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Does arteriovenous fistula operation cause neuropathy in upper extremity? An EMG study.

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Abstract

Aim: Neuron function is impaired in uremic patients and peripheral neuropathy occurs in 60-80% of patients with end-stage renal disease. However, the effects of arteriovenous fistula intervention on the nerve functions in those are uncertain. The purpose of this study is to weigh the effects of arteriovenous fistula intervention on the nerve functions by using electromyography among patients who have end-stage renal disease.

Materials and Methods : Forty-three renal insufficiency patients on dialysis, living in Somalia, who had undergone arteriovenous fistula operation, were included in the present prospective study. Demographic characteristics were recorded. The electromyographic measures (both motor and sensorial) of median, ulnar, radial nerve on the operated side arm were assessed. Tibial, peroneal and sural nerve electromyographic measures were also evaluated. After the arteriovenous fistula operation, the electromyographic measures were again assessed to determine the effects of arteriovenous fistula intervention on the nerve functions.

Results: The mean age of patients was 56±17 years and 56.3% of them were male. 88% of the recruited patients underwent radiocephalic fistula operation while in the remaining 12% type of the fistula was brachiocephalic. Between the pre and the post-operative electromyographic measures, there were not any significant changes except tibial nerve motor distal latency. The mean tibial nerve motor distal latency decreased with operation from 6.59±1.39 ms to 6.17±1.18 ms (p =0.038). Upper extremity motor and sensory nerve amplitudes, except ulnar sensory nerve amplitude, were found to have a non-significant decrease trend after surgery. Lower extremity motor and sensory nerve amplitudes non-significantly increased after surgery.

Conclusions: This is the first prospective study to investigate the relationship of nerve functions with arteriovenous fistula operation by monitoring the electromyographic measures among end-stage renal disease patients. The present results demonstrated that arteriovenous fistula operation did not have unfavorable effects on nerve functions in the adjacent operation side. Further studies are needed with a larger sample size to verify this issue.

Introduction

Neurological complications frequently occur in end-stage renal failure. Uremia and circulating toxins are implicated in the etiology of degeneration of neuron functions in those [1]. The primary histopathological abnormality is revealed to be an axonal polyneuropathy with secondary segmental demyelination [2]. Inhibition of neurotrophic enzymes by circulating toxins, alterations in endoneural barrier function, and dysfunction of axonal membrane Na^+/K^+ ATP ase are presumed to play roles in etiopathogenesis [3-4]. Additionally, lack of sufficient cleansing effect of dialysis on uremic toxins has been proposed to contribute neuropathy in patients with chronic renal failure [5].

On the other hand, surgical creation of arteriovenous fistula, which is considered to be an ideal access for hemodialysis delivery, may be associated with peripheral neuropathy in end-stage renal failure patients. The possible mechanisms for this association are: 1) nerve trauma while performing the local vascular anastomoses; 2) ischemic changes [6] and 3) post-operative edema [7-8].

Electromyography (EMG) is a diagnostic test that measures the electrical activity of a muscle to evaluate the health of muscle and the motor neuron. EMG results can show nerve dysfunction, muscle dysfunction or diffi-

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culty with nerve-to-muscle signal transfer. EMG is also an useful diagnostic tool in neuropathy [9]. Moreover, EMG can help determine whether the neuropathy is a result of damage to the axons (axonal neuropathy) or the myelin (demyelinating neuropathy), or both. Normal EMG significantly decreases the likelihood of peripheral neuropathy, whereas abnormal nerve conduction findings confirm the diagnosis [10]. However, the effects of surgical creation of arteriovenous fistula on the EMG assessment of the nerves are uncertain.

In the present study, therefore, we aimed to weigh the effects of arteriovenous fistula operation on the nerve functions by using electromyography among patients who had end-stage renal disease.

Materials and Methods

Study population

Forty-three end-stage renal failure patients who planned to undergo arteriovenous fistula operation were included in the present prospective study. The study protocol was approved by local institutional ethics committee and all participants provided informed written consents. The exclusion criteria of the present work were as follows: amyloidosis, previously documented neuropathy, neuropathy due to trauma or other metabolic diseases, and cancer.

All included subjects who underwent a surgical creation of arteriovenous fistula were prospectively enrolled. Baseline clinical information including EMG parameters was recorded.

When fistula maturation was completed, the EMG parameters were again assessed on the day before hemodialysis. Follow-up information was conducted.

