Case in Point

Pulsed Radio Frequency Energy for the Treatment of Phantom Limb Pain

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Phantom limb pain can be difficult to treat and is not always relieved by conventional therapies. Following treatment with pulsed radio frequency energy, a patient with an above-knee amputation experienced immediate and significant pain reduction.

Phantom limb pain (PLP) is one of the most difficult and puzzling challenges faced by patients after limb amputation. Postamputation sensation in the missing limb has been described since the 16th century.[1] Almost all individuals who have had an amputation have a sensation of a phantom limb, including some with congenital absence of a limb or spinal cord injury affecting sensation.[2-5] Many patients report not only sensation, but also pain in the phantom limb; in about half these patients, the pain may be moderate to severe and for some may become chronic.[6,7] Several theories about the etiology of PLP have been offered, including peripheral, spinal, central, and psychological.[2] All seem to have some merit, and it is likely they may synergistically contribute to persistent pain.

Optimal treatment of phantom pain has proven to be elusive, since what works for one patient may have no benefit for another. Treatment regimens over the years have included medications, such as nonsteroidal antiinflammatory agents, narcotics, anticonvulsants, antidepressants, different types of nerve and regional blocks, nerve ablation, electrical nerve stimulation, and psychological treatment. No single technique has proven to be effective in all patients.

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Pulsed radio frequency energy (PRFE) has been used in recent years for the treatment of chronic pain associated with debrided wounds, pain after surgery, and intractable pain.[8-11] This case involves a patient with an above-knee amputation and severe PLP of long duration in whom conventional therapies (multiple narcotics, neurologic, and psychotropic medications) failed to relieve the patient's symptoms. After PRFE to the residual limb area, the patient experienced an immediate and significant reduction in pain.

CASE REPORT

A 59-year-old male with diabetes mellitus, coronary artery disease, and severe bilateral peripheral arterial disease (PAD) was well known to his VA vascular service. He presented with severe PLP. The patient had a complicated surgical history, which began 5 years earlier with surgical treatment for severe claudication, with rest pain in both lower extremities. Initial surgeries involved the left lower extremity and included a left femoral-popliteal bypass with a Gore-Tex graft, right iliac and femoral endarterectomies, left groin exploration and profundoplasty, right groin exploration, right iliofemoral artery bypass, an aortobifemoral bypass, followed by bilateral femoral thrombectomies. Despite these procedures, he required higher levels of amputation for ongoing ischemia. He ultimately underwent a left above-knee amputation. Extended treatment of his right lower extremity was finalized with a right femoral-to-popliteal bypass with a vein graft and a right transmetatarsal amputation. His last surgery consisted of the removal of an infected aortobifemoral bypass graft.

At presentation, the patient reported constant chronic, sharp, stabbing pain in the distal part of his left phantom limb. This pain had begun with the below-knee amputation and had persisted with his above-knee amputation. Previous to and contingent with the PLP, he also had severe ischemic limb pain. Pain was described as greater than 10 on a severity scale of 1 to 10. He required morphine delivered via a patient-controlled analgesia (PCA) pump with intermittent hydrocodone and oxycodone throughout the day for pain relief. After 4 weeks, the patient began refusing morphine, because he disliked the associated decrease in his mental capacity. Later, he developed severe depression secondary to the pain. He was prescribed trazodone and lorazepam. His activities of daily living were severely limited; he stayed in bed and used his wheelchair only on occasion.

The patient was started on a trial of PRFE. The device applicator was placed directly over the pain-

ful residual limb area, and treatment was administered for 30 minutes twice daily. The patient reported a marked reduction in pain within minutes after the first treatment. After 4 weeks of PRFE treatment, he reported intermittent pain that was scored as 6 on the severity scale, a level of pain that he found to be tolerable and manageable using hydrocodone or oxycodone 2 to 3 times a day as needed. With this reduction in pain, his depression also decreased, allowing him to stop antidepressant medication. The patient was able to lead a more active lifestyle, was no longer bedbound, and was working toward the fitting of a prosthesis.

DISCUSSION

PLP is a well-described phenomenon in amputees, although the cause is uncertain. Currently, the prevailing hypothesis is a central mechanism, although peripheral and spinal mechanisms also have supporting rationale.[12-18] Most likely, the cause of phantom pain is multifactorial, involving peripheral, spinal, and central mechanisms.

