Techniques in Regional Anesthesia and Pain Management (2005) 9, 81-85

Techniques in
Regional Anesthesia
& Pain Management

Cervical facet radiofrequency

Ricardo Vallejo, MD, PhD, FIPP

From the Millenium Pain Center, Bloomington, Illinois; and Illinois State University, Normal, Illinois.

KEYWORDS:
Medial branch;
Pulse radiofrequency;
Neurolysis

The use of electricity to treat painful conditions is not novel in medicine. Initially, direct current was used to create lesions of the nerves, but the unpredictable results lead to the adoption of alternating current. Current radiofrequency generators allow us to locate the target nerve, decrease the chance of unwanted nerve damage, and control temperature in the surrounding tissues. The cervical facets commonly cause cervicogenic headaches or cervicobrachialgia. The medial branches of the cervical dorsal rami innervate the facets and are easily accessible for radiofrequency, with the addition of fluoroscopy. Two modalities of radiofrequency are currently available. The traditional neurolytic technique creates high temperatures around the tip of the needle burning the target tissues, while pulse radiofrequency creates an electrical field around the nerve, that modulates nerve conduction while preventing nerve damage. We describe the most common technical approaches to perform the above mentioned procedures, with a rationale to decide why and when to perform pulse radiofrequency or neurolysis.

The incidence of chronic neck pain is thought to occur in 22% of women and in 16% of men. Trauma is the most frequent predisposing factor.[1] Other predisposing factors to chronic neck pain include particular professional activities, such as tractor drivers, heavy lifting, and prolonged activity at computer.[2] Cervical zygapophysial joint pain is common in patients with chronic neck pain after whiplash.[3] Among those patients with dominant headache after whiplash, comparative blocks revealed that the prevalence of C2-C3 zygapophysial joint pain was 50%. The most frequently affected facets causing pain after whiplash injury are C2 to 3, followed by C5 to 6, and then C4 to 5.[4] Application of radiofrequency lesioning (RFL) to the nerve supply of the cervical facet joints can provide long-term relief from pain emanating from the joints. Appropriate diagnostic injections of the medial branches that innervate the symptomatic facet joint or joints should be performed before RFL to improve the success rate of RFL. Based on the high incidence of false positive response rates after single nerve block, this physician routinely performs two diagnostic blocks on different occasions. Because nothing is done to resolve the cause of the pain, it is important to realize the palliative nature of the procedure.[5]

Anatomy

The cervical facet (zygopophysial) joints are formed by the superior and inferior articular process of two adjacent vertebrae. The cervical facets, from C3 to 4 to C7-T1, are lined with synovium and possess joint capsule.

The cervical zygopophysial joints (from C3-4 to C7-T1) are innervated by the medial branches of the cervical dorsal rami (Figure 1).[6] The medial branches curve medially, "hugging the waists" of their segmental articular pillars, and divide as the nerve approaches the posterior aspect of the articular pillar.[6] Each dorsal ramus sends medial branches to the facet joints at its own level, and one level below.[7]

The C2 to 3 facet joint is innervated by the third occipital nerve (TON) (one of the medial branches of the C3 dorsal ramus), and in some degree, by one of the medial branches of C2 dorsal ramus. The TON curves dorsally and medially around the superior articular process of C3, and travels along the C2 to 3 facet joint.

Unique to the cervical spine is the presence of the vertebral artery, which passes though the transverse foramen of the transverse processes of the C1 to C6 vertebrae.[3]

Address reprint requests and correspondence: Ricardo Vallejo, MD, PhD, FIPP, Millennium Pain Center, 1015 S. Mercer Ave., Bloomington, IL 61701.
E-mail address: vallejo1019@yahoo.com.

