

# BLOCKING OUT THE PAIN

## Electric nerve block treatments for *sciatic neuritis*.

**N**erve blocks are procedures during which an anesthetic agent is introduced or injected to interrupt nerve impulses.<sup>1</sup> Two of the most used medical dictionaries (Taber's<sup>2</sup> and Gould's<sup>3</sup>) include electricity as a means to produce nerve block. The term 'electric nerve block' was coined by Dr. Jenkner<sup>4</sup> several years ago to describe the use of electrical impulses to create a nerve block instead of injecting an anesthetizing agent into the site.

Electric nerve blocks (ENBs) represent a long tradition of the use of electricity in medicine<sup>5</sup> along with electrocardiography (EKG), electroencephalography (EEG), electromyography (EMG), transcutaneous electrical nerve stimulation (TENS) for low back pain, electroconversion therapy (ECT) for depression, dorsal column stimulators (DCS) for chronic pain control, bone growth stimulators after orthopedic surgery, and neuromuscular stimulation for disuse atrophy — all capitalizing on the electrical properties of the human body.

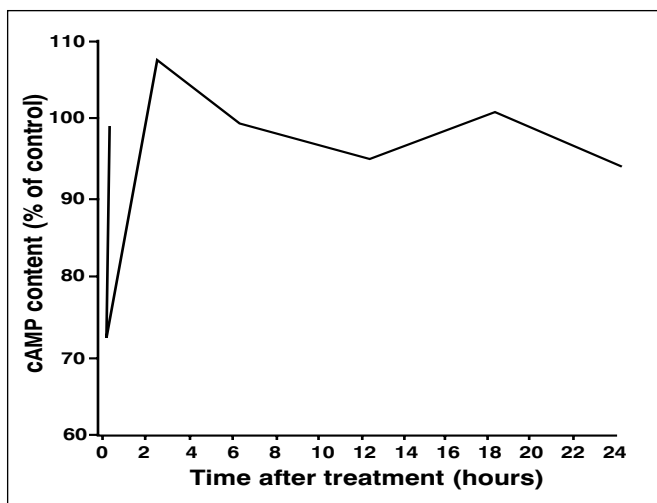


FIGURE 1. Cellular cAMP content of cells as a function of time after treatment.<sup>8</sup>

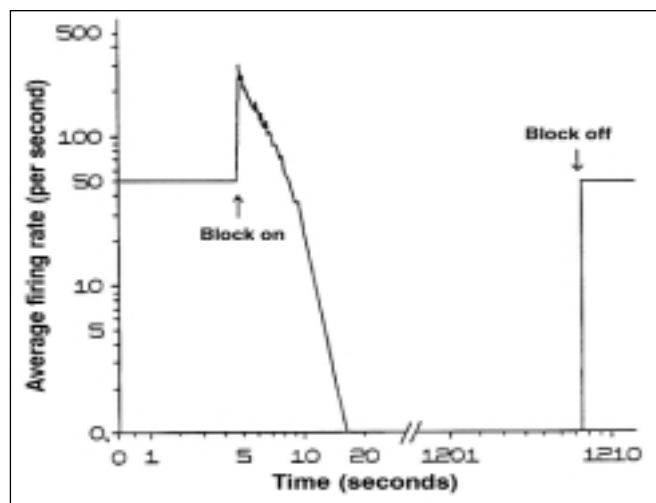


FIGURE 2. Single fiber average firing rate while stimulating at 60 pps and blocking at 4,000 pps.<sup>9</sup>

The utilization of electrodes to produce high frequency electrical impulses to create numbness in a localized area requires correct medical diagnoses and knowledge of the physiologic mechanism of ENBs to optimize outcomes. Pain nerves typically repolarize — i.e., get ready to fire again — at a frequency slower than 1/1000 sec. Thus, the absolute minimum blocking frequency must be 1,000 Hz or greater; typically 4,000 to 20,000 Hz is used. Such frequencies prevent the pain nerves from repolarizing and firing repeatedly and instead achieve a neural blockade (nerve block). The efficacy of nerve blocks is illustrated by Hardy, et al<sup>6</sup> in performing surgery while blocking sensory nerve impulses with electricity.