Electromyography analysis

All recruited patients underwent median, ulnar, and radial motor-sensory nerve conduction studies on the upper extremity where arteriovenous fistulas were created. Tibial, peroneal and sural nerve conduction studies were also performed. All analysis was performed by a single neurophysiologist. Standard EMG techniques were used in nerve conduction studies. Combined motor action potentials (CMAP) were obtained by receiving supramaximal stimulation from standard stimulation sites, and recording by superficial recording electrodes from standard recording sites. Sensory nerve action potentials (SNAP) in the upper and lower extremities were carried out antidromically. Ten results were averaged to define a sensory nerve action potential. During the examinations, special attention was paid not to give electric current to the close places of the arteriovenous fistula. No complications were encountered during the nerve conduction studies. The presence of polyneuropathy was defined as one or more abnormalities in the CMAP and the SNAP values obtained from at least two nerves [11].

Statistical analysis

The SPSS 18.0 (IBM Corporation, Chicago, USA) was used for statistical analysis. Continuous variables were expressed as mean and standard deviation while categorical variables were presented as numbers and percentages (%). The distribution of the data was evaluated with the Histogram chart and Shapiro–Wilk normality test. The Wilcoxon signed-rank test was used to test differences of paired data without normal distribution. Independent samples were compared with non-parametric Mann-Whitney U test. The frequencies of categorical variables were compared using Pearson χ^2 test, when appropriate. A P-value $< .05$ was considered statistically significant.

Table 1. Baseline characteristics of the patients

Parameters	Patients (n=32)
Age (years)	56 ± 17
Males	18 (56.3 %)
Hypertension	18 (56.3 %)
Duration of the Hypertension(years)	4.01 ± 6.88
Diabetes mellitus	10 (31.2%)
Duration of the Diabetes (years)	4.10 ± 8.26
Type of the arteriovenous fistula	
Radio-cephalic fistula	28 (87.5%)
Brachio-cephalic fistula	4 (12.5%)

Data are mean ± SD.

Results

Forty-three patients were prospectively included in the present study. Eight patients left to follow-up and 3 patients died during the study. Thus the analyses were done with the data of 32 patients. The baseline characteristics of the patients are shown in Table 1.

The mean age of the patients was 56±17 years, 56.3 % were males. Most common fistula type was radiocephalic arteriovenous fistula. 88% of the recruited patients underwent radiocephalic fistula operation (n=28). In the remaining 12% (n=4), type of the fistula was brachiocephalic.

On the baseline EMG results with respect to amplitude, age was found to have significant effects. There was a strong relationship between the decrease in tibial motor nerve amplitude and the advance in age ($r = -0.714$, $p < 0.001$). The decrease in the radial, the median and the ulnar sensory nerves amplitudes were significantly associated with older age ($r = -0.524$, $p < 0.001$, $r = -0.579$, $p < 0.001$, $r = -0.562$, $p < 0.001$, respectively). Reduced sural nerve amplitude and distal latency were also found to be associated with advanced age ($r = -0.517$, $p < 0.001$).

A total of 13 of the 32 patients were diagnosed with polyneuropathy (40.6%) at the baseline EMG. There were relationships between polyneuropathy and diabetes mellitus, hypertension, and age ($r = -0.437$, $p=0.01$, $r = -0.380$, $p = 0.05$, $r = -0.480$, $p = 0.03$, respectively). Moreover duration of the diabetes mellitus and hypertension were found to correlate with polyneuropathy ($r = -0.404$, $p = 0.02$, $r = -0.444$, $p = 0.01$, respectively).

The electromyographic measures of the patients at baseline and at the postoperative period were shown in Table 2.

Between the preoperative and the postoperative EMG evaluation, there were not any significant changes except tibial nerve motor distal latency. The mean tibial nerve motor distal latency decreased with operation from

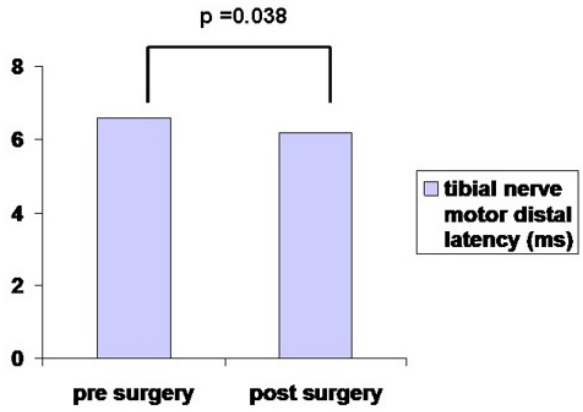

Figure 1. The mean tibial nerve motor distal latency at baseline and after the arteriovenous fistula operation

6.59±1.39 ms to 6.17±1.18 ms (p = 0.038) (Figure 1). Additionally, upper extremity motor and sensory nerve amplitudes, except ulnar sensory nerve amplitude, were found to have a non-significant decrease trend after surgery. However lower extremity motor and sensory nerve amplitudes non-significantly increased after surgery.

