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Computed Tomography-Guided Radiofrequency Ablation of the Cervical Dorsal Root Ganglia in 27 Patients with Cervical and Occipital Postherpetic Neuralgia

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Background: Postherpetic neuralgia (PHN) is a common complication of herpes zoster virus infection that is associated with intense pain. The present study aimed to investigate the use of computed tomography (CT)-guided radiofrequency ablation (RFA) of the cervical dorsal root ganglia (DRG) for treatment of cervical and occipital PHN in 27 patients at a single center.

Material/Methods: Twenty-seven patients with PHN in the cervical and/or occipital region were enrolled. After imaging the area of PHN in the patients, axial scanning was performed on the upper cervical segment in the spinal scanning mode. The puncture path was defined and then RFA therapy (90°C for 180 s) was performed by targeting the corresponding intervertebral foramen. Patients were followed 2 days later and at 1, 3, 6, and 12 months after surgery. Observation at each follow-up visit included rating of pain on a visual analog scale (VAS) and assessment of complications and adverse events.

Results: VAS scores significantly decreased in patients with PHN after RFA compared with their scores before RFA ($P<0.05$). Skin sensation decreased in the area that was originally painful and allodynia significantly diminished.

Conclusions: The findings from this small study from a single center showed that CT-guided percutaneous RFA of cervical DRG safely and effectively reduced cervical and occipital PHN in the short term.

Keywords: Neuralgia, Postherpetic • Radiofrequency Therapy

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Background

Post-herpetic neuralgia (PHN) is a chronic neuralgia syndrome with pain that lasts more than 1 month after lesions from herpes zoster virus (HZV) infection have healed [1]. PHN is difficult to treat in the clinic and analgesia is unsatisfactory with many treatments, such as oral analgesics, nerve blocks [2,3], dual pump combination therapy [4], use of an intrasheath morphine pump, and spinal cord electrical stimulation [5]. Studies show radiofrequency ablation (RFA) near the thoracic dorsal root ganglia (DRG) has not been widely used to treat PHN because the procedure is difficult and complications are possible [6]. As a result, in the future, non-destructive pulsed radiofrequency (PRF) therapy may replace conventional RFA for treatment of thoracic pain.

A retrospective study of stellate ganglion (SG)-PRF of facial and upper limb PHN showed that it was safer and more effective than an SG block, which suggests the potential of PRF in the treatment of PHN [7]. However, Sun C et al [8] found that RFA of the DRG for PHN treatment can achieve greater analgesia over a longer period of time. For PHN, PRF at 65 volts reportedly is better than 45 and 55 volts, and it also has been shown to be safe. However, the tissue temperature near the electrode rose as high as 50°C when the PRF voltage was increased to 65. The area of skin numbness also was larger on the third day after the operation, but there were no significant differences from the other 2 voltage groups at 30 days after the procedure [9]. Lin et al [10] found that computed tomography (CT)-guided RFA of patients with cervical (C8)-thoracic (T1) PHN reduced their pain. DRG-RFA guided by integrated X-ray and CT may improve the efficacy and safety of treatment of intractable chest pain in patients with cancer [11]. Based on these results, the present study aimed to investigate the use of CT-guided RFA of the cervical DRG for the treatment of cervical and occipital postherpetic neuralgia in 27 patients at a single center.

Material and Methods

Study Population

From January 2016 to June 2019, 27 patients with intractable cervical PHN were enrolled. The sites of herpes primogenesis were all in the C2-C4 spinal nerve innervation area of the neck (**Figure 1**). All of the patients reported sharp pain that felt like burning or cutting, which was suggestive of hyperpathia and hyperpselaphesia. A visual analog scale (VAS) was used to assess their pain level (0 points: painless, 10 points: unbearable pain). All of the patients had a history of oral analgesia or multiple nerve block therapy, with poor results.

Figure 1. Herpetic lesions in the cervical (C2-C3) spinal innervation regions of the neck.

