Knowledge of electromyography (EMG) in patients undergoing EMG examinations

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Summary

The aim of this study was to evaluate knowledge of electromyography (EMG) in patients undergoing the procedure.
In one year, 1,586 consecutive patients (mean age 56 years; 58.8% women) were admitted to two EMG labs to undergo EMG for the first time.
The patients found to be "informed" about the how an EMG examination is performed and about the purpose of EMG numbered 448 (28.2%), while those found to be "informed" only about the manner of its execution or only about its purpose numbered 161 (10.2%) and 151 (9.5%), respectively. The remaining 826 (52.1%) patients had either no information, or the information they had was very poor or incorrect (this was particularly true if they had been consulting websites).
Being "informed" was associated with level of education (high), type of referring physician (specialist) and with an appropriate referral diagnosis specified in the EMG request.
The quality of patient information on EMG was found to be very poor and could be improved. Physicians referring patients for EMG examinations, especially general practitioners, should assume primary responsibility for patient education and counseling in this field.

KEY WORDS: electromyography, EMG request, health information, Internet, nerve conduction studies, patient education.

Introduction

Electrodiagnostic testing (EDX), commonly called electromyography (EMG), includes nerve conduction velocity (NCV) studies, "real" needle EMG and repetitive nerve stimulation. EMG is one of the diagnostic tools most frequently requested in neurology and it is essential for assessing muscle, peripheral nervous system and neuromuscular junction disorders. EMG is a functional examination and is widely considered an extension of the clinical neurological examination (Fuller, 2005). "Real" needle EMG causes patient discomfort and may carry a risk of side effects (Al-Shekhlee et al., 2003; Rubin, 2012). Surface EMG (sEMG) can be a complementary examination or a potential alternative to EMG for investigating neuromuscular disorders. sEMG is a painless technique by which myoelectrical signals are analyzed non-invasively using surface electrodes placed on the skin overlying the muscle. An American Academy of Neurology review concluded that sEMG is unacceptable as a clinical tool in the diagnosis of neuromuscular disease and low back pain. More recently the American Association of Neuromuscular & Electrodiagnostic Medicine partially revised this statement and affirmed that sEMG can detect the presence of neuromuscular disease (class III evidence), but there are insufficient data to support its utility for distinguishing between neuropathic and myopathic conditions or for diagnosing specific neuromuscular diseases (Pullman et al., 2000; Meekins et al., 2008). Therefore EDX remains irreplaceable and, even though it is uncomfortable, "needle EMG will continue to have pride of place in the clinical neurophysiologist's armamentarium" (Burke, 2010).

In daily practice, electromyographers often observe poor appropriateness of requests for EMG examinations and find that patients are often not informed about how EMG is performed or about its real utility (Mondelli et al., 1998; Podnar, 2005; Cocito et al., 2006; Di Fabio et al., 2013; Mondelli et al., 2014).

This prospective study set out to evaluate the knowledge of EMG among patients undergoing this examination, considering the type, quality and reliability of the information they have. A further aim was to look for associations between this information and the demographic characteristics of patients, the types of referring physician, and the data accompanying EMG requests. We hypothesized that there would emerge a relationship between the information patients have (on the manner of execution and the purpose of EMG) and the referral diagnosis (when indicated) accompanying EMG requests and the appropriateness of these requests.

Materials and methods

The study concerns all patients consecutively undergoing EMG for the first time at two "primary" (i.e. first level of screening) outpatient EMG labs, from January 2 to December 31, 2011. The patients who had already undergone EMG in the same or in another EMG lab and patients referred for medico-legal purposes were excluded. After taking their medical history and before performing neurological and EMG examinations we asked the patients whether they knew how and why EMG is performed. A patient was considered "informed" if she/he knew, at least, that the EMG is a test that uses an electric current or a needle, that it may be painful or cause discomfort, and that it is used to study the function of muscles and nerves. We also asked how the patient obtained his/her information: from referring physicians or in other ways (from friends or relatives or through websites, books, newspapers, magazines etc.). We collected the following data in a database: age, sex, level of education, occupation and residence of the patients, type of referring physicians (general practitioners or specialists), suspected diagnosis as indicated on the EDX request (i.e. referral diagnosis), congruence of the referral diagnosis with the clinical diagnostic assessment performed by the electromyographer before performing EMG (i.e. "appropriateness" of the request), patient knowledge of the manner of execution and purpose of EMG.

