Clinical effects of pulsed radiofrequency to the thoracic sympathetic ganglion versus the cervical sympathetic chain in patients with upper-extremity complex regional pain syndrome
A retrospective analysis

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Abstract

Pulsed radiofrequency (PRF) to the thoracic sympathetic ganglion (TSG PRF) or to the cervical sympathetic chain (CSC PRF) can be performed to overcome transient effects of single sympathetic blocks in patients with upper-extremity complex regional pain syndrome (CRPS).

We retrospectively compared the clinical effects of TSG PRF and CSC PRF. Seven TSG PRF cases and 10 CSC PRF cases were enrolled in the present analysis. We assessed effectiveness with multiple clinical measurements: a numerical rating scale (NRS) of pain before and 1 week after the procedure, postprocedure temperature, effect duration, and a self-described patient satisfaction score.

The temperature was significantly higher in TSG PRF cases than in CSC PRF cases. Pain values (according to the NRS) 1 week after the procedure were significantly lower, and the effect duration was significantly longer, after TSG PRF than after CSC PRF.

TSG PRF is a more effective procedure than CSC PRF for managing chronic upper-extremity CRPS.

Abbreviations: CRPS = complex regional pain syndrome, CSC = cervical sympathetic chain, EM field = electromagnetic field, PRF = pulsed radiofrequency, RF = radiofrequency, SG = stellate ganglion, SGB = stellate ganglion block, TSG = thoracic sympathetic ganglion, TSGB = thoracic sympathetic ganglion block.

Keywords: cervical sympathetic chain, complex regional pain syndrome, pulsed radiofrequency, stellate ganglion, thoracic sympathetic ganglion

1. Introduction

Stellate ganglion (SG) and thoracic sympathetic ganglion (TSG) have a major role in sympathetic innervation of the upper extremities. The rami communicantes originate from the SG, which is connected to the brachial plexus. Other fibers, called Kuntz fibers, which originate from the second or third TSG, and directly connect to the brachial plexus bypassing the SG or middle cervical ganglion, have been described.[1]

Stellate ganglion block (SGB) is the most common sympathetic block method for treating upper-extremity complex regional pain syndrome (CRPS). Thoracic sympathetic ganglion block (TSGB) has also been reported to be effective for CRPS.[2] However, in patients with chronic CRPS, single sympathetic blocks usually only have a temporary effect.

To extend these transient effects, chemical or surgical sympathectomy can be performed, but tissue or nerve damage may occur.[3,4] Thermal radiofrequency (RF) may be considered as an alternative, but RF carries a risk of thermal injury.[5] Moreover, if the treatment region is at the thoracic or cervical level, complications can be catastrophic.

Pulsed radiofrequency (PRF) applies a pulsed energy current to form an electromagnetic (EM) field and does not cause thermal injury or neuronal damage because it never rises above 42°C.[6] Although PRF is increasingly used to treat various pain conditions,[7] its application to sympathetic nerve has been rarely reported.[8,9] We previously reported our clinical experience using PRF on the cervical sympathetic chain (CSC PRF).[9] However, there are no published reports on the application of PRF to the TSG (TSG PRF).

Herein, we performed TSG PRF and retrospectively compared its clinical effect with that of CSC PRF and present this analysis as preliminary data for future prospective studies.

2. Methods

2.1. Participants

We retrospectively reviewed the medical records of patients with chronic upper-extremity CRPS who underwent CSC PRF or TSG PRF between February 2015 and August 2017. This analysis was approved by the Institutional Ethics Committee of Daejeon St. Mary's Hospital, Republic of Korea (DC18RESI0058).

The patient diagnoses met the diagnostic criteria recommended by the International Association for the Study of Pain.[10] Conservative treatments, including anticonvulsants, antidepressants, opioids, and nerve blocks including epidural block, paravertebral block, and peripheral block, along with SGB, TSGB, and intravenous ketamine infusion, were all found to have only a limited effect.

2.2. Procedure

2.2.1. TSG PRF. For TSG PRF, the patient was placed on the table in a prone position with the fluoroscope rotated ipsilaterally by 15° to 20°. After local infiltration, a 10-cm long, 22-gauge RFK needle with a 10-mm active tip (Radionics Inc, Burlington, MA) was introduced toward the lateral margin of the second thoracic vertebral margin. After the needle touches the vertebral body, it was advanced to the posterior one-third of the vertebral body in the fluoroscopic lateral view. TSG location was confirmed by injecting 1 to 3 ml of contrast agent (Fig. 1A, B).

