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A retrospective case series of ultrasound-guided suprascapular nerve pulsed radiofrequency treatment for hemiplegic shoulder pain in patients with chronic stroke

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Purpose: Hemiplegic shoulder pain (HSP) is the most common pain condition after stroke. Pulsed radiofrequency (PRF) treatment of the suprascapular nerve (SSN) effectively relieves shoulder pain conditions. To date, there is no study about the effects of PRF treatment for HSP. Thus, our aim was to report on a case series about its use in chronic stroke.

Patients and methods: Six chronic stroke patients with HSP (visual analog scale [VAS] score for pain ≥30 mm) underwent ultrasound-guided SSN PRF treatment. All were evaluated before treatment and at 4 and 16 weeks of follow-up. The main outcome was VAS score. Secondary outcomes were Modified Ashworth Scale, shoulder passive range of motion (PROM), Disability Assessment Scale (DAS), Fugl-Meyer Assessment, and EuroQol-5 dimension questionnaire (EuroQol-5D) scores.

Results: As compared with baseline, improvement was observed in the following parameters: VAS for pain (at 4 weeks, P=0.023; at 16 weeks, P=0.023); shoulder PROM for abduction (at 4 weeks, P=0.023; at 16 weeks, P=0.024), flexion (at 4 and 16 weeks, P=0.024), extension (at 4 and 16 weeks, P=0.02), and external rotation (4 and 16 weeks, P=0.02); DAS for hygiene (at 4 and 16 weeks, P=0.024), dressing (at 4 weeks, P=0.02; at 16 weeks, P=0.024), and pain (at 4 weeks, P=0.024; at 16 weeks, P=0.023); and EuroQol-5D (at 4 and 16 weeks, P=0.024).

Conclusion: Our observations support the use of ultrasound-guided SSN PRF treatment for HSP in chronic stroke patients.

Keywords: chronic pain, pain management, rehabilitation

Introduction

Hemiplegic shoulder pain (HSP) is the most common pain condition in stroke patients and a major contributor to poststroke disability.[1,2] Its multifactorial etiology includes impaired motor function (muscle tone changes), soft tissue lesions (rotator cuff and biceps tendon disorders, adhesive capsulitis), and altered peripheral or central nervous system (CNS) activity (complex regional pain syndrome type 1, peripheral nerve entrapment, neglect, sensory impairment, central pain, central sensitization).[3,4]

Radiofrequency treatments are offered for various pain syndromes according to the assumption that selectively heating nervous structures can impede nociceptive input.[5] From a technical point of view, they can be delivered using a continuous modality or a pulsed one.[5,6] Continuous radiofrequency (CRF) is a neurolytic technique that applies heat for selective destruction of pain-carrying nerve fibers (A-δ and C fibers).[5] It uses a

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constant high-frequency alternating current to induce coagulative necrosis at the target tissue by producing temperatures ≥45°C.[6] Considering the possible adverse events of CRF neuroablation (eg, lasting motor deficits, neuritis and deafferentation pain), pulsed radiofrequency (PRF) was developed as an alternative modality that uses short, high-voltage current bursts to obtain more reversible and less destructive effects than CRF.[5–7] As to the mechanism of action of PRF, to date, most studies point toward a neuromodulatory-type effect based on an alteration in synaptic transmission.[8,9] However, there is an ongoing discussion about the lesioning effect of PRF. In particular, Cosman and Cosman[10] and Cosman et al[11] reported that PRF produces heat bursts (with temperatures in the range) associated with destructive heat lesions (whose size is affected also by the tip gage, tip length, and time). Nevertheless, PRF has demonstrated a remarkable margin of safety.[9]

To provide pain relief and facilitate rehabilitation of patients with shoulder pain, physicians often perform suprascapular nerve (SSN) block as a useful management in various conditions.[12–16] This can be done by means of analgesics, corticosteroid, and electrical stimulation techniques.[14,15] As to the use of SSN PRF treatment for shoulder pain, a good clinical efficacy lasting for 6 months with scant complications has been reported in the literature.[17,18]

With regard to patients with stroke, the SSN block injection with corticosteroid and anesthetic was found to be effective and safe for the treatment of HSP.[19] Even if this is in line also with our daily practice, we have a growing clinical experience concerning the use of SSN PRF treatment for HSP in order to obtain more stable and long-lasting effects. Unfortunately, to date, there is no study on it. Thus, our aim was to report on a case series about the effects of ultrasound-guided SSN PRF treatment in chronic stroke patients with HSP.

Patients and methods

This single-center, retrospective, chart review case series analyzed data from six chronic stroke patients with HSP who had undergone ultrasound-guided SSN PRF treatment at our Clinical Unit from February 2017 to June 2017.

