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Case Report

Ultrasound-guided pulsed radiofrequency ablation of stellate ganglion in upper-extremity phantom limb pain: a case series

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Background: Phantom limb pain (PLP) is the most common type of pain experienced by amputees and is chronic and complex, with manifestations including pain in a limb that no longer exists. To date, treatments that are pharmaceutical or surgical in nature are relatively ineffective at bringing much relief as the pathophysiology of PLP is somewhat obscure. Chronic pain syndromes such as PLP may benefit from sympathetic nervous system modulation through the stellate ganglion.

Case: Ten refractory PLP patients treated with ultrasound-guided stellate ganglion pulsed radiofrequency ablation (SG PRF) after a diagnostic stellate ganglion block took effect: A case series Patients were assessed before and after the treatment at 1 week, 1 month, and 3 months. Significant reductions in pain as measured using a numerical rating scale; Pain Disability Indexwas improved, and Medication Quantification Scale also was improved. Minimal side effects.

Conclusions: Ultrasound-guided SG PRF has provided promising results for PLP by giving the patient with sustained pain relief and functional improvement without much side effects. Further studies need to be done to validate this finding.

Keywords: Complex regional pain syndrome; Neuropathic pain; Phantom limb; Pulsed radiofrequency ablation; Stellate ganglion; Ultrasound.

KSPS

Phantom limb pain (PLP) is the persistent perception of pain in a missing limb [1]. Although 50–80 percent of amputees experience PLP, it is poorly understood, with no clear consensus on its mechanism or management.

Amputees experience PLP within the first week following amputation [2]; however, it may be delayed for months or years [3]. Ambroise Paré (1552) postulated that peripheral causes, as well as cerebral pain memory, may be responsible for PLP; however, despite significant advancements in the study of pain physiology, the processes driving PLP are not entirely known.

Pain experts have long recognized that the stellate ganglion block (SGB) method uses local anesthetics to treat chronic facial or upper limb pain and that brachial plexus injury induces complex regional pain syndrome, although repeated blocks are needed for individuals whose effective periods are brief [4]. Other methods, such as a continuous catheter block of the sympathetic ganglia, have been developed to counteract the short-term nature of a single sympathetic block. However, long-term catheterization frequently requires hospitalization and increases the risk of infection. The remaining two treatment options, chemical neurolysis and thermal radiofrequency (RF), carry unnecessary risks that may result in irreparable neural damage [5]. Therefore, the use of neurodestructive techniques to treat cervical lesions is extremely dangerous. One may anticipate a long-lasting impact of RF thermocoagulation of the stellate ganglion (SG), which causes nerve degeneration through heat energy [6]. Many pain syndromes, such as complex regional pain syndrome (CRPS), post-herpetic neuralgia, post-mastectomy neuropathic pain, and chronic facial pain, benefit from stellate ganglion pulsed radiofrequency ablation (SG PRF). However, there is a lack of evidence supporting the use of SG PRF in the management of PLP.

In this case series, we treated 10 patients with upper-extremity PLP using ultrasound-guided SG PRF. Our main goal was to evaluate post-procedure pain reduction, and our secondary objectives were to assess patient satisfaction and drug dosage consumption of various neuropathic medications, such as pregabalin and gabapentin, and to identify any problems.

CASE REPORT

This study complied with the Declaration of Helsinki, and ethical approval was granted by the local Institutional ethical (approval letter no. AIIMS/IEC/24/595).

We included 10 cases of upper-extremity amputees in the age group of 18–65 years in this case series, for whom the diagnosis of PLP was for more than 3 months and their baseline numeric rating scale (NRS) score was more than 3. All these patients had responded to a diagnostic stellate ganglion block with more than 50% pain relief. All patients were on neuropathic medications such as pregabalin or gabapentin, although sometimes analgesics such as tramadol and aceclofenac were used in an occasional patient. Exclusion criteria included complex regional pain syndrome, brachial plexus injuries, neuropsychiatric disorders, and coagulation disorders. Written informed consent was obtained prior to entry.