Ethics Statement

The study was approved by the Ethics Committee of the First Affiliated Hospital of Jiaxing University and written informed consent was provided by all patients before they enrolled.

Preoperative preparation included chest CT, electrocardiography, blood biochemistry, routine blood testing, and testing of coagulation. The investigators confirmed that the patients had no contraindications to puncture and they controlled for complications. The expected effect and possible complications of use of the CT-guided Cervical DRG-RFA technology (Siemens Somatom Emotion system, Siemens Healthcare, Malvern, Pennsylvania, United States) were explained to the families in detail and they signed informed consent. The radiofrequency lesion generator system (PMG230, Baylis Medical Company, Inc., Rouyn-Noranda, Quebec, Canada), the monitor, rescue drugs, and equipment then were prepared. Patients fasted for 4 to 6 h before surgery and an i.v. and an indwelling trocar were on standby for use to open infusion channels. The area to be treated with RFA for cervical DRG was identified based on the spinal nerve innervation area of the original skin lesion and the pain site and then marked.

Operative Methods

The RFA procedure was performed as previously described [9]. The patients were in a supine position on the CT table with the side of the body with PHN facing up. ECG monitoring was performed continuously during the procedure. A position grid was placed on the affected side of the neck and axial scanning was performed on the upper cervical spine [C1-C4] in 3-mm segments after a CT image was taken for positioning in spine mode. The target intervertebral foramen at the spinal nerve root level was identified and an optimal puncture path was defined. After routine skin sterilization, draping, and administration of local

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Figure 2. The radiofrequency ablation (RFA) puncture path for treatment of the cervical dorsal root ganglion. (**A**) An RFA puncture path through the C2 dorsal root node. (**B**) An RFA puncture path through the C3 dorsal root node. (**C**) An RFA puncture path through the C4 dorsal root node. 1: radiofrequency puncture needle, 2: odontoid of the axis, 3: foramen intervertebrale, 4: lamina, 5: cavum pharyngis, 6: vertebral artery, 7: centrum.

