Case Report

Efficacy of Transverse Tripolar Spinal Cord Stimulator for the Relief of Chronic Low Back Pain from Failed Back Surgery

Asokumar Buvanendran, MD, and Timothy J. Lubenow, MD

From: Department of Anesthesiology, Rush University Medical Center, Chicago, IL

Dr. Buvanendran is Associate Professor, Department of Anesthesiology, Rush Medical College, Chicago, IL.
Dr. Lubenow is Professor, Department of Anesthesiology, Rush Medical College, Chicago, IL.

Address correspondence:
Asokumar Buvanendran, MD
Department of Anesthesiology
Rush University Medical Center
1653 West Congress Parkway
Chicago, IL 60612
E-mail: Asokumar@aol.com.

Disclaimer: Support was provided by University Anesthesiologists S.C.
Conflict of interest: None.

Manuscript received: 01/14/2008
Revised manuscript received: 2/14/2008
Accepted for publication: 02/28/2008

Free full manuscript:
www.painphysicianjournal.com

Background: Failed back surgery syndrome is a common clinical entity for which spinal cord stimulation has been found to be an effective mode of analgesia, but with variable success rates.

Objective: To determine if focal stimulation of the dorsal columns with a transverse tripolar lead might achieve deeper penetration of the electrical stimulus into the spinal cord and therefore provide greater analgesia to the back.

Design: Case report.

Methods: We describe a 42-year-old female with failed back surgery syndrome that had greater back pain than leg pain. The tripolar lead configuration was achieved by placing percutaneously an octapolar lead in the spinal midline followed by 2 adjacent quadripolar leads, advanced to the T7-T10 vertebral bodies.

Results: Tripolar stimulation pattern resulted in more than 70% pain relief in this patient during the screening trial, while stimulation of one or 2 electrodes only provided 20% pain relief. After implantation of a permanent tripolar electrode system with a single rechargeable battery, the pain relief was maintained for one year.

Conclusion: This is case report describing a case of a patient with chronic low back pain with a diagnosis of failed back surgery syndrome in which transverse tripolar stimulation using an octapolar and 2 quadripolar leads appeared to be beneficial. The transverse tripolar system consists of a central cathode surrounded by anodes, using 3 leads. This arrangement may contribute to maximum dorsal column stimulation with minimal dorsal root stimulation and provide analgesia to the lower back.

Key words: Epidural, low back pain, spinal cord stimulation, failed back surgery syndrome, tripolar stimulation

Pain Physician 2008; 11:3:333-338

Failed back surgery syndrome (FBSS) does not have one specific treatment because it does not have one specific cause (1). Although there are many modalities that give some degree of success in certain categories of patients, there is no therapeutic modality that uniformly relieves this type of pain. The lack of a reliable pain relieving technique has prompted the development of newer devices in the search for an effective treatment.

Spinal cord stimulation (SCS) was initially introduced by Shealy et al (2), with the postulate that activity in large myelinated somatosensory fibers inhibits the activity of neurons in the dorsal horns that transmit noxious information. There are different postulates on the mechanism of analgesia by SCS such as activation of neurotransmitters (3), activation of sympathetic efferents, or the gate-control theory. While there have been significant technical advances in this technology of SCS, pain in the lower back remains relatively less responsive to stimulation compared to the extremities for patients with FBSS. The low success rate of SCS for low back pain has been attributed to inadequate paresthesias in the lower back area (4). Based on the geometry of the electromagnetic field and electrical properties of the intraspinal structures, focal stimulation of the dorsal columns with a transverse tripolar (3 leads arranged in a specific fashion) lead configuraton might achieve deeper penetration of the electrical stimulus into the spinal cord and therefore change the distribution of paresthesias (5). Implantable SCS systems can now use up to 16 independent contacts to deliver square-wave electrical pulses and can support multiple columns of electrodes, to allow for anatomical asymmetry and provide better paresthesia coverage of painful areas. Computerized models have demonstrated that this transverse tripolar system may be effective for the relief of low back pain for patients with FBSS (6). In this case report, we present a patient with FBSS in whom we were unable to achieve paresthesias in the low back and extremities in order to provide pain relief without utilizing transverse tripolar stimulation.

