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Evaluation of Pulsed Radiofrequency and Neurostimulation in Management of Adult Brachial Plexus Injury

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Original Article

Summary

Background: *Motor and sensory problems in the upper limb are brought on by brachial plexus injury. In the treatment of upper limb peripheral neuropathy, pulsed radiofrequency and neuro-stimulation may offer a non-neurodestructive pain management method for neuropathic pain and for functional recovery.*

Aim of the study: *To evaluate the efficacy of ultrasound-guided pulsed radiofrequency and neurostimulation in the treatment of adult brachial plexus injury.*

Patient and method: *A randomized clinical trial study that conducted at General Surgery operation room of Private Nursing Home Hospital / Medical City / Baghdad. It included 34 patients who were diagnosed to have brachial plexus injury with a visual analogue score of 40 mm or higher with sensory deficit and reduced muscle power and failed to respond to optimized conservative treatment.*

Result: *In this study, mean of VAS was significantly decreased after treatment compared to that before treatment. Functional recovery was improved between 70 and 79% in 23.5%; also it was improved between 40 and 49% in 23.5%.*

Conclusion: *Pulsed radiofrequency and neuro-stimulation is an especially favorable intervention which have led to improved outcomes in cases of BP injuries regarding pain control and functional recovery. It is a safe technique.*

Keywords: *Brachial plexus, pain, injury, pulsed radiofrequency, neuro-stimulation, treatment*

1. INTRODUCTION

Brachial plexus (BP) are complex peripheral nervous system structures that serve the upper limbs (1). It is composed of five nerve roots (C5–T1) that start in the neck's posterior triangle, go into the axilla, and end in the musculocutaneous, axillary, radial, median, and ulnar nerves. The C4 and T2 nerve roots may contribute to the plexus (2). Brachial plexopathies are a heterogeneous group of rare and potentially disabling diseases (3). They are divided into traumatic, non-traumatic, and iatrogenic categories. They have been classified as complete or partial depending on the degree of engagement (4). They are most common in younger males between the ages of 15 and 25 (5). The rootlets that make up cervical roots are found inside the spinal cord and are unmeningeally covered in connective tissue. Because of this anatomical quirk, rootlets are susceptible to spinal cord avulsion injuries (6). According to their location, BP injuries can be classified clinically as upper plexus or lower plexus injuries. The upper limb experiences motor and sensory problems as a result. Despite the coexistence of both motor and sensory dysfunctions, it is typical to have disproportionately high levels of one or the other (7). Chronic pain reported in almost 50% - 82.7% of BP injuries (8, 9). it is severe in 41% of them (10). Three years after the damage, only 30% of patients still have pain, indicating that there is a natural gradual improvement over time. Immediately following the injury, 90% of patients experience discomfort (11). Continuous radiofrequency and other neurodestructive procedures are constrained by the risk of neurological function loss and deafferentation pain (12). Pulsed radiofrequency (PRF) is a minimally invasive treatment that may be performed as a day operation, is well tolerated, and can significantly reduce pain while allowing patients to resume regular activities and experience a noticeable increase in their quality of life. We suggest that PRF of the BP may offer a non-neurodestructive pain management method in the management of upper limb peripheral neuropathy (13). Radiofrequency proved to be safe and does not lead to more motor or sensory loss which represent a key benefit of this technique. It reduces pain by changing the pain signal transmission along the pain-sensing pathway (14). In order to inhibit transmission of nerve impulses which are eventually interpreted as pain in the sensorimotor cortex, neurostimulation is effectively apply electrical impulses to different areas of the central or peripheral nervous system.

Its origin is based on the gate theory postulated by Wall and Melzack in 1965. Electrical

stimulation was found to promote axonal regeneration and functional rehabilitation after injury as well as alleviate neuropathic pain, and reduce the atrophy of the denervated skeletal muscle and promote the recovery of sensory function (15). The aim of this study was to evaluate the efficacy of ultrasound-guided PRF and neuro-stimulation in the treatment of BP injury.

2. PATIENTS and METHODS

Study design, setting, and time:

This was a randomized clinical trial study that conducted at General Surgery operation room of Private Nursing Home Hospital / Medical City / Baghdad for a period of 14 months from January 2021 to March 2022.

Study Population and sample size:

The study included 34 adult patients who were diagnosed to have brachial plexus injury with a visual analogue (VAS) score of 40 mm or higher and did not responded to previously administered conservative treatment like steroids or non-steroidal anti-inflammatory medications or drugs for neuropathic pain for at least six months and scheduled for PRF and neurostimulation and completed the final evaluation at the end of three months. Diagnosis made according to Budapest criteria [(16)]. Patients had any local or systemic infection, coagulopathies, psychological disorder, pregnant women, patients with any other contraindication for the surgical procedure, those who lost to follow up, and patient refusal were excluded from this study. All patients signed an informed consent that allows us to review their medical records for research purposes as long as the patient anonymity and confidentiality of their medical records are maintained.