The inclusion criteria were age ≥18 years, first-ever unilateral stroke, Mini Mental State Examination ≥24,[20] HSP ≥30 mm on the visual analog scale (VAS),[21] time since stroke >6 months, and time since last botulinum toxin treatment >6 months. The exclusion criteria were participation in other trials, change in pain medication during the follow-up period, aphasia, neurolytic or surgical procedures for upper limb spasticity, and other conditions at the affected shoulder (rotator cuff disorders, frozen shoulder, thoracic outlet syndrome, osteoarthritis, bursitis, recent trauma, bone fracture, joint replacement).

All participants were outpatients. All patients provided written informed consent, which included consent for data extraction from chart review as needed. The study was carried out according to the Declaration of Helsinki and approved by the local ethics committee (Comitato Etico per la Sperimentazione Clinica delle Province di Verona e Rovigo). Patients did not participate in any rehabilitation program during the follow-up period.

Treatment procedures

All patients were treated by the same physician. PRF was performed with the patient in the sitting position during the whole procedure. Before treatment, local anesthesia to the cutaneous and subcutaneous tissues was administered with 2 mL of lidocaine 2%. A 22-gage, 100 mm, 5 mm active-tip radiofrequency needle was guided to the suprascapular notch under ultrasonography (linear transducer with a scanning frequency of 12 MHz).[22] Anatomic landmarks were used for transducer position (the spine of the scapula, the acromion and the acromial end of the clavicle, and the coracoid process) and SSN localization (the trapezius muscle, the supraspinatus muscle, the supraspinous fossa, and the suprascapular and the spinoglenoid notch). The SSN was identified as a hyperechoic structure 3–4 cm deep and below the transverse scapular ligament in the scapular notch.[23] Following elicitation of paresthesia response in the shoulder region to a 50 Hz, 1 ms, 0.5 V sensorial stimulus and appropriate muscular response to a 2 Hz, 1 ms, 0.4 V motor stimulus, PRF treatment was applied at 485 kHz, 42 V, 20 ms, 42°C for 300 s (5 min; TherMedico NK1; schwa-medico GmbH, Ehringshausen, Germany).[22,23] Patients were discharged if no significant complications occurred (eg, pain, bleeding, or pneumothorax).

Evaluation procedure

All patients were evaluated before treatment (T0), at 4 weeks (T1), and at 16 weeks (T2) of follow-up. Patients remained seated during the evaluation procedure.

Primary outcome

The primary outcome was the VAS for pain, which consists of a 100 mm vertical line anchored with extremes of subjective pain.[21]

Secondary outcomes

Secondary outcomes were the Modified Ashworth Scale (MAS), the shoulder passive range of motion (PROM), the Disability Assessment Scale (DAS), the Fugl-Meyer Assessment (FM), and the EuroQol-5 dimension questionnaire (EQ-5D).

The MAS was used to measure shoulder adductor muscles tone. This 6-point scale grades resistance to rapid passive stretch from 0 (no increase in muscle tone) to 5 (joint is rigid).[24,25] Shoulder flexion, extension, abduction, and external rotation PROM was measured using a handheld goniometer. Measurement sensitivity was arbitrarily set at 5°.[26] The DAS was used to evaluate the extent of functional impairment in the domains of patient hygiene, dressing, limb position, and pain as follows: 0, no disability; 1, mild disability; 2, moderate disability; and 3, severe disability.[27,28] The FM was used to evaluate the ability of the affected upper limb to perform selective movements. The maximum score on the FM upper limb section was 66, with subscores of 36 for the upper arm, 10 for the wrist, 14 for the hand, and 6 for coordination and speed of movement.[29] Quality of life was assessed by the EQ-5D score on a visual scale from 0 (worst imaginable health state) to 100 (best imaginable health state).[30]

Statistical analysis

Statistical analysis was carried out using the Statistical Package for Social Sciences for Macintosh, version 20.0 (IBM Corporation, Armonk, NY, USA). The Wilcoxon signed-rank test was applied to compare differences in T1 vs T0 and T2 vs T0. The alpha level for significance was set at $P<0.05$. The Bonferroni correction was used for multiple comparisons, resulting in $P<0.025$ as the significance threshold.

Results

No adverse events occurred during the follow-up period. Table 1 presents the demographic and clinical characteristics of each patient.

Primary outcome

Significant improvements on the VAS after PRF treatment of the SSN were observed at T1 ($P=0.023$; $Z=-2.27$) and T2 ($P=0.023$; $Z=-2.27$; Table 2).