Case Report

A 42-year-old female presented to the pain clinic with chronic low back pain of 7 years duration with radiation to the posterior aspect of the lower extremities bilaterally. Lumbar radiculopathy was confirmed by EMG. The verbal pain score (VPS) was rated at 9/10. She had a significant medical history for asthma. The patient had undergone lumbar spinal fusion surgery at L4-S1 with pedicle screws, 2 years prior to presentation. Though the patient had relief from the lumbar surgery initially, the back pain and lumbar radiculopathy returned after 3 months. She had conservative management including exercise and opioids (hydrocodone). Following this she underwent multiple epidural steroid and lumbar facet joint injections (5 at an outside facility), all providing only temporary relief. The patient described 70% of the pain in the low back and the remainder in the lower extremities. This patient was given a diagnosis of FBSS with predominate back pain greater than the leg pain. There were no signs of allodynia or any signs suggestive of neuropathic pain. Significant physical examination findings included decreased range of motion of the lumbar spine with flexion limited to 60^0 and extension 100^0. An imaging study of the lumbar spine demonstrated good position of the pedicle screws, and degenerated disc of the lumbar spine with scar tissue around the lumbar nerve roots L4 and L5 bilaterally, and no significant spinal stenosis. Following a psychological evaluation, including psychometric testing (Minnesota Multiphasic Personality Inventory, Beck Depression Inventory, and State-Trait Anxiety Inventory), the patient was consented for a trial with SCS.

Under sterile conditions, a tripolar SCS system was placed and an intraoperative trial performed. The tripolar lead configuration was achieved by placing percutaneously an octapolar lead (Octad, Medtronic®, Minneapolis MN, 1x 8 compact lead [#3778-45AA] with 4 mm spacing between the active points) in the midline and 2 quadripolar leads (Medtronic® Pisces-Quadripolar compact leads [#3887-33], also with 4mm spacing) on either side (≈ 1 – 1.5 mm) of the octapolar lead. The needle entry into the epidural space was at L1-L2 at a very shallow angle of 15^0 –25^0 (Fig. 1A), which allowed the advancement of the leads under fluoroscopic guidance to opposite the dorsal column (Fig. 1B). The leads were advanced to the T7-T10 vertebral bodies (Fig. 1C); this is an optimal position for obtaining SCS paresthesia to the painful areas of the back and legs.

Three stimulation patterns are displayed in Fig. 2, and all 3 were tested during the initial trial, using a single external power source (Medtronic screener #3625). As shown in Fig. 2, stimulation pattern 1 (using 2 leads only) provided paresthesias and pain relief to both lower extremities only, with 20% overall pain relief. Stimulation pattern 2 (one center lead) provided paresthesia and pain relief to the buttock area only, with 20% overall pain relief. However, the transverse tripolar stimulation (pattern 3 — using all 3 leads with a guarded cathode) provided paresthesia and pain relief to the back, buttocks, and legs bilaterally. The patient had greater than 70% pain relief with the trial leads that were left for a period of 4 days and then removed at the clinic. The pulse width used was 450 μs with a pulse rate of 35/sec for all stimulation patterns. The VPS during the trial was 3/10.

At a later planned date (4 weeks) the patient was taken for permanent implantation of the tripolar elec-