Electrical energy at the optimum frequencies (4,000 to 20,000 Hz) penetrates and conveys more energy to the neurons because of the lower impedance at these

frequencies<sup>7</sup> and has an intra-neuronal effect on cyclic adenosine mono-phosphate (cAMP) activity. cAMP is an intracellular second messenger which transmits signals for cell activity. Knedlitschek, et al<sup>8</sup> showed that intracellular cAMP is depleted after being subjected to 4,000 Hz of electrical energy at adequate voltage (see figure 1). The steep initial decrease in cellular cyclic AMP (adenosine monophosphate) is consistent with these molecules being used by the cell for metabolism.

Note that the data presented in figure 1 was the result of an electrical treatment at 1 volt and a frequency of 4,000 Hz over a period of 3 minutes. The result was a 28 percent depletion of the available cyclic AMP. A typical ENB treatment with a duration of 8 to 20 minutes would be expected to completely expend the cAMP supply.<sup>8</sup>

Bowman<sup>9</sup> has shown that frequencies

in the range of 4,000 to 20,000 Hz result in interruption of nerve firing (see figure 2). Wyss<sup>10</sup> has shown that these frequencies also result in sustained depolarization. Both of these phenomena are, by definition, nerve blocks, which result from voltage gated channels being kept open. There is an electrical energy threshold that must be exceeded for nerve block to occur. At optimal frequency and sufficient voltage, nerve firing completely stops even when being simultaneously stimulated.<sup>9</sup>

### Clinical Results

This study summarizes 3,527 ENB treatments performed by the author, with the vast majority of the treatments resulting in significant, immediate improvement in pain as measured by verbal response scores (VRS). Figure 3 groups patients into treatment outcomes with the criteria calculated as a percentage improvement (the after-VRS score subtracted from the before-VRS score, then divided by the before-VRS score). Histograms 1 thru 6 reflect the “improvement percentage” groupings which are commonly used in electromedical literature.<sup>7</sup>

Group 1 patients, reflecting about 1 percent of the population, reported negative improvement though none had any visible consequence of the ENB treatment. Group 2 patients (about 8 percent of the total) reported exactly the same verbal pain score before and after treatments. The remainder of the patients (groupings 3 thru 6) reported pain improvements ranging up to 100%. Those patients reporting improvement less

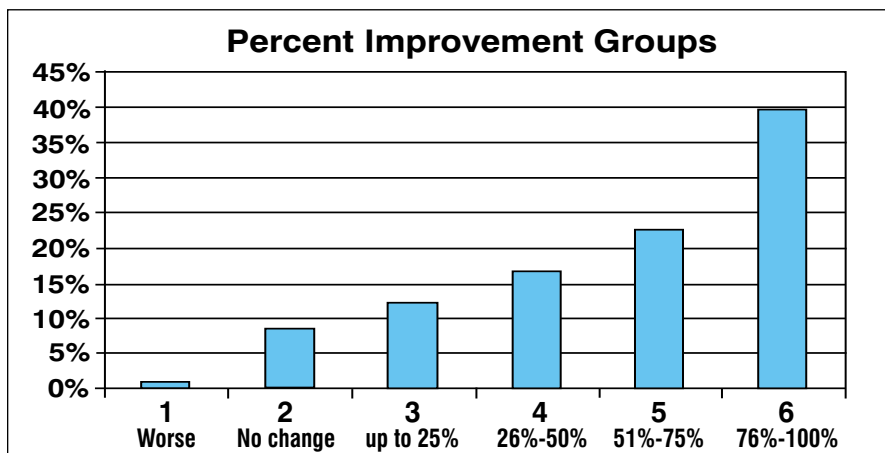


FIGURE 3: Data recorded by the author over the course of 3,527 treatments.

than 50 percent comprised 38 percent of the total; those patients reporting at least 50 percent improvement comprised 62 percent of the total.

The remainder of this article will focus on the electromedical treatment of the sciatic nerve utilizing electric nerve blocks and will serve as an example to explore the important concepts applicable to ENBs in general. The sciatic nerve illustration has several advantages in that there are no nearby complicating structures, chemical nerve blocks are infrequently used, and other treatments are typically not successful.

### Neuroanatomy of the Sciatic Nerve

The sciatic nerve is the finger-sized confluence of the nerve fibers that comes mainly from the L4, L5, and S1 nerve roots and courses through the lumbosacral plexus inside the pelvis to exit at the sciatic notch. It then passes under and perpendicular to the piriformis muscle posterior to the hip joint on its way down the leg. This nerve bundle splits into the common peroneal and tibial nerves just superior to the popliteal fossa. There is a concentration of sympathetic fibers on, and in, the sheath of these lumbosacral nerve roots and the sciatic nerve itself.

