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Original contribution

A posterior approach to cervical nerve root block and pulsed radiofrequency treatment for cervical radicular pain: a retrospective study

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Abstract
Background: Catastrophic complications have been reported for selective cervical nerve root block (SCNRB) or pulsed radiofrequency (PRF) via an anterolateral transforaminal approach. A posterior approach to these procedures under computed tomography guidance has been reported. Here, we report the clinical outcomes of 42 patients with chronic cervical radicular pain (CCRP) treated with a combination of SCNRB and PRF through a posterior approach under fluoroscopy guidance.
Methods: We retrospectively reviewed the clinical outcomes of 42 consecutive patients with CCRP who received a combination of SCNRB and PRF through a posterior approach under fluoroscopy guidance. The thresholds of electrical stimulation and imaging of the nerve roots after contrast injection were used to evaluate the accuracy of needle placement. The numeric rating scale was used to measure the pain and numbness levels as primary clinical outcomes, which were evaluate in scheduled follow-up visits of up to 3 months.
Results: A total of 53 procedures were performed on 42 patients at the levels of C5-C8. All patients reported concordant paresthesia in response to electrical stimulation. The average sensory and motor thresholds of stimulation were 0.28 ± 0.14 and 0.36 ± 0.14 V, respectively. Injection of nonionic contrast resulted in excellent spread along the target nerve root in large majority of the procedures. The numeric rating scale scores for both pain and numbness improved significantly at 1 day, 1 week, and 1 and 3 months after the treatment. No serious adverse effects were observed in any of the patients.
Conclusions: The posterior approach to combined SCNRB and PRF under fluoroscopy guidance appears to be safe and efficacious in the management of CCRP.

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1. Introduction

Chronic cervical radicular pain (CCRP) due to radiculopathy or radiculitis is a common cause for patients to seek medical care and often refractory to conservative treatments such as physical therapy, antiinflammatory drugs, anticonvulsants, and

antidepressants. The reported annual incidence of cervical radiculopathy is approximately 83 cases per 100,000 and increases to 203 cases per 100,000 in the fifth decade of life and beyond [1]. Cervical radiculopathy may be caused by degenerative processes such as cervical intervertebral disc prolapse, which comprises 20%-25% of all cases. In the large majority of the case though, it is caused by a combination of factors including narrowing of the intervertebral foramen, intervertebral disc herniation, osteoarthritis of facet joints, and spondylolisthesis of cervical spine, collectively known as cervical spondylosis. Nerve root compression due to trauma, abscess, hematoma, or tumor is relatively rare but must not be overlooked [1-3].

Selective cervical nerve root block (SCNRB) and pulsed radiofrequency (PRF) treatment have been used to manage CCRP [4-6]. Typically, each of these procedures is performed via an anterolateral approach under fluoroscopy guidance. However, serious complications have been reported, including cerebral and spinal cord infarction after steroid injections via the anterolateral approach of SCNRB [7-21]. These reports have raised significant concerns about the safety of this approach in clinical practice. Furthermore, the 2 procedures are usually performed separately, and only short-term pain relief is achieved by either one of the procedures. To improve safety and outcomes of CCRP treatment, we adopted a posterior approach to SCNRB and PRF of the dorsal root ganglion to avoid the major vascular, neural, and other structures. Furthermore, we used a combination of these 2 therapies to achieve better clinical outcomes. We hypothesized that the combination therapy is safe and more effective in reducing CCRP.

2. Material and methods

The research protocol was approved by the Institutional Review Board of Nanshan Hospital of Guangdong Medical School. Written informed consents were obtained from all participants before the procedure. Patients were treated in the Pain Clinic of Nanshan Hospital from March 2010 to March 2013.

The inclusion criteria for the study were patients of both sexes and at least 20 years old, with moderate-to-severe CCRP (NRS >5) resistant to conservative management, no indication for open surgical intervention or magnetic resonance imaging evidence of nerve root compression, and absence of progressive motor deficit. The exclusion criteria were uncorrected coagulopathy, infection, cervical myelopathy, malignancy, pregnancy, or significant psychopathology. Consecutively treated patients were included in this study, and no randomization process was performed.

