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Association of Nerve Conduction Studies and Blood Parameters in Patients with Neuropathic Symptoms

Osman KORUCU[1]*, Murat DAĞDEVİREN[2], Merve Ceren AKGÖR[1]

1. Atatürk Sanatoryum Training and Research Hospital, Department of Neurology, Ankara, Türkiye
2. Ankara Etlik City Hospital, Department of Endocrinology, Ankara, Türkiye
**Corresponding author*

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ORCID:
OK: 0000-0001-6354-3297
MD: 0000-0003-4715-2557
MCA:0000-0002-5169-2233

Corresponding author:
Osman Korucu,
Atatürk Sanatoryum Training and Research Hospital, Ankara, Türkiye
osmankorucu@yahoo.com

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Abstract

Background: Diabetic neuropathy, particularly distal symmetric polyneuropathy, which is common complication of uncontrolled diyabetes mellitus (DM). Recent studies have linked impaired fasting glucose, OGTT results, HbA1c levels, and electromyography findings with neuropathy,but there is inconsistency in which parameters are most significant. The study aims to clarify the associations between metabolic parameters and neuropathy.

Method: In this retrospective study, 1,000 neuropathic pain patients were reviewed, and 310 meeting the criteria were included. They were grouped as newly diagnosed or previously diagnosed with diabetes. The study aims to evaluate the relationship between insulin, insulin resistance, OGTT, fasting glucose, HbA1c, vitamin B12, and nerve conduction studies. Statistical analyses will be performed using SPSS 18.0, with a significance level of $p \leq 0.05$.

Results: The study included 310 patients (165 women, 145 men), with 255 diagnosed with polyneuropathy. Neuropathy was more common in diabetic patients (p=0.0001) and significantly associated with age (p=0.0001). No correlations were found with glucose metabolism parameters. Sensory and sensorimotor polyneuropathy were most common in non-diabetic patients.

Conclusion: This study suggests aging accelerates nerve degeneration and vascular changes in polyneuropathy. No strong link was found between glucose metabolism and neuropathy, but insulin resistance remains relevant. Larger studies are needed to explore metabolic risk factors, especially prediabetes. Early diagnosis and management are crucial to prevent progressive neuropathy.

Keywords
Diabetes mellitus, diabetic neuropathy, electromyography

Introduction

Diabetes Mellitus (DM) is a metabolic disease characterised by hyperglycaemia, resulting from defects in insulin secretion, action or both due to the interaction of genetic and environmental factors as well as lifestyle changes. Uncontrolled diabetes mellitus contributes to the development of acute and chronic complications that affect morbidity and mortality and represent a significant public health problem. Among these complications, diabetic neuropathy is one of the most common.

Diabetic neuropathy can manifest in various clinical forms, the most presentation is distal symmetric polyneuropathy. Sensory axonal loss leads to painful symptoms such as burning, stabbing or arching sensations, along with paraesthesia, predominantly in the distal extremities [1]. The diagnosis of neuropathic pain is considered feasible if the patient's clinical presentation is corroborated by bedside tests and electrophysiological assessments [2]. Neuropathic pain symptoms are well known to exacerbate during the nighttime. While it is a prevalent complication of DM and commonly observed in individuals with DM, neuropathic pain may also manifest prior to the formal diagnosis of the disease [3]. Similarly, in patients who have started insulin therapy, a condition known as treatment induced neuropathy also referred as insulin neuritis may be observed in the early stages [4]. Insulin neuritis is a short-term condition that occurs at the onset of insulin therapy, while diabetic neuropathy is typically

associated with prolonged high blood sugar levels and is characterized by permanent nerve damage. Although the timing, severity, and response to treatment of patient symptoms provide important clues for differentiating these conditions, HbA1c and OGTT play significant roles. HbA1c reflects long-term glucose control and helps assess the risk of permanent nerve damage, while OGTT results can distinguish between short-term insulin therapy and long-term diabetic conditions. Therefore, evaluating these parameters is critical for managing both conditions. However, further studies are needed to better understand the mechanisms and long-term effects between insulin neuritis and diabetic neuropathy. In patients with a definitive diagnosis of diabetes, particularly those with long-standing diabetes and typically of middle to advanced age, nerve conduction studies often reveal positive findings. Research has shown that impaired fasting glucose, as well as the results of the 1st and 2nd hour of the oral glucose tolerance test (OGTT), HbA1c levels, and electromyography (EMG) findings (especially sural nerve responses) are associated with neuropathy. However, in one of these studies, the 2nd-hour OGTT was found to be significant, while another study emphasized the importance of the 1st hour. The studies included patients with an average age of around 50 years. In recent years, changes in dietary habits have led to a significant increase in clinic visits due to neuropathic complaints among individuals aged 20 to 40 [5,6]. In this context, conditions such as insulin resistance and impaired OGTT have been identified in the patients evaluated, and appropriate treatment recommendations are provided. However, there are significant uncertainties in the literature and clinical practice regarding which parameters are associated with neuropathy. Therefore, we have planned this research to deepen the understanding of this area.