All patients were subjected to detailed thorough history (Socio-demographic, previous medical, surgical, and drug history). Complete physical and neurological examinations with vital signs measurement were done. Nerve conduction study and Electromyography (EMG) were performed before the intervention to assess the health of muscles and the nerve cells that control them. Also we repeat them two or three months after intervention and compared the outcomes

Procedure:

1. To perform the treatment technique, patient was put in supine position. Oxygen was supplied by mask. Monitoring of BP, HR, RR, and SPO_2 was done. Sterilization and preparation of the area was performed with povidone-iodine solution, sterile cover of the u/s probe and local anesthesia to injection site.
2. Puncture point was marked at the intersection of the ray and the skin.
3. A 21-gauge insulated needle (RF Cannula) with five cm length which had active tip of 5 or 10 mm was inserted gently into the area beside the trunk under U/S control.
4. The stellate was pulled out from the cannula and electrode inserted which connected to a cable which in turn connected to RF generator (Cosman G4).
5. We chose 4-minutes PRF and 11-minutes stimulation (one minute sensory and 10 minutes' motor).
6. Depomedrol 1cc mixed with 2cc Xylocaine (2%) and 2cc normal saline was injected after finishing the procedure.

Follow-up:

It was done to all patients after two to three months to assess the efficacy and safety of the treatment. Patients were assessed before the procedure and at follow-up visit by Nerve conduction study and EMG. Pain was assessed by VAS which is 100-mm unidimensional scale in which (0) indicates no pain and (100) represents the worst pain ever experienced, it's one of the pain rating scales used first time at 1921.

Statistical analysis:

Data of patients were transformed into computerized database using the statistical package for social sciences (SPSS 26). Scale (continuous variables presented as mean, standard deviation , standard error and ranges. While qualitative (categorical) variables presented as frequencies (number of patients) and proportions (%). Repeated measure, Paired t test was applied to assess the significance of difference (change) in VAS score after treatment., The difference was considered statistically significant when the calculated P. value ≤ 0.05.

3. RESULTS

This study included 34 patients with a mean of age of 31.52 ± 15.2 years; majority of the patients, (82.4%), aged 20 years or above. Males were dominant , contributed for 76.5% with a male to female ratio of 3.25 to one, (**Table 1 and Figure 1**).

The mean VAS score before treatment was 59.4 ± 3.5 (95%CI: 52.5 – 64.9) and it was significantly decreased after treatment to be 10.5 ± 3.1 (95%CI: 4.42 – 15.6), (P. value = 0.001). On the other hand, the mean difference (change) in VAS score after treatment than its baseline (pretreatment) value was 48.9 ± 4.2 and the magnitude of reduction (percentage change) was 82.3% ± 8.6%, (**Table 2 and Figure 2**).

It had been found that the functional recovery was improved by 30%- 39% in 3 patients (8.8%), improvement of 40%-49%, reported in 8 patients (23.5%), 50% - 59% in 6 (17.6%) patients, 60% - 69% in 6 (17.6%) patients, 70% - 79% in 8 patients (23.5%) and ≥ 80% in 3 (8.8%) of patients. The mean functional recovery was 53.5% ± 15.2% (**Table 3**).

Table 1. Age and gender distribution of the studied group (N=34)

Variable		Number of patients	%
Age (Year)	< 20	6	17.6
	20 – 39	20	58.8
	≥ 40	8	23.6
	Mean (SD)	31.5 (15.2)	-
Gender	Male	26	76.5
	Female	8	23.5