Discussion

The results of the present study demonstrated that arteriovenous fistula creation did not have unfavorable effect on nerve conduction in the operated side arm, as evidenced by monitoring the electromyographic measures, among end-stage renal failure patients. Moreover, tibial nerve motor conduction, as measured by distal latency, was found to be improved after arteriovenous fistula operation. This recovery in tibial nerve motor distal latency was assumed to result from cleansing effect of dialysis which started after the fistula creation.

The term peripheral neuropathy is usually used to state the degeneration of peripheral nerves which serve different motor, sensory, and autonomic functions. Peripheral neuropathy can be divided into two main types with respect to damaged part of the neuron; axonal and demyelinating [10]. Axonal neuropathies are due to gradual dying back of the axons while the latter has been associated with degeneration of the myelin, though axonal damage often occurs as the disease advances [12]. In clinical practice, EMG is used to specify whether the neuropathy is a result of damage to the axons or the myelin or both. Axonal loss causes lower amplitudes, and demyelinization leads to prolonged latency and slow conduction velocity [10]. On the other hand, uremic neuropathy is a sophisticated neuropathy due to axonal degeneration of the sensory and motor nerves which usually start from the lower extremities. Secondary demyelination often accompanies axonal degeneration in patients with uraemic neuropathy [4, 13]. Previous studies have revealed that distal motor latency of the lower extremities is prolonged while both motor and sensorial conduction velocities are reduced in patients with end stage renal failure [13, 14]. Moreover there has been no consensus on whether those improve with time by dialysis cleansing effect [15, 16]. In our study population, although

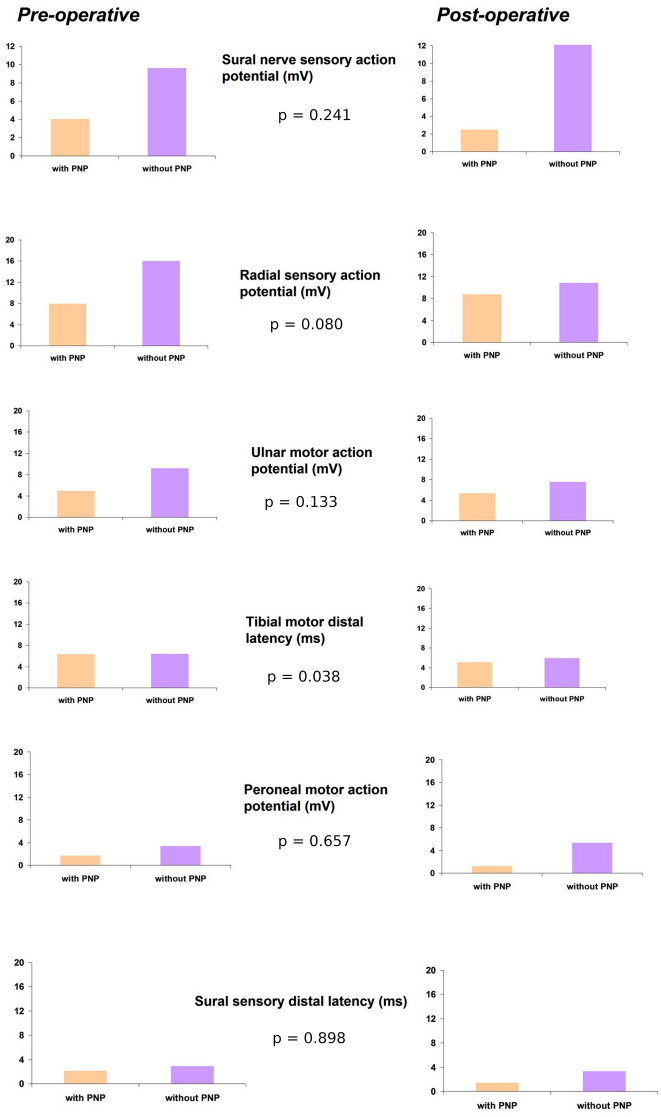

Figure 2. The difference in electromyography measures between the pre-surgery and the post-surgery with respect to polyneuropathy

in a relatively short period of follow up, tibial nerve motor distal latency decreased after hemodialysis. However there were not any significant changes in the other EMG measurements. Prospective settings investigating the association between dialysis and EMG measurements should be considered to clarify this issue.

It is known that there is a trend to decrease in peripheral nerve amplitudes with age [17]. In our study population, where the mean age was 56 years, we have found an inverse correlation of moderate significance between median, ulnar, radial and sural nerve conduction velocity and age. However there was a feeble association between tibial motor nerve conduction velocity and aging. Thus, it could be speculated that tibial motor nerve might have been more exposed to trauma in our study population.