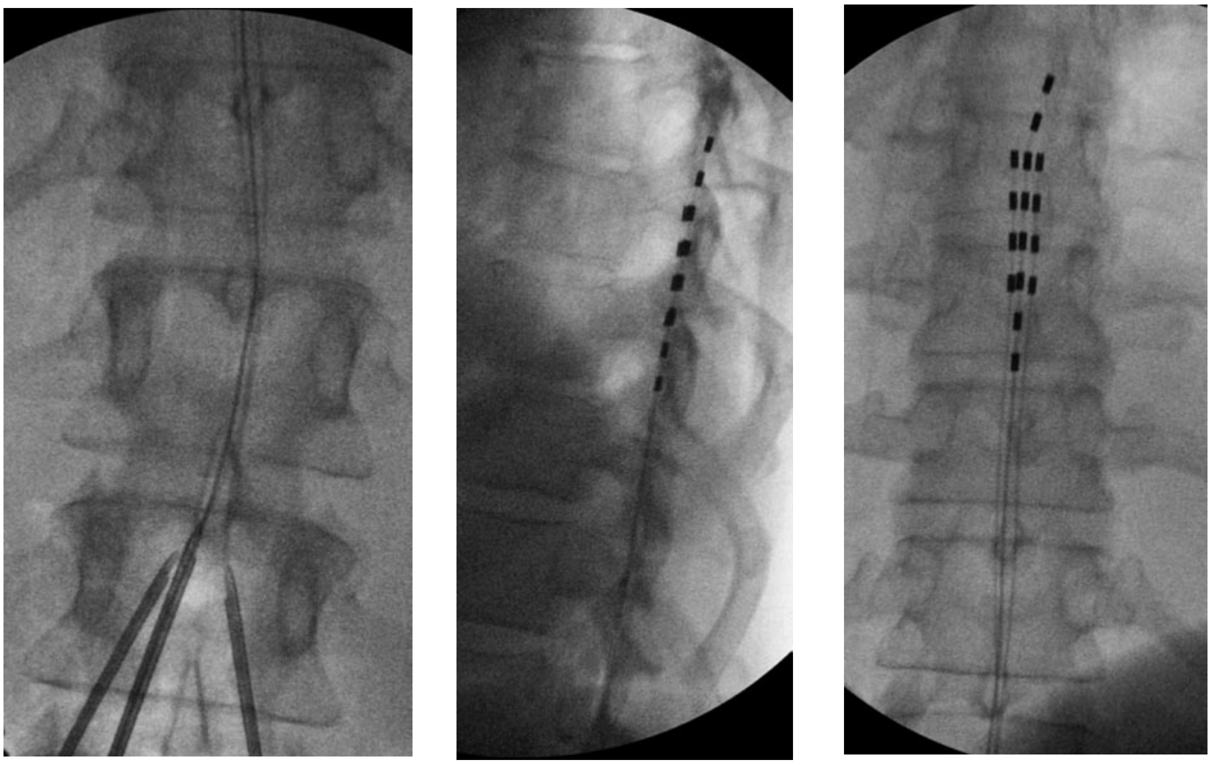

Fig.1. *(A) Needle entry into epidural space. (B) Dorsal epidural electrode position (lateral view). (C) Electrodes in final T7 – T10 vertebral position.*

trodes in the same position as the trial leads. Under local anesthesia and sedation, adequate exposure of the upper lumbar area was created for placement of the 3 planned leads. The epidural needle was entered at the L1-L2 interspace, and the electrodes were passed cephalad to T10. The octapolar lead was placed initially, followed by the 2 quadripolar leads adjacent to the initial lead. Three titanium anchors (Medtronic® Titan 3550-39) were utilized to secure the leads to deep tissues including the ligaments, after ensuring adequate positioning of the leads and verification of stimulation patterns as at the trial configuration. A bifurcation extension wire was used to connect the two quadripolar leads to a rechargeable-battery stimulator (Medtronic® Restore Prime [#37701]), in addition to an extension wire from the octapolar lead. The final generator settings were pulse width 450 μs, pulse rate 35/sec, and voltage 5.0-8.5 volts.

The patient has been followed for one year and has shown no major change in stimulation parameters and paresthesia coverage with analgesia. The patient was re-programmed 3 times over the year, with slight increases in voltage each time. The VPS at the one-year time point was 3 – 4/10. The patient was on transdermal fentanyl patch of 75 μg every 72 hours prior to the SCS implant. In addition the patient was also on an anti-convulsant and an anti-depressant. Polypharmacy was attempted prior to the discussion about SCS. After the SCS implant, the patient was slowly titrated down in medication and was able to be weaned from the long acting drugs to tramadol 200 mg/day after one year.

Discussion

This is a case report describing the efficacy of transverse tripolar stimulation using an octapolar and 2 quadripolar leads for a patient having chronic low back pain with FBSS. It is based on the computer

