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Financial Sustainability of Neuromodulation for Pain

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KEYWORDS

• Neuromodulation • Pain • Financial sustainability • Cost effectiveness • Markov analysis • ICER • QALY

KEY POINTS

- Neuromodulation, especially spinal cord stimulation, has significant evidence suggesting that it is more cost effective than continued medical management and traditional spine surgery.
- Many studies of cost effectiveness have limited applicability due to assumptions made in their development, differences in health care systems and shifting technologies and costs over time.
- There is a need for prospective registries in neuromodulation and alternative therapies that include analysis of cost effectiveness.

INTRODUCTION

When considering the financial sustainability of neuromodulation for pain, one needs to consider the varying costs involved with this therapy. These can include costs leading up to neuromodulation versus costs after neuromodulation is instituted; comparisons between different types of neuromodulation; comparisons between neuromodulation and conventional therapy; and comparisons between neuromodulation and other invasive modalities, such as spinal decompression with or without fusion. In addition, any consideration of cost also needs to take quality into account. Even if a therapy is expensive, it is considered cost-effective if it leads to significant increase in quality of life and economic productivity of the patient. This review considers these questions, methodologies used to assess them, and variations between different health delivery systems.

METHODOLOGY

Early studies tended to examine costs before an intervention and compare them with costs after an intervention. If the costs increase significantly, the intervention will not seem (on the surface) to be cost-effective. However, even if the costs of health care use decreased after the intervention, it is often unclear whether the costs would have gone down anyway because of the natural history of the disease decreasing in severity over time (regression to the mean). Patients are more likely to seek an intervention when their symptoms are at their worst.

The simplest way of looking at cost-effectiveness seems to be to examine costs of care within the structure of prospective, randomized controlled trials, but these may not reflect real life situations, because patients in clinical trials tend to receive more attention and care. They have avenues to reach research coordinators and clinicians, which can obviate expensive emergency department (ED) visits and imaging. Therefore, matched cohorts of patients where one group undergoes an intervention, and another similar group does not are often considered more representative of real life. This accounts for the natural history of the disease condition. However, there are often questions about whether the groups are adequately matched. There could be reasons that one group underwent the intervention, and the other did not that are not reflected in commonly used matched characteristics that are easily captured, such as age, pain severity, race, socioeconomic class, or International Classification of Diseases-10 code. It could even be that

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the drive to seek the intervention or choose one intervention over another could positively influence outcome.

An additional issue is that costs vary among stakeholders.[1] Private insurers consider the cost of medical care, but governmental insurers may also consider loss of taxpayer revenue from inability to work and nonmedical costs, such as need for increased social support. Employers want their employees to return to work and not draw disability payments. Patients consider costs of insurance, copayments, and indirect costs, such as time that caregivers may need to take off work.

Even if the costs are higher for some period after the intervention, it may be perceived as being worthwhile for long-term improvement in quality of life. Quality of life is generally expressed as quality-adjusted life-years (QALYs), where a QALY of 1 is equivalent to 1 year of perfect health and a QALY of 0 is death.[2] There are standardized measures based on patient surveys, such as the EQ-5D (EuroQol, Rotterdam, The Netherlands), which are used to calculate QALYs.

QALYs are assigned to different outcomes. For example, the patient who gets 5 years of benefit from their spinal cord stimulator with significant improvement in pain and function is going to have a higher number of QALYs when compared with the patient who lost benefit at a year and then developed an infection, requiring explantation. Cost-effectiveness is generally expressed as the incremental cost-effectiveness ratio (ICER), defined as the difference in cost between two treatments divided by the difference in effects of the two treatments. Although the United States Affordable Care Act prohibited decisions on health insurance coverage based on cost per QALY, this is not true in other countries. Most modern industrialized nations are willing to pay $50,000 to $100,000 per QALY.

Decision trees and Markov models are developed to account for the probabilities of different outcomes of differing values. Incidences of different outcomes are varied as part of a sensitivity analysis to determine a threshold for willingness to pay (e.g., it might only make sense to cover the procedure if the complication rate can be brought lower than 5%).

Of course, the devil is in the details. There are different results for the same intervention for different indications. A therapy may not be cost-effective at 1 year but can be at 3 or 5 years (or vice versa), so duration of follow-up is paramount. Costs for treatment and implants can vary widely between countries: the average expense of a spinal cord stimulator system is CAN$21,595 in Canada and $32,882 in the United States with Medicare coverage.[3] Caution should be applied when referring to studies of cost-effectiveness that are more than 10 years old because of changes in pricing. In addition, other social issues can lead to differences in cost: the United States is an outlier in ED use. Imaging use and costs are higher in the United States. Conversely, higher rates of opioid use and abuse in the United States lead to increased disability and death, so an opioid-sparing modality, such as neuromodulation, may be particularly attractive.