Material and Method

Our study received ethical approval from the Ethics Committee of Ankara Atatürk Sanatorium Training and Research Hospital with the decision numbered 15/2483, dated 22.02.2022. The retrospective study included patients who were evaluated in the neurology outpatient clinic due to neuropathic pain complaints, diagnosed with neuropathic pain, underwent EMG (nerve conduction study), and had blood tests conducted for etiology, including glucose, OGTT (75 g), vitamin B12, HbA1c, insulin, and insulin resistance. A total of 1,000 patient records from a five-year period between January 1, 2017, and June 30, 2022, were scanned from the hospital system. The diagnosis of diabetic neuropathy was made based on the criteria established by the American Academy of Neurology and the American Association of Electrodiagnostic Medicine [7]. Of these, 310 patients were included in the study. The first group was comprised of newly presenting patients with unknown diabetes mellitus (DM) diagnosis, while the second group consisted of patients with a known DM diagnosis who had HbA1c levels measured and underwent nerve conduction studies. After evaluating the data from the first group, the nerve conduction studies and HbA1c values of the first and second groups were compared. Patients with abnormal thyroid function tests, kidney function tests, those with thyroid disease, acute and chronic renal failure, as well as those diagnosed with Guillain-Barré Syndrome, chronic inflammatory demyelinating polyneuropathy (CIDP), and hereditary neuropathy were excluded from the study. Our aim is to evaluate the relationship between insulin, insulin resistance, OGTT, fasting glucose, HbA1c, vitamin B12, and nerve conduction studies in patients with neuropathic pain complaints, and to compare the nerve conduction and HbA1c results of this group with those of patients with diabetic polyneuropathy.

Statistical Analysis

Statistical analyses were performed using SPSS 18.0 (SPSS Inc, Chicago, IL, USA) software. When evaluating the data, the normality of continuous variables will be assessed using the Kolmogorov-Smirnov test; descriptive statistics for normally distributed data will be presented as mean ± standard deviation. The Pearson Chi-square test will be used for the comparison of categorical data. For the comparison of continuous variables that do not follow a normal distribution, the Mann-Whitney U test (for two groups) and the Kruskal-Wallis test (for more than two groups) will be applied. The Student's t-test (for two groups) and ANOVA (for more than two groups) will be used for the comparison of continuous variables that follow a normal distribution. A statistical significance level of $p \leq 0.05$ will be accepted.

Results

A total of 310 patients, comprising 165 women and 145 men, were included in the study. Among these patients, 255 had nerve conduction study results consistent with polyneuropathy, while 55 patients had normal nerve conduction study results. There was no statistically significant difference in nerve conduction study outcomes between genders (p=0.181). However, when nerve conduction study results were evaluated based on the diagnosis of diabetes, a statistically significant difference was observed between the two groups (p=0.0001) **(Table 1).** Patients with a diagnosis diabetes

Table 1: Relationship between presence of diabetes mellitus and nerve conduction study.

		Nerve Conduction Study Results				
		Normal	Sensory-motor Neuropathy	Entrapment Neuropathy	Sensory Neuropathy	
Diabetes	No	31(16.2%)	72 (37.7%)	20 (10.5%)	68 (35.6%)	191
Mellitus	Yes	3(2.5%)	78 (65.5%)	1 (0.8%)	37 (31.1%)	119
Total		34(11%)	150 (48.4%)	21 (6.8%)	105 (33.9%)	310

were more likely to exhibit neuropathy in nerve conduction studies.

When examining the relationship between the nerve conduction study results (presence/absence of polyneuropathy), age, and laboratory parameters, a statistically significant association was identified between age and the presence of polyneuropathy (p=0.0001).

In the cohort with normal nerve conduction study results, the mean age (median (interquartile range (IQR)) was 57 (26.25), while the mean ages for sensorimotor polyneuropathy, entrapment neuropathy, and sensory neuropathy were 72 (11), 59 (14), and 69 (18.5), respectively. Notably, the average age within the neuropathy group was higher.

Furthermore, no significant correlations were observed between the nerve conduction study results and the parameters of fasting blood glucose, insulin, HOMA index, OGTT (0, 1, and 2 hours), HbA1c, and vitamin B12 levels, with p-values of 0.501, 0.087, 0.226, 0.349, 0.426, 0.547, and 0.110, respectively. Among the 191 patients included in the study who did not have a prior diagnosis of diabetes, 124 underwent an OGTT (75 grams), and 42 had their insulin levels and HOMA index assessed. Although no statistically significant differences were noted between the groups aside from age, among the 42 patients without a prior diabetes diagnosis, sensory neuropathy was identified in 16, sensorimotor polyneuropathy in 14, and entrapment neuropathy in 7, while 5 patients exhibited normal nerve conduction study results. In the cohort of 124 patients who underwent OGTT (75 grams) without a prior diabetes diagnosis, sensory neuropathy was found in 50, sensorimotor polyneuropathy in 35, and entrapment neuropathy in 17, whereas 22 patients had normal nerve conduction study findings.