Sensory and motor stimulation were performed with currents of 50 and 2 Hz, respectively. After confirming the patient was not experiencing a dermatome-related tingling sensation or muscle twitching, PRF was performed for 360 seconds at 42°C with 20 milliseconds of current at 2 Hz and 45 V. The procedure was then repeated at the level of the third thoracic vertebra in the same manner as described above.

2.2.2. CSC PRF. For CSC PRF, the patient was placed in a supine position with the head turned 15° to 20° toward the opposite side, and the injection site was disinfected with povidone. A 5 to 12 MHz linear transducer (Phillips Inc, Amsterdam, Netherlands) was used to identify the anterior tubercle of the transverse process of the sixth cervical vertebra.

After skin infiltration, a 5-cm, 22-gauge RFK needle with a 5-mm active tip (Radionics Inc) was introduced in an in-plane manner. The needle tip was then placed between the longus colli muscle and the prevertebral fascia (Fig. 2A).

We used color Doppler images to confirm vessel locations (Fig. 2B). Sensory and motor stimulation were applied at 50 and 2 Hz, respectively, while the patient was checked for paresthesia or phonation to confirm the needle has not been malpositioned. Next, PRF was conducted at 42°C for 420 seconds, and the probe
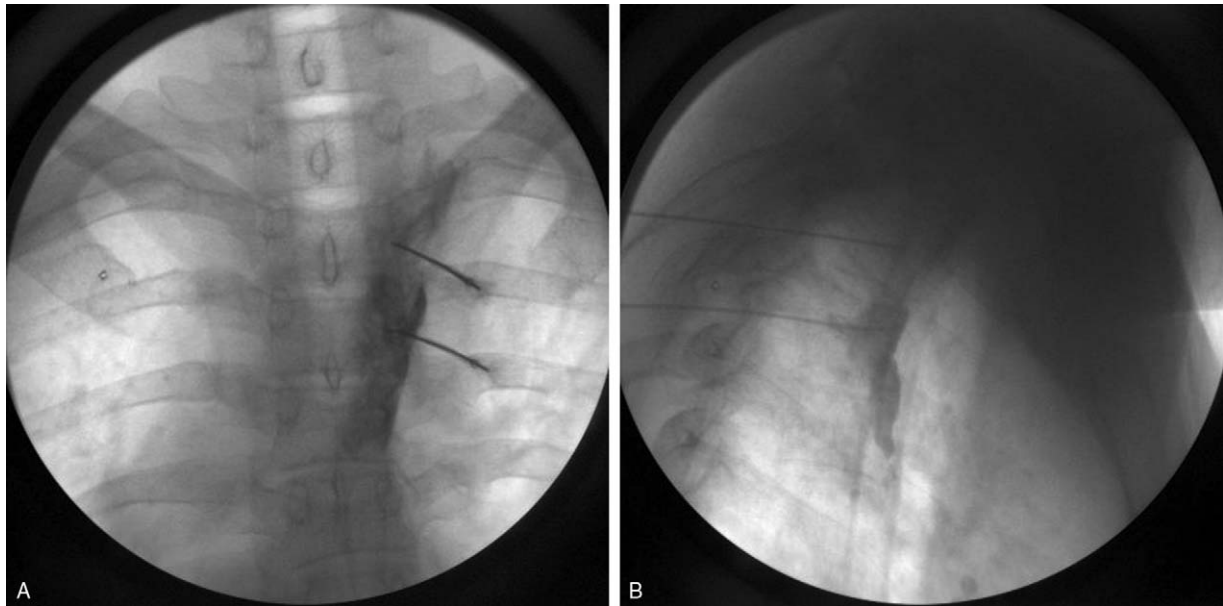
Figure 1. Fluoroscopic images of anteroposterior (A) and lateral (B) views during TSG PRF. Note the perpendicular angle between TSG and needle in fluoroscopic lateral view. TSG PRF = thoracic sympathetic ganglion pulsed radiofrequency, TSG = thoracic sympathetic ganglion.

