



Review Article

SPINAL CORD STIMULATION: A DOMINANT THERAPY FOR REFRACTORY ANGINA PECTORIS

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ABSTRACT

Despite sophisticated medical and surgical procedures, including percutaneous endovascular methods, a large number of patients suffer from chronic refractory angina pectoris. Refractory angina pectoris is a chronic condition characterized by the presence of severe chest pain, caused by coronary artery disease (CAD), which cannot be relieved by coronary intervention, coronary artery bypass grafting, and optimal medical treatment. Improvement of pain relief in this category of patients requires the use of adjuvant therapies, of which spinal cord stimulation (SCS) seems to be most promising. Controlled studies suggest that in patients with chronic refractory angina, SCS provides symptomatic relief that is equivalent to that provided by surgical or endovascular reperfusion procedures, but with a lower rate of complications and rehospitalization. SCS is today considered as first-line treatment of refractory angina pectoris, by the European society of Cardiology, with an anti-ischemic effect.

Key words: Refractory angina pectoris, Spinal cord stimulation, Coronary artery disease

INTRODUCTION

CVD (cardiovascular disease) is the leading cause of death in the United States and the death caused by CAD (coronary artery disease) is responsible for approximately half of all deaths from CVD¹. The term ‘refractory angina pectoris’ is used to describe patients with severe chest pain due to CAD that is not relieved by conventional treatment, i.e., pharmacological, surgical or both. The future group of patients with refractory angina pectoris will be different from today’s patients and represent a ‘moving target’ as risk factors, efficacy of treatment and indications continue to change. There is a strong evidence for SCS giving symptomatic benefits (decrease in anginal attacks), improved quality of life and improvement of functional status. In addition, SCS seems to be cost effective with a ‘break-even’ after approximately 15-16 months².

Ischemic heart disease

Ischemia in the myocardium develops when there is a mismatch between myocardial oxygen supply and demand. This imbalance often caused by a reduction in blood flow as a result of increased coronary arterial tone or thrombus formation. This condition is known as supply ischemia or low-flow ischemia and typically is present during acute coronary syndromes such as angina or MI. Under different conditions ischemia can result from increased myocardial oxygen demand in the presence of a fixed supply. This condition is known as demand ischemic or high flow ischemia and typically exists in the setting of chronic stable angina where patients have a fixed supply to the myocardium and undergo exercise or experience stress. Although, it is used to consider these mechanism separately to facilitate understanding of how myocardial ischemia develops in reality most patients with either chronic stable angina or ACS (acute coronary syndrome) develop ischemia from both an increase in oxygen demand and a reduction in oxygen supply. Local ischemia can be reduced by the modalities that are pharmacological, interventional, or both³.

Characteristics of Refractory Angina pectoris

There is no generic refractory angina patient. Patient may have different electrocardiographic changes during angina involving multiple leads or a few leads, troponin I may have positive or negative, left ventricular function may be normal or abnormal and coronary pathology varies tremendously in the extent. One can be suspicious that a patient may be potentially refractory and have a poor prognosis if biochemical markers such as troponin T or I are elevated and also if C-reactive protein levels are elevated⁴.

SCS in refractory angina pectoris

Spinal cord stimulation has been used in clinical practice for more than three decades. The primary use of this therapy has been in spine-related disorders. In recent years, the therapy has been used more extensively in disease of the vascular system. The issue of SCS depriving the patient of anginal ‘warning signals’ has always been a concern. SCS does not appear to influence heart rate variability. It is thought to stabilize intracardiac neuronal function, help to prevent the occurrence of reperfusion arrhythmias, and possibly prevent sudden cardiac death. Evidence that SCS has direct analgesic effects is confirmed by techniques of brain imaging the pain response. Changes in regional cerebral blood flow in areas involved with nociception and cardiovascular control as measured by positron emission tomography (PET) have been documented in patients treated with SCS⁵. The clinical application of SCS to treat chronic refractory angina was published by a group from Western Australia, who reported a decrease in both antianginal attacks and nitrate consumption. Despite a large number of subsequent clinical trials and fundamental research that advocated neuromodulation as an effective treatment modality for patients with disabling chronic refractory angina pectoris⁶.

