXAMINED					
Peripheral Polyneuropathy			Myasthenia Gravis		
Motor Neuron Disease (ALS, ...)			Myopathy		

Special Instructions: At the time of the EMG appointment, the patient's skin should be clean without lotions, oils or creams. No other special preparation is required. The patient can take all their medications as prescribed. Please indicate if the patient is taking a blood thinner, or is on medication for myasthenia gravis, or has a pacemaker or stimulator. There are no aftereffects and the patient can return to their usual activities immediately upon leaving the laboratory. The results of the EMG examination are faxed and mailed to the referring physician, who in turn, will explain the results to the patient. If you have further questions, please call the EMG laboratory at .....

Fig. 1. A sample of an EMG referral form.

The EDX consultant performs needle EMG, because data are obtained on-line and could not be repeated. A concentric or monopolar needle electrode with the smallest diameter possible should be utilized, to reduce the extent of pain. Patient should be comforted throughout the procedure; if requested, a pause should be granted in the midst of the study. Needle EMG examination protocols for common disorders seen in the EMG laboratory are shown in

WHAT YOU SHOULD KNOW ABOUT YOUR EMG TESTING

The EMG (ElectroMyoGraphy) examination

The EMG examination is a diagnostic examination of nerve and muscle function. Your doctor has arranged this test to assist in establishing a diagnosis and plan treatment. The EMG examination includes (1) nerve conduction studies and (2) muscle testing.

Nerve conduction studies are performed by placing discs on the skin over nerves and muscles and recording the responses to electrical stimulation of the nerves. The nerves are stimulated with mild electrical impulses that give an unusual and surprising sensation (much like the sensation in the fingers experienced when you hit you elbow on a desk).

The muscle testing involves direct recording of muscle activity at rest and during contraction by inserting small needles into various muscles. A pinprick sensation is experienced when the needle is inserted and sometimes a mild, dull ache is noted while the needle is in place. No electrical shocks are given. The needle picks up the electrical activity generated by normally by the muscle. This electrical activity is displayed on a screen and over a loudspeaker so that the physician can see and hear it.

The EMG examination is safe, well tolerated, and involves only minor discomfort. It takes about one and a half hours. However, it is not unusual for more time to be required.

Special Instructions

At the time of your EMG appointment, your skin should be clean and without lotions, oils or creams. No special preparation is required. You can take all your medications as prescribed by your doctor. Please notify the technologist if you are taking a blood thinner (warfarin or Coumadin), are on medication for myasthenia gravis (Mestinon) or have a pacemaker or stimulator. There are no after effects and you may return to your usual activities upon leaving the EMG laboratory.

Test Results

The results of the EMG examination are sent to your doctor, who in turn, will explain them to you and plan the appropriate treatment.

Fig. 2. A sample of an EMG laboratory patient information leaflet.

Table 2. In an extremely anxious patient or in a non-sedated child, the needle EMG should focus on muscles with the highest likelihood of abnormality, since only few muscles may be ultimately sampled. For example, sampling the vastus lateralis and deltoid may be the only possible muscles examined in a child with possible proximal myopathy.

Table 1
Suggested nerve conduction studies for common referrals to the EMG laboratory

Disorder	Nerve tested (s = sensory, m = motor)[a]
Cervical radiculopathy	Median (s)
	Ulnar (s)
	Radial (s)
	Median (m)
	Ulnar (m)
Carpal tunnel syndrome	Nerves tested for cervical radiculopathy
	plus one or more of the internal hand comparison studies if indicated[b]
Lumbosacral radiculopathy	Sural (s)
	Peroneal (m)
	Tibial (m)
	Bilateral tibial H-reflexes
Ulnar neuropathy	Nerves tested for cervical radiculopathy plus
	Dorsal ulnar (s)
	Ulnar (m) recording first dorsal interosseous
Peroneal neuropathy	Nerves tested for lumbosacral radiculopathy plus
	Superficial peroneal (s)
	Peroneal (m) recording tibialis anterior
Peripheral Polyneuropathy	Nerves tested for cervical and lumbosacral radiculopathy
Motor neuron disease	Nerves tested for cervical and lumbosacral radiculopathy
Myopathy	Median (s)
	Sural (s)
	Median (m)
	Tibial (m)

[a] Nerves should be tested on the symptomatic side. Contralateral studies are recommended for comparison and in patients with bilateral symptoms.

[b] This may include the mixed median and ulnar plantar study, median and ulnar sensory recording ring finger, or median and ulnar motor recording 2nd lumbrical and 2nd interossei respectively.

EMG laboratory report

When completed, the EDX consultant should explain the findings in brief to the patient, bearing in mind that the electromyographer is often not the referring or treating physician. Discussion of a serious illness, such as amyotrophic lateral sclerosis, may be best left to the referring physician. Suggestions for clinical management should not be discussed with patient (except in general terms if necessary) unless the referring physician has requested a formal neuromuscular consultation.

