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Supraspinal stimulation for treatment of refractory pain

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ABSTRACT

Refractory pain syndromes often have far reaching effects and are quite a challenge for primary care providers and specialists alike to treat. With the help of site-specific neuromodulation and appropriate patient selection these difficult to treat pain syndromes may be managed. In this article, we focus on supraspinal stimulation (SSS) for treatment of intractable pain and discuss off-label uses of deep brain stimulation (DBS) and motor cortex stimulation (MCS) in context to emerging indications in neuromodulation. Consideration for neuromodulatory treatment begins with rigorous patient selection based on exhaustive conservative management, elimination of secondary gains, and a proper psychology evaluation. Trial stimulation prior to DBS is nearly always performed while trial stimulation prior to MCS surgery is symptom dependent. Overall, a review of the literature demonstrates that DBS should be considered for refractory conditions including nociceptive/neuropathic pain, phantom limb pain, and chronic cluster headache (CCH). MCS should be considered primarily for trigeminal neuropathic pain (TNP) and central pain. DBS outcome studies for post-stroke pain as well as MCS studies for complex regional pain syndrome (CRPS) show more modest results and are also discussed in detail.

Contents

1. Introduction

In the not so distant past, neurosurgical management of pain was limited to lesioning and ablative procedures treating only the most severely impaired patients with time limited effects. Today,

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