The clinical assessment included vital signs, neurologic examination, psychological assessment, pain intensity and duration, comorbidities, and plain x-ray of the cervical spine. In addition, magnetic resonance imaging was done for all

patients to rule out conditions that were defined in the exclusion criteria. Blood tests were performed to screen for coagulopathy and infectious disease. The demographic data and clinical characteristics are tabulated in Table 1.

2.1. Procedures

All procedures were performed by pain physicians who have extensive experiences with cervical transforaminal nerve block and PRF under fluoroscopy guidance. Patients were placed in a prone position on an operating table in a digital subtraction angiography room. Sedation was not required in any of the patients for this approach. True anteroposterior fluoroscopy images of the cervical spine were obtained with the targeted level of vertebral body at the center of the image. After skin preparation with aseptic technique, an 18-gauge introducing intravenous cannula needle (Car1-Braun-Strasse 1,D-34212, Melsungen, Germany) was first placed from a posterior approach into the lateral margin of the pedicle column above the posterior tubercle of the targeted cervical transverse process. A 20-gauge curved blunt RF cannula (Baylis BMC, Montreal, Canada) was then placed (Fig. 1A). The needle was first made contact with the articular pillar with the curved tip pointing medially. It was then rotated 180° to pass ventrally through the lateral margin of the articular pillar and rotated again back to the medially curved direction. The final position of the RF cannula tip was located at the "U-shaped" transverse process in a lateral view (Fig. 1B). Once the electrode was satisfactorily positioned, the RF probe was inserted to replace the stylet. The final position of electrode was determined by 2 criteria: (1) sensory stimulation (50 Hz) that created paresthesia concordant to the usual chronic pain distribution and (2) motor stimulation (2 Hz) that caused muscle contraction in the respective myotomal distribution at an intensity that was greater than the sensory stimulation. The thresholds of sensory and motor stimulation were recorded.

Table 1 Patient demographics, diagnosis, and nerve roots involved

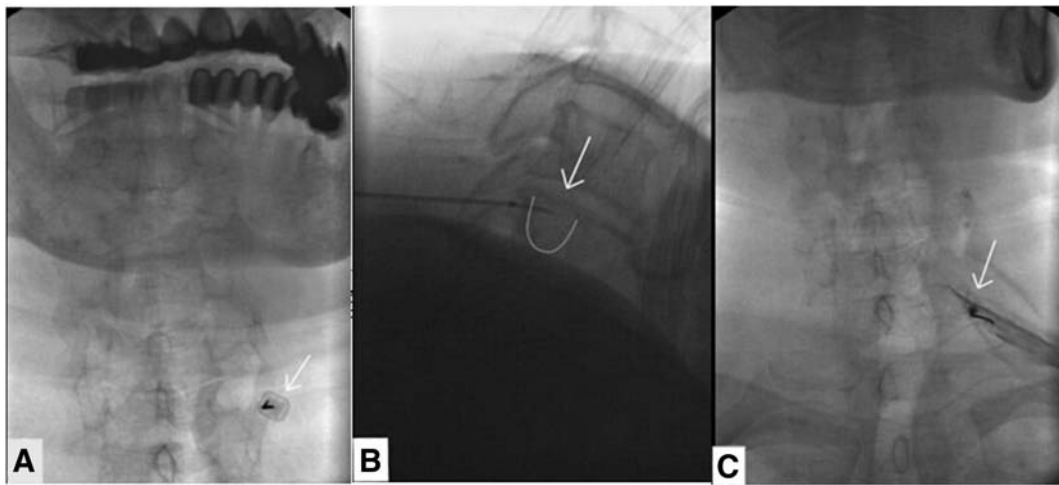| Demographics	n = 42 patients
Age (mean ± SD)	55.5 ± 10.2
Male/female	29/13
Duration of symptoms (mean ± SD)	18 ± 14.2 (mo)
Diagnosis	
Cervical radicular pain	22
Cervical radiculopathy	20
Symptom with numbness	16
Symptom with weakness	8
One level/2 level	31/11
Left/right	23/21
C5	8
C6	22
C7	17
C8	6

Fig. 1 Posterior approach to cervical nerve root block or pulsed RF. **A**, Radiofrequency cannula placement with an introducer in anteroposterior view. The cannula was placed at the lateral margin of the right C6 transverse process. **B**, Radiofrequency cannula placement in lateral view. The tip of a curved RF cannula was placed in a depth overlaying on the "U-shaped" transverse process of the C6 vertebra as highlighted. **C**, Contrast spread along the C6 nerve root. Injection of 0.5-1 mL nonionic contrast revealed the contour of the right C6 nerve root with no central spread to the epidural space.