The two electromyographers had previously agreed on what exact questions to ask patients and when a patient would be considered "informed". All the patients gave their informed consent to the study.

Descriptive statistics were given as mean values and standard deviation, frequencies and percentages. Differences, between "informed" and "not informed" patients, in demographic characteristics, type of referring physician, presence of a referral diagnosis and appropriateness of the EMG request were analyzed using χ^2 and Mann-Whitney tests.

We also performed a multivariate logistic regression analysis calculating odds ratios and 95% confidence intervals to assess the strength of the associations between two dependent variables, evaluated separately (1-information on the manner of execution of EMG and 2-information on the purpose of EMG: incorrect/absent=0; present and correct=1), and a series of independent variables, namely age (years, continuous variable), gender (female=0, male=1), level of education (no formal education/primary-lower secondary education=0, upper secondary education or university degree=1), occupation (unemployed, blue collar and housewife=0, white collar and student=1; pensioners were coded 0 or 1 according to whether they had, before retiring, been a blue or white collar worker), density of the municipality of residence (density <250 inhabitants/km^2=0, density >250 inhabitants/km^2=1), type of referring physician (general practitioner=0, specialist=1), presence of referral diagnosis and appropriateness of the EMG request (no=0, yes=1). A "dummy" variable representing each EMG lab was also introduced in the models to control the variability in EMG labs.

All analyses were performed using the statistical package SPSS 13.0. An alpha-error of 0.05 was accepted.

Results

The 2,876 patients referred to two EMG labs in 2011 comprised: i) 1,586 patients undergoing EMG for the first time (55.1%); ii) 902 patients who had already undergone EMG in the same or in another lab (31.4%); and iii) 388 patients undergoing EMG for medico-legal purposes (13.5%). We considered only the first group, which consisted of 933 females and 653 males having a mean age of 56 years (range 15-101). The EMG requests came from general practitioners in 1,050 patients (66.2%) and from orthopedists in 172 (10.8%), neurologists in 113 (7.1%), rheumatologists in 67 (4.2%), neurosurgeons in 54 (3.4%), occupational physicians in 41 (2.6%), physiatrists in 27 (1.7%) and other specialists in 62 (3.9%). All the specialists were grouped together for the statistical analysis. The referral diagnosis was specified in 1,033 EMG requests (65.1%). The most common referral diagnosis was carpal tunnel syndrome (558 out of 1,033=54%). The EMG requests were appropriate in 743 out of the 1,033 (71.9%) patients with a referral diagnosis. For the statistical analysis, patients with an inappropriate EMG request and those with an EMG request without a referral diagnosis were grouped together (n=843).

Tables I and II show the patients' demographic findings, the types of referring physician and the presence and appropriateness of the referral diagnosis in all the patients and in the patients divided into "informed" and "not informed" groups, as well as the differences between these two groups.

Overall, the patients found to be "informed" about the manner of execution and the purpose of EMG numbered 448 (28.2%), while those found to be "informed" only about the manner of execution and only about the purpose of the EMG numbered 161 (10.2%) and 151 (9.5%), respectively. The remaining 826 (52.1%) patients either had no information or the information they had was very poor or incorrect. Most of the patients with incorrect information were aged under 50 years and had obtained their information from websites.

Overall, the patients who had correct information on the manner of EMG execution numbered 599 (37.8%), of whom 368 had received the information from referring physicians, 142 from friends or relatives who had already undergone EMG and 89 through other channels, especially websites.

Overall, the patients who had correct information on the purpose of EMG numbered 609 (38.4%), of whom 461 had been informed by referring physicians, 93 by friends or relatives and 55 via other channels.

Differences between "informed" and "not informed" patients emerged in all demographic variables (age, level of education, occupation, residence), in the type of referring physician, and in the presence and appropriateness of referral diagnosis with the EMG request.

The regression analysis revealed that being informed about the manner of execution and purpose of EMG

Table I - Data in the whole sample and in the patients who were "informed" and "not informed" about the nature of the EMG procedure.