To date, there has been little evidence of outcomes with respect to nerve damage in patients who underwent arteriovenous fistula operation. Owing to uncertain presentation and lack of suspicion the diagnosis of nerve injuries in most cases, particularly involving sensory nerves,

Table 2. The difference in electromyography measures between the pre-surgery and the post-surgery

Measures	Pre-surgery	Post-surgery	p
Median Nerve			
Motor Action Potential (mV)	6.30±2.64	5.82±2.10	0.178
Motor Distal Latency (ms)	4.65±0.88	6.30±0.64	0.758
Motor Conduction Velocity (m/s)	46.47±11.25	47.6±8.48	0.767
Sensory Action Potential (mV)	20.09±13.60	18.43±12.11	0.951
Sensory Distal Latency (ms)	3.99±0.73	3.94±0.72	0.926
Ulnar Nerve			
Motor Action Potential (mV)	7.60±3.36	6.98±2.69	0.133
Motor Distal Latency (ms)	3.70±0.56	3.58±0.73	0.289
Motor Conduction Velocity (m/s)	57.24±8.27	60.18±9.15	0.054
Sensory Action Potential (mV)	17.08±11.57	19.01±11.59	0.213
Sensory Distal Latency (ms)	3.56±0.57	3.46±0.62	0.492
Radial Nerve			
Motor Action Potential (mV)	3.37±1.48	3.04±1.13	0.121
Motor Distal Latency (ms)	2.97±0.71	2.95±0.86	0.767
Sensory Action Potential (mV)	13.74±8.35	10.60±6.30	0.080
Sensory Distal Latency (ms)	2.95±0.74	3.21±0.71	0.209
Tibial Nerve			
Motor Action Potential (mV)	5.17±3.08	5.54±3.36	0.839
Motor Distal Latency (ms)	6.59±1.39	6.17±1.18	0.038
Motor Conduction Velocity (m/s)	39.01±5.44	38.28±9.27	0.804
Peroneal Nerve			
Motor Action Potential (mV)	2.83±1.61	2.95±1.66	0.657
Motor Distal Latency (ms)	4.64±1.35	4.42±1.17	0.186
Motor Conduction Velocity (m/s)	41.91±6.00	41.95±9.32	0.356
Sural Nerve			
Sensory Action Potential (mV)	9.20±7.07	11.52±8.94	0.241
Sensory Distal Latency (ms)	3.31±0.54	3.32±0.63	0.898

Data are mean ± SD. $p < 0.05$

is thought to have been missed [7]. Nerves, especially adjacent to fistula sites, are at risk if care is not taken during the operation. As example; radial nerve travels behind the radial artery in the forearm and could be injured during the radiocephalic fistula operation. It provides cutaneous sensory innervation to most of the back of the hand, except for the back of the little finger and adjacent half of the ring finger. Thus in the case of injury, numbness or dysaesthesia pain may occurs in this area. The damage also has motor consequences; loss of extension at the elbow, wrist, fingers and loss of supination of the forearm [18]. However, injury of the radial nerve during radiocephalic fistula creation leads to mild and usually transient symptoms [19]. In the present study, in which 88% of the recruited patients underwent radio-cephalic fistula operation, there were not any radial nerve injuries, as evidenced by monitoring the electromyographic measures.

On the other hand, motor nerves of the hand run alongside of the brachial artery in the antecubital fossa [20]. During the brachiocephalic fistula operation motor nerves of the hand, theoretically, could be damaged. However there has been no report of a major motor nerve injury in patients underwent brachiocephalic fistula creation [7]. In the present study, also, none of our patients experienced a major motor nerve injury of the hand which was proven by both physical examination and EMG study.

Limitations

The main limitation of the present study was the limited number of enrolled patients and the study conclusions need confirmation with larger studies. Second, we did not have detailed data on patient's previous history, and laboratory parameters such as; vitamin B12 level, folate, and thyroid stimulating hormone which are recommended to be in the first step investigations in patients with peripheral neuropathy [11]. Third, given the exclusion criteria set out to exclude drivers that could influence EMG results, the usefulness of our results may be restricted to a particular population. We couldn't follow the long-term results of fistula creation such as, flow rate, quality of vascular structures and Doppler findings. Finally, there is a possibility of the presence of several unmeasured confounders and intra-observer variability on the EMG analysis.

Conclusion

This is the first prospective study to investigate the relationship of peripheral neuropathy with arteriovenous fistula operation by monitoring the electromyographic measures among end-stage renal disease patients. The present results demonstrated that arteriovenous fistula operation did not have unfavorable effects on nerve functions in the adjacent operation side. Further studies are needed with a larger sample size to verify this issue.

Ethical Approval

Ethics committee approval was received from the Ethics Committee of Republic of Turkey Ministry of Health Turkey, Recep Tayyip Erdogan,Somalia Mogadishu Training And Research Hospital (No: 2018/36.MTH/4547-56).

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