Pulsed RF was conducted at 42°C for 240 seconds. After PRF treatment, nonionic contrast Omnipaque (0.5-1.0 mL) was injected with real-time fluoroscopy to rule out intravascular spread, confirm the position of the tip of the electrode, and reveal contour of the cervical nerve root (Fig. 1C). The images were saved for each patient, and a mixture of medications was then injected. The injectates contained 5-mg betamethasone dipropionate, 2-mg betamethasone disodium phosphate, 1 mL 0.9% NaCl, and 1 mL 2% lidocaine (1-1.5 mL mixture was injected per level).

2.2. Follow-up evaluation

We followed up the patients in the pain clinic to evaluate and document the responses to the treatment. The 11-point numeric rating scale (NRS) of 0-10 was used to measure pain intensity with 0 being no pain and 10 being the worst pain imaginable. A same rating scale was used to measure the severity of numbness with 0 being no numbness and 10 representing the worst numbness imaginable. The assessments of pain and numbness were performed before the procedure and at 1 day, 1 week, and 1 and 3 months after the procedure. The patients were asked to report any complication or side effect during the follow-up evaluations.

2.3. Statistical analysis

The demographic data, duration of symptoms at presentation, nerve root involved per clinical examination, and duration of the procedure were documented. The changes in NRS scores of pain intensity and numbness severity at 1 day, 1 week, and 1 and 3 months after treatment were analyzed using 1-way analysis of variance followed by Bonferroni tests for multiple comparisons against the preprocedure baseline levels. SPSS software package (SPSS version 14.0 for Windows; SPSS Inc, Chicago, IL) was used for the analysis.

3. Results

3.1. The procedure

A total of 53 combined SCNRB–dorsal root ganglion PRF procedures were performed on 42 patients, with 8 procedures for C5, 22 for C6, 17 for C7, and 6 for C8 (Table 1). Electrical stimulation at 50 Hz elicited paresthesia concordant to the usual pain distribution in all patients. The average sensory threshold was 0.28 ± 0.14 V. Stimulation at 2 Hz with intensity above sensory threshold elicited motor responses in the corresponding myotomes. The average motor threshold was 0.36 ± 0.14. With satisfactory stimulation, PRF was delivered with 42° for 4 minutes at voltage range of 30-65 V. Injection of nonionic contrast resulted in excellent spread showing clear contour of the nerve root in 48 nerve roots as exemplified in Figure 1C. The injection of contrast did not show clear nerve root contour in the remaining 5 nerve roots. All patients tolerated the procedures well without any sedation. The operating time for the procedure ranged from 10-30 minutes. No complications were reported by any of the patients.

3.2. Clinical outcomes

The combined PRF and SCNRB resulted in clinically meaningful and statistically significant pain reduction 1 day, 1 week, and 1 and 3 months after the procedure. Figure 2

shows the average NRS pain scores that are significantly reduced from the preprocedure levels. Compared with the preprocedure pain intensity, the reduction in average NRS score after the procedure was ≥4 points at all follow-up intervals, up to 3 months. These reductions were all statistically significant. Similarly, the numbness intensity also improved significantly. The average NRS numbness scores improved by at least 3 points at all the follow-up intervals, compared with the preprocedure severity (Fig. 3). The reduction in numbness scores was also statistically significant at all evaluation intervals. The average NRS scores, expressed as mean ± SD, for both pain and numbness are shown in Table 2.