Secondary outcomes

No significant improvement in the MAS score was found at T1 and T2. Significant improvements in the PROM of shoulder abduction were found at T1 ($P=0.023$; $Z=-2.271$) and T2 ($P=0.024$; $Z=-2.264$), shoulder flexion at T1 ($P=0.024$; $Z=-2.25$) and T2 ($P=0.024$; $Z=-2.25$), shoulder extension at T1 ($P=0.02$; $Z=-2.33$) and T2 ($P=0.02$; $Z=-2.33$), and external rotation at T1 ($P=0.02$; $Z=-2.33$) and T2 ($P=0.02$; $Z=-2.33$). Significant improvements in the DAS score for hygiene were found at T1 ($P=0.024$; $Z=-2.25$) and T2 ($P=0.024$; $Z=-2.25$), dressing at T1 ($P= 0.02$; $Z=-2.33$) and T2 ($P=0.024$; $Z=-2.264$), and pain at T1 ($P=0.024$; $Z=-2.264$) and T2 ($P=0.023$; $Z=-2.271$) but for limb position. No significant improvement in FM was found at T1 and T2. Significant improvements in the EQ-5D were found at T1 ($P=0.024$; $Z=-2.264$) and T2 ($P=0.024$; $Z=-2.264$; Table 2).

Discussion

The SSN provides 70% of sensory innervation to the shoulder joint.[31] In chronic shoulder pain conditions, the afferent fibers of SSN may become entrapped by injured tissues or sensitized due to chronic pain.[13,32] The SSN block provides temporary cessation of nociceptive information from the affected shoulder to CNS.[12–16] Previous studies involving patients with HSP mainly focused on SSN block by combining local anesthetics with cortisone.[19,26,33–36] Early studies on this issue were contradictory. Lee and Khunadorn[37] reported poor efficacy of SSN block on HSP relief, whereas Boonsong et al[33] claimed that blocking the SSN was safe and effective for HSP. A later, properly sized, randomized controlled trial by Adey-Wakeling et al[19] supported Boonsong et al's findings about the superiority of SSN block (1 mL of 40 mg/mL methylprednisolone + 10 mL of 0.5% bupivacaine hydrochloride) on placebo for

Table 1 Demographic and clinical characteristics of patients

Characteristics	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6
Age (years)	61	70	65	55	76	65
Sex	Male	Female	Female	Female	Male	Male
Time since stroke onset (years)	2	5	9	2	4	7
DN4 (score)	4	1	0	1	0	7
Pain medication	Opioids	NSAIDs	NSAIDs	Opioids	Opioids	Opioids

Abbreviations: DN4, Douleur Neuropathique in 4 Questions; NSAIDs, non-steroidal anti-inflammatory drugs.

Table 2 Data at all time points and comparisons of treatment effects on all outcome measures

Outcomes	Before treatment (T0)	4-week follow-up (T1)	16-week follow-up (T2)	Wilcoxon signed-rank test	
				T1 vs T0, *P* value (*Z*)	T2 vs T0, *P* value (*Z*)
VAS (0–100 mm), mean (SD)	88.3 (7.5)	15.0 (12.2)	11.7 (9.8)	0.023 (–2.271)*	0.023 (–2.271)*
MAS shoulder adductors (0–5), median (IQR)	1.50 (1.00; 3.00)	1.00 (1.00; 2.00)	1.00 (1.00; 2.00)	0.083 (–1.732)	0.083 (–1.732)
Shoulder flexion PROM (degrees), mean (SD)	73.3 (28.8)	98.3 (28.6)	98.3 (28.6)	0.024 (–2.251)*	0.024 (–2.251)*
Shoulder extension PROM (degrees), mean (SD)	38.3 (4.1)	50.0 (1.5)	50.0 (2.7)	0.020 (–2.333)*	0.20 (–2.333)*
Shoulder abduction PROM (degrees), mean (SD)	71.7 (19.4)	105.0 (16.4)	106.7 (16.3)	0.023 (–2.271)*	0.024 (–2.264)*
Shoulder external rotation PROM (degrees), mean (SD)	34.2 (11.1)	45.8 (9.2)	45.8 (9.1)	0.020 (–2.333)*	0.20 (–2.333)*
DAS hygiene (0–3), median (IQR)	3.00 (2.75; 3.00)	1.00 (1.00; 2.00)	0.00 (0.00; 1.00)	0.024 (–2.251)*	0.024 (–2.251)*
DAS dressing (0–3), median (IQR)	2.50 (1.75; 3.00)	1.00 (0.75; 2.00)	0.00 (0.00; 1.00)	0.020 (–2.333)*	0.024 (–2.264)*
DAS limb position (0–3), median (IQR)	2.50 (0.75; 3.00)	0.50 (0.00; 1.00)	0.25 (0.00; 1.00)	0.041 (–2.041)	0.039 (–2,060)
DAS pain (0–3), median (IQR)	2.50 (2.00; 3.00)	0.00 (0.00; 1.25)	0.00 (0.00; 0.25)	0.024 (–2.264)*	0.023 (–2.271)*
FM upper limb, median (IQR)	8.50 (4.75; 21.00)	9.00 (4.75; 27.25)	9.00 (4.75; 27.25)	0.102 (–1.633)	0.102 (–1.633)
EQ-5D, median (IQR)	50.00 (37.50; 52.50)	70.00 (60.00; 80.00)	75.00 (67.50; 80.00)	0.024 (–2.264)*	0.024 (–2.264)*