### Pathophysiology of Sciatic Nerve Pain

The primary pathology of sciatic nerve pain almost certainly involves malfunctioning sympathetic C-fibers<sup>7</sup> and probably the A-delta fibers. While mechan-

ical impact resulting in motor and sensory nerve damage may be a causal factor, fiber damage and/or irritation from other sources can also occur. In fact, it is suspected that nerve pain may indicate

*“Electric nerve blocks can be effective when the pathology directly involves the sciatic nerve and the ENB is utilized as one of multiple tools in a comprehensive medical treatment program.”*

that small fiber damage may be present even when electromyographic and nerve conduction studies of the motor (A-alpha) and sensory (A-beta) nerve fibers appear normal.

### Primary Indicated Diagnoses

Blocking nerve signals along the sciatic

nerve, or the sympathetic C-fibers and A-delta fibers that coat it, is a logical treatment for a number of conditions, including:

- sciatic neuritis
- sciatic notch pain
- piriformis syndrome pain
- sacroiliac pain
- lower extremity reflex sympathetic dystrophy (RSD) pain
- lower extremity causalgia pain
- lower extremity myofascial pain syndrome
- lower quadrant sympathetic pain
- buttocks pain
- posterior leg pain
- posterior leg sympathetic pain
- sciatica

The latter, sciatica, describes a clinical situation where pain is perceived as coming from the distribution of the sciatic nerve in the leg and is erroneously used to describe pain caused by disc impact on the L4, L5 and/or S1 nerve roots. If the pathology is not within the sciatic nerve, the best electrical treatment may be something other than the electrode placements described here.

Each of the other conditions listed is a diffuse pain condition that, if more focal and distal, may suggest more focused treatments to the peroneal or tibial nerve distributions. Note that ENBs treat pain, not necessarily the underlying pathology. Nerve blocks are designed to provide a “window of opportunity” for the body to heal itself, for therapy, or for surgery.

### Diagnostic Considerations

Electric nerve blocks can be effective when the pathology directly involves the sciatic nerve and the ENB is utilized as one of multiple tools in a comprehensive medical treatment program. ENB treatment is not directly used to treat lumbar nerve roots disease caused by lumbar disc problems.

Sciatica should describe pain as a result of irritation of the sciatic nerve. Unfortunately, sciatica has come to refer to generic pain running through the buttocks and down the back of the leg. L4, L5, and S1 radiculopathies all may be less precisely called sciatica. Sacroiliac joint (SIJ) pain can be fairly similar to sciatic pain if the pain is in the upper leg, but usually tends to follow the L4 dermatome, and SIJ maneuvers tend to be positive.<sup>11</sup>

While sensory nerve testing may sup-

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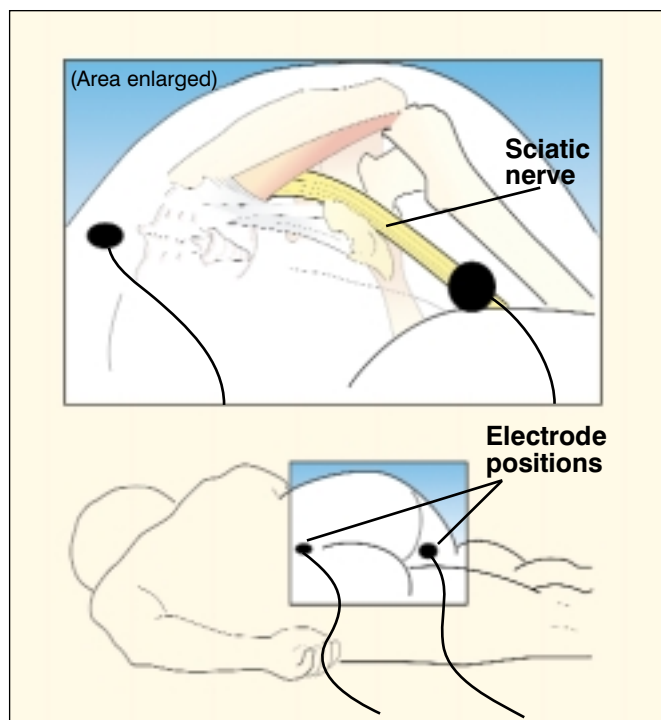
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**FIGURE 4:** *Electrode placement for ENB of sciatic nerve after a figure in reference 17.*

port the C-fiber and A-delta fiber pain manifested by reflex sympathetic dystrophy (RSD), causalgia, etc., these diagnoses are basically deduced from the patient's history, physical examination, and clinical observations. Burning pain, characteristic of these sympathetic pains, comes from the C-fibers that coat the nerve trunks and other tissue planes, while the sharp, lacerating pain comes from the A-delta fibers.