Mechanism of action of SCS

SPC may give rise to reduced oxygen consumption via a number of putative mechanisms. It has been shown in animal experimental studies that β -endorphin, via antagonistic effects on local opioid receptors (μ -receptors) in the myocardium, reduce oxygen consumption. Stimulation induced release of β -endorphin in the myocardium has been suggested as one possible mechanism to the decrease in the myocardial oxygen consumption. In addition, SCS seems to reduce sympathetic activity. The mechanism of action of SCS in myocardial ischemia is not yet fully elucidated; several mechanisms might contribute to the beneficial effect of SCS, including effects on myocardial blood flow as well as neuro-hormonal mechanisms. The underlying mechanism of action has been suggested to be modulation of autonomic tone-sympatholytic, vagomimetic or both. However, the mechanism of action is most likely complex and involves changes in nervous, cardiac and endocrine tissues⁷.

Efficacy of SCS in severe and refractory angina pectoris

The available studies indicate that SCS treatment is associated with a symptom of relief and improvement of quality of life. The beneficial effects of SCS seem to persist after long term treatment, up to 5 years after implantation according to studies⁸. Many Publications from different centers indicate that the antianginal effect of SCS is paralleled by a reduction in myocardial ischemia. In addition, anginal pain was delayed and myocardial oxygen consumption was decreased by SCS at comparable heart rate induced by atrial pacing⁹. However, regardless of the efficacy of

SCS, all patients eventually experience angina when the workload of the heart is increased to higher levels. The quality and distribution of the pain is similar to the original symptoms. The concern regarding the SCS-related deprivation of a warning signal of myocardial ischemia is clearly not rational. While it may be argued that patients with chronic refractory angina are at a lower risk of malignant cardiac arrhythmias, the decrease of myocardial ischemia provided by SCS may potentially decrease the rhythm disturbances¹⁰. Proper use of SCS implies that the epidural electrode is inserted at a level that paresthesias are elicited over the area of anginal pain. Although this prevents adequate blinding of the therapy, several randomized controlled trials have convincingly established the clinical efficacy of SCS in chronic refractory angina pectoris¹¹.

Implantation procedure

The electrode implantation procedure for the treatment of refractory angina is similar to the method used for other SCS indications. Percutaneous puncture (usually between Th4 and Th8) and fluoroscopic guidance should be performed under local anesthesia to elicit the paresthesia in the appropriate area. The proper positioning of the electrode is essential to the success of SCS, and this procedure is the only way to verify that the segment of spinal cord that innervates the heart is being stimulated. In most cases, paresthesias that cover the area of anginal pain are obtained when the tip of the electrode is placed in the posterior epidural space at the level of Th1 or Th2, slightly left to the spinal midline. One of the most common causes of SCS failure is related to the incorrect positioning of the electrode¹².