SD: standard deviation of mean

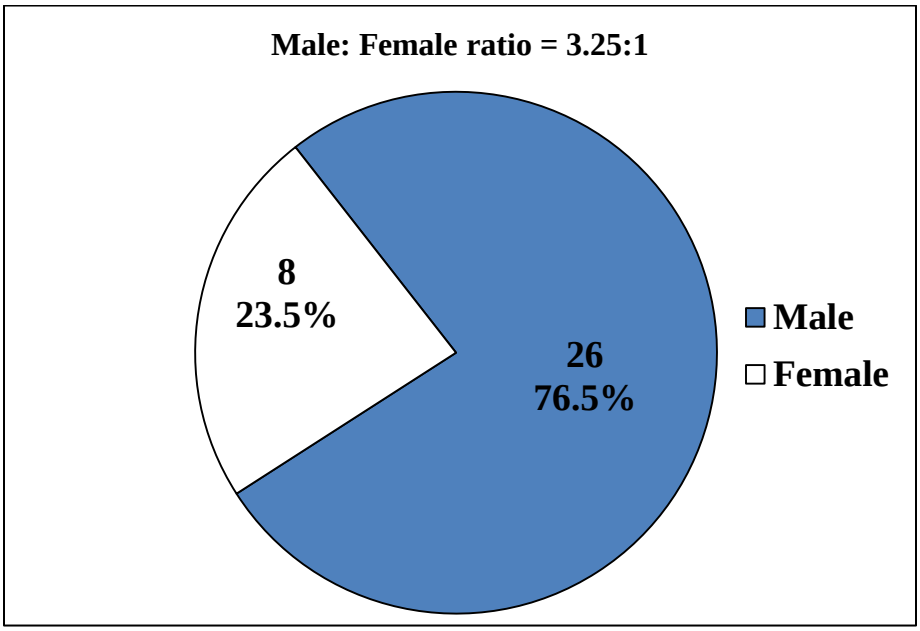

Figure 1. Pie-chart showing gender distribution and male to female ratio of the 34 patients in the study

Table 2 . Comparison in VAS for pain before and after treatment

Time	VAS score		
	Mean	SE	95% CI
Pretreatment	59.4	3.5	52.5 – 64.9
Two months after treatment	10.5	3.1	4.42- 15.6
Mean Difference	48.9	4.2	40.7 – 55.1
Percentage change	82.3%	8.6%	77.4%- 84.9
P - Value = 0.001			

SE: standard error of mean, CI: confidence interval

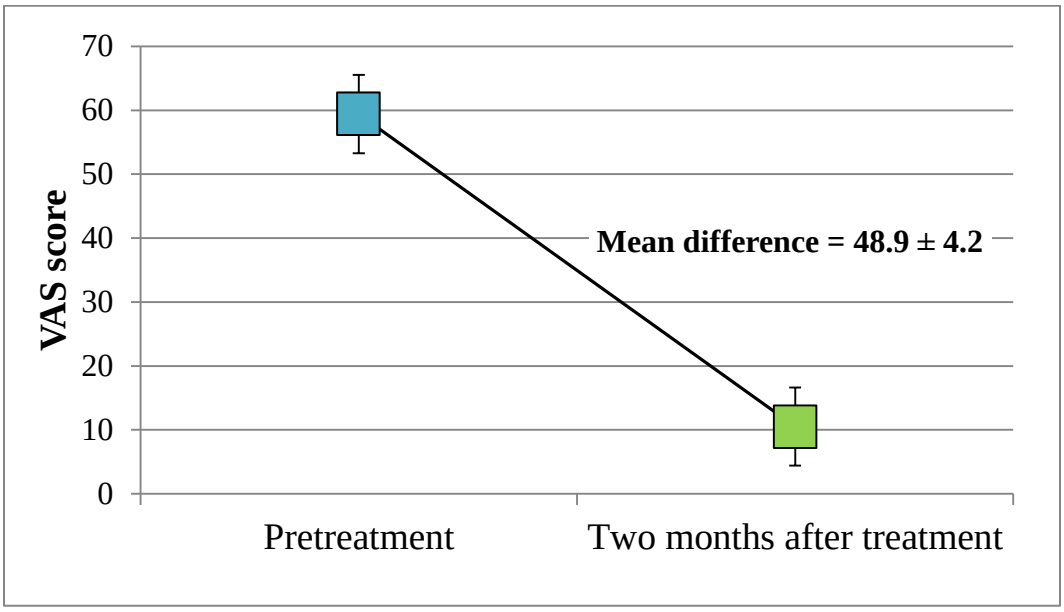

Figure 2. Marker-Line chart showing the change in VAS scores after treatment

Table 3. Functional recovery and need for second intervention

Variable		Number of patients	%
Functional Recovery (Sensory/Motor)	30% - 39%	3	8.8
	40% - 49%	8	23.5
	50% - 59%	6	17.6
	60% - 69%	6	17.6
	70% - 79%	8	23.5
	≥ 80%	3	8.8
	Mean (SD)	53.5 ± 15.2%	-
Second intervention	Yes	10	29.4
	No	24	70.6