Figure 2. Ultrasound images of the CSC PRF at C6 (A) and C7 levels (B, C). AT = anterior tubercle of the transverse process of C6, CA = carotid artery, LC = longus colli muscle, VA = vertebral artery, White arrowheads: needle.

was subsequently moved in a caudal direction. We confirmed that the probe was at the C7 level by checking that the anterior 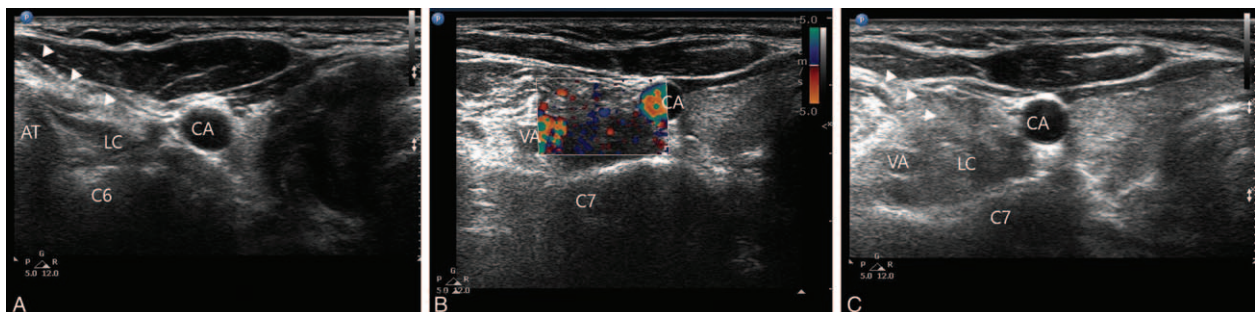tubercle of the transverse process has disappeared. The PRF procedure was applied at the C7 level in the same manner as described above (Fig. 2C).

2.3. Outcome measurements

Age, sex, procedure direction, numerical rating scale (NRS) before the procedure, NRS 1 week after the procedure, and temperature before and after the procedure were collected from medical records for analysis.

The temperature was measured before and after the procedure using a touch thermometer attached to the volar side of both hands. Following the protocol of a previous study, if the temperature difference between the 2 hands was more than 1.5°C, the sympathetic block was considered successful.[11]

To investigate the effect duration of the procedure, we asked all patients how much time passed until their pain returned to preprocedural level. After procedure effects disappeared, we asked patients to provide a self-described rating of the clinical benefit of TSG PRF or CSC PRF according to the following categories: substantial (≥50% benefit), moderate (30–49%), or minimal (<30%). This type of satisfaction questionnaire has been shown to be a useful method for measuring clinical outcomes of certain procedures.[12]

2.4. Statistical analysis

Data are presented as mean ± standard deviation for continuous variables. Data normality was evaluated using the Kolmogorov–Smirnov test. The Mann–Whitney U test or the independent t test was used to compare the clinical parameters between TSG PRF and CSC PRF for continuous variables. The Chi-square test or Fisher exact test was used for categorical variables. All data were analyzed using SPSS version 18.0 (SPSS Inc, Chicago, IL), and a P-value <.05 was considered statistically significant.

3. Results

CSC PRF was performed on 12 patients, and TSG PRF was performed on 5 patients. Two of the 12 patients who underwent CSC PRF were excluded from our analysis because temperature changes were not recorded after the procedure. TSG PRF was performed in 5 patients, of whom 2 underwent the procedure twice. As a result, 10 CSC PRF cases and 7 TSG PRF cases were analyzed.

Demographic data, including age, gender, CRPS duration, type of CRPS, and lesion direction showed no significant difference between TSG PRF cases and CSC PRF cases (Table 1).

Table 1

Patient demographic data.

	TSG PRF (5 patients)	CSC PRF (10 patients)	*P*-value
Age	48.2 ± 13.16	47.6 ± 10.04	.923
Gender (male/female)	3/2	8/2	.560
CRPS duration, mo	66.19 ± 14.81	61.20 ± 26.80	.650
Type of CRPS (I/II)	5/0	8/2	.524
PRF direction (right/left)	2/3	5/5	.714

CSC = complex regional pain syndrome, PRF = pulsed radiofrequency, TSG = thoracic sympathetic ganglion.

Table 2

Clinical outcomes of the procedure.