	All patients	Informed	Not informed	Informed vs Not informed
Number (%)	1,586 (100%)	599 (37.8%)	987 (62.2%)	
Age (years)	56±16.7	52.8±16	58±16.8	Z=-6.11, p<.00001
Gender				
Female	933 (58.8%)	364 (60.8%)	569 (57.6%)	χ^2=1.5, p=0.22
Male	653 (41.2%)	235 (39.2%)	418 (42.4%)	
Residence				
Low-density municipality	1,094 (69%)	388 (64.8%)	706 (71.5%)	χ^2=7.9, p=0.048
High-density municipality	492 (31%)	211 (35.2%)	281 (28.5%)	
Level of education				
1. no formal education	145 (9.1%)	31 (5.2%)	114 (11.6%)	χ^2=63.2, p<.00001
2. five years of primary education	348 (21.9%)	99 (16.5%)	249 (25.2%)	
3. lower secondary education	530 (33.4%)	191 (31.9%)	339 (34.3%)	
4. upper secondary education	432 (27.2%)	209 (34.9%)	223 (22.6%)	
5. university degree	131 (8.3%)	69 (11.5%)	62 (6.3%)	
Occupation				
blue collar	571 (36%)	220 (36.7%)	351 (35.6%)	*χ^2=22.42 p<0.00001
white collar	317 (20%)	161 (26.9%)	156 (15.8%)	
housewife	473 (29.8%)	140 (23.4%)	333 (33.7%)	
pensioner	184 (11.6%)	61 (10.2%)	123 (12.5%)	
student	20 (1.3%)	9 (1.5%)	11 (1.1%)	
unemployed	21 (1.3%)	8 (1.3%)	13 (1.3%)	
Referring physicians				
general practitioners	1,050 (66.2%)	337 (56.3%)	713 (72.2%)	χ^2=42.5, p<.00001
specialists	536 (33.8%)	262 (43.7%)	274 (27.8%)	
Referral diagnosis on EMG request?				
No	555 (35%)	158 (26.4%)	397 (40.2%)	χ^2=3.4, p<.00001
Yes	1,031 (65%)	441 (73.6%)	590 (59.8%)	
EMG request appropriate?				
No	208 (20.2%)	76 (17.3%)	132 (22.3%)	χ^2=3.96, p=0.045
Yes	824 (79.8%)	364 (82.7%)	460 (77.7%)	

* blue collar, housewife, unemployed, ex-blue collar pensioner ("informed" n=398 and "not informed" n=763) vs white collar, student, ex-white collar pensioner ("informed" n=201 and "not informed" n=224)

Table II - Data in the whole sample and in the patients who were "informed" and "not informed" about the purpose of EMG.

	All patients	Informed	Not informed	Informed vs Not informed
Number (%)	1,586 (100%)	609 (38.4%)	977 (61.6%)	
Age (years)	56±16.7	52.9±15.7	57.9±17	Z=-6.03, p<.00001
Gender				
Female	933 (58.8%)	366 (60.1%)	567 (58%)	χ^2=0.66, p=0.42
Male	653 (41.2%)	243(39.9%)	410 (42%)	
Residence				
High-density municipality	1,094 (69%)	400 (65.7%)	694 (71%)	χ^2=5.02, p=0.05
Low-density municipality	492 (31%)	209 (34.3%)	283 (29%)	
Level of education				
1. no formal education	145 (9.1%)	22 (3.6%)	123 (12.6%)	χ^2=82.4, p<.00001
2. five years of primary education	348 (21.9%)	100 (16.4%)	248 (25.4%)	
3. lower secondary education	530 (33.4%)	203 (33.3%)	327 (33.5%)	
4. upper secondary education	432 (27.2%)	213 (35%)	219 (22.4%)	
5. university degree	131 (8.3%)	71 (11.7%)	60 (6.1%)	
Occupation				
blue collar	571 (36%)	235 (38.6%)	336 (34.4%)	*χ^2=14.8, p=0.00012
white collar	317 (20%)	161 (26.4%)	156 (16%)	
housewife	473 (29.8%)	142 (23.3%)	331 (33.8%)	
pensioner	184 (11.6%)	54 (8.9%)	130 (13.3%)	
student	20 (1.3%)	9 (1.5%)	11 (1.1%)	
unemployed	21 (1.3%)	8 (1.3%)	13 (1.3%)	
Referring physicians				
general practitioners	1,050 (66.2%)	335 (55%)	715 (73.2%)	χ^2=55.4, p<.00001
specialists	536 (33.8%)	274 (45%)	262 (26.8%)	
Referral diagnosis on EMG request?				
No	555 (35%)	101 (16.6%)	454 (46.5%)	χ^2=147.3, p<.00001
Yes	1,031 (65%)	508 (83.4%)	523 (53.5%)	
EMG request appropriate?				
No	208 (20.2%)	77 (15.2%)	131 (25%)	χ^2=15.5, p=.00008
Yes	824 (79.8%)	431 (84.8%)	393 (75%)	