Under ultrasound guidance, the stellate ganglion at the level of the C7 vertebra was localized with a 22G RF needle. PRF was delivered at 42°C for 120 s, and a combination of lidocaine and dexamethasone was injected once the position of the needle was ascertained to be correct. Vitals like Heart Rate (HR), Systolic blood pressure (SBP), Diastolic blood pressure (DBP) were recorded pre and post procedure (Table 1). Post-procedure follow-ups were carried out at 1 week, 1 month, and 3 months using NRS, pain disability index (PDI) and medication quantification scale (MQS).

Baseline is followed by one week then one month then three months of post procedure follow-up using NRS, PDI, and MQS. A notable decrease in pain intensity was observed after SG PRF in all patients. The baseline NRS score of 7.7 ± 0.94 was reduced to 5 ± 0.78 at 1 week and further reduced at 1 month (3 ± 0.82) and at 3 months (2.7 ± 0.67) post-procedure ($P < 0.001$). The PDI score also improved, from 61.1 ± 6.26 at baseline to 49.6 ± 10.83 at 1 week, 29.3 ± 6.46 at 1 month, and 26.9 ± 5.32 at 3 months ($P < 0.001$). The trend of the MQS score also followed the same descending pattern, from a baseline of 11.25 ± 3.09 to 10.14 ± 2.23 at 1 week, to 5.86 ± 1.63 at 1 month, and finally to 3.55 ± 1.51 at 3 months ($P < 0.001$). Minimal side effects occurred, where only two patients manifested mild soreness at the injection site (Table 2).

Table 1. Showing the Parameters before and after the Procedure

Parameters	Before	After
Heart rate (bpm)	86.9 ± 8.59	86.5 ± 6.9
Systolic blood pressure (mmHg)	116.7 ± 4.66	110.5 ± 7.69
Diastolic blood pressure (mmHg)	74.9 ± 11.78	70.3 ± 11.76

Values are presented as mean ± SD.

Table 2. Demographic and Baseline Characteristics

Demographic parameters	Value (n = 10)
Age (yr)	40.4 ± 12.89
Sex	
M	8
F	2
Body mass index (kg/m^2)	25.6 ± 2.7
NRS	
Baseline	7.7 ± 0.95
1 wk	5.11 ± 0.88
1 mo	3 ± 0.83
3 mo	2.7 ± 0.67
PDI	
Baseline	61.1 ± 6.26
1 wk	49.6 ± 10.83
1 mo	29.3 ± 6.46
3 mo	26.9 ± 5.32
MQS	
Baseline	11.25 ± 3.096
1 wk	10.14 ± 2.23
1 mo	5.86 ± 1.63
3 mo	3.55 ± 1.51

Values are presented as mean ± SD. NRS: numerical rating scale, MQS: Medication Quantification Sale, PDI: Pain Disability Index.

DISCUSSION

Phantom complex is a term used to describe a phenomenon in which a person experiences sensory or motor experiences in a missing limb or body part or experiences a limb or body part as smaller, larger, or altered in some way other than before the loss. This phenomenon is most commonly associated with limb loss (e.g., due to amputation) and often with PLP. The other component of the complex includes the phantom sensation, where a person experiences a non-painful tingling sensation of the absent limb, and residual limb pain or stump pain denotes pain in the residual limb area. Superadded phantom sensations are touch- and pressure-like sensations experienced on the phantom limb by items such as clothes [3,7]. Pain physicians continue to face difficulties in treating PLP. A favored technique incorporates pharmacological, physical, psychological, adjuvant, and interventional therapies in refractory patients [8].

Ten patients were treated for phantom limb pain in the current study using PRF of the stellate ganglion. The primary finding of this study was that ultrasound-guided SG PRF had good outcomes in terms of considerable pain reduction ($P < 0.001$) up to 3 months post-procedure, with positive patient responses and only injection site soreness as the adverse outcome in a minority of patients (n = 2).