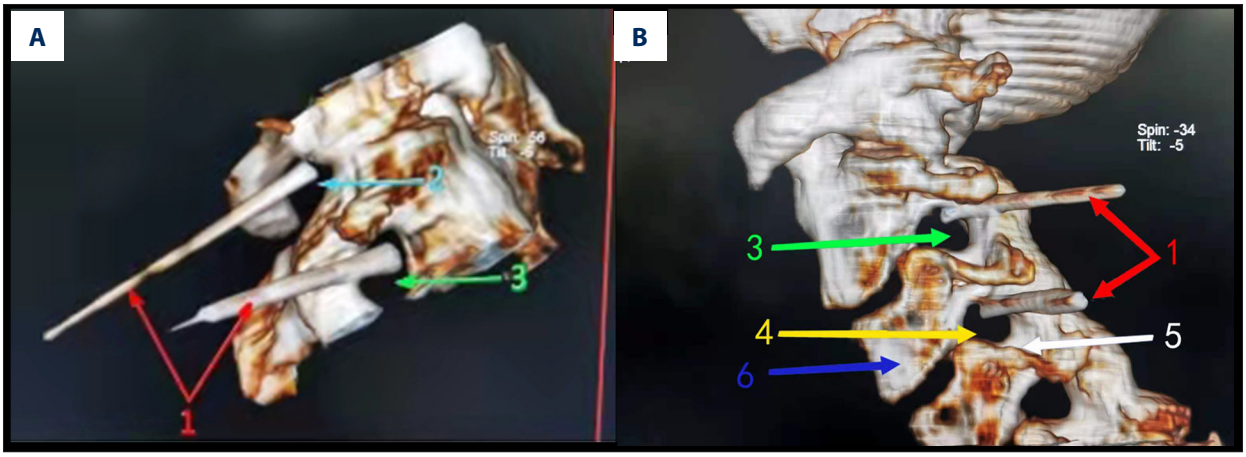

Figure 3. A 3-dimensional reconstruction of puncture position on the cervical dorsal root ganglion during radiofrequency ablation. (**A**) The puncture needle was located in the intervertebral foramen of C2 and C3 spinal canal, seen here from the side. (**B**) The puncture needle was located in the intervertebral foramen of C3 and C4 spinal canal, seen here from the lower side. 1: radiofrequency puncture needle, 2: C2 foramen intervertebrale, 3: C3 foramen intervertebrale, 4: C4 foramen intervertebrale, 5: transverse foramen, 6: centrum.

anesthesia, a radiofrequency trocar scan (PMG100-5, Zhejiang Volt Medical device Co., Ltd, Zhejiang, China) was performed to confirm the needle position and ensure that the tip was at the dorsal root ganglion of the targeted nerve within the intervertebral foramen (**Figure 2A-2C**). A 3-dimensional reconstruction of the CT scan image (**Figure 3A, 3B**) was carefully checked to confirm that the needle was in the target intervertebral foramen. Electrical stimulation then was applied to the herpetic area. A sensation test was performed at 50 Hz and <0.2 volts to numb the area supplied by the nerve and a neuromotor test was performed at 2 Hz and <0.5 volts to prevent fasciculation in the area supplied by the nerve. If currents measuring 0.1 to 0.5 mA induced pain in the region that was originally painful, continuous RFA was performed at 90°C for 180 s. The treatment ended when the patient no longer had any pain, numbness, or allodynia in the region that was originally painful. After RFA, if a patient had no sensation, twitch, or numbness in the original treatment area, the needle tip was adjusted and RFA was applied again. The patients' muscle strength and speech function, and pain scores for their upper and lower limbs and necks were checked after the RFA treatment was completed.

Statistics

Data were presented as mean±standard deviations and analyzed using SPSS 16.0 software (SPSS, Inc., Chicago, Illinois, United States). A comparison of continuous data was performed using a *t* test. $P<0.05$ was considered statistically significant.

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Results

Presurgical Patient Characteristics

Twenty-seven patients (16 men and 11 women) with intractable cervical PHN were enrolled. In 5 of them, PHN was in C2-C3 innervation area, in 13 patients it was in the C3-C4 innervation area, and in 9 it was in the C2-C4 innervation area. The mean age of the patients was 54.6±6.4 years (range 47-89 years old). Fifteen patients had PHN on the left side and 12 patients had it on the right side. The mean duration of PHN was 7.6±2.9 months (range 1 month to 12 years).

VAS Scores Before and After RFA

VAS scores were significantly lower than presurgical values 2 days after the procedure (pre-RFA: 6.85±0.60; post-RFA: 3.43±0.43, $P<0.05$).There was no significant difference in VAS scores at any time after surgery (1, 3, 6, and 12 months; all $P>0.05$).

Safety Evaluation

During the procedure, oxygen saturation was above 96% in all patients. Hypertension was observed in 21 patients and Uradil (average 43.5 mg; range 12.5 mg to 75 mg) was used multiple times to control blood pressure. Bradycardia occurred in 9 patients and i.v. atropine was used to elevate the heart rate to the preoperative level. After RFA, 2 patients experienced mild hematoma of the neck, which resolved after cold compression. No decrease in muscle strength was seen in the patients' upper and lower limbs or necks, and no intentional or cerebrovascular accidents occurred.

