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Factors Determining the Painfulness of Electroneuromyography

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Summary. *Introduction.* Electroneuromyography (ENMG) is a useful diagnostic test for the evaluation of neuromuscular disorders. The procedure is considered unpleasant or even painful due to the use of electrical stimuli and needle electrodes. In this study, we investigated the influence of demographic factors on the perception of pain during ENMG examination as well as the connection between the perception of pain and the extent of the examination, the presence of chronic pain, its characteristics, and levels of anxiety and depression in patients.

Methods. 400 patients who were referred to ENMG examination participated in a questionnaire survey after the procedure. The questionnaire included rating of pain intensity experienced during ENMG procedure using numerical rating scale (NRS), basic demographic information, information about the extent of the examination, questions about previously experienced pain, and the Hospital Anxiety and Depression Scale (HADS).

Results. The mean of NRS score was 3.76±2.6. There was a negative correlation between pain intensity during ENMG and education level ($r=-0.12$, $p=0.03$). There was a significant ($p=0.011$) correlation between the intensity of pain and the extent of ENMG examination. The procedure was more painful for the patients who experienced continuous pain before the procedure ($p=0.002$), and the intensity correlated with qualitative aspects of pain. There was a significant correlation between pain intensity during the examination and the emotional state of the patient ($p<0.001$).

Conclusions. The only correlation between pain intensity and demographic factors was a negative correlation with education level. There was a significant correlation between experienced pain before the procedure and the intensity of pain during the examination. There was a significant correlation between the intensity of pain during the examination and levels of anxiety and depression.

Keywords: pain, electroneuromyography, chronic pain.

INTRODUCTION

Pain is a complex experience which depends on various physiological and psychological factors. For many years, numerous studies have tried to determine exact brain mechanisms responsible for pain processing. It is known that different parts of brain are responsible for sensory and affective components of pain [1]. And while the structures that analyze sensory-discriminative aspects of pain are well known, the exact mechanism of the processing of the affective aspect of pain remains unexplained. It makes the experience of pain widely subjective and difficult for healthcare professionals to objectively assess and answer the question why the same medical procedure is painful for one group of patients and not painful for others.

Electroneuromyography (ENMG) is a useful diagnostic test for the evaluation of neuromuscular disorders. The procedure is considered unpleasant or even painful due to the use of electrical stimuli of short (0.1–0.3 ms) duration and needle electrodes. Even though the majority of patients are able to tolerate the discomfort of the examination, some report severe pain that limits patient cooperation and leads to incomplete study.

Various studies have investigated numerous factors determining the painfulness of ENMG examination as well as interventions to increase tolerability of the procedure. In

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those studies, no correlations have been found between perceived pain and race, height, weight, body mass index, the duration of the procedure, the number of areas examined or the qualities of the examiner [2–5]. Results regarding the link between the painfulness of ENMG examination and gender, age or education level are still controversial [2, 4–9]. Therefore, in this study, we sought to investigate not only the influence of demographic factors on the perception of pain during ENMG examination but also the connection between the perception of pain and the extent of the examination, the presence of chronic pain, its characteristics, and levels of anxiety and depression in patients.

METHODS

A questionnaire survey was conducted at the Department of Neurology of Lithuanian University of Health Sciences (LSMU) Kaunas Clinics from January 2018 to March 2018. The respondents were 400 patients referred to ENMG examination for a wide range of provisional clinical diagnoses. Patients were included if they were over 18 years of age, could understand the questionnaire, and were willing to participate. The questionnaire was approved by Kaunas Regional Biomedical Research Ethics Committee (No. BEC-MF-137).

The objectives of our survey were to assess the intensity of pain in patients immediately after ENMG procedure and to evaluate its connection with the extent of the examination and demographic factors. We also aimed to assess characteristics of persistent pain before the procedure and its influence on the intensity of pain during ENMG. And lastly, we sought to evaluate the correlation between levels of anxiety and depression and painfulness of the procedure.

The survey was conducted right after ENMG examination. In our study, the examination was performed by three experienced doctors using the same machine, the same type of electrodes and techniques following research-based recommendations. The procedure involved a nerve conduction study of a minimum of 4 peripheral nerves using electrical stimuli of short (0.1–0.3 ms) duration. 196 patients also underwent electromyography (EMG) using a standard concentric needle electrode. Examination of 81 patients, in addition to the usual stimulation sites, included proximal stimuli of longer (0.8–1 ms) duration at Erb's point. The procedure was routinely explained to the patients and their questions were answered.