4. Discussion

The anterolateral approach to transforaminal cervical epidural injections is currently used in the management of cervical radicular pain by administration of a mixture of local anesthetic and steroid at the level of the affected nerve root. Several observational studied have demonstrated significant clinical improvements after cervical transforaminal epidural steroid injections [22-25]. However, the transforaminal administration route has been the subject of much discussion and even controversy in recent literature. In a retrospective study of 1036 fluoroscopically guided transforaminal injections, Ma et al [26] reported a 1.64% overall rate of complications. Reports of catastrophic complications have particularly received considerable attention [11-21]. The rate of complications associated with the anterolateral approach to placement of the needles was significantly higher than that
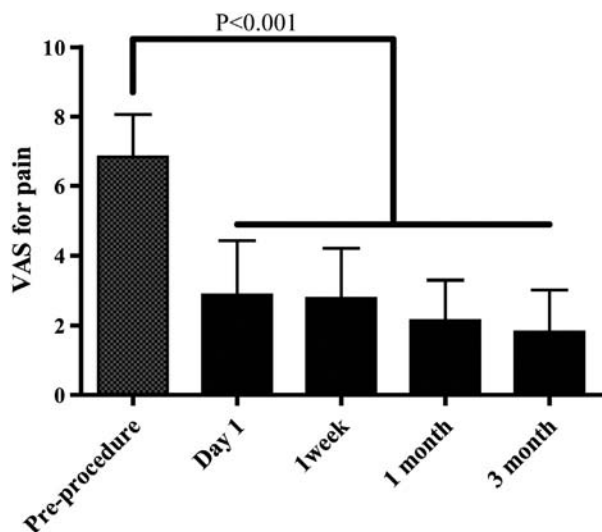

Fig. 2 Reduction of pain intensity after the combined PRF and SCNRB. The average NRS pain scores were significantly reduced from the preprocedure level at the follow-up intervals of 1 day, 1 week, and 1 and 3 months (Bonferroni t test for multiple paired comparisons, $P<.001$).
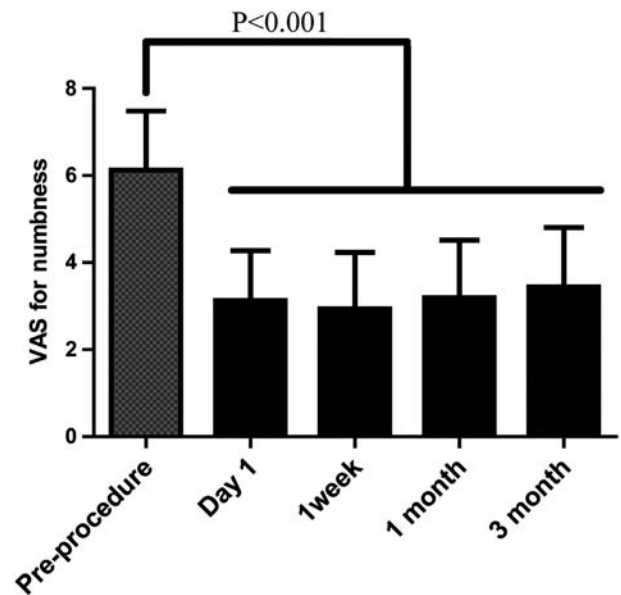

Fig. 3 Reduction of numbness intensity after the combined PRF and SCNRB. The average NRS numbness scores were significantly reduced from the preprocedure level at the follow-up intervals of 1 day, 1 week, and 1 and 3 months (Bonferroni t test for multiple paired comparisons, $P<.001$).

with a more posterior positioning of the needle [26]. Our group has used a posterior approach to cervical nerve root block and PRF under fluoroscopy guidance as an effort to minimize the risks of inadvertent injection into the vertebral artery and its branches that supply the spinal cord. The data of this study showed that the patients tolerated the procedure well without any sedation. All procedures were completed without any adverse events or complications. Although the sample size is too small to determine the safety of this approach, it appears that this approach could be performed as a plausible alternative to the anterolateral transforaminal approach.

This study demonstrated a clinically important and statistically significant pain reduction that lasted for at least 3 months after the combined PRF and steroid injection procedure (Fig. 2). Similarly, the severity of numbness in the arm and/or fingers also improved significantly in the 3-month follow-up period (Fig. 3). The results of this combined approach are much

Table 2   Clinical outcomes after combined PRF and SCNRB

Time	NRS for pain (n = 42)	NRS for numbness (n = 16)
	Mean ± SD	Mean ± SD
Preprocedure	6.83 ± 1.22	6.13 ± .133
Postprocedure		
1 d	2.88 ± 1.55 *	3.13 ± 1.15 *
1 wk	2.79 ± 1.42 *	2.94 ± .944 *
1 mo	2.14 ± 1.16 *	3.19 ± .199 *
3 mo	1.80 ± 1.21 *	3.44 ± .441 *
P value	$P < .0001$†	$P < .0001$ *