### Treatment Considerations

Electromedical treatments are preferable to chemical nerve blocks especially when it is difficult to locate the pathology or when the pathology is widespread along the length of the sciatic nerve. This is especially true in the treatment of the likely pathology in patients lacking neurologic or orthopedic clinical findings. It is easier to proceed in advanced cases of these problems since electromedical treatments present low risk factors. If the electromedical treatments work, then these diagnoses are supported, and the treatment plan and prognosis can be better determined.

When scar tissue is present from prior chemical nerve blocks, the scar tissue acts as insulation so that typical placement of ENB electrodes may not be successful in achieving neuron blockade and pain relief. In this situation, an electromedical Bier block, which involves bathing the whole limb with electricity at the frequencies previously mentioned, can be done with minimal risk. Because local widespread inflammation is often involved, the concept of bathing nerves along tissue planes throughout the area of pain with electric current makes sense and helps the treating practitioner and patient realize an immediate reduction in pain and near-term accelerated recovery.

In the face of allodynia and hyperesthesia, electromedical treatments and other therapy may also directly help decrease disuse atrophy and actually cure some diseases, which other-

wise may cause muscle atrophy, skin color changes, and functional decreases in strength and range of motion.

If the so-called "sciatica" is actually an L4, L5, and S1 radiculopathy, then selective nerve root blocks are more indicated, whether done electrically or chemically. Pathology located more distal may be adequately treated with a sciatic nerve block.

### Targeted Tissue

Given the anatomy of the sciatic nerve, electrode placement becomes one of optimizing the amount of electrical energy concentrated on the hypothesized pathology. While neuron blockade can occur by bathing at least five centimeters of the length<sup>12</sup> across the sciatic nerve, it really makes more sense to treat along the length of the nerve.

The nerves, being the 'wires' of the body and having relatively low impedance, facilitate concentration of the electrical energy. Placing the electrodes as shown in Figure 4 makes the path of least impedance be along the sciatic nerve. This placement may be more effective than across the nerve since a greater length of the sciatic nerve is involved. It is also possible that the electrode placement will vary for patients with different body habitus. However, this general placement should, in the majority of cases, direct the electrical current along the sciatic nerve, optimizing the chance for nerve block, and pain relief, to occur.

Most chronic pain conditions include malfunctioning sympathetic C-fibers, and often A-delta fibers. It is well known that there are numerous C-fibers, which are unmyelinated (un-

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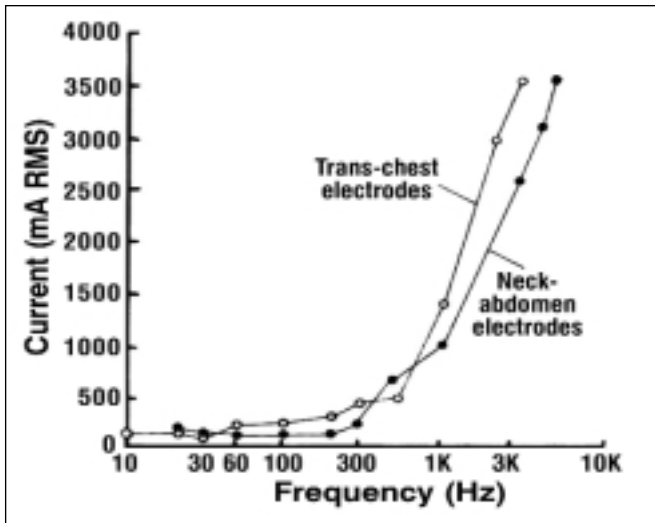


FIGURE 5. Threshold for ventricular fibrillation as a function of current intensity and frequency.<sup>16</sup>

sulated), and A-delta fibers, which are small myelinated fibers around the sciatic nerve.<sup>13</sup> Therefore, it makes sense that ENBs should be very effective in providing immediate pain relief and potentially promoting recovery of any C-fiber pathology and malfunction.

