Factors Predicting Long-Term Outcomes among Patients Treated with Spinal Cord Stimulation

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INTRODUCTION

The response rate to conventional treatment among individuals with chronic pain is poor (Sachy, 2010). While 75% of patients with chronic pain sought medical care, only 56% reported good pain relief (Shi, Langer, Cohen, & Cleland, 2007). Implantable therapies, such as spinal cord stimulation (SCS) and intrathecal pain pumps, are used in the treatment algorithm when opioids and other therapies fail to produce adequate pain relief (Golovac, 2010; Meyerson & Linderoth, 2006). SCS, also referred to as dorsal column stimulation (DCS), is an implantable device involving the positioning of an electrode in the epidural space of the spinal cord at the level of the nerve roots innervating the painful area (Brook, Georgy, & Olan, 2009). An electrical current from the electrode brings about paresthesia, a sensation that suppresses pain (Kemler, Barendese, De Vet, Van den Wildenberg, & Van Kleef, 2006). The device itself uses no medication, making SCS an attractive alternative option for many patients since their pain is largely unresponsive to their present medication regimen (Casasola, 2010). This treatment modality offers patients with chronic intractable pain another way to increase functional ability and productivity and ultimately offers a chance to regain health and improve quality of life (QOL) (Kemler et al., 2006).

SCS can reduce pain levels by 50% or more, allowing decreases in pain medication in more than 60% of patients (Verilli, Mitchell, Vivian, & Sinclair, 2009). However, despite advances in surgical technique and system technology, 25% to 50% of patients who have undergone a successful screening process report loss of analgesia within 12 to 24 months of permanent implantation (Atkinson, Brooker, O'Callaghan, Salmon, Semple, & Majedi, 2011; Doleys, 2006).

Patient selection has been identified as the key to the long-term success with implantable therapies (Brook, Georgy, & Olan, 2009). The selection process is based on choosing patients with an underlying desire to get better and who also have etiologies that have been shown to benefit from SCS. The criteria for selection is usually based on several factors, including the exact pathology and type of pain generator, the amount of pain that is neuropathic, and the patient's motivation and participation (Mekhail, Cheng, Narouse, Kapural, & Deer, 2010). Another very important factor is the timely application of therapy with the best results occurring within the first three years of the onset of pain (Mekhail et al., 2010).

Pain may become more established over time (Kumar, Wilson, Taylor, & Gupta, 2006) and the development of tolerance can be challenging for SCS long-term efficacy (Golovac, 2010; Kumar, Buchser, Linderoth, Meglio, & Van Buyten, 2007). However, long-term relief from implantable therapies may also be related to patient characteristics, such as educational level, age, type of pain, and sex (Atkinson et al., 2011; Doleys, 2006; Golovac, 2010). This article has the following objectives: a) Identify patient characteristics (age, sex, type of pain, and educational level) that may be predictive of long-term outcomes with SCS; b) Explain neuromodulation and its role in pain relief; c) Identify distinguishing features of neuropathic versus nociceptive pain; d) Identify the role of sex hormones in pain perception; and e) Explain the role of technology in interventional pain modalities.

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BACKGROUND

In normal pain processing, physiologically specialized peripheral sensory neurons, called nociceptors, respond to noxious stimuli (Moffat & Rae, 2010). Neuropathic pain represents abnormal pain processing, arising as a direct consequence of a lesion or disease. Signs and symptoms of this type of pain relate with the areas innervated by the damaged nerve structures (Nickel, Seifert, Lanz, & Maihofer, 2012).

While nociceptive pain originates from muscles, joints, and ligaments, neuropathic pain involves injury to the nerves (Nickel et al., 2012).