SD: standard deviation of mean

4. DISCUSSION

Chronic discomfort in the injured upper limb is also a common complication of BP injuries, in addition to functional impairments of the motor and sensory systems. The extent of the damage and the quantity of avulsed nerve roots, especially the lower roots, are correlated with the intensity of the pain (17). PRF ablation has the advantage of providing prolonged pain relief without the condemning effects of neurodestructive techniques (18). Additionally, nerve stimulation offered a comparatively secure, long-lasting, and efficient method to manage upper limb neuropathic pain as well as functional recovery (19). The current study observed that mean of VAS was significantly decreased after treatment (P= 0.001). The current study agreed to Ding et al study, as compared with the preoperative group, the postoperative VAS in patients received PRF for management of post-herpetic upper limb pain (group A) and patients treated by nerve block (group B) both decreased, and the difference was statistically significant ($P < 0.05$). The VAS decreased significantly in group A at one-month (20). In Wu et al study, a comparison of two groups of patients (intervention group, patients received physical therapy with PRF, and the control group, patients received only physical therapy indicated a significant improvement in the intervention group at all-time points in VAS score ($P < 0.05$) (21). Moreover, Chung et al study described a case series of PRF in the treatment of supra-scapular neuropathy, they reported that PRF treatment resulted in a significant reduction in VAS pain score. The reduction in pain was maintained at the 1 year follow-up (22). In the same concern, Frederico and colleagues observed that technique of neurostimulation may have long-term utility in the treatment of painful conditions of upper limb, as observed at 12-month follow-up, that mean of VAS score was significantly improved ($P = 0.005$) (23). In this study, functional recovery was between 70 and 79% in 23.5%; also it was between 40 and 49% in 23.5%. In a study conducted by Wu et al., 42 patients were enrolled and managed by PRF for upper limb painful adhesion capsulitis, results of that study revealed that when compare the intervention group to controls, shorter time was required to achieve significant pain relief, ($P<0.001$) in intervention group, on the other hand, the VAS scores reduced by 40% in intervention group compared to only 4.7% in controls (21). Moreover, Chung et al study described a case series of PRF in the treatment of supra-scapular neuropathy, they reported that PRF treatment resulted in a significant reduction in VAS pain score, as reduced from 70-80% to 50-60% at the 2-

weeks follow-up, and to 20-30% at the 1-month follow-up. The reduction in pain was maintained at the 1 year follow-up (22). A close results published in a study conducted by Frederico et al, where they reported that after 12 months of follow-up, 80% of patients receiving neurostimulation experienced pain relief of 50% or more on the VAS scale, and 20% of patients experienced pain reduction of greater than 30%. (P = 0.006) (23). In the same concern, a study done by Bouche et al used a neurostimulation in nerve injury, they observed a pain relief >50% in 58–83% of the patients (19).

From other point of view, animal model studies on cervical dorsal root ganglia showed a significant selective effect for PRF on the small diameter fibers (C and A) with enhancement of the c-fos reaction in the dorsal horn within one week post treatment, despite the fact that the mechanism of PRF lesioning is still unclear (24). Additionally, PRF can cause synaptic potential to be permanently inhibited, preventing pain from being transmitted. Consequently, PRF may inhibit neuronal conduction via neuromodulation (25). Additionally, PRF has shown to have a preventive effect on the excitatory neurotransmitters release, brought on by nociceptive stimuli (26), reduce the expression of calcitonin gene-related peptide in dorsal root ganglion (27), P2x3 also it has an inhibitory effect on the P2x 3 receptor expression in the spinal dorsal horn and dorsal root ganglion (28), moreover, it can decrease the peripheral pro-inflammatory cytokines expression like TNF alpha and interleukin 6, in addition to beta catenin in spinal cord (29). Simultaneously, PRF may up-regulates Glial Cell Derived Neurotrophic Factor transcription and translation (30), up-regulates GABABR1, NA-K ATPase and GABAB-R1, Na/K-ATPase and 5-HT3r genes, modification and partial restoration of KCC2 to increase histone acetylation and KCC2 expression and Gamma-Aminobutyric Acid synaptic function (31). When compared to other treatments, PRF is relatively safe, but it is still invasive and can have an impact on cellular structures. In light of this, A more focused approach to peripheral nerves can make the procedure safer and more efficient, and high-resolution ultrasound provides additional guidance(22).

5. CONCLUSIONS

PRF and neuro-stimulation are especially favorable interventions which have led to improved outcomes in cases of BP injuries regarding pain control and functional recovery. It is safe technique.

Ethical Clearance:

Ethical issues were taken from the research ethics committee. Informed consent was obtained from each participant. Data collection was in accordance with the World Medical Association (WMA) declaration of Helsinki for the Ethical Principles for Medical Research Involving Human Subjects, 2013 and all information and privacy of participants were kept confidentially.

Conflict of interest: Authors declared none

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