It is hypothesized that a pair of electrodes positioned on either side of the main pathology and longitudinally along the nerve length, together with a second set of electrodes across the pathology would provide additional benefit. An interferential beat frequency will concomitantly be set up at the intersection of the currents on the sciatic nerve; the beat frequency may be more beneficial than TENS treatments due to the higher carrier frequency (usually 4,000 Hz).

### Presumed Conduction Pathway

Experience and basic physical principles strongly suggest that the electric current does not merely track just below the skin surface. The current penetrates the skin and passes by volume conduction to sympathetic nerve C-fibers and A-delta fibers, mostly on the surface of the sciatic nerve. These small nerves are the paths of lowest impedance because they are relatively un-insulated, and since they contain ionic fluid, transmit electrical energy according to cable theory.<sup>14</sup>

There is scatter of the electric current as it passes through the skin and other tissue interfaces on the contralateral low back and the ipsilateral posterior thigh distal to the buttocks. One can imagine a fuzzy cylinder of current following a fairly direct path from electrode to electrode, however the full current is strongly interrupted by high impedance bone.

Voltage-gated channels of the sympathetic C-fibers exposed to sufficient electric energy will be blocked within fifteen minutes; to maximize the blockade, 20 minutes has become the standard.<sup>7</sup> The time to onset of analgesia is similar to the times necessary for local chemical anesthesia to occur.<sup>12</sup>

### Small (Targeting) Electrode Placement

Palpating the lumbar midline and the iliac crest helps the practitioner in placing the proximal, small electrodes over the contralateral L4, L5, and S1 nerve roots in the lower spinal col-

umn. The buttock crease on the pathologic side should be easy to identify before and at the time of placement (see figure 4).

The relatively small (2 to 3 cm in diameter), targeting electrode should be a medium-to-small, self-adhesive, sponge and/or vasopneumatic device. It should be placed 3-4 centimeters left of the lower lumbar midline at the height of the posterior superior iliac crest (see figure 4). The electric current will enter the pathway along the contralateral lumbar nerve roots immediately across the spinal midline to the ipsilateral roots (bone of the vertebral column is a poor conductor) on down toward the large (dispersal) electrode.

If a second set of electrodes is used, the small electrode should be placed over the sciatic notch so that the electric current traverses the sciatic nerve on the current's way to the dispersal electrode.

### Large (Dispersal) Electrode Placement

The relatively large (3 to 5 cm in diameter) dispersal electrode should be a medium-to-large self-adhesive, sponge and/or vasopneumatic device. It should be placed below the buttock crease in the posterior thigh midline (see figure 4). Depending on the extent of the affected sciatic tissue, this electrode can be placed anywhere on the back of the thigh down to the popliteal fossa.

If a second set is used, the dispersal electrode should be placed on the ipsilateral hypogastric area or on the proximal, anterior thigh. One can choose a medial angle over the sciatic notch so that the electric current traverses the sciatic nerve on the current's way to the dispersal electrode. The correct placement of the targeting electrode is determined by the dispersal electrode placement. Absent high-impedance obstacles such as bone, one can visualize the electrical pathway as a straight line between the electrodes and passing thru the target nerve. Electrical current will traverse the shortest distance and/or lowest impedance pathway.

### Treatment Procedure

The practitioner sets the intensity to tolerance during the first 30 seconds of the treatment. Turning the intensity up during the treatment may result in damage to the insensate skin from the nerve block itself. The ideal treatment lasts for 20 minutes and should be a frequency of around 15 kHz (anywhere between 4,000 and 20,000 Hz will do). Sweeping across bands of frequencies within this range appear to result in the recruitment of a wider band of nerve fibers, thus, causing more complete cessation of pain and discomfort.

### Evaluative Methods and Limitations

Nerve blocks utilized to block sympathetic fibers, whether electromedical or chemical, affect skin temperature by blocking the efferent sympathetic C-fibers to the small arterioles, distally. Comparing thermal gradients before and after treatment can be helpful in documenting the effectiveness of the treatment in blocking these fibers.