A range of chronic pain disorders can be treated with pulsed radiofrequency (PRF), which is a minimally invasive technique. When administered by a competent practitioner to a carefully chosen patient population, it is considered a safe and effective pain intervention, with few adverse effects. Since “pulses” of electric current are generated at the electrode tip without a noticeably increased temperature, neuromodulation is its mode of action. Chronic neck and back pain, trigeminal neuralgia, persistent shoulder pain, and persistent low back pain are among the painful disorders that have been successfully treated using PRF [9].

However, the analgesic mode of action of PRF remains unclear. Because pain alleviation lasts longer than sensory loss in the relevant dermatome, researchers are searching for another route of analgesic action that is not temperature-dependent. It has been hypothesized that the electric field, not the temperature change or magnetic field, causes the observed "nonthermal" or "nondestructive" clinical effects and that the heat produced by this technique is a byproduct. In addition, effects of PRFs are more reversible and less destructive than those of conventional RFs [10]. Animal studies have shown alterations in gene expression in the dorsal root ganglion and dorsal horn involved in pain processing after PRF exposure, which is assumed to be caused by the rapidly changing electric field created by PRF.

PRF is applied by percutaneous implantation of an insulated electrode needle perpendicular to the target location using motor and sensory nerve stimulation as well as fluoroscopic radiological guidance. Following the confirmation of the target neuronal structure, brief radiofrequency-range current bursts were delivered for 20 ms, followed by a silent interval of 480 ms. This caused distance-dependent high-voltage oscillations and transitory suppression of the evoked synaptic activity. During this silencing interval, heat was dissipated, preventing local temperatures from rising beyond 42°C and preventing tissue coagulation and nerve damage. When administered as a daycare treatment under local anesthesia, PRF is often well tolerated by patients who are sedated.

Compared to RF, PRF, a type of thermal RF, inflicts less thermal damage [11]. Therefore, it is often used to alleviate chronic pain. The target nerve may be biologically affected by the electromagnetic field created by the fast electrical pulsing of the PRF. In a recognized therapeutic process, PRF increases c-Fos expression and synaptic alterations related to its transmission [12].

Sympathetic overactivity has long been hypothesized to play a role in the development of pain in post-amputee patients [13,14]. Shabaan et al. [15] conducted a prospective controlled study of ultrasound versus fluoroscopy-guided SG PRF in patients with neuropathic pain, especially post-mastectomy CRPS and very few in PLP. When compared to the pre-block readings, there was a considerable decrease in the VAS score, morphine use, and pregabalin use after the block.

Overall, we found that individuals with upper-extremity PLP responded favorably to ultrasound-guided PRF of the stellate ganglion. To date, only a few studies on PLP have been conducted. Therefore, PRF of the stellate ganglion appears to be a viable alternative for treating PLP of the upper limbs, and the use of ultrasonography can improve the simplicity and safety of this technique. In the near future, well-designed prospective studies with a sizable sample size are strongly recommended.

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CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

DATA AVAILABILITY STATEMENT

Data will only be disclosed if there are relevant reasons or queries by researchers from corresponding author.

AUTHOR CONTRIBUTIONS

Writing - original draft: Ajit Kumar, Manasa Kantha, Sonal Goyal, Pradeep Atter. Conceptualization: Manasa Kantha, Sonal Goyal. Data curation: Manasa Kantha, Sonal Goyal. Formal analysis: Pradeep Atter. Methodology: Ajit Kumar, Manasa Kantha, Pradeep Atter. Project administration: Ajit Kumar, Sonal Goyal. Visualization: Manasa Kantha. Investigation: Pradeep Atter. Resources: Sonal Goyal. Supervision: Ajit Kumar. Validation: Ajit Kumar, Pradeep Atter.

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