1084-208X/$ -see front matter © 2005 Elsevier Inc. All rights reserved.
doi:10.1053/j.trap.2005.05.006

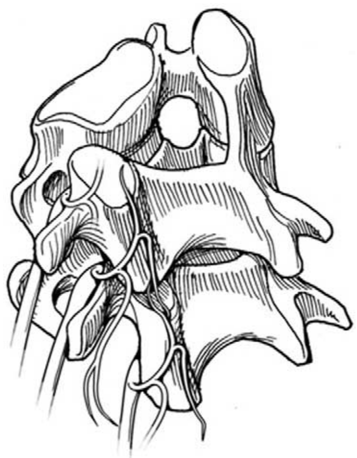

Figure 1 Medial branches of dorsal rami.

Basic principles of radiofrequency

Application of electrical current to lesion specific nerve targets has been clinically used since the 1940s when direct current (DC) was applied. The unpredictability of the lesions led to the adoption of alternating current (AC) and high frequency waves (about 300 kHz).

Currently, radiofrequency generators can measure tissue temperature around the electrode tip, perform electrical stimulation to facilitate nerve location, (decreasing the chance for nerve damage), and measure tissue impedance. This allows the operator to rule out the presence of short circuits or electrical disconnection. To create the lesion, a 27-gauge thermocouple probe (for monitoring tip temperature) is advanced through a special 22- to 23-gauge cannula, that is insulated along its shaft, leaving only the tip exposed to current. Radiofrequency can generate two different types of reactions at its tip:

1 Radiofrequency (RFL) neuroablative lesions are created when high temperatures (80°C for 90 seconds) are applied around the tip of the needle. Temperatures above 44°C are required to cause cell death.[6] In this type of lesion, the temperature produced is parallel to the tip axis, with the maximum lesion around the proximal part at the tip of the needle, and the minimal lesion at the distal part (Figure 2A).
2 Interestingly, results of a double-blind randomized study found that patients diagnosed with cervicobraquialgia reported similar outcomes when R FL was applied at 67°C, and 40°C.[8] This raises a question regarding the therapeutic need of heat.[8] Pulse radiofrequency applies bursts of current of 20 msec at a rate of 2 Hz, allowing 480 msec rest periods that permit the temperature to dissipate. Common parameters used in pulse radiofrequency are: 45 V for 120 seconds, with the temperature rarely exceeding 42°C. The exact mechanism of action of the pulse radiofrequency is unknown. It seems that the *Electrical Field* (EF) generated from the tip of the needle reversibly disrupts the transmission of impulses across small unmyelinated fibers without destroying them (Figure 2B). Large myelinated fibers are not affected.[9] The direction and magnitude of the EF depends on the shape of the needle. Cylindrical active tips generate weak EF, while sharp conductors create strong EF propulsion forward.

The histological appearance of the lesion is significantly different. Neuroablative lesions generate massive edema and Wallerian degeneration. Pulse radiofrequency produces minimal tissue reaction.[10]

Some basic rules that apply to radiofrequency include: At higher temperatures, the local inflammatory reaction will be greater. A larger lesion is formed with a larger electrode. Tissues with low electrical resistance (cerebral spinal fluid or blood) will remove heat from the area, and therefore limit lesion size.[11]

Before performing any lesion, it is important to ensure that the tip of the needle is not too close to a motor nerve. To do so, one should look for the strongest sensory stimulation at a frequency of 50 Hz with the lowest possible voltage. Once the sensory nerve has been located, motor stimulation at low frequency (2 Hz), and at a voltage at least two times higher than is required for sensory stimulation, is performed. If a muscle twitch is observed, the needle may be too close to a motor nerve, and the needle should be relocated. Sensory and motor stimulation greatly enhances the precision of the lesion.

It is important to emphasize that the tip of the needle should be parallel to the target if the purpose is to ablate the nerve. The tip should be perpendicular to the nerve if the goal is to apply pulse radiofrequency. Possible beneficial effects of this later approach include a reduced heat effect with the creation of a greater electrical field, with a theoretical reduced risk of neuroma formation. However, there is no scientific evidence to support this theory.[12]

Required equipment

The procedure should be performed under fluoroscopic guidance (C-arm). Equipment and medications for cardiopulmonary resuscitation should be readily available in case of anaphylactic reactions, or cardiovascular collapse, due to intrathecal or intravascular injection of local anesthetic. Required monitoring equipment includes: EKG monitor, pulse oximetry, and blood pressure.