SPINAL CORD STIMULATION

Most of the research done on cost-effectiveness for neuromodulation has focused on spinal cord stimulation (SCS), as nicely reviewed by Odonkor and colleagues.[3] Most analyses have been done for back and leg pain after spinal surgery, although there have also been some for complex regional pain syndrome (CRPS), peripheral arterial disease, refractory angina pectoris, neuropathic leg pain, and chronic back and leg pain without prior spinal surgery. In general, SCS was cost-effective when compared with conventional therapy, even with the higher implant and maintenance costs in the United States. There is reduction in postoperative use of physiotherapy, chiropractic treatment, massage therapy, injections, ED visits, imaging studies, and pharmacotherapy in the SCS group.[4] Despite the increased costs of rechargeable internal pulse generators (IPGs), they are generally cost-effective if the life expectancy of a primary cell is less than 4 years. The increased effectiveness and higher positive trial rate of some systems, such as those with 10-kHz stimulation relative to those with paresthesia-inducing stimulation paradigms, may make them cost-effective despite their increased cost.[5] However, these findings are somewhat suspect in that the data used to assess paresthesia-inducing stimulation were from 9 years before[6] with older technology.

Of note, there is evidence that delaying SCS therapy with nonoperative options tended to lead to decreased cost-effectiveness in addition to decreased efficacy. Patients with longer preimplant histories of pain had higher opioid use, and more frequent office visits and hospitalizations.

By examining insurance company data from 2000 to 2012 using the Truven Reuters MarketScan database (Truven Health Analytics, Ann Arbor, MI), Farber and colleagues[7] were able to identify 122,827 patients with failed back surgery syndrome with at least a year of continuous data. Truven data include inpatient and outpatient claims from 200 million patients with employer-

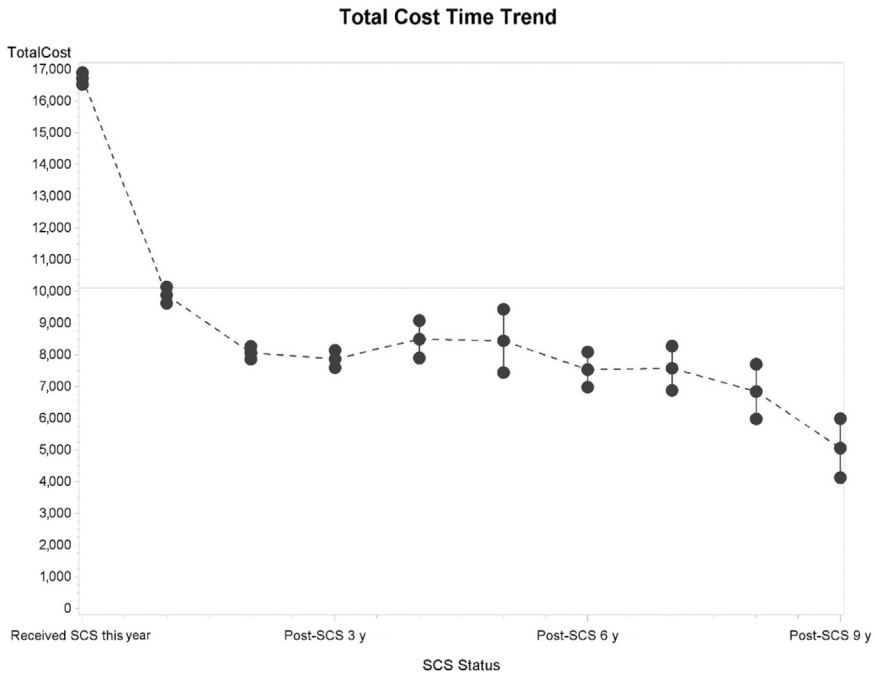

Fig. 1. Cost trends following SCS implantation for failed back surgery syndrome. (Farber SH, Han JL, Elsamadicy AA, et al. Long-term cost utility of spinal cord stimulation in patients with failed back surgery syndrome. *Pain Phys* 2017;20(6):E797-E805).[7]

based health insurance, Medicare, and Medicaid. About 4% of patients who had chronic pain after lumbar spinal surgery went on to have SCS systems implanted. Although the nature of the database precluded analysis of pain control and patient satisfaction, there was significant reduction in costs after SCS implantation, generally because of decreased health care use. The costs before implant were more than double in the subgroup who underwent SCS when compared with the conventional medical management (CMM) group, suggesting that they had more disabling pain that led to higher health care use. However, even at 1 year, the SCS group had much lower health care expenditures. These differences were maintained at 9 years after SCS implantation (**Fig. 1**).[8] It is unclear how many patients in the CMM group had expert care from pain physicians, while it is reasonable to assume that most, if not all, of those in the SCS patient group did. Therefore, it is difficult to parse whether the decreased costs associated with SCS were caused by more expert care from pain medicine physicians as opposed to the procedure itself.