Multiple psychological studies have proven that visual analog scores (VAS) and verbal response scales (VRS) are valuable reflections of the effectiveness of these treatments. Likewise, subjective observations of appearance, motion, and function can also provide useful information in evaluating clinical results.

### Concomitant Effects/Benefits

The frequencies utilized in ENBs carry the electrical signal and energy thru the nerve cells and likely stimulate intra-neural cAMP<sup>8</sup> activity. cAMP then relays the message to open the voltage-gated channels and to start other metabolic activity. This sequence can be described as direct normalization of the neural cell function, which directly reverses sensitive pain feedback circuits. In other words, without repeated peripheral re-exacerbation, these electromedical treatments have the potential to cure the pain pathology. Dr. Hans Jurgen coined the term “multifacilitory stimulation” to describe these intracellular results and other benefits of electromedical treatments at frequencies greater than those that stimulate nerve firing.<sup>15</sup>

In comparison to chemical nerve blocks, ENBs avoid inserting a needle through other tissue and into the sciatic nerve and thereby eliminates risks such as injected fluid dissecting along the wrong tissue plane (resulting in no effect) or the creation of new scar tissue at the site of fluid injection.

### Precautions

In the practice of electromedicine, avoiding conduction through the carotid sinus is logical and appropriate, yet risk is minimal for a couple of reasons. Basically, the cardiac system operates at one cycle per second (normal heart rates are 60 to 100 beats per minute), whereas the electromedical equipment generate alternating currents at a frequency of at least 4,000 Hz. Research<sup>16</sup> has shown that the higher the frequency, the lower the problem (see figure 5). On the other hand, as the total electrical energy increases, the chance of overriding the natural frequency increases. This possibility is limited by skin sensitivity, and thus the total energy injected is proportional to the area of the electrode.

The Federal Drug Administration (FDA) strictly controls the amount of voltage and current that can be safely applied to the human body. The maximum labeled current for currently-marketed equipment is 100 mA (milliamperes). For the frequencies used to achieve nerve block (typically 4,000 Hz to 20,000 Hz), it would require 20 times that electric current (2,000 mA) to cause ventricular fibrillation of the heart, even when electrodes are placed directly cross the heart.<sup>16</sup>

### Risks/Side Effects

Because the total electrical current going through both the small and large electrodes is the same, the critical variable is the current density.<sup>7</sup> The so-called targeting electrode can then be considered to concentrate electrical energy at the targeted nerve(s). The practitioner should know that the point in the circuit with the greatest current density is at the skin surface beneath the electrode and the potential exists for skin burns — especially for small, self-adhesive electrodes. However such occurrences are rare to nonexistent when sponges are used as electrodes.

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### Treatment Course

Daily electromedical sessions for three weeks should result in positive outcomes in a vast majority of cases, as long as the peripheral pathology is being treated at the same time.

The author and his colleagues have found that the first five treatments, if done within two weeks, should result in tangible benefits. As stated and shown previously (figure 3), few patients get worse; most get better. Absent noticeable benefit, the practitioner should move on to other treatment alternatives. Experience has shown that an average of 10 to 15 treatments, separated by three days or less, are necessary to achieve optimal or

maximal benefit. Longer intervals between treatments usually make more treatments necessary.

Better results are obtained when combined with adjunctive therapy, such as nutritional support, modalities, therapeutic exercise, chiropractic manipulations, chemical injections, psychological techniques, etc. Frequent reassessment improves outcome because the practitioner can make adjustments in the electromedical or adjunct care. Subjective (pain scores) and functional (ROM, MMT, etc.) assessment should both be done periodically, immediately before and after the ENBs.

### Discontinuation

Negative and/or limited results may be cause for re-evaluation. Three consecutive treatments without an indication of improvement is probably enough to cause the practitioner to review the entire case and re-evaluate the diagnosis. Absent effective treatments of the pain-generating pathology, further electromedical treatment can be postponed until there is a better chance of reversing the neurogenic pathology.

Temporary improvements commonly result from these treatments. This type of outcome occurs more often than a complete cure. A revised treatment combination or completely different approaches may be necessary if the ENB treatments cause more pain, are too temporary, or appear to have no effect.

If improvements plateau, peripheral pathology may be the limiting factor. If the pain is chronic, central components are probably also present. For chronic pain conditions, the goal of ENBs is a generally decreased level of pain and improved function. ENBs and other electrotherapeutic techniques possess documented central effects that can be useful in medical care of these patients.