After the examination, the patients were asked to provide rating of pain intensity experienced during ENMG procedure using numerical rating scale (0–10, with 0 indicating no pain and 10 indicating the worst pain possible) [10, 11]. The extent of the procedure was noted by the examiner: whether it was a usual electroneurography (ENG) or including proximal stimulation or EMG. The questionnaire included basic demographic information such as age, gender, family status, education level, and employment status. It also evaluated frequency of recently experienced pain of any other origin (headaches, backaches, joint pain etc.). Provided that pain was experienced daily or constantly, the patients were asked to fill out Lithuanian pain questionnaire (A. Pakula, 1986) [12] which is a Lithuanian version of McGill pain questionnaire [13]. In this questionnaire, pain descriptors are divided into 14 subscales: 8 of them are sensory (temporal, spatial, punctate pressure, incisive pressure, constrictive pressure, traction pressure, thermal, and undefined area) and 6 are affective (tension, autonomic, fear, punishment, reaction, and pain evaluation). Every descriptor has a numeric value and a maximum score of 10. Accordingly, the indices of sensory and affective descriptors were determined, as well as the total number of the descriptors chosen. To measure levels of anxiety and depression in the patients, the Hospital Anxiety and Depression Scale (HADS) was used. It consists of 14 questions which evaluate symptoms of anxiety and depression and is widely used in medical practice. The questionnaire comprises 7 questions for anxiety and 7 questions for depression which are scored separately. The condition can be considered either normal (0–7) or with symptoms present which can be mild (8–10), moderate (11–14) or severe (15–21) [14].

Statistical analysis was performed using IBM SPSS 23.0 program. Qualitative data was evaluated using chi-square (^{2}) test. Student's t tests were used to compare the means in independent and paired samples. The correlation coefficient (r) of Spearman was calculated to evaluate the correlation between two variables. The results were considered to be significant with $p<0.05$.

RESULTS

400 patients participated in this survey: 127 (31.7%) men and 273 (68.3%) women, mean age of them being 54.8±14.1 years. 79 (19.8%) patients experienced no pain during the examination (0 on numerical rating scale (NRS)). 321 (80.2%) patients reported pain during ENMG: 88 (22%) experienced mild pain (NRS 1–3), 136 (34%) – moderate pain (NRS 4–5), 58 (14.5%) – severe pain (NRS 6–7), and 39 (9.7%) – very severe pain (NRS 8–10) (Fig. 1). The mean NRS score was 3.76±2.6.