A radiofrequency generator will display voltage generated, impedance, voltage, and temperature. To avoid unde-

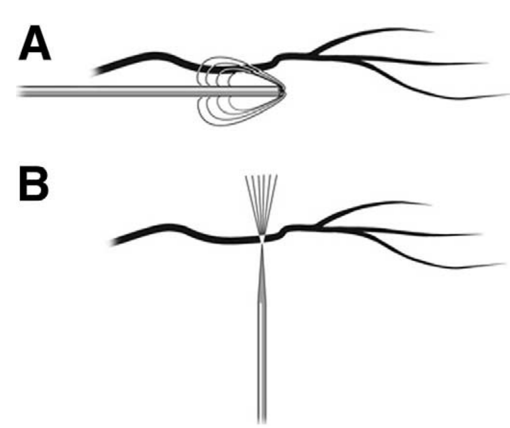

Figure 2 (A) Needle oriented for neuroablation. (B) Needle oriented for pulse radiofrequency.

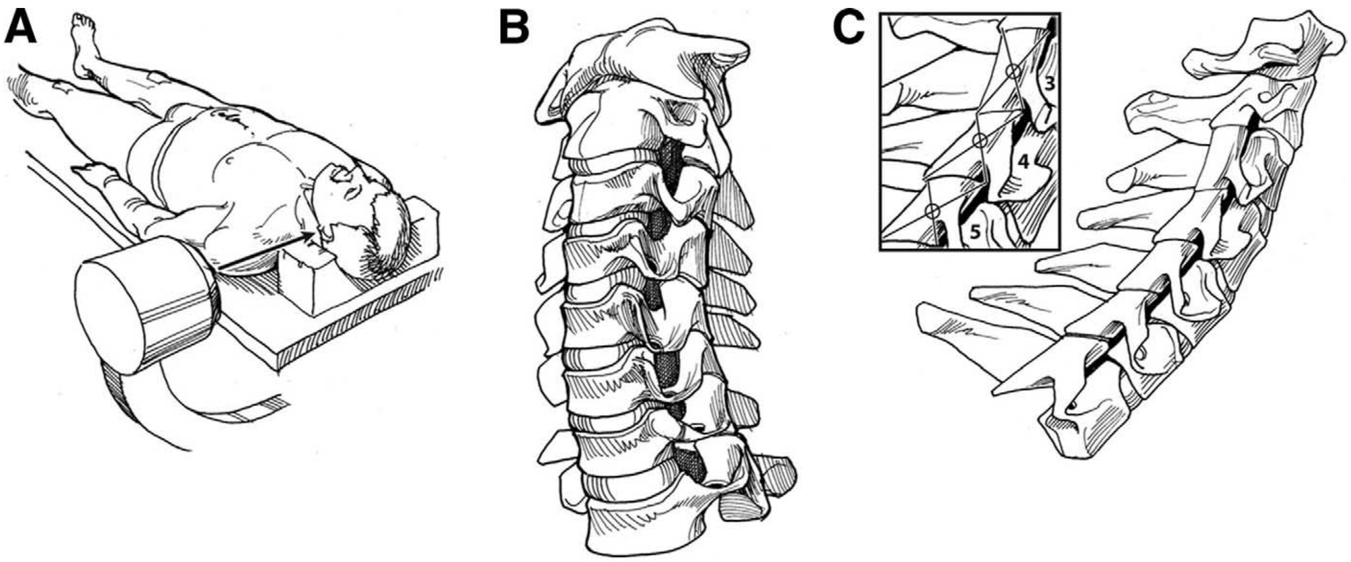

Figure 3 (A) Patient supine for lateral C-arm view. (B) Oblique view of intervertebral foramina of C-spine. (C) Target point for medial branches of C3, C4, and C5.

sired complications, the operator must make sure that the dispersing pad is applied correctly to the patient before starting any procedure.

Placement of the needle may be uncomfortable for the patients. To make the placement of the needle more bearable, this physician provides them with light sedation.