* blue collar, housewife, unemployed, ex-blue-collar pensioner ("informed" n=414 and "not informed" n=750) vs white collar, student, ex-white collar pensioner ("informed" n=195 and "not informed" n=227).

Table III - Multivariate logistic regression analysis with correct information on the purpose of EMG as the dependent variable.

Independent variable	OR	95% CI	SE	p
Age (years)	0.99	0.98-1.03	0.01	0.057
Gender (male)	0.93	0.74-1.16	0.12	0.53
Residence (high-density municipality)	1.16	0.91-1.48	0.12	0.23
Level of education (high)	1.86	1.43-2.43	0.14	<0.000
Occupation (white collar/student)	1.07	0.84-1.37	0.13	0.58
Referring physician (specialist)	1.77	1.4-2.37	0.12	<0.000
Specification of referral diagnosis (yes)	2.59	1.86-3.62	0.17	<0.000
Appropriateness of EMG request (yes)	2.06	1.54-2.76	0.15	0.001

Abbreviations: OR=odds ratio; CI=confidence interval; SE=standard error.

Table IV - Multivariate logistic regression analysis with correct information on the nature of the EMG procedure as the dependent variable.

Independent variable	OR	95% CI	SE	p
Age (years)	0.99	0.98-1.02	0.01	0.055
Gender (male)	0.88	0.7-1.08	0.11	0.22
Residence (high-density municipality)	1.24	0.99-1.57	0.12	0.06
Level of education (high)	1.67	1.3-2.15	0.13	<0.000
Occupation (white collar/student)	1.10	0.87-1.39	0.12	0.42
Referring physician (specialist)	1.79	1.43-2.24	0.12	<0.000
Specification of referral diagnosis (yes)	1.26	0.92-1.73	0.16	0.15
Appropriateness of EMG request (yes)	1.55	1.16-2.07	0.15	0.003

Abbreviations: OR=odds ratio; CI=confidence interval; SE=standard error.

was associated with a high level of patient education, with referral by specialist physicians and with appropriate referral diagnoses. The presence of a referral diagnosis accompanying the EMG request was associated only with knowledge of the purpose of EMG (Tables III and IV).

Discussion

Patient information on EMG was found to be limited and of poor quality. More than half of the patients were not informed or had received incorrect information about the manner of execution and purpose of EMG. The referring doctors had correctly informed 23.2% of the patients about the execution of the EMG and 29.1% of the patients about the purpose of EMG. The patients who had obtained correct information through other persons or through websites amounted to 14.6% and 9.3%, respectively. Possession of correct information was associated with a high level of education, with referral by specialist physicians, and with made by specialists were more likely to be appropriate than those made by general practitioners. Patients' lack of information was closely linked to lack of information or incorrect information (provided by referring physicians, especially general practitioners) on the EMG request. The EMG requests often lacked a referral diagnosis and many EMG requests were inappropriate, especially those made by general practitioners. These findings are similar to those of a previous report by our group (Mondelli et al., 1998) and are confirmed by others (Podnar, 2005; Cocito et al., 2006; Di Fabio et al., 2013; Mondelli et al., 2014). The American Association of Neuromuscular & Electrodiagnostic Medicine suggested that when an electromyographer, "evaluating a patient referred for EMG, determines that the patient most likely is not suffering from a neuromuscular disorder, he should communicate this opinion to the patient and to the referring doctor and should give the patient the right to cancel EMG with the purpose of optimising the diagnostic pathway" (AAEM, 1999). Italian EMG labs often do not follow this advice. But this is another problem and is not the object of this study.