Discussion

HZV infection is self-limited, but treatment of PHN is difficult. Because of the complex mechanisms of PHN, the treatment is usually not limited to a single method. In our study, we offered DRG-RFA to all patients with PHN involving the cervical and occipital dermatome. In 22 patients, VAS scores and allodynia symptoms significantly decreased in the 12-month period after DRG-RFA, proving that the treatment was effective. The mechanism by which RFA relieves PHN pain is not fully understood. Based on electrophysiological principles, both hyperalgesia and hypersensitivity of PHN require the integrity of nerve structure and function. Once the spinal nerve is damaged by RFA, peripheral sensory signals cannot be transmitted to the DRGs through the spinal nerves. Because RFA eliminates the possibility of interactive transmission and reconversion of electrical signals, it is well suited to be a major treatment for RFA, as has been shown in previous research. RFA is not commonly used for PHN because the puncture required is difficult and there are concerns about potential complications [6]. Because X-ray and CT guidance reportedly improve the efficacy and safety of DRG-RFA for treatment of intractable chest pain in cancer patients [11], CT-guided puncture was selected for the present study. During the puncture process, CT scanning was adjusted several times to avoid possible damage to the vertebral artery. A puncture was made with the radiofrequency tip as far as possible into the upper third of the intervertebral foramina (below the notch of the lower pedicle of the upper vertebral pedicle).

PRF is the method most commonly studied for radiofrequency treatment of PHN because it does not damage the spinal nerves and has the advantage of preserving nerve function. Makharita et al [12] reported that ultrasound-guided PRF of the intercostal nerves in combination with pharmacotherapy seems to be a safe and effective treatment for PHN. Kim et al [13] reported that DRG-PRF is more effective than a continuous epidural block in treating zoster-related pain after the acute phase of zoster. A neuromodulation method such as DRG-PRF may be useful for reducing the progression of neuropathic changes caused by persistent transmission of pain signals after the acute phase of zoster. By monitoring elevation in serum brain-derived neurotrophic factor levels, Saxena et al [14] have demonstrated that integrated multimodal therapy using minimally invasive PRF and pregabalin is effective for early reduction in pain associated with PHN. Cohen et al [15] found that DRG-PRF is superior to pharmacotherapy and PRF at the intercostal nerves in patients with chronic postsurgical thoracic pain.

Because the effect of PRF is not profound or lasting, however, its use for PHN should be combined with drug therapy or another intervention aimed at reducing pain induced by HZV. Benzon et al [16] suggested that sequential treatment schemes should be adopted for different diseases and pain levels when techniques such as oral medication, a nerve block, or PRF do not produce satisfactory effects. Zhenkai Han et al [9] found that high-voltage PRF resulted in significantly lower VAS scores and better quality of life in patients with PHN during long-term follow-up. Heavner et al [17] have found that protein denaturation during PRF only occurred when the temperature reached 60°C. Therefore, we believe that the efficacy of PRF is not long-lasting because it does not damage the structural and functional integrity of spinal nerves.

Radiofrequency thermal coagulation can block an affected nerve and destroy the integrity of the nerve's structure and function. Therefore, it prevents the transmission of nociceptive signals to the central nervous system, thus mitigating the perception of pain. Our results showed that the allodynia and unprovoked pain seen in 88.9% of the patients (24 of 27) was reduced by more than 50% after undergoing RFA of

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the cervical DRGs. Therefore, RFA may be a better option than PRF for patients with refractory PHN.

Unlike the thoracic and lumbar spinal nerves, the cervical spinal DRGs are adjacent to the vertebral artery and run through the transverse foramen, exiting out of the cervical intervertebral foramen. Consequently, a cervical radiofrequency puncture is difficult. Successful RFA of cervical spine DRGs requires that the radiofrequency needle be kept away from the vertebral artery during puncture and that it does not penetrate the intervertebral foramen, preventing damage to the cervical spinal cord. Therefore, for RFA of the C2 DRG, we positioned patients on the healthy side of the body and the needle puncture was from back to front. In this way, the puncture needle was away from the vertebral artery and the angle of puncture ensured that the spinal cord was not injured (**Figure 2A**). Puncture also is risky because cervical DRGs are adjacent to the cervical spinal cord in the intervertebral foramen and close to the vertebral artery in the external mouth. CT guidance greatly reduces the risk of such a procedure because it reveals the position of the needle tip, cervical spinal cord, and vertebral arteries.