We typically use two different electrode systems: the Sluijter-Mehta electrode kit™ (SMK) and the Racz-Finch electrode kit™ (RFK). The SMK (straight tip) is ideal when one's goal is to position the tip of the needle perpendicular to the target nerve. The lateral approach is one example of this technique. The sharp tip creates a stronger electrical field and theoretically improves the results of the pulse radiofrequency technique. The RFK (curved tip) may offer an advantage, when the objective is to place the active needle tip parallel to the target nerve because it is easier by rotating the needle to place the tip precisely in the target area. For this reason, this physician uses the RFK needle for neuroablative procedures.

Technique

Lateral approach

When performing radiofrequency for the upper cervical facet joints (C2-3, C3-4, C4-5, C5-6), I prefer to have the patient in the supine position, with the neck in neutral position, as it gives one better access to the neck and allows an increased patient tolerance. The C-arm is placed in a lateral view (Figure 3A). Then the patient's head is slowly rotated, so as the bilateral articular processes are superimposed. Then the C-arm is slightly rotated to oblique view, allowing the physician to see the intervertebral foramen (Figure 3B). Behind the pedicles, immediately posterior to the foramen, it will be easy to differentiate the articular pillars with their typical rhomboid shape. After skin is prepped and draped in an aseptic fashion, the skin and subcutaneous tissues overlying the target facet medial braches of entry are anesthetized with lidocaine 1%, using a 25.5-gauge needle. Extreme caution should be use when anesthetizing subcutaneous tissues, as the "anesthetizing" 25.5-gauge needle may reach the facet. Even worse, it may reach intravascular structures or the intrathecal space of thin patients. Once skin and subcutaneous tissues have been anesthetized, a 22-gauge, 5-cm, SMK needle with an active 5-mm tip is inserted 1 or 2 cm behind the target point.

At the level of C3, C4, and C5, the target medial branch nerve will be in the point of intersection of two lines, drawn from each corner of the rhomboid (Figure 3C). As one moves lower, the medial branches start to be located more cephalad and medial. At C7, the medial branch is often located crossing the triangular superior articular process of C7 (Figure 4). For the TON that supplies the C2 to 3 facet, the target area is the entire anterolateral surface of the superior articular process of C3, as well as the middle third of the facet joint. Once one is comfortable with the needle position in the oblique view, before beginning stimulation, it is always convenient to verify the needle tip location in the concavities of the articular processes with an AP view. This physician usually performs three lesions at each medial branch, except for the TON where five to six lesions are made.

At this point, sensory and motor stimulation are performed to adjust the needle position. Once one is satisfied, the generator is set to deliver pulse radiofrequency at a voltage around 45 V for 120 seconds. With these parame-

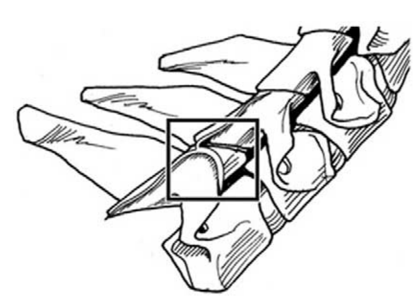

Figure 4 Medial branch of C7.