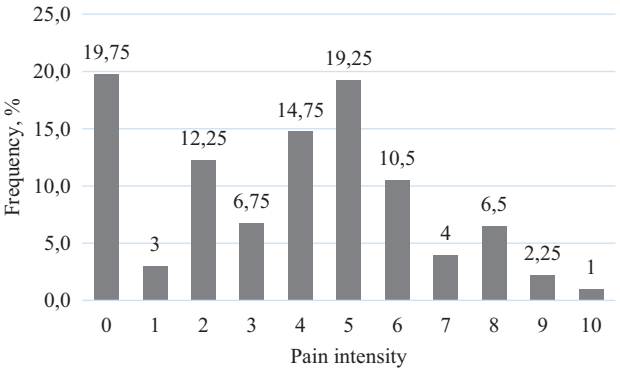

Fig. 1. **Intensity of pain experienced during ENMG examination**

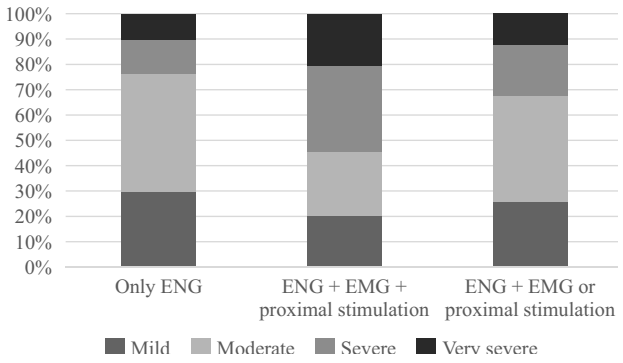

Fig. 2. **Intensity of pain and the extent of examination**

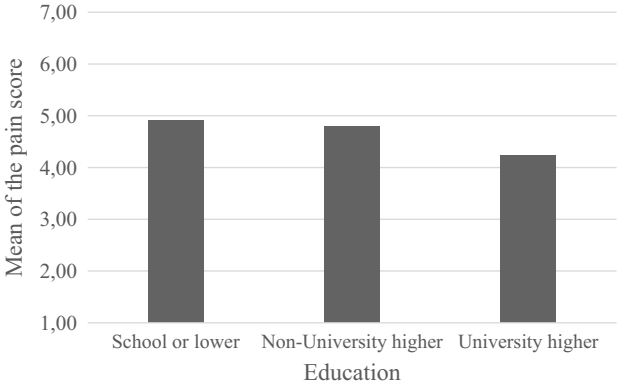

Fig. 3. **Intensity of pain and education**

There was a significant (p=0.011) correlation between the intensity of pain and the extent of ENMG examination (Fig. 2).

Analyzing associations between pain experienced during the examination and demographic factors, we found no significant differences between men's (mean 4.87±2.1) and women's (mean 4.61±2.1) experienced pain (p=0.31). No correlations were noted between the intensity of pain and age (p=0.3), employment status (p=0.085) or family status (p=0.108). However, there was a weak negative correlation between pain intensity during ENMG and education level (r=-0.12, p=0.03) (Fig. 3).

220 (83%) patients of those who experienced pain during the examination had experienced continuous pain before the examination (daily or constant pain). The mean of the intensity of pain experienced during the examination was significantly higher in patients with continuous pain (4.93±2.1) than in those who experienced pain once a week or less often (4.16±1.9) (p=0.002). Analyzing qualitative aspects of pain using Lithuanian pain questionnaire, we found that sensory descriptors were chosen by 258 patients and affective – by 239 patients. Qualitative index of the sensory aspect of pain was 23.1±14.6, while qualitative index of the affective aspect of pain was 17.84±10.4. Studying sensory descriptors, we found that the most frequently chosen were those from the undefined area subscale (76.6%) and the least chosen belonged to the incisive pressure subscale (32.83%) (Fig. 4). Analyzing affective qualities of pain, we found that the most common descriptors were from the punishment subscale (78.87%) and, on the contrary, the least chosen were from the autonomic

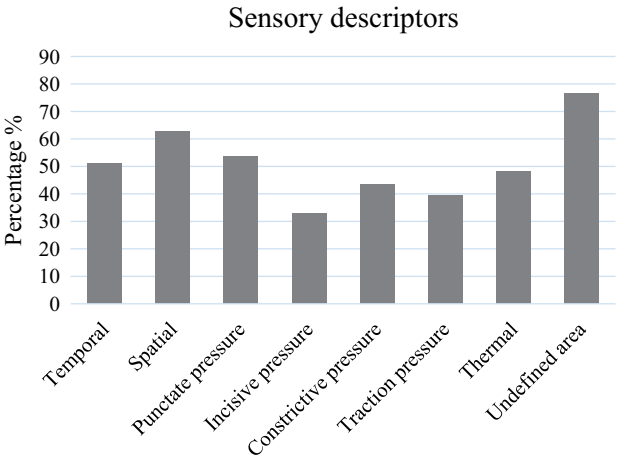

Figure 4. **Distribution of sensory descriptors**

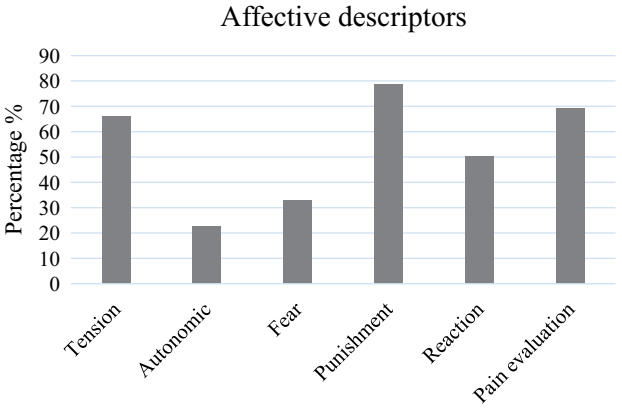

Figure 5. **Distribution of affective descriptors**

subscale (22.64%) (Fig. 5). Moreover, there were correlations between the intensity of pain experienced during ENMG examination, the index of sensory aspect of pain, the index of affective aspect of continuous pain, and the total number of chosen descriptors (Table 1).