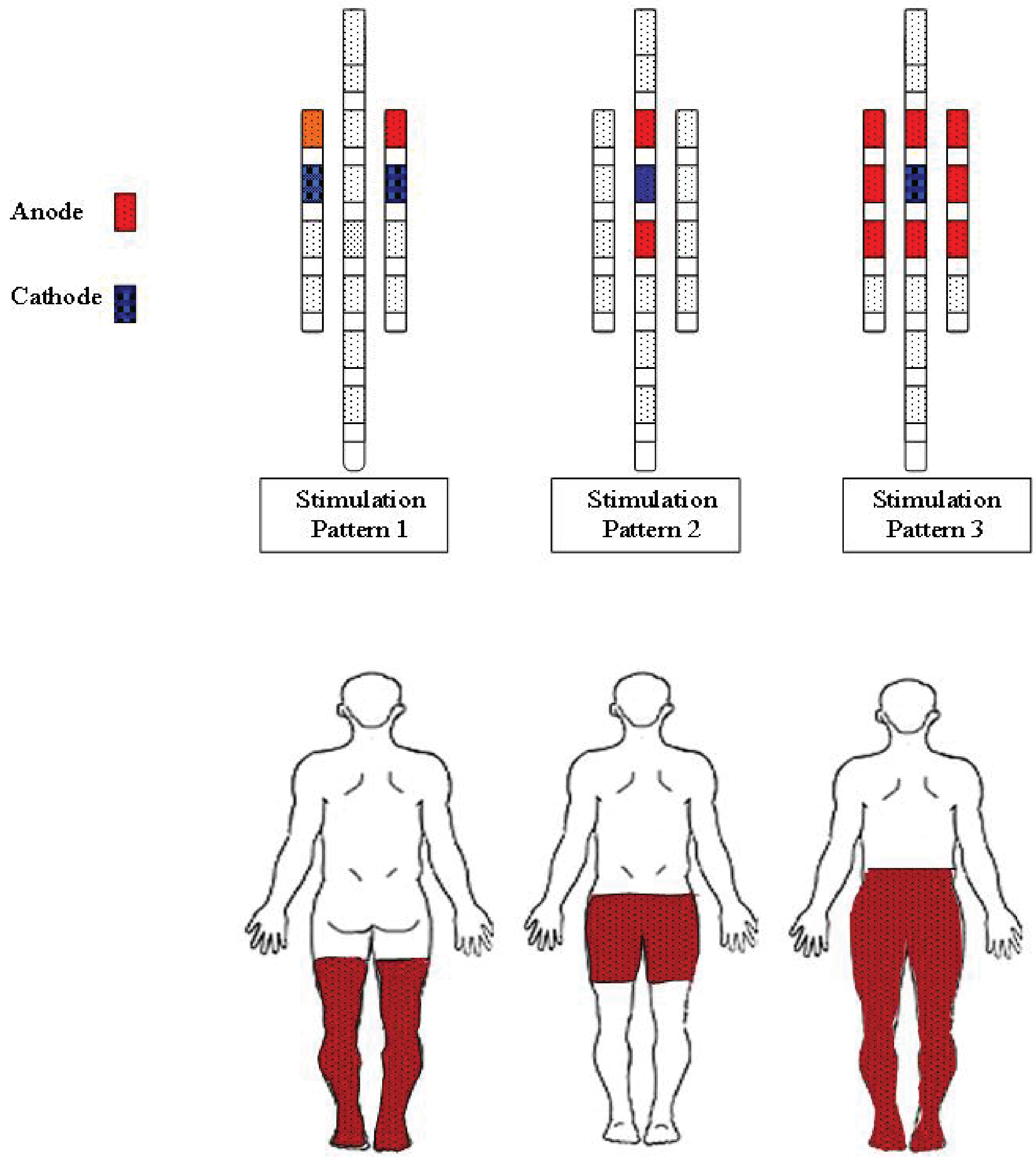

Fig 2. *Lead stimulation patterns and regions of paresthesia with tripolar electrodes.*

model of a transverse tripolar pattern, which shows significant dorsal column recruitment by enabling the current stimulus to the spinal cord to provide pain relief to the lower back (6). This system uses an independent-amplitude lead stimulation pattern for pain relief of the lower back and extremities. The transverse tripolar system consists of a central cathode surrounded by anodes using 3 leads arranged in a specific fashion (6). Transverse tripolar stimulation can be employed, with one octapolar compact lead and 2 standard quadripolar leads, forming a unique 4-8-4 pattern (Fig. 2). Currently most pain physicians use 2 electrode leads and anchor them in an optimal fashion to prevent lead migration. In patients undergoing permanent transverse tripolar SCS, adequate surgical exposure of the muscles and fascia needs to be established for proper anchoring of the 3 leads in the specific fashion as shown in Figs. 1A-C. The anchors were placed around the lumbar region L1 region and were sutured to the deep ligamentous tissue.

For a successful outcome, it is vital to obtain the correct paresthesia coverage. Paresthesia is a tingling sensation that is felt in those dermatomes related to the activated spinal cord area. When SCS systems are implanted for pain management, the complete painful area should be covered by paresthesia (7). Electrical stimulation from the SCS depends on the conductivity of the intraspinal elements in relation to the lead position. The contact arrays are placed in the epidural space opposite the dorsal columns parallel to the spinal cord. The longitudinal cathode position is more important than the arrangement of anodes in a linear array to attain an adequate recruitment threshold for neuronal activation. To aid in the evaluation of electrical stimulation, computer models with electrical fields and current densities are extremely helpful (8). A single lead with the cathode optimally placed can lead to dorsal root stimulation (9), however, placement of dual leads can lead to double stimulus rate activation in dorsal column areas that receive stimuli, leading to new patterns of stimulation and wide areas of nervous tissue activation. The parallel orientation and medial location of nerve fibers in the lumbar dorsal columns favors the use of leads parallel to the axis of the spinal cord (10). The deepest penetration of the cord without creation of a wider electrical field is produced by a technique of "guarding." When the cathode is in the center and is surrounded by anode configuration (as in this patient –tripolar stimulation), the cathodal field is prevented from expanding beyond the anode on either side. This configuration leads to the best recruitment ratio of the dorsal column to the dorsal root fibers, with minimal motor effects (11,12). Stimulation of the dorsal roots not only elicits segmental paresthesia but also provides a reflex muscle contraction which makes it very uncomfortable to the patients.