Often the alternative to SCS is not CMM but repeat spinal surgery. In one systematic review,[9] 11 studies of cost-effectiveness in lumbar spinal surgery were found to be of adequate quality. At a population level, surgeries for decompression were cost-effective relative to CMM at 1 year, but surgery for spondylolisthesis only became cost-effective at 4 years. However, as other studies have noted,[10] there is wide variability in costs and outcomes of lumbar spinal surgery.

The oft-cited trial by North and colleagues[11] from 2005 prospectively randomized patients with radicular symptoms after lumbar spinal surgery to either repeat spinal surgery or SCS. The patients did not have a progressive neurologic deficit and were not grossly unstable. SCS was superior in terms of opioid use and pain relief with lower neurologic morbidity and had a lower crossover rate to the other treatment modality. Economic analysis, at least within the UK National Health System, suggested that SCS confers an additional 0.98 QALYs when compared with repeat spinal surgery, for an ICER of £6392 per QALY. Spine surgeons tend to argue against the validity of these findings because of the small sample size in the trial (n = 50) at a single center and advances in the field since then, including better understanding of sagittal balance and improved surgical techniques. However, SCS has also advanced, and now features more complex lead design and different stimulation paradigms that have led to better results.[12,13] Although it may be difficult to organize and fund an updated prospective study of SCS versus repeat spine surgery,

there is a need for registries that would enable cohort matching of such patients to update this prior analysis.

DORSAL ROOT GANGLION STIMULATION

In the industry-funded ACCURATE study, dorsal root ganglion (DRG) stimulation was compared with SCS with paresthesia-inducing stimulation paradigms in the treatment of CRPS types 1 and 2 of the lower extremities.[14] Subsequent analysis of the costs was based on MarketScan data,[15] with the assumption that the costs were the same for both technologies because they share a CPT code. The 10-year estimated costs of DRG stimulation ($153,992 ± $36,651) were higher than those associated with SCS ($128,269 ± $27,771) and CMM ($106,173 ± $27,005), mostly based on an estimate that the IPG for a DRG system would last 3.5 years and the rechargeable IPG for the SCS system would last 9 years. Clearly the costs of DRG and SCS are higher than CMM in this model, but the ICER was $34,695 per QALY gained with DRG over CMM, whereas the ICER of SCS compared with CMM was $22,084 per QALY. The difference in cost between DRG and SCS narrows because of the higher positive trial rate and increased efficacy of DRG stimulation versus SCS in the trial. When comparing DRG with SCS, the ICER was $68,095 per QALY. Thus, if cost is an issue and one considers willingness to pay as part of coverage decisions (ie, outside the United States), DRG is only favored over conventional SCS if one is willing to pay more than $68,000 per QALY. A cutoff of $50,000/QALY would favor SCS. Subsequent analyses with newer IPGs for DRG stimulation, with an estimated life of 6.5 years, make DRG much more cost-effective with an ICER of DRG versus SCS of $30,452/QALY.

However, the loss of efficacy rate and complication rate for DRG were based on the 12-month outcomes of the ACCURATE trial and expert opinion. Because this technology has not been available for 10 years, extrapolations were necessary. It was assumed that efficacy would remain stable from 12 months to 10 years. Despite clear evidence that many patients with CRPS improve over time with CMM,[16,17] costs in the CMM arm were assumed to be stable for 10 years. Thus, even though sensitivity analysis was carried out using a Monte Carlo simulation with 10,000 trials, many of the assumptions may make this analysis invalid. There is also no comparison of DRG versus paresthesia-free SCS stimulation paradigms. With advances in technology, much of the data may no longer be relevant.