While the role of electrical impulses in the treatment of pain has a long history (Mobbs & Blum, 2007), it is only recently that the mechanism of action of neuromodulation is beginning to be understood. Despite its growing indications, the mode of action for SCS remains largely unknown. SCS is an electrical circuit created between the battery source and the tissues. The current is converted into pulsations and transmitted to the electrodes in the SCS leads that are implanted within the nervous tissue. When the nerves in the dorsal columns are stimulated, pain perception is reduced (Bagnall, 2010). The Gate Control Theory, from which SCS emerged, implied that activation of fibers in the dorsal aspect of the spinal cord inhibited transmission of pain and predicted that all types of pain would be suppressed (Linderoth & Foreman, 1999; Melzack & Wall, 1965). Mechanisms of pain relief through neuromodulatory actions in the spinal cord and peripheral nerves have been described as an enhanced pain inhibition produced through a reduction of neurotransmitters, such as gamma-aminobutyric acid (GABA), in the brain (Meyerson & Linderoth, 2006) or the release of neuropeptides, such as substance P, from the sensory nerve fibers (Casasola, 2009).

Type of pain has been indicated as an important predictor of SCS outcome (Atkinson et al., 2010; Casasola, 2010; Cruccu & Truini, 2009; Mekhail et al., 2010). SCS has been traditionally used as a treatment for failed back surgery syndrome (FBSS), which can present with a combination of neuropathic and nociceptive origins. However, it has also been demonstrated to be beneficial in the treatment of neuropathic pain syndromes, such as complex regional pain syndrome (CRPS) (Taylor, Van Buyten, & Buscher, 2005). Additional neuropathic indications in which SCS is beneficial include refractory angina pectoris and peripheral peripheral vascular disease (PVD) (Brook, Georgy, & Olan, 2009). Additional pain syndromes benefitting from SCS would include phantom limb pain, post thoracotomy syndrome, and intercostal neuralgia (Brook et al., 2009).

The site of back pain has become an important indicator in the selection process for SCS. Controversial viewpoints exist regarding the use of SCS for nociceptive or axial back pain (Linderoth, Foreman, & Meyerson, 2009). Axial pain is the lumbar component of back pain, which is represented by nociceptive characteristics, such as throbbing and aching. This is in contrast to the neuropathic component of back pain (leg pain), which has more of a burning quality (Linderoth et al., 2009). Neuropathic pain following back surgery is considered the most common indicator for SCS with many studies demonstrating 50% improvement of pain and a reduction of pain medication usage (Brook et al., 2009). Controversy exists as to the success of neuromodulation with axial (nociceptive) back pain with some studies reporting poor outcomes (Atkinson et. al., 2011) and others reporting good outcomes (Barolat, 2009; North, Kidd, Farrokhi, Piantadosi, 2005).

SCS has been shown to alleviate pain in a sample of patients diagnosed with intractable pain syndrome of which 80% experienced initial pain relief of 50% (Kumar, Toth, Nath, & Laing, 1997). However, at the five year follow up period, only 47% experienced 50% or greater pain relief, indicating a gradual decline in pain relief over time (Kumar et al., 1997). Reasons for this late failure were complications with hardware of the SCS, such as electrode malfunction, tolerance, and the duration of time between surgical intervention for the pain and the time of SCS implantation (Kumar et al., 1997). The longer the time duration, the poorer the outcome with SCS, suggesting that the pain becomes firmly established over time (Kumar et al., 2002).

In addition to physiological and technological influences, the role of demographic variables in the outcome of SCS is evident, as seen in Table 1. Recent studies have demonstrated that variables, such as age, sex, level of education and duration of pain, are implicated in pain perception (Barbareschi, Sanderman, Leegte, Veldenhuisen, & Jaarsma, 2011; Fillingim, King, Riberro-Dasiva, Rachim-Williams, & Riley, 2009; Racine, Tousignant, Kloda, Dion, Dupuis, & Choiniere, 2012; Wandner, Scipio, Hirsh, Torres, & Robinson, 2012). Pain perception is an underlying factor in the amount of pain relief obtained with SCS (Shi, Langer, Cohen, & Cleeland, 2007). Age differences in pain perception vary within the literature. Older adults demonstrated more pain sensitivity and willingness to