### Results

The following are summary results experienced by the author while performing electrical nerve blocks on the sciatic nerve over the past five years.

- Overall, for any single ENB, 80% of the treatments achieve at least 25% improvement.
- Only a few patients get complete immediate permanent relief in one treatment.
- Over half of the patients treated

achieve a successful outcome (maintained improved function and perceived decrease in pain) over a course of 5 to 15 treatments.

■ Individual variation occurs in all circumstances, yet some short-term relief occurs in more than 80% of these cases with 20% reporting complete immediate relief.

■ The average duration of relief is one to three days. Some experience only a few hours of relief; an occasional subject will be essentially cured. Recurrence depends on actual pathology, patient activities and concomitant treatments.

■ A successful course of treatment usually shows gradual improvement towards maintaining improved function and a perceived decreased level of pain. Less than two percent of patients will have worsened pain and discomfort due to toxic substance release.

### Exceptional Possibilities

Because of the low risk profile, these ENBs can and should be used for maintenance care. Unlike chemical nerve blocks, ENB treatments stimulate cyclic AMP in the cells (see figure 1), which not only opens the voltage-gated channels, but also stimulates normalization of cell function. These treatments should therefore work especially well for neurogenic pain. Sympathetic pain, including all the diagnoses listed above, is mostly neurogenic dysfunction and the resultant pain of the sympathetic nerves. These electromedical treatments include the scientific potential of being a cure for these disease conditions in and of themselves.

### Potential Pitfalls

Without visible tissue changes and improvement in the pain, there may not be a peripheral pain generator. Blockade of the sciatic nerve is difficult to confirm, because the pain pathways can be missed; these pathways may not always follow along the outside of the sciatic nerve.

Trauma from needles used in chemical nerve blocks and the caustic effects of those chemicals cause scar tissue accumulation. If multiple previous chemical blocks have preceded ENBs, the resultant scar tissue around the sciatic nerve will likely interfere with penetration of the electric current to the sympathetic C-fibers.

A misdiagnosis of sciatic nerve pathol-

ogy, when the correct diagnosis is actually a lumbar nerve root pathology, will yield less than expected results from these electrode placements. One would thus expect positive results only if these roots are stimulated by low, more distal nociception or by more distal non-nociceptive signals. The pain could be at both the lumbar nerve roots and the sciatic notch, leaving only half relief or quick recurrence.

When the pathology is actually a radiculitis and the larger electrode is over the lumbar roots, the current density will have likely been too low to promote neuron blockade. If the sympathetic nerve damage is more distal, patients may get pain relief without changing the pathology.

If sacroiliac joint (SIJ) sprain/strain is the cause of the pain, the pathology could be proximal to the sciatic notch and thus this treatment may not work well. It is difficult for the patient to immobilize the involved tissue, making recurrent pain expected.

Severe-to-acute central and sympathetic pain cases may result from anatomical and physiologic changes in central nerve system neurons and are clinically similar to phantom pain. Deafferent or central hypersensitivity syndrome respond poorly or not at all to peripheral procedures of any type. It is not impossible for central pain to occur with changes in the neurons of the dorsal horns, in the spinal pain tracks, and/or in the brain, in subcortical pathways and in the sensory strip. Psychogenic pain of various forms may also bring complaints of unchanged or worsened pain.

### Summary Conclusions

Electric Nerve Blocks, utilized in conjunction with other medical procedures, are powerful tools to treat the pathology and pain originating from the sciatic nerve and its downstream distribution. ENBs are less risky than chemical blocks since the possibility of scarring at injection sites is eliminated. ENBs are useful supplemental tools for patients presenting with pain.

In order to maximize outcomes utilizing electric nerve blocks, practitioners must be able to:

- Diagnose pathology involving the sciatic nerve.
- Develop a treatment plan with the patient that may include ENBs to the

sciatic nerve.

- Use appropriate equipment.
- Correctly place the electrodes.
- Document treatment and outcomes, including before and after pain scores.
- Provide supplemental medical advice and care. ■

*Dr. James Woessner holds a doctorate in bio-science in conjunction with a medical degree. His professional training includes neurology and physiatry. He has administered over 4,000 electric nerve blocks since pioneering these procedures in 1997. Dr. Woessner may be contacted at Advanced Phys Med, 3628 50th Street, Lubbock, TX 79413; 806-780-2080.*

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