The results of the EDX study should be conveyed promptly to the referring physicians. An EMG laboratory report is the best way to transmit the results of the EDX assessment to the referring physician. Occasionally, the EDX consultant should contact the referring physician if the EMG findings reflect a grave disease or if planned surgery needs to proceed or be cancelled due to these findings.

Generating a concise and understandable EMG laboratory report is an important function of the electromyographer [2]. The EDX report should

Table 2
Suggested needle EMG protocol for common referrals to the EMG laboratory

Disorder	Muscle examined
Cervical radiculopathy or carpal tunnel syndrome	First dorsal interosseous
	Abductor pollicis brevis[a]
	Flexor pollicis longus
	Extensor indices proprius
	Pronator teres
	Biceps
	Triceps
	Deltoid
	Mid and low cervical paraspinal muscles
Lumbosacral radiculopathy	Tibialis anterior
	Medial gastrocnemius
	Extensor hallucis
	Flexor digitorum longus
	Vastus lateralis
	Gluteus medius
	Mid and low lumbar paraspinals
Ulnar neuropathy	Muscles tested for cervical radiculopathy plus
	Abductor digiti minimi
	Flexor carpi ulnaris
	Flexor digitorum profundus (ulnar part)
Peroneal neuropathy	Muscles tested for lumbosacral radiculopathy plus
	Peroneus longus
	Short head of biceps femoris
Peripheral Polyneuropathy	Muscles tested for lumbosacral radiculopathy plus
	Abductor hallucis
	Extensor digitorum brevis
	First dorsal interosseous[b]
Motor neuron disease	Muscles tested for cervical and lumbosacral radiculopathy in three limbs plus thoracic paraspinals
Myopathy	Tibialis anterior
	Medial Gastrocnemius
	Vastus lateralis
	Vastus medialis
	Gluteus medius
	Brachioradialis
	Biceps
	Triceps
	Deltoid
	Mid and low lumbar paraspinals

[a] Suggested in carpal tunnel syndrome only since it is extremely painful to sample.
[b] More proximal muscles should be tested if first dorsal interosseous is abnormal to establish a distal to proximal gradient.

be typed (not hand written) because it constitutes an integral part of the patient's medical records. The report should contain all the pertinent data acquired during the study, despite that many referring physicians are only interested in the final conclusion. In addition to the demographic data

(patient name, age, birth date, sex, hospital number, date of study, and referring physician), the EMG laboratory report should include the following:

(1) *Reason for referral to the EMG laboratory.* This should include a brief and pertinent clinical summary, highlighting the limbs involved, the temporal course of the illness (with date of onset if applicable) and the complicating factors, which may influence the EDX findings. These factors include diabetes mellitus, local swelling, limb deformity, history of poliomyelitis, or previous lumbar or cervical spinal surgery. An example of a note outlining the reason for referral is the following: ''Acute right foot drop noted after recent craniotomy on 03/03/2001. The patient has diabetes mellitus and remote history of lumbar laminectomy. Evaluate for peroneal neuropathy and lumbosacral radiculopathy.''
(2) *Nerve conduction studies table.* This segment of the report should always be a part of the EMG laboratory report, and is particularly directed to physicians who are well versed with the EDX examination. Recording and revealing limb temperature is extremely useful, since many of the NCS parameters are greatly affected by cool limbs. Since F-wave and H-reflex latencies are length-dependent, the patient's height should be highlighted in the report. The tabulated NCS form should be detailed but not overcrowded with unnecessary numbers. Nerves stimulated, stimulation sites and recording points are extremely important. Amplitudes (distal and proximal), latencies, conduction velocities, and F-wave latencies should be noted. Contralateral findings and normal laboratory values should also be shown, preferably on the same row within the NCS table (Fig. 3).
(3) *Needle EMG table.* This should list all the muscles tested with their detailed findings (Fig. 4). Several columns should follow each muscle revealing the following: Insertional activity (increased, decreased, myotonic discharges, etc.), spontaneous activity (fibrillation potentials, fasciculation potentials, complex repetitive discharges, etc.), MUAP activation (normal, fair, or poor) and recruitment (normal, decreased, early), and MUAP morphology (amplitude, duration, percentage polyphasia). A separate column should be left for additional comments such as tremor, nascent MUAPs, mixed small and large MUAPs, etc. If an advanced EMG study is done (such as quantitative MUAP analysis, MUNE), the findings should be shown in a table or outlined in details in the summary of findings.
(4) *Summary of the findings.* It is good practice to recap the pertinent aspects of the EDX study in one or two paragraphs. All the data obtained should be assessed and abnormalities relevant negatives highlighted. This summary set the stage for formulating meaningful impression.