Note: *Statistically significant after the Bonferroni correction (*P*<0.025).
Abbreviations: VAS, visual analog scale; SD, standard deviation; MAS, Modified Ashworth Scale; IQR, interquartile range; PROM, passive range of motion; DAS, Disability Assessment Scale; FM, Fugl-Meyer Assessment; EQ-5D, EuroQol-5 dimension questionnaire.

reducing HSP intensity. The effectiveness of SSN block by combining local anesthetics with cortisone has been further confirmed in long-term chronic stroke patients with HSP.[26] With regard to our clinical practice, we usually treat (subacute or chronic) stroke patients with HSP by means of pain (oral) medication (mainly using non-steroidal anti-inflammatory drugs or opioids; Table 1). In the case of scant pain reduction, we then perform SSN block by combining local anesthetics with cortisone in order to obtain a relief of pain and consequently facilitate neurorehabilitation. In the case of patients with short-lasting benefits after pharmacological SSN block, we provide ultrasound-guided SSN PRF treatment with a growing positive experience. Thus, from this point of view, the anesthetic SSN block might be considered also as a test for the effectiveness of treating SSN in patients with HSP. To the best of our knowledge, this is the first report about the effects of ultrasound-guided SSN PRF treatment in chronic stroke patients with HSP. As to the primary outcome, we observed a significant reduction in pain intensity up to 16 weeks after PRF treatment. This is in keeping with previous findings about the long-term (up to 6 months) effects of PRF SSN treatment.[17] As to secondary outcomes, we observed that PRF treatment of the SSN might effectively lead to increased shoulder PROM, reduced joint disability, and improved quality of life up to 16 weeks after treatment. This is very relevant for rehabilitation. Indeed, while pain relief accompanied improvement in PROM and quality of life, also reducing self-rated disability of the affected upper limb, our findings indicate the need for combining physical rehabilitation and antispastic drugs with analgesic strategies to reduce muscle tone and obtain functional improvements.[38,39] Thus, PRF treatment of the SSN might be proposed as a treatment option in stroke rehabilitation to facilitate shoulder mobilization and neuromotor techniques in patients with HSP.

To date, the mechanism of action of PRF treatment for pain relief is still an object of debate. From a physical point of view, the leading explanation for PRF effects is low electric field phenomenon that may induce a long-term depression of synaptic transmission.[9] On the other hand, from a biological point of view, PRF seems to have effects also on cell morphology and pain signaling.[9] In particular, PRF may enhance the descending noradrenergic and serotonergic inhibitory pathways, which are involved in pain modulation mechanisms.[40] Furthermore, a neuromodulatory effect has been suggested via alternating gene expression (eg, c-Fos, ATF-3) in pain processing neurons by which PRF treatment may provide long-lasting pain relief.[9,18,41] On these bases, in order to interpret our observations, we might suggest

a potential reduction in central sensitization secondary to a decrease in nociceptive stimuli, which would be in line with the hypothesized nociceptive and neuropathic nature of HSP.[3] Moreover, we cannot exclude some kinds of neural tissue modification due to the PRF transient "heat spikes" (~45°C to 50°C around the needle tip, depending on the tissue impedance as reported in the literature), whose ablative effect is unknown.[10]

This study has several limitations. First, it did not have a prospective design and the sample size was small. We estimated that a total of 27 patients would provide 90% power to detect a difference of 13 mm on the VAS (minimal clinically important difference) at the primary end point.[42] Second, there was no control group treated with placebo or other treatments (eg, intra-articular injection, local anesthesia, botulinum toxin, physical therapy) for shoulder pain. Third, no further ultrasound evaluation of the SSN was done after PRF. Thus, we have no information about any SSN structural change or nerve echo signal modification after treatment.

Conclusion

Our observations support the use of ultrasound-guided SSN PRF treatment for HSP in chronic stroke patients. Future larger randomized controlled trials are desirable to produce new findings and possibly confirm ours about this issue.

Author contributions

All authors contributed toward data analysis, drafting and critically revising the paper, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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