	TSG PRF (7 cases)	CSC PRF (10 cases)	*P*-value
NRS before PRF	7.71 ± 0.76	7.80 ± 0.92	.842
NRS 1 week after PRF	3.14 ± 1.06	4.60 ± 1.07	.015*
Temperature difference	2.53 ± 0.63°C	1.39 ± 0.96°C	.010*
Successful sympathetic block, n (%)	7/7 (100%)	4/10 (40%)	.035*
Effect duration, d	85.71 ± 40.35	34.90 ± 27.18	.007*

CSC = complex regional pain syndrome, NRS = numerical rating scale, PRF = pulsed radiofrequency, TSG = thoracic sympathetic ganglion.
* $p < 0.05$

The mean temperature difference was 2.52 ± 0.63°C for TSG PRF and 1.39 ± 0.96°C for CSC PRF. The differences in temperature change between the 2 procedure types were statistically significant (P = .016). The rate of successful sympathetic blocking was also higher in the TSG PRF group (TSG PRF: 100.0% vs CSC PRF: 40.0%, P = .035). There was no significant preprocedure difference in NRS between the procedure groups, but 1 week after the procedure, NRS was significantly lower in the TSG PRF group than in the CSC PRF group (TSG PRF: 3.14 ± 1.06 vs CSC PRF: 4.60 ± 1.07, P = .015). The effect duration of the procedure was also significantly longer in the TSG PRF group than in the CSC PRF group (TSG PRF: 85.71 ± 40.35 days vs CSC PRF: 34.90 ± 27.18 days, P = .007) (Table 2).

Regarding patient satisfaction among TSG PRF patients, 6 out of 7 cases reported receiving substantial benefits from their procedure, while 4 out of 10 CSC PRF patients reported substantial benefits; the difference was not statistically significant (P = .059; Table 3). No specific complications, such as infection or hematoma formation, were observed.

4. Discussion

In this study, TSG PRF yielded overall superior clinical outcomes compared with CSC PRF. Although the exact mechanism of the PRF effect has not yet been clearly elucidated, evidence of increased c-fos expression, selective nerve degeneration of small nociceptive fibers, and synaptic changes related to nerve transmission have been reported to be associated with PRF.[7] The EM fields formed during PRF are known to contribute to these biological changes of the target nerve.[6] The density of the generated EM field is greatest in the forward direction of the needle tip; thus, placing the needle perpendicular to the target nerve can maximize the PRF effect.[6] Additionally, the effect range of the EM field is much smaller than that of a few milliliters of local anesthetic.[9] Therefore, when performing PRF, it is ideal to position the needle tip as close as possible to the target nerve.

For sympatholytic effects, the ideal PRF target of the cervical region is the SG. However, the SG is actually located at the T1 level, and there are many vulnerable adjacent structures, including the vertebral artery[13]; therefore, it is not easy to

Table 3

Patient's self-described degree of benefit.

	TSG PRF (7 cases)	CSC PRF (10 cases)	*P*-value
Substantial (≥50%)	6	4	
Moderate (30–49%)	1	6	.059
Minimal (<30%)	0	0	

CSC = complex regional pain syndrome, PRF = pulsed radiofrequency, TSG = thoracic sympathetic ganglion.

position the needle tip at the actual SG location. The CSCs located at C6 and C7 are realistic alternative targets for SGB and are the PRF targets in clinical applications. Nevertheless, even with ultrasound guidance, identifying sympathetic tissue such as the CSC is still difficult. Therefore, when performing CSC PRF, it is not possible to be certain that the target sympathetic tissue and needle tip are close enough to be affected by the EM field.

On the contrary, when performing TSG PRF with fluoroscopic guidance, the needle tip can approach the true anatomical location of TSG. Considering perpendicular angle between the needle and the TSG in the commonly used intervention method with fluoroscopic guidance (Fig. 1B), PRF will efficiently transfer energy to the TSG.

We believe that, during TSG PRF under fluoroscopic guidance, better accessibility to the actual location of the target sympathetic ganglion and easier generation of the perpendicular angle between the RF needle and the target ganglion contributed to the superior clinical results of the TSG PRF compared with CSC PRF in this study.

The present analysis was not based on proper sample size due to retrospective nature. This is a major limitation of our study. In addition, although all patients reported various degrees of reduction in cold sensation after PRF, we did not perform a diagnostic method such as thermography to verify this objectively. Along with a small sample size, this is another limitation of the retrospective nature of our study.

Nevertheless, this is the first study to compare the effects of PRF on sympathetic nerves in different regions, and it could serve as a preliminary guide for future prospective studies.

In conclusion, both CSC PRF and TSG PRF can be easily and safely performed in clinical practice without concern for thermal injury or complications associated with local anesthetics. However, TSG PRF was a more effective option for management of chronic upper-extremity CRPS. Based on this preliminary study, a well-designed, prospective study with adequate sample size would be a valuable advancement of this work.

Author contributions

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