About 14% of our patients sought information on EMG on the Internet; almost all of them were under 50 years of age. More than two-thirds of these patients received incorrect information using the Internet, especially regarding the purpose and the possible complications of EMG. Many patients reported that websites focus on the pain due to the needle and electric current and consider EMG dangerous because it may cause iatrogenic complications, especially hematoma. EMG and NCV studies can cause patients some discomfort, but EDX is usually well tolerated and rarely causes side effects. Needle EMG is an invasive procedure and can potentially produce iatrogenic effects such as bleeding (a little bleeding is the rule), hematoma, infection and pneumothorax (Al-Shekhlee et al., 2003; Rubin, 2012). Many recent studies showed that hematoma is a very rare complication even in patients taking anticoagulant and antiplatelet medications (Gruis et al., 2006; Gertken et al., 2011; Boon et al., 2012; London et al., 2012). Even if a hematoma was documented on ultrasonography after EMG, no patients experienced symptoms (Lynch et al., 2008). Pneumothorax is a rare but potentially dangerous complication and may occur following EMG of thoracic and paraspinal muscles and especially the diaphragm (Al-Shekhlee et al., 2003; Bolton, 2008). The use of ultrasonography during needle electrode insertion in the diaphragm muscle drastically reduces the risk of pneumothorax (Boon et al., 2008). Some websites also suggested that NCV studies are very painful and dangerous. In reality, NCV examination is commonly performed using surface stimulation and recording electrodes and it is not an invasive procedure unless the "near-nerve" technique is used. The

current is also safe in patients with implanted cardiac devices (Mellion et al., 2010; Cronin et al., 2013; Ohira et al., 2013). In addition, carpal tunnel syndrome, which is the most frequent diagnostic suspicion on EMG requests, almost always requires NCV study and needle EMG is rarely utilized. We did not systematically investigate the quality of websites dealing with EMG but the website-sourced information on EMG reported by the patients tended to be incorrect and this is a problem common to all medical topics. For example, studies reporting systematic quality assessment surveys of websites on carpal tunnel syndrome, radiculopathy and other orthopedic disorders demonstrated that websites failed to be sufficiently comprehensive and accurate, and that many websites that provide "medical" information have been created by people who are not doctors, purely for commercial purposes, or in some cases to promote private medical practice (Beredjiklian et al., 2000, Eysenbach et al., 2002, Mathur et al., 2005, Greene et al., 2005, Hungerford, 2009; Morr et al., 2010, Lutsky et al., 2013). Therefore, referring physicians should guide their patients to the right information. We observed that the referring physicians, especially the specialists, when they informed their patients, did so properly. Also, information given by friends and relatives who had already undergone EMG was almost always correct, but very few of the patients were informed in this way. Almost no patient obtained information from books, newspapers, magazines and medical journals. Although ethical medical practice requires that patients be given correct information, many physicians, especially general practitioners, continue to prescribe examinations, including EMG, without providing consistent and adequate information.

We are aware that our results may potentially be affected by our expectations and that they cannot be generalized. They depend on many variables such as the patients' demographic characteristics, the culture of the population considered, aspects of healthcare organization, and variations in medical practice, reimbursement policy and EMG laboratory type (primary or secondary, devoted to outpatients or inpatients). However, in our study we tried to standardize the questions put to the patients. Our sample was sufficiently large to obtain significant results and can be considered representative of our area, given that the patients represented 52% of the subjects who underwent EMG examinations during 2011 in the public EMG labs in our province.

We reported poor information pertaining to EMG in a previous paper (Mondelli et al., 1998) and Cocito et al. (2006) confirmed our observation, but a systematic study on the quality of information on EMG was never performed.

In conclusion, the quality of patient information on EMG is very poor and could be improved. Referring doctors should seek to bring about a significant improvement in the quality and completeness of the available information. Physicians referring patients for EMG examinations, especially general practitioners, should assume primary responsibility for patient education and counseling in this field.

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