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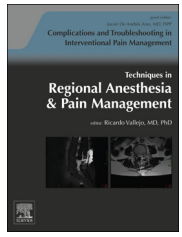

Neuromodulation techniques, complications, and troubleshooting

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ABSTRACT

Spinal cord stimulation has become one of the mainstays of chronic treatment for patients in pain units. It is a safe, effective, and reversible technique, although the rate of complications is approximately 30%-40%. The most common complication, despite technological breakthroughs and advances in equipment, continues to be electrode migration, which currently occurs in approximately 13% of cases. The most serious complication is related to neurologic problems after infections in the epidural space. A review of technique-related complications is performed, classifying them into mechanical and biological complications, including the strategies to avoid them, mainly through careful patient selection, correct surgical technique, and good selection of the programmed electrical parameters.

Neurostimulation

Introduction

Over the past few decades, spinal cord stimulation (SCS) has become one of the main treatments in the therapeutic arsenal at pain treatment units. New systems have been developed,[1] neurostimulation indications have been extended, although the main indications continue to be neuropathic pain[2] and pain of vascular ischemic origin (stages III and IV peripheral vascular disease using the Leriche-Fontaine classification),[3,4] and new electrode implantation techniques have been developed for new locations in the nervous system, such as subcutaneous implantation.[5] This has all led to a significant advance for health care professionals specializing in pain treatment, although a satisfactory outcome of the technique continues to be based on the same factors: good patient selection, which appears to be one of the main factors to reduce complications, especially long-term complications, good surgical technique and, lastly good management of the electrical parameters at the time of programming.[6]

In all these cases, there are 2 types of techniques that may be used: a percutaneous technique and a "surgical" technique, which requires performance of a laminectomy to enable the insertion of the electrodes. In the former, the electrodes are inserted percutaneously, whereas in the latter, a laminectomy is performed to enable placement of the electrodes. In both cases, there is no difference in the second part of the technique: placing the generator and connecting the electrodes. The implantation technique can be considered a safe, reversible, and effective technique for pain relief and improvement of the patients' performance and quality of life. Both techniques have been shown to be effective in all these aspects.

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Table 1 – Mechanical and biological complications.

Mechanical	Biological
Electrode fracture	Infection
Electrode migration	Allergy
Battery failure	Seroma
Disconnection of the connections or electrodes	Epidural fibrosis
	Epidural hematoma
	Dural puncture
	Nerve injury
	Spinal cord injury
	Nerve compression
	Stimulation changes

Despite being considered a safe and reversible technique, the documented rate of complications requiring surgical review is 30%-40%, with good patient selection currently being the most important factor for obtaining an optimal final outcome.[7-11]

Complications can be classified as hardware-related complications and biological complications. The former are more common than the latter, mainly those derived from problems with the electrodes, such as migration, which currently continues to be the most common complication.[12] On other occasions, complications can be classified as preoperative, intraoperative, and postoperative (Tables 1 and 2). Most complications are neither serious nor life threatening for the patient and resolve on removal of the system.[8] The most serious complication reported to date is paralysis occurring after infection at the electrode site,[13] although cervical spinal cord compression syndrome has also been reported owing to compression by the system implanted at the cervical level.[14] The objective of this article is to discuss the complications derived from the implantation of electrodes, classified as mechanical complications and biological complications, and to provide some guidance for their treatment.

Mechanical complications

As mentioned in the introduction of the article, although mechanical complications are numerically the most important, it is important to bear in mind that patient selection appears to be essential for the treatment to work well, not only in the short term, but, more importantly, in the long term.

Before proposing this treatment in a patient, the following should be assessed: the type of pathology of the patient, with neuropathic pain being the gold standard as an indication for the technique, whether conventional treatment has not been effective, and whether the patient has any major psychiatric condition or any issues of secondary gain or litigation, and also that the patient has no problems of drug or alcohol addiction.[14-17]

Electrode breakage and migration

Electrode migration continues to be the most common complication (Figure 1) of this technique, with an incidence varying between 13.7% and 23%,[8,18] although these figures may even decrease to 6.4%, if we consider migration only when surgical treatment is required to correct it.

Electrode migration has evidently decreased with improvements in equipment. The development of different anchorage systems and the types of electrodes used, either cylindrical or paddle electrodes, also have an influence on this type of complication, with migration being more common with the former than with the later, with an incidence of 6.4% for cylindrical electrodes vs 3% for paddle electrodes.[19] As expected, the rate of electrode replacement after their migration has decreased with the first monopolar electrodes (45%) in comparison with quadripolar leads (11%), owing to the possibility of recapturing paresthesia or of reprogramming the patient with new programming systems.[20,21]

Electrode migration is seen in those cases that require a surgical intervention to replace the electrode owing to loss of paresthesia at the site of pain, which cannot be recaptured by reprogramming the system. Multiple causes are given, which may explain why migration occurs in a system implanted and anchored in the muscle fascia. Longitudinal migration appears to be due to lack of experience of the implanting physician in suturing the anchor, inadequate anchorage, excessive pressure on the anchor with no prior attachment of the electrode to the anchor, attachment to fatty tissue causing it to break free, trauma, or excessive patient movement.[22]

This complication is easy to recognize. The patient loses paresthesia at the stimulated site and it is not possible to recapture it with reprogramming. It is important to bear in mind that with this type of complication, the patient's paresthesia continues, although the location of the paresthesia would not be at the initially programmed site. Possible migration is confirmed by x-ray, compared with the patient's previous x-ray. The methods to reduce this type of complication include paying special attention when attaching the electrode, checking for the presence of any loops in the anchorage site and also in the generator implantation site, using the anchorage devices provided by the different

Table 2 – Time period–dependent complications.

Preoperative	Intraoperative	Postoperative		
Patient selection	Pain	Immediate	Late	
	Lack of collaboration	Superficial bleeding	Hardware	Biological
	Technical difficulty	Epidural bleeding	Battery failure	Infection
	Coverage failure	Superficial infection	Electrode fracture	Seroma
		Headache	Loss of connections	Epidural hematoma
		CSF fistula	Electrode migration	Paralysis