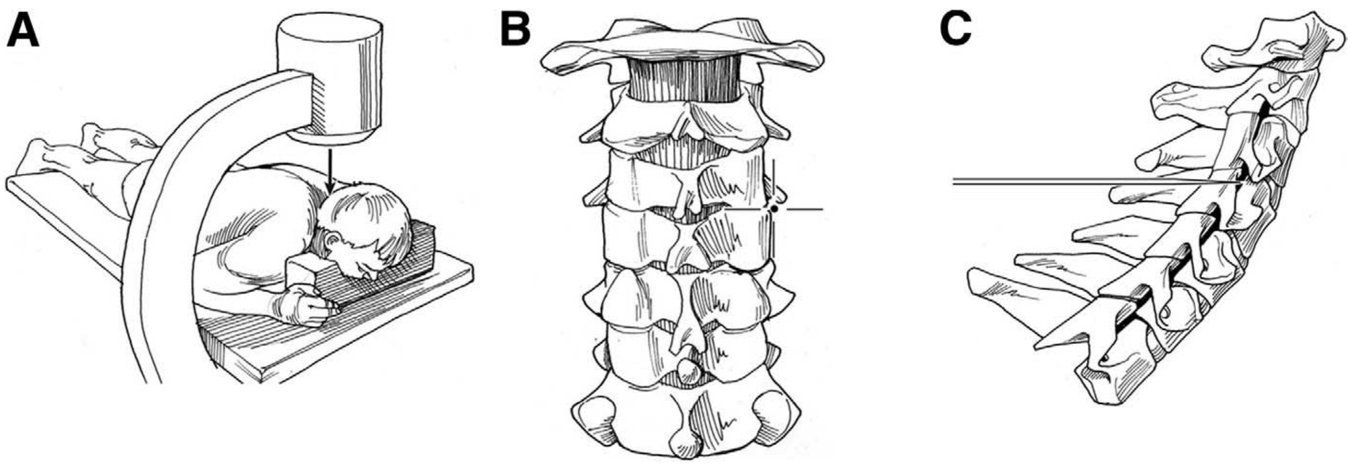

Figure 5 (A) Patient in prone position for A-P view. (B) A-P view of posterior approach. (C) Lateral view of posterior approach.

ters, the temperature rarely exceeds 42°C. It is not necessary to give any local anesthetic before the lesion. If the impedance is above 350 ohms at the final needle position, 0.2 mL of local anesthetic is usually given before the procedure to improve electrical conduction. It is important to warn the patient about residual discomfort after the procedure, which may last for 1 or 2 weeks.

Posterior approach

Due to the obstruction created by the shoulders, the cervical facet joint and the branches of the lower cervical levels may be difficult to visualize in the supine position. For this reason, the posterior approach may be more convenient for those levels. This approach is more suitable for radiofrequency neuroablation because the trajectory of the needle will place the tip along the axis of the medial branch, hugging the articular pillar. The patient is positioned in prone position. A small pillow is placed underneath the chest and neck, with minimal flexion of the neck, thus permitting the decrease of cervical spinal lordosis (Figure 5A). The C-arm is placed in the AP view, and is slowly rotated to make sure that the spinous processes are in midline. Then the waists of the articular process are identified. It is easy in the AP view of the cervical region, to confuse the lateral margin of the vertebral bodies (which are more medial), with the actual lateral aspect of the articular process, which is the real target. This confusion may lead to the placement of the needle too medial, increasing the risk spinal cord injury. Once those points are located, skin is prepped and draped in an aseptic fashion. Using a 25.5-gauge needle, the skin and subcutaneous tissues overlying the point of entry are anesthetized with lidocaine 1%.

At this point, a 22- or 23-gauge, 10-cm RFK needle with an active 10-mm tip is inserted in a parallel angle to the radiograph beam, in a tunnel-view vision (Figure 5B). Constant change of the C-arm view to lateral view is advised to make sure that the needle never lies anterior to a line passing through the posterior border of the intervertebral foramen. One of the theoretical advantages of the posterior approach is that, following the recommended guidelines, the needle will be in contact with muscle and bone, thus decreasing the risk of intravascular or intrathecal injection. When advancing the needle, care should be taken at all times to keep the needle away from the midline. Once bone has been contacted, at the above-mentioned area over the pedicle, the C-arm is rotated to the lateral view, and slight rotation of the needle is used to slide the needle over the articular process, until the tip is in the center of the pedicle (Figure 5C). One should always make sure the location is behind the intervertebral foramen to avoid lesions of the spinal root or the vertebral artery. Before starting the RF lesion, confirmation of needle in AP and lateral views should be done. Sensory and motor stimulation is then performed. Stimulation of the multifidus muscles may be seen when performing motor stimulation, but contraction of muscles in the shoulder or the arm may indicate the proximity of the needle to a motor nerve root. Radiofrequency lesioning is performed at 80°C for 90 seconds. To improve the chances of lesioning the medial branch, the needle is rotated 90° and a second lesion with similar parameters is performed.