Fig. 3. A sample of the first page of an EMG laboratory report, revealing patient demographics, limb(s) temperature, height, reason for referral and tabulated nerve conduction studies.

Electromyography Laboratory Report

UniversityHospitals HealthSystem
University Hospitals of Cleveland

University Hospitals of Cleveland
EMG Laboratory
11100 Euclid Avenue
Cleveland, Ohio 44106-5098
(216) 844-1923
(216) 844-7624 (fax)

Name:
Hospital No: 2648849
Sex: Male
Height: 71 (in)
Referring Physician: Dr.

Date: 9/18/01
Birth date: 8/6/68
Age: 33
Temp: 33 (C) Hand
Temp: 35 (C) Foot

CASE WESTERN RESERVE UNIVERSITY
School of Medicine

Reason for Referral :

Nerve Conduction Studies

Nerve Stimulated	Stimulation Site	Recording Site	Amplitude *Motor=mV; Sensory=μV*			Distal/Peak Latency *msec*			Conduction Velocity *m/sec*			F-wave Latency *msec*	
			Rt	Lt	NL	Rt	Lt	NL	Rt	Lt	NL	Rt	Lt
Median (S)	Wrist	Index		28	>20		3.5	<3.4					
Median (S)	Wrist	Middle		31	>20		3.4	<3.4					
Ulnar (S)	Wrist	Little		15	>12		2.6	<3.1					
Radial (S)	Forearm	Snfbox		32	>18		2.1	<2.7					
Sural (S)	Calf	Ankle		14	>5		4.0	<4.5					
Median (M)	Wrist	APB		9.8	>6		3.5	<3.9					27.9
Median (M)	Elbow	APB		8.4			8.5			55	>50		
Ulnar (M)	Wrist	ADM		9.6	>7		1.8	<3.1					28.8
Ulnar (M)	Bel Elb	ADM		7.6			6.3			51	>50		
Ulnar (M)	Ab Elb	ADM		6.6			8.6			57	>50		
Peroneal (M)	Ankle	EDB		4.6	>3		3.2	<5.5					50.1
Peroneal (M)	Ab Knee	EDB		6.9			13.5			43	>40		
Tibial (M)	Ankle	AH		12.2	>8		6.8	<6.0					52.6
Tibial (M)	Knee	AH		10.4			14.2			58	>40		
Tibial (H - Reflex (M))	Knee	Soleus	5.1	13.8		6.6	8.0						
Tibial (H - Reflex)	Knee	Soleus	7.4	6.7		33.9	31.1						

(NR = No Response; Rt = right; Lt = Left; APB = Abductor Pollicis Brevis; ADM = Abductor Digiti Minimi; EDB = Extensor Digitorum Brevis; AH = Abductor Hallucis).

Referring Physician: Dr.

10/1/2001
2688491

Needle Examination

Muscle	Insertional Activity	Spontaneous Activity		Voluntary Motor Unit Potentials					Comment
				Recruitment pattern		Configuration			
		Fibs	Fascs	Recruitment	Activation	Duration	Amplitude	Polyphasia	
Left									
FDI-1st Dorsal Int	Normal	0	0	Normal	Normal	Normal	Normal	Normal	
APB-Abd poll brev	Normal	0	0	SL Decr	Normal	+1	+1	Normal	
AHB-Abd hall brev	Normal	0	0	SL Decr	Normal	+1	Normal	Normal	
EDB-Ext dig brevis	↑	+2	0	MK Decr	Normal	+2	+1	Normal	Two units only
TA-Tib Anterior	↑	+2	0	MO Decr	Normal	Normal	Normal	+1	
MG-Medial Gastroc	Normal	0	0	Normal	Normal	Normal	Normal	Normal	
TP-Tib posterior	↑	+2	0	MO Decr	Normal	+1	Normal	+1	
VL-Vastus lateralis	↑	+/-	0	MO Decr	Normal	+1	Normal	N/+1	
VM-Vastus medialis	↑	0	0	MO Decr	Normal	N/+1	Normal	N/+1	
IL-Iliacus	↑	+/-	0	MO Decr	Normal	+1	Normal	Normal	
AD-Thigh adductors	↑	+2	0	MO Decr	Normal	+2	Normal	+2	MUPs with satellites
Gluteus medius	Normal	0	0	SL Decr	Normal	+1	+1	Normal	
Lumbar Psp-Upper	Normal	0	0	N/A	N/A	N/A	N/A	N/A	
Lumbar Psp - Middle	↑	+1	0	N/A	N/A	N/A	N/A	N/A	
Lumbar Psp - Lower	↑	0	0	N/A	N/A	N/A	N/A	N/A	
Right									
T7 Paraspinal	Normal	0	0	N/A	N/A	N/A	N/A	N/A	
T9 Paraspinal	Normal	0	0	N/A	N/A	N/A	N/A	N/A	
AHB-Abd hall brev	Normal	0	0	Normal	Normal	N/+1	Normal	Normal	
EDB-Ext dig brevis	Normal	0	0	MO Decr	Normal	+1	N/+1	Normal	
TA-Tib Anterior	Normal	0	0	Normal	Normal	Normal	Normal	Normal	
VL-Vastus lateralis	Normal	0	0	Normal	Normal	Normal	Normal	Normal	