There has not been any head-to-head comparison between the tripole laminotomy lead technique and the percutaneous tripole leads that we used. However, the obvious disadvantage with the laminotomy leads is the need to do a thoracic laminotomy and the more extensive surgical trauma, with the associated complications. A multicenter study with a paddle-type tripolar lead inserted following laminectomy has been evaluated for neuropathic pain patients (13).

Conclusion

Although previous reports have attempted to determine the perception thresholds and field of pain using a transverse tripolar system (14), 2 different controllers for multiple electrodes were used which may have contributed to poor success (15). This current case report is unique in describing a case of a patient with use of transverse tripolar stimulation with a single stimulator module and 3 leads arranged in a specific fashion to provide excellent pain relief to the low back pain area. Previous prospective studies with SCS in FBSS patients have provided better pain relief for the legs compared to the low back (16).

The current availability of octapolar, quadripolar, and extension devices that can connect into a single stimulator module may make the transverse tripolar system an attractive option for FBSS patients but greater back than leg pain, however no conclusions can be made on the basis of a case report.

References

1. Guyer RD, Patterson M, Ohnmeiss DD. Failed back surgery syndrome: Diagnostic evaluation. *J Am Acad Orthop Surg* 2006; 14:534-543.
2. Shealy CN, Mortimer JT, Reswick JB. Electrical inhibition of pain by stimulation of the dorsal columns: Preliminary clinical report. *Anesth Analg* 1967; 46:489-491.
3. Simpson RK, Robertson CS, Goodman JC. Segmental recovery of amino acid neurotransmitters during posterior epidural stimulation after spinal cord injury. *J Am Paraplegia Soc* 1993; 16:34-41.
4. Barolat G, Massaro F, He J, Zeme S, Ketcik B. Mapping of sensory response to epidural stimulation of the intraspinal neural structures in man. *J Neurosurg* 1993; 78:233-239.
5. Holsheimer J. Effectiveness of spinal cord stimulation in the management of chronic pain: analysis of technical drawbacks and solutions. *Neurosurgery* 1997; 40:990-999.
6. Struijk JJ, Holsheimer J. Transverse tripolar spinal cord stimulation: Theoretical performance of a dual channel system. *Med Biol Eng Comput* 1996;34: 273-279.
7. Barolat G. Current status of epidural spinal cord stimulation. *Neurosurgery Quarterly* 1995; 5:98-124.
8. Holsheimer J, Wesselink WA. Effect of anode-cathode configuration on paresthesia coverage in spinal cord stimulation. *Neurosurgery* 1997; 41:654-660.
9. Holsheimer J, Struijk JJ, Tas NR. Effects of electrode geometry and combination on nerve fibre selectivity in spinal cord stimulation. *Med Biol Eng Comput* 1995; 33: 676-682.
10. Smith MC, Deacon P. Topograpical anatomy of the posterior columns of the spinal cord in man. The long ascending fibres. *Brain* 1984; 107:671-698.
11. Prager J, Ross EL, Wesselink WA. Spinal cord stimulation using a midline cathode has a better dorsal column recruitment ratio. *Anesthesiology* 2006;A709.
12. Caraway D, Miyazawa G, Greenberg J, King G. A midline single cathode offers preferential dorsal column recruitment with spinal cord stimulation. *Anesthesiology* 2006;A172.
13. Oakley JC, Espinosa E, Bothe H, McKean J, Allen P, Burchiel K, Quartey G, Spincemaille G, Nuttin B, Gielen F, King G, Holsheimer J. Transverse tripolar spinal cord stimulation: Results of an international multicenter study *Neuromodulation* 2006; 9:192–203
14. Struijk JJ, Holsheimer J, Spincemaille GHJ, Gielen FLH, Hoekema R. Theoretical performance and clinical evaluation of transverse tripolar spinal cord stimulation. *IEEE Trans Rehab Eng* 1998; 6:277- 283.
15. Slavin KV, Burchiel KJ, Anderson VC, Cooke B. Efficacy of transverse tripolar stimulation for relief of chronic low back pain. *Stereotact Funct Neurosurg* 1999; 73:126-130.
16. Barolat G, Oakley J, Law JD, North RB, Ketcik B, Sharan A. Epidural spinal cord stimulation with a multiple electrode paddle lead is effective in treating intractable low back pain. *Neuromodulation* 2001; 4:59-66.