Discussion

In this study, the relationship between nerve conduction study results and levels of age, fasting blood glucose, insulin, HOMA index, OGTT, HbA1c, and vitamin B12 was evaluated. Our findings indicate that age has a significant association with the development of polyneuropathy (p<0.001) [8]. Notably, the highest mean age among patients diagnosed with sensorimotor polyneuropathy supports the notion that age may be an important risk factor in the development of neuropathy. Numerous studies in the literature also corroborate the association between age and the onset of polyneuropathy, which can be explained by age-related neural degeneration, vascular changes, and the impact of metabolic processes [9].

Conversely, no significant relationships were found between the nerve conduction study results and fasting blood glucose, insulin, HOMA index, OGTT (0, 1, and 2 hours), HbA1c, and vitamin B12 levels. These results suggest that, in patients without a prior diabetes diagnosis, the early development of neuropathy may not only be influenced by hyperglycaemia but also by insulin resistance, components of metabolic syndrome, or undiagnosed diabetes. Particularly, the detection of neuropathy in 88% (37/42) of the 42 patients whose insulin and HOMA levels were assessed emphasizes the potential impact of insulin resistance on neuropathy. However, the lack of statistically significant differences between the groups may be attributed to the limited sample size or the influence of other neuropathy etiologies. Among the 124 patients who underwent an OGTT and did not have a prior diagnosis of diabetes, sensory neuropathy was identified in 50, while 35 exhibited sensorimotor polyneuropathies, suggesting that disturbances in glucose metabolism may contribute to nerve damage. Studies have indicated that neuropathy can develop even during the prediabetic period. However, due to the lack of specification regarding the metabolic category (normoglycemia, impaired fasting glucose, impaired glucose tolerance, or latent diabetes) to which the patients belonged based on OGTT results, further analyses are required to better evaluate the impact of glycaemic status on the development of neuropathy [10,11]. Our study has several limitations, firstly, the retrospective nature of patient selection precluded a detailed examination of other metabolic parameters related to glucose regulation (e.g., lipid profiles, inflammatory markers).

Additionally, assessments of autonomic dysfunction or tests to identify small fiber neuropathy were not conducted to fully elucidate the etiology of neuropathy. Finally, as insulin and HOMA data were only available for a specific subgroup, prospective studies with larger sample sizes are needed to more robustly evaluate the contribution of insulin resistance to neuropathy.

In conclusion, this study demonstrates that age is significantly associated with neuropathy, whereas no clear relationship was found between nerve conduction study results and parameters of glucose metabolism. Nevertheless, the effects of insulin resistance or prediabetic conditions on neuropathy warrant further investigation. Early diagnosis of neuropathy and management of metabolic risk factors in prediabetic individuals may be crucial for preventing progressive nerve damage.

Conclusion

Fibroblasts This study systematically investigates the relationship between various metabolic parameters associated with polyneuropathy, highlighting the significant influence of age on the development of neuropathy and supporting the existence of risk factors that escalate with advancing age. The findings suggest that the aging process may exacerbate the progression of polyneuropathy through its detrimental effects on nerve degeneration and vascular alterations. Conversely, the absence of a statistically significant association between glucose metabolism parameters and nerve conduction study outcomes implies the potential impact of additional etiological factors and metabolic pathways in neuropathy pathogenesis.

Notably, the role of insulin resistance is underscored by the elevated rates of neuropathy detection; however, the lack of significant intergroup differences emphasizes the necessity for prospective studies with larger sample sizes to further elucidate these relationships. Additionally, to comprehensively evaluate the contribution of glucose metabolism disturbances, including prediabetes, to nerve injury, it is imperative to collect more extensive data regarding the metabolic status of the participants. In summary, this investigation establishes a significant association between age and neuropathy, while highlighting the need for a more comprehensive exploration of the effects of alterations in glucose metabolism on neuropathy development. The findings underscore the critical importance of early diagnosis of neuropathy in prediabetic individuals and the strategic management of metabolic risk factors to mitigate the risk of progressive nerve damage. Future research should meticulously examine the roles of insulin resistance and other metabolic parameters, alongside a focus on managing and understanding metabolic risk factors associated with neuropathy development, such as toxic exposures (e.g., alcohol consumption) and chemotherapy agents. This study contributes to the existing body of literature by emphasizing the necessity of early detection of neuropathy, particularly in prediabetic populations, and advocates for the integration of these findings into clinical practice to facilitate the development of targeted early intervention strategies for effective neuropathy management.

Author contribution statement

All authors (OK, MD, MCA) participated in the planning, writing, editing, and review of this manuscript.

Conflicts of interest

All the authors declare that they have no financial or personal relationships with other people or organizations that could potentially and inappropriately influence (bias) their work and conclusions.

Ethical approval

This study received ethical approval from the Ethics Committee of Ankara Atatürk Sanatorium Training and Research Hospital with the decision numbered 15/2483, dated 22.02.2022.

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