  * Compared with preprocedure control.

better than those reported previously with transforaminal epidural steroid injection through the anterolateral approach [4,23,24]. The longer lasting effects of this procedure are particularly attractive because one of the concerns with cervical epidural steroid injection is the lack of significant and long lasting pain relief. For example, a recent randomized comparative study by Cohen et al [27] reported that cervical epidural injection did not produce significant difference between the conservative treatment group and the epidural injection group. Even the group that received a combination of conservative treatment and epidural injection did not reach a significant level of difference. The scores for arm pain only reduced 1.8, 2.0, and 3.1 points from pretreatment baseline at 1-month follow-up, and the scores for neck pain only reduced 1.1, 1.2, and 2.2 for the 3 groups, respectively [28]. In contrast, the approach used in this study achieved more than 4 points pain score reduction at 1 and 3 months after the procedure. Thus, this approach promises to overcome one of the most significant limitations of epidural steroid injection and deserves further investigation. The PRF treatment may be responsible for the improved clinical outcomes.

Another major concern with cervical epidural injection is the potential risks associated with the procedure that include paraplegia and death, possibly due to spinal cord or brainstem infarction. The posterior approach to cervical nerve root block and PRF under fluoroscopy guidance may avoid the risks of intrathecal or intraspinal injection and vertebral artery puncture compared with the anterolateral approach to transforaminal epidural injection [4]. However, it does not by any means avoid other critical blood vessels, such as the radicular arteries arising from the cervical vessels (ascending cervical artery, deep cervical artery, etc) [29]. These posteriorly placed arteries have been observed by anatomic dissection [29] and ultrasound [30].

In this study, accurate positioning of the electrodes via the posterior route was first indicated by paresthesia and motor responses to electrical stimulation. All the 42 patients reported paresthesia and motor responses concordant to the usual pain distributions at very low stimulation thresholds (0.28±0.14 for sensory and 0.36±0.14 for motor stimulation), indicating that the electrode was close to the target nerve. Accurate needle positioning was further confirmed by nonionic contrast injection. In most of the cases, the spread of the contrast was excellent, outlining the contour of the target cervical nerve roots with minimal spread into the central epidural space. This observation is consistent with the report that the posterior approach with computed tomography guidance did not result in significant spread of medication to the epidural space and provided effective pain relief safely [31].There were no serious complications except for vasovagal reactions in 4 patients from that report. However, the computed tomography–guided procedure exposes patients to a much higher level of radiation and costs more compared with the fluoroscopy-guided approach reported here.

There are several limitations in this study. First, it is limited by the inherent weakness of retrospective studies including potential bias in patient selection, measurement, and variations in procedural techniques and nuances. Second, the sample size is too small to determine the safety of this procedure because the complication rate for cervical epidural injections is relatively low. In fact, there were no studies ever designed for this purpose for any pain procedures because it would require a very large sample size to demonstrate a significant reduction of complications. Third, the follow-up duration of 3 months is still relatively short, and we could not determine the long-term effects of this combined procedure (PRF treatment plus selective nerve root block). Fourth, although the combination of PRF with selective nerve root blocks produced significantly superior clinical outcomes compared with epidural steroid injection alone, we could not determine whether the better outcomes are due to the therapeutic effects of PRF, block of the nerve roots, or the combination of these treatments. One of the reasons we took this approach was that we intended to use the RF equipment for electrical stimulation of the nerves for accuracy of needle placement. Pulsed RF was conveniently conducted given the low risk and potential benefit to the patients. Given the fact that epidural steroid injections usually provide short-term pain relief, we would speculate that the impressive outcomes of at least 3 months' pain relief and numbness reduction are primarily due to the therapeutic effects of PRF treatment in this study. This is consistent with a previous study that demonstrated that a long-term efficacy of PRF and a 71.5% satisfaction rate in patients with CCRP [5]. Further studies with randomized and placebo controlled trials are needed to investigate the therapeutic effects of each of these treatments.

We conclude that the posterior approach to SCNRB and PRF under fluoroscopy guidance appeared to be safe and that the combined treatment was efficacious in the management of cervical radicular pain. The combination therapy with SCNRB and PRF yielded much better outcomes than transforaminal epidural steroid injection.

Acknowledgment

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