Complications

Like any other minimally invasive procedure, theoretical risks associated with the needle placement include hematoma formation, infection, and allergic reaction to the local anesthetic. Potential complications inherent to radiofrequency are the development of burns if the dispersing ground is not properly applied.

The posterior approach offers the advantage that the vertebral artery, the spinal nerves, and the radicular arteries lay anterior to the final anterior location of the needle. Damage to these structures may be avoided if technique is followed correctly.

The lateral approach carries the risk of injury to the vertebral artery and spinal nerves if the needle is directed too anteriorly.

Other possible complications include: vasovagal syncope (2%), neuritis (2%), numbness in the dermatomal distribution of the ablated nerve (29%), and dysesthesias in the dermatomal distribution of the ablated nerve (19%).[13]

Conclusion

When performed properly, radiofrequency lesioning (RFL) applied to the nerve supply of the cervical facet joints can provide long-term relief from pain emanating from the joints. Appropriate diagnostic injections of the medial branches that innervate the symptomatic facet joint or joints should be performed before RFL to improve the success rate.

Complications can be avoided by proper needle placement, making sure that equipment is in good operating condition and checking that the dispersing ground is properly applied. Lastly, the procedure itself should be monitored by the generator operator.

Acknowledgments

I thank Kristine M. Dennis for manuscript preparation.

References

1. Guez M, Hildingsson C, Nilsson M, et al: The prevalence of neck pain: a population-based study from northern Sweden. Acta Orthoop Scand 73:455-459, 2002
2. Sluijter ME: Cervicobraquialgia, in Sluijter ME (ed): Radiofrequency (part 2). Flivopress SA, Meggen (LU), Switzerland, 2003, pp 9-22
3. Bogduk N, Marsland A: The cervical zygopophysial joints as a source of neck pain. Spine 13:610-617, 1988
4. Lord S, et al: Chronic cervical zygapophysial joint pain after whiplash. A placebo-controlled prevalence study. Spine 21:1737-1744, 1996
5. Govind J, Bogduk N: International Spinal Injection Society Practice Guidelines and Protocol: percutaneous radiofrequency cervical medial branch neurotomy. ISIS 10th Annual Scientific Meeting 51-75, 2002
6. Bogduk N: The clinical anatomy of the cervical dorsal rami. Spine 7:319-330, 1982
7. Lord SM, Leslie B, Bogduk N: Percutaneous radiofrequency neurotomy in the treatment of cervical zygopophysial joint pain: a caution. Neurosurgery 36:732-739, 1995
8. Slappendel, et al: The efficacy of radiofrequency lesioning of the cervical spinal dorsal root ganglion in a double blinded randomized study: no difference between 40 degrees C and 67 degrees C treatments. Pain 73:159-163, 1997
9. van Kleef M, Barendse GA, Dingemans WA, et al: Effects of producing a radiofrequency lesion adjacent to the dorsal root ganglion in patients with thoracic segmental pain. Clin J Pain 11:325-332, 1995
10. Podhajsky. Histological effects and comparison of 42 C RF and heat lesions in DRG and sciatic nerve. 11th ISIS meeting.
11. Raj PP, Lou L, Erdine S, et al: Physics and principles of cryoneurolysis and radiofrequency lesioning, in Rajj PP, Lou L, Erdine S, Staats PS (eds): Radiographic imaging for Regional Anesthesia and Pain Management. Philadelphia, PA, Churchill Livingstone, 2003, pp 30-36
12. Gauci CA: The physics of radiofrequency and pulsed radiofrequency, in Gauci CA (ed): Manual of RF Techniques, A practical manual of radiofrequency procedures in chronic pain management. Meggen, Switzerland, Flivo Press, 2004, pp 8-17
13. Bogduk N: ISIS practice guidelines and protocol: percutaneous radiofrequency cervical medial branch neurotomy. ISIS 10th Annual Scientific Meeting, 2002