(CRD = Complex repetitive discharge; N-Myoton = Neuromyotonia; SL Decr = Slightly Decreased; MO Decr = Moderately Decreased; MkDecr = Markedly Decreased; +1, +2, +3 = slightly, moderately, markedly increased; -1, -2, -3 = slightly, moderately, markedly reduced; N/+1 = borderline increased; N/-1 = borderline reduced).

Fig. 4. A sample of the needle EMG form in the EMG laboratory report (This is usually followed by the summary and impression which are not shown).

(5) *Impression (or conclusion)*. This is the most important component of the EMG laboratory report because it represents the final link between the EDX consultant and referring physician. The impression should be brief, yet clear, and disclose as much information as possible. The impression should reflect the extremity tested and the extent of the EDX test (extensive or limited) if the EMG examination deviates from the standard. If the EDX examination was limited or incomplete, such as due to poor patient tolerance, this should be explicitly explained in the impression. If the EDX study is normal, the impression should also state that there was no evidence of the specific disorder for which the patient was referred. If the EDX study detects a peripheral nervous system lesion, the site of pathology with its severity, chronicity, and pathophysiology, should be delineated if possible. The EDX examination often makes an anatomic or physiologic diagnosis, but not clinical syndromes. For example, the EDX study often can diagnose a median mononeuropathy at the wrist or ulnar mononeuropathy across the elbow, but not carpal tunnel syndrome or cubital tunnel syndrome, respectively. In these situations, the electromyographer may report that the findings are consistent with or compatible with the appropriate suspected clinical syndrome. At times, a brief list of differential diagnosis may be useful. For example, if myotonia is detected on needle EMG, a list of the common inherited myotonic disorders and the drug-induced myotonias may be useful to the referring physician. Rarely, the EDX examination may be diagnostic of a specific disorder such as Lambert-Eaton myasthenic syndrome. If a repeat EMG study is needed, the report's impression should state the proposed time frame for such a study. In situations where multiple EDX findings are detected, they should preferably be listed relevant to their individual relation to the suspected diagnosis, followed by the likely incidental or asymptomatic findings.

Finally, the EDX consultant should be as objective as possible and should not fall into the habit of using the clinical information excessively to make a diagnosis not substantiated fully by the EDX findings. For example, the EDX of a patient with a remote elbow fracture and suspected tardy ulnar palsy may show an axon-loss ulnar mononeuropathy without focal slowing or conduction block but with denervation of the ulnar innervated muscles in the forearm. The electromyographer should report that the ulnar neuropathy is localized at or above the elbow and refrain from localizing the lesion to the elbow, in order to confirm the surgeon's suspected clinical diagnosis. Apart from some prognostication in patients with nerve injuries, the EDX report should not include treatment or management recommendations. In situations where the electromyographer is the treating physician or is asked to provide a neuromuscular consultation, a detailed neurological history, examination, diagnosis, management, and prognosis should be included in a separate neurological consultation report.

References

[1] Wilbourn AJ, Ferrante MA. Clinical electromyography. In: Joynt RJ, Griggs RC, editors. Baker's clinical neurology [book on CD-ROM]. Philadelphia: WB Saunders; 2000.
[2] Aminoff MJ: Electromyography in clinical practice. 3rd edition, New York: Churchill-Livingstone; 1998.
[3] Dumitru D. Electrodiagnostic medicine. Philadelphia: Hanley and Belfus; 1995.
[4] Katirji B. Electromyography in clinical practice: A case study approach. St. Louis: MO: Mosby; 1998.
[5] Preston DC, Shapiro BE. Electromyography and neuromuscular disorders. Boston: Butterworth-Heinemann; 1998.
[6] Shapiro BE, Katirji B, Preston DC. Clinical electromyography. In: Katirji B, Kaminski HJ, Preston DC, Ruff RL, Shapiro EB, editors. Neuromuscular disorders in clinical practice. Boston: Butterworth-Heinemann; 2002.
[7] Stalberg E, Trontelj JV. Single fiber electromyography: Studies in healthy and diseased muscle. 2nd edition. New York: Raven Press; 1994.
[8] Nandedkar SD, Barkhaus PE. Quantitative EMG. In Katirji B, Kaminski HJ, Preston DC, Ruff RL, Shapiro EB, editors. Neuromuscular disorders in clinical practice. Boston: Butterworth-Heinemann;, 2002.