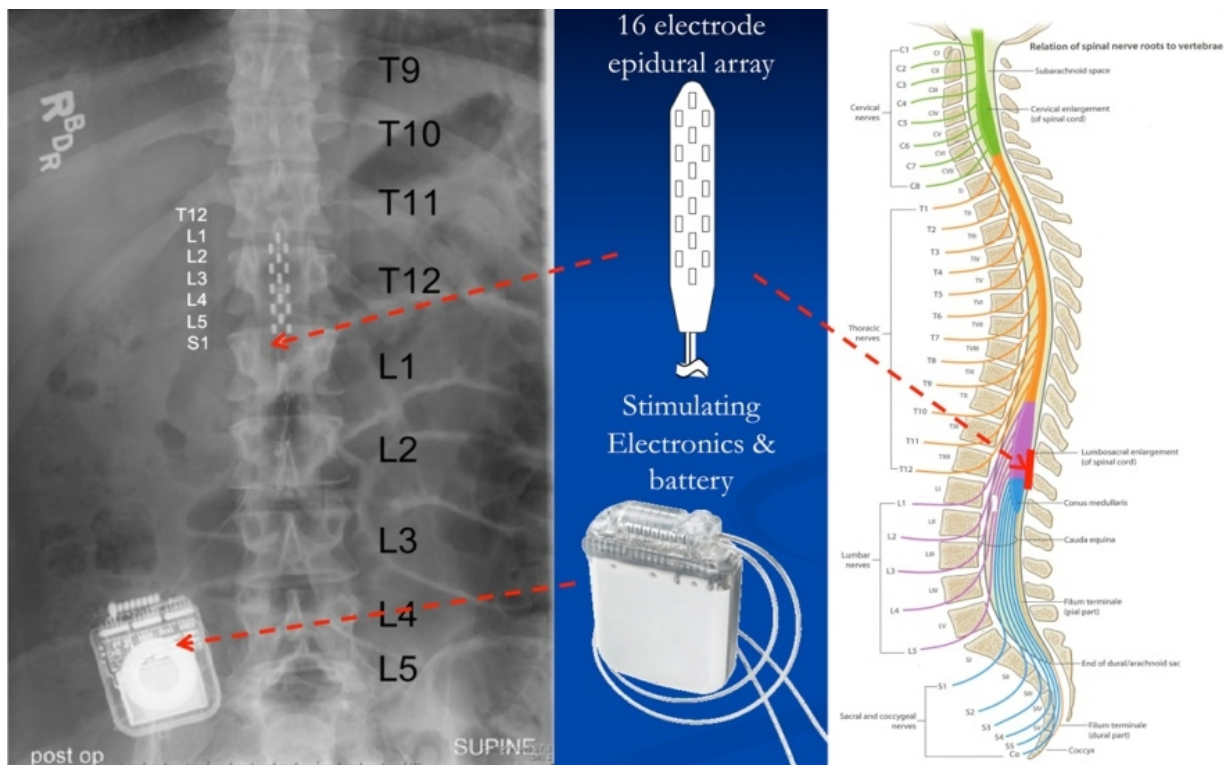


Figure 1: 16-electrode array for epidural stimulation was surgically implanted in the epidural space of the patient's lower back (that is between the vertebra and the spinal cord). The electrode lead was routed from the array in patient's back to an abdominal pouch under the skin where an iPod-sized stimulating electronics unit and battery were implanted.

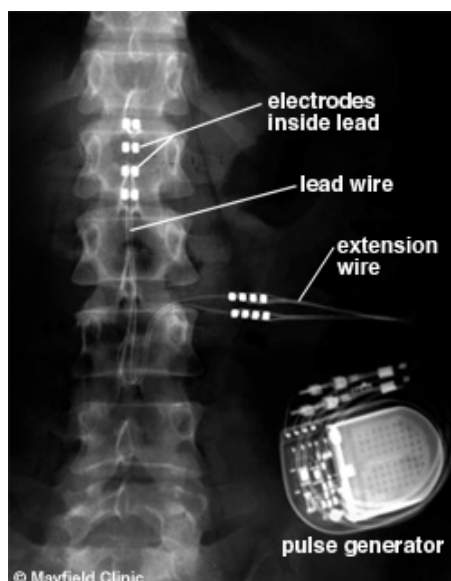


Figure 2: An X-ray of the spine shows the spinal cord stimulation system in place

Comparison between SCS and CABG

Spinal cord stimulation or epidural spinal electrical stimulation has been used in the treatment of chronic neurogenic pain for several years. SCS has also been used in the treatment of peripheral vascular disease with satisfactory clinical results in terms of increased local blood flow and promoted healing ulcers. SCS has been used to treat intractable angina pectoris with promising clinical results in terms of symptom relief and reduction in myocardial ischemia. The anti-anginal effect is secondary to an anti-ischemic effect, which in turn seems to be due to a reduction in myocardial oxygen consumption; however, a redistribution of coronary blood flow cannot be excluded. Revascularization procedures, i.e. coronary artery bypass grafting (CABG) and percutaneous transluminal coronary angioplasty (PTCA), are standard treatments in severe angina pectoris. There are several groups of patients for whom CABG is known to be associated with an increased complication risk. SCS has been used in the treatment of severe angina pectoris despite optimum medication in patients who are not accessible for revascularization¹³.

Complications

The complication rate of SCS for angina is very low. Minor complications include lead migration, electrode fracture, early battery exhaustion as well as infection usually of the pulse generator pocket, which does not necessarily require the explanation of the system. Although theoretically possible, permanent neurological damage was not described in conjunction with the implantation of an SCS electrode. Device-related complications may occur more frequently with other indications for SCS presumably because of different electrode locations, previous spinal injury and more active patients¹⁴.

CONCLUSION

Treatment with SCS is an effective treatment for a variety of conditions in current pain practice. This therapy is relatively safe if it is done appropriately with careful patient selection. The data regarding efficacy and cost effectiveness of SCS compare very favorably to these regarding medical therapy. Bypass surgery or percutaneous coronary stenting. Similarly, SCS is associated with a lower morbidity and mortality than either standard medical treatment or revascularization procedures. Compared to CABG there

was no difference with regard to symptom relief, but the mortality and cerebrovascular morbidity were in the SCS group. Unique indications for SCS in the treatment of brain and spinal cord injury and tumors are being explored and the role of spinal neuromodulation will continue to expand as its effects are better understood.

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