Usually the pain in PLP is distal and is described as cramping, stabbing, shooting, or burning.[14,15] Pain becomes disabling in up to 10% to 25% of patients.[14] For many amputees, painful experiences that occurred before the amputation (as ischemic pain) are felt as "real-time" pain in the phantom part, and peripheral factors help sustain these painful memories.[14-16,18] Stress and depression also may exacerbate the problem.[19,20]

Treatment of phantom pain is difficult because few therapies have proven to be effective all the time. Some studies suggest that the pain diminishes with the phantom sensation in the first 2 years after amputation, although not all studies agree.[15,21-23] Distinguishing PLP from residual limb pain (RLP) is an important factor in treatment. Sixty-six percent of patients with PLP also have pain in the remnant limb.[24] RLP can be caused by external factors, such as a poorly fitted prosthesis, or intrinsic factors, such as a painful neuroma, bony hypertrophy, heterotrophic bone formation, popliteal artery aneurysm, lipoma, scar tissue, infection, ischemia, or stress fracture. Complex regional pain syndrome may become a factor as well.[25] Recommended treatment for phantom pain follows similar protocols as those for neuropathic pain with medication, various nerve blocks, energy-based therapy, acupuncture, hot and cold compression, biofeedback, and other methods.[6,26] Each affords improvement in some patients, but none have proven efficacious in the long-term.[14,24]

The patient had experienced severe unremitting pain for almost 2 years. He required morphine for any pain relief but was reluctant to take it because of the secondary change in mental capacity; he later developed depression. He had undergone numerous procedures in his residual limb and groin, and it was uncertain whether RLP from continued surgical trauma or ongoing disease process was the basis of his problem. Susceptibility to PLP increases with additional surgeries and trauma. A peripheral cause was assumed in this patient; therefore, he was placed on the PRFE trial. PRFE resulted in decreasing wound pain, healing of pressure ulcers, relieving chronic spinal radicular pain, and relieving pain associated with lumbosacral spondylosis.[8-11]

METHOD

Unlike pulsed radiofrequency ablation, which disintegrates hypersensitive nerve axons through thermal burn, PRFE delivers electromagnetic energy transcutaneously, interrupting nociceptive pathways.[27] The device is portable, noninvasive, and delivers nonthermal PRFE through a spiral antenna, placed adjacent to the treatment area. The device generates pulses, 42 µsec at 1,000 times per second, creating an electromagnetic field that bathes the treatment area. The electromagnetic field has a strength of 591 V/m and a magnetic field strength of 6.4 A/m at a distance of 5 cm from the applicator. The dose is preset and self-regulated to ensure consistent therapeutic dosing. Therapy can be administered directly through clothing and bandages. Treatment generally is self-administered without nursing supervision and is performed twice daily for 30 minutes. The device shuts off automatically at the end of the 30-minute treatment.

The exact mechanisms of how PRFE works are still under investigation. In vitro studies have shown that PRFE interacts with calcium ion channels, stimulates secondary messenger systems in cells, and enhances gene expression of several key proteins involved in the inflammatory response.[28-30] PRFE may also influence transforming growth factors, their receptors, and secondary messengers, which have been shown to have a significant role in mediating nociceptive pain.[31,32] An earlier hypothesis postulated that PRFE may decrease pain by mobilizing electrical charges that surround damaged tissue.[33]

Clinical application of PRFE to relieve postsurgical pain has been well established. Guo and colleagues recently published the findings of a meta-analysis of PRFE used to treat postsurgical pain in 355 patients and

edema in 350 patients. Statistically significant clinical improvement was noted in patients receiving active PRFE treatment to reduce both pain and edema.[34]

CONCLUSION

The patient's response to treatment was immediate and significant. His depression resolved, and he was no longer bedbound. His quality of life had improved considerably, but he was never able to wear a prosthesis secondary to his severe ischemic disease. The researchers hypothesize that the reduction of peripheral inflammation and the reduction of peripheral nociception signaling helped provide this patient with rapid, significant, sustained pain relief. Currently, the patient continues to self-administer his PRFE treatment applications at home as needed for severe pain. The device used has a set treatment field strength, wavelength, frequency, and pulse pattern that cannot be modified by the patient, ensuring consistent dosing. He also receives oxycontin (twice daily) for baseline pain. He does not ambulate secondary to unresolved severe PAD. Nonetheless, he reports being happy with his current level of pain relief and activities of daily living.

Treating amputees with PLP is challenging and will probably continue to require individualized multimodal strategies. PRFE was successful in this patient and warrants further study in the treatment of PLP.

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