For cervical DRG-RFA to treat PHN, we used a radiofrequency trocar with a bare end that measured 5 mm, which reduced the likelihood that a puncture would damage the vertebral arteries. We recommend keeping the exposed end of the radiofrequency needle short so the thermal damage does not affect an area so large that it affects the cervical spinal cord and vertebral arteries.

During administration of RFA to cervical spinal nerves, the operator also should be familiar with the arrangement of cervical spinal nerves to ensure that the responsible nerve is treated. Because the way the cervical and thoracolumbar spinal nerves traverse the intervertebral foramen differs, the operator should memorize the cutaneous innervation area of spinal nerves. The thoracic and lumbar spinal nerves all exit from the intervertebral foramen at the lower margin of the corresponding vertebral body side. For example, the T3 spinal nerve originates from the thoracic spinal cord and exits the spinal canal through the intervertebral foramen, below the vertebral body side of the third thoracic vertebra, as do the lumbar spinal nerves. The cervical spinal nerves, however, are different: There are 8 pairs of cervical spinal nerves in 7 cervical vertebrae. The first pair of cervical spinal nerves (C1) exit the spinal canal through the upper lateral margin of the first cervical vertebra. Other pairs of cervical spinal nerves also exit the spinal canal through the upper lateral foramina of the corresponding cervical vertebra. The C2 spinal nerve exits the spinal canal from the intervertebral foramen between the first and second vertebrae on the upper and lateral side of the 2 vertebrae. The C8 spinal nerve exits the spinal canal through the intervertebral foramen between the seventh cervical vertebrae and the first thoracic vertebra on the sublateral side of the seventh cervical vertebrae. Knowing how the cervical spinal nerves are arranged will prevent treatment of the wrong target area with RFA. For example, the C2 spinal nerve is not located in the intervertebral foramen between the second and third cervical vertebrae. Therefore, when we used RFA to treat PHN in the neck, we performed an electrophysiological test and 3-dimensional CT reconstruction after successful puncture to ensure that radiofrequency was applied to the responsible nerve. Had we treated the wrong nerve, the results would be unsatisfactory and the off-target RFA could have affected the patient's upper limb motor function. For example, RFA applied to the C4 spinal nerve root in the intervertebral foramina between the fourth and fifth cervical vertebrae would damage the C5 spinal nerve root involved in the brachial plexus, resulting in a dysfunction in upper limb lift.

Providers administering RFA also should take into consideration that most patients with PHN patients are middle-aged and elderly (average age 54.6 years), and they often have cardiovascular and cerebrovascular diseases. Puncture and radiofrequency performed under local anesthesia often increase intraoperative blood pressure because of pain. In the present study, 77.8% of patients (21 of 27) developed intraoperative hypertension (≥20% increase above baseline). As a resource on radiofrequency treatment of cervical spinal nerve root PHN, we referred to the study by Xiao-Mei Ren et al [18] of treatment of primary trigeminal neuralgia with extracranial non-semilunar ganglia radiofrequency thermal coagulation. We recommend that radiofrequency treatment of cervical DRGs be performed with administration of inhaled oxygen to and close monitoring of patients. Preparation of rescue equipment and vasoactive drugs also is suggested for patient safety.

Our study has several limitations. First, the sample size was small and it was conducted in a single center. Second, we did not have a control group. Third, several observation indicators, such as those for allodynia and frequency of spontaneous pain, are not perfect. In the future, we plan to conduct a multicenter study with a more comprehensive design and a larger sample size.

Conclusions

The findings from the present small, single-center study showed that CT-guided percutaneous RFA of cervical DRGs was safe and effective for reducing cervical and occipital postherpetic neuralgia in the short term.

Conflict of Interest

None declared.

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Declaration of Figures Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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