PERIPHERAL NERVE STIMULATION

Peripheral nerve stimulation is an expanding field. Although first described by Scribonius Largus with Torpedo fish in 153 CE,[18] the modern era of implants for peripheral nerve stimulation began with Wall and Sweet[19] in 1967. Since then, most iterations involved directly exposing the nerve, wrapping a paddle electrode around the nerve,[18] and connecting the lead to an IPG. There were significant issues with scarring around nerves preventing normal sliding, and the potential need to cross joints to place an IPG. However, there are multiple new options for stimulation that do not involve IPGs and can be placed through a Touhy needle under fluoroscopic or ultrasound guidance.[20,21] The patient places a pad over a receiver to transmit energy to the system at much lower cost than an IPG. Because of the lack of an IPG, there is little financial justification for performing a trial before a permanent implant. Performing a lead placement with an externalized wire as a trial before implanting a permanent lead and receiver as permanent system essentially doubles the cost. In addition, because of concern about infection, the length of the trial and number of stimulation parameters that can be tried are limited.[22] Insurers are generally still requiring trials because of their lack of understanding of the finances. A cost-effectiveness analysis using claims data is sorely needed to rectify this situation.

Currently, the only available study on cost-effectiveness of peripheral nerve stimulation is for occipital nerve stimulation for cluster headache in a French registry.[23] Data for 3 months were extrapolated to 1 year with significant benefit versus CMM before implant. The average extrapolated total cost for 1 year was €1344 lower for the occipital nerve stimulation strategy with a gain of 0.28 QALY, resulting in an ICER of €4846/QALY. However, costs related to health care use could have gone down anyway because of regression to the mean. Characteristics of the French health care system may not be relevant to other countries.

DEEP BRAIN STIMULATION

The earliest examples of the use of deep brain stimulation in the 1950s were for pain.[24] However, the Food and Drug Administration withdrew approval for deep brain stimulation for pain in 1989. In response, Medtronic (Dublin, Ireland) sponsored two prospective trials to examine its efficacy. Although these trials were completed in 1993 and 1998, they were not reported until 2001, presumably because of the poor outcomes.[25] In general, only 20% of patients had positive results. The

success rate could not be significantly improved by improving patient selection.[26] Thus, although the Affordable Care Act prohibits coverage decisions based on cost, one might surmise that the low success rate and high costs of this procedure has led to lack of coverage for these patients, despite the lack of more effective alternatives in a patient population for whom this is the last resort.

MOTOR CORTEX STIMULATION

Motor cortex stimulation (MCS) has been performed since 1988 for various types of unilateral face and arm deafferentation pain, with varying results. Despite being supported by two prospective randomized controlled trials,[27,28] the efficacy in reducing preoperative pain by greater than 40% is generally thought to be about 50%.[29] The costs of the initial procedure are high, because a craniotomy is generally involved and most clinicians perform an inpatient externalized trial before committing the patient to a permanent system with an IPG.

One way to increase the cost-effectiveness is to increase the likelihood of a successful trial. MCS is more effective for facial pain, phantom limb pain, and CRPS, compared with poststroke pain or pain associated with brachial plexus avulsion.[28] Machine learning has been used to identify preoperative characteristics to increase the likelihood of a positive response to 66%.[30] However, many would find it unpalatable to deny care based on gender, which is the most important factor in this dataset in predicting response, even more than response to repetitive transcranial magnetic stimulation.

Zaghi and colleagues[31] analyzed cost-effectiveness of MCS versus repetitive transcranial magnetic stimulation and transcranial direct current stimulation. Costs were estimated based on time, salary, rent, and hospitalization-related costs, but the sources are not clear. Claims data were not used. MCS was estimated at $42,000, which seems low. ICERs were expressed as cost per unit of Visual Analog Scale. Subsequent analysis has suggested that improvements in quality of life are not wholly dependent on reduction in numeric pain scores.[32] Given the methodologic problems of this article, not much can be said about the cost-effectiveness of MCS, even though this study favored MCS.

SUMMARY

Analyses of cost-effectiveness are important in driving coverage policies. Many types of neuromodulation have been found to be cost-effective when compared with continued, ineffective therapy or other interventions. However, care needs to be taken in looking at the assumptions used in model development. Although most studies look at 2-year outcomes, that may be insufficient for accurate analyses of cost-effectiveness. With advances in technology leading to better positive trial rates and efficacy, neuromodulation may become even more cost-effective over time. Registries that include patient-reported outcomes and financial data are needed to generate matched cohort trials that can more accurately compare outcomes and help direct resources effectively.

CLINICS CARE POINTS

- Be cautious of the assumptions used in cost analyses of medical or surgical interventions.
- View old data with out-of-date technology with skepticism when trying to compare to current practice.
- Consider how applicable a cost analysis is to your medical practice environment.

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