Analyzing the status of anxiety and depression of the patients using HADS, we found that the mean of anxiety level was 7.1±4.4 (range 0–19) and the mean of depression level was 4.9±3.7 (range 0–18). There was a significant correlation between the intensity of pain during the examination and the emotional state of the patient (p<0.001) (Table 2).

Table 1. **Correlations between the intensity of pain and qualitative pain characteristics**

		Index of sensory descriptors	Index of affective descriptors	Number of descriptors
Pain score	*r*	0.364	0.489	0.505
	p	p<0.001	p<0.001	p<0.001

Table 2. **Correlations between the intensity of pain and levels of anxiety and depression**

		Anxiety	Depression
Pain score	*r*	0.428	0.321
	p	p<0.001	p<0.001

DISCUSSION

Our study confirmed that ENMG examination is associated with pain. Nonetheless, the dispersion of pain intensity is broad ranging from one fifth of patients who experienced no pain to ~1% of patients who refused to complete the examination because of severe pain. The intensity of pain recorded during this study is consistent with the literature: the mean of the intensity of pain in a study of 2012 was 3.6±2.5 during ENG and 3.8±2.8 during EMG (in our study it is 3.7±2.6) while the mean in two studies of 2013 was 3.4±1 [5, 15].

Regarding the elements of the procedure, many of them have been already analyzed in previous studies: the importance of the duration of the examination, the number of stimuli or the number of examined areas, the relation of ENMG-induced pain to the duration and the intensity of electrical stimuli, the type of recording electrode, and the insertion technique of needle electrodes [2–6, 8, 15–18]. Therefore, in this study, we decided to consider the type of stimulus used (whether only electrical stimuli or also needle electrodes were used) since it was not evaluated in previous studies. We found that patients who underwent EMG and proximal stimulation in addition to the usual ENG experienced more pain during the procedure. This might be due to a longer duration of the procedure as well as to the combination of stimuli of different origin which might be lowering pain threshold.

Analyzing connections between experienced pain and demographic data, we obtained similar results as in previous studies, with slight differences. This study, unlike the previous ones, determined a mild negative correlation between experienced pain and education level [2, 5, 6]. This is likely because of a considerably larger sample of patients and, unlike in other studies, the distribution of different levels of education was proportional in our study. It might be also explained by the fact that higher education promotes critical thinking and more thorough evaluation of any kind of information provided. In addition, we considered the extent of ENMG examination which had not been done previously. Similar to various studies, we found no significant correlation between the intensity of pain and gender [3, 5, 9]. However, there are numerous studies which say that women are more susceptible to ENMG-related pain [2, 4, 6, 7, 19]. In one case the patient sample was not homogenous (there were fewer women than men), in other cases only needle EMG was analyzed [2, 4, 6]. Moreover, it is established that thorough information about the examination is more efficient to reduce anxiety in women than in men, which can be linked to experienced pain [7, 20]. In our study, all patients received detailed information about the examination and possible unpleasant sensations. Much like in previous studies, we found no links between pain intensity and age [2–5, 8, 9]. What is more, we found no correlations between the intensity of ENMG-related pain and family status nor employment status.

The examination was more painful for those who were suffering from any kind of daily or constant pain comparing to those who were experiencing any kind of pain once a week or less frequently. It could be explained by sensitization occurring in the central nervous system (CNS) following prolonged pain and subsequently occurring modification of nociceptive pathway as well as neuroplastic changes in CNS [21–26].

Moreover, analyzing qualitative pain characteristics using Lithuanian version of McGill pain questionnaire, we found a moderate correlation between the intensity of ENMG-related pain and sensory and affective components of chronic pain of any other kind. These results are consistent with previous studies [27]. In this study, we found that even though more people had chosen sensory descriptors of pain and the index of sensory component of pain was higher, there was a stronger correlation between the intensity of pain during the examination and the index of affective component of pain. That could be explained by the fact that sensory and affective aspects of pain are related to different paths of transmission of signals in CNS. The sensory aspect of pain is related to the transmission of signals from periphery through lateral thalamus and somatosensory cortex, as well as the posterior insular cortex [28]. And the affective component is related to the emotional responses to the stimulus which involves the limbic system [29].

Analyzing emotional state of the patients, we confirmed that anxiety is related to the experience of pain and it lowers pain threshold [30–33]. There are a few studies that have analyzed anxiety levels in patients before and after ENMG examination but the results are inconsistent due to the fact that anxiety can be induced not only by the examination but also by other unrelated circumstances [6, 34]. It is important to mark that ENMG-related anxiety is closely related to the information received beforehand and to how detailed the information was [7]. We determined levels of anxiety and depression in patients immediately after the examination using HAD scale and found a significant correlation between those levels and the intensity of pain. These results correspond to the results of previous studies [35–37].

CONCLUSION

In this study, we found no significant correlations between the intensity of pain and demographic factors with the exception of a weak correlation between the intensity of pain and education level. There was a significant correlation between pain experienced before the procedure and the intensity of pain during the examination. Affective qualities of continuous pain had stronger correlation with the intensity of pain than sensory qualities. Moreover, there was a significant correlation between intensity of pain during the examination and levels of anxiety and depression.

Despite unpleasant sensations, ENMG is a highly useful test for the evaluation of neuromuscular disorders. Thus, healthcare personnel are always determined to minimize patients' discomfort. Doctors use examination techniques and electrodes following research-based recom-

mendations to cause as little pain as possible. Our study found that pain experienced during ENMG examination is closely related to chronic pain and to the patient's emotional state. Therefore, we would suggest treating chronic pain, depression, and especially anxiety while the patient is awaiting ENMG examination in order for the patient to experience as little pain as possible and obtain accurate results during the procedure.

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VEIKSNIAI, LEMIANTYS ELEKTRONEUROMIOGRAFIJOS TYRIMO METU PATIRIAMO SKAUSMO INTENSYVUMĄ

Santrauka

Įvadas. Elektroneuromiografija (ENMG) yra tyrimo metodas, skirtas periferinių nervų ir raumenų ligų diagnostikai. Tyrimas laikomas nemaloniu, kartais skausmingu, nes jo metu naudojami trumpi (0,1–0,3 ms) elektros stimulai, o tiriant raumenis – adatiniai elektrodai. Nors dauguma pacientų tyrimą toleruoja gerai, nedidelė dalis pacientų jaučia nepakeliamą skausmą ir tyrimo atsisako. Norėdami nustatyti veiksnius, lemiančius ENMG tyrimo skausmingumą, nusprendėme atlikti didelės imties tyrimą, kurio metu analizuota ne tik daug kartų tirtų demografinių veiksnių įtaka skausmo pojūčiui, bet ir skausmo ryšys su tyrimo apimtimi, lėtiniu skausmu, jo pobūdžiu ir paciento emocine būkle.

Tiriamieji ir tyrimo metodas. Atliktoje anoniminėje apklausoje dalyvavo 400 pacientų, kuriems buvo atliktas ENMG tyrimas. Anketą sudarė klausimai apie ENMG tyrimo metu patirto skausmo intensyvumą, naudojant Skaitmeninės analogijos skalę (SAS), demografinius duomenis, tyrimo apimtį, iki tyrimo patirtą kitos kilmės skausmą ir klausimai iš Hospitalinės nerimo ir depresijos skalės (angl. *Hospital Anxiety and Depression Scale*, HADS).

Rezultatai. Tyrimo metu patirto skausmo intensyvumo vidurkis buvo 3,76 ± 2,6. Nustatyta silpna neigiama koreliacija tarp skausmo intensyvumo ir išsilavinimo ($r = -0,12$, $p = 0,03$). Rasta statistiškai reikšminga ($p = 0,011$) koreliacija tarp skausmo intensyvumo ir ENMG tyrimo apimties. Tyrimas buvo skausmingesnis pacientams, iki tyrimo patyrusiems kitos kilmės skausmą ($p = 0,002$). Nustatyta koreliacija tarp anksčiau patirto skausmo kokybinių charakteristikų (jutiminių bei emocinių) ir tyrimo metu patirto skausmo intensyvumo. Rasta reikšminga koreliacija tarp ENMG tyrimo metu patirto skausmo ir emocinės paciento būklės ($p < 0,001$).

Išvados. Analizuojant demografinių veiksnių ryšį su ENMG skausmingumu, rasta neigiama koreliacija tarp tyrimo metu patirto skausmo ir išsilavinimo. Nustatyta reikšminga koreliacija tarp iki tyrimo patirto skausmo ir tyrimo skausmingumo. Nustatytas statistiškai reikšmingas ryšys tarp tyrimo metu patirto skausmo bei depresijos ir nerimo lygio.

Raktažodžiai: skausmas, elektroneuromiografijos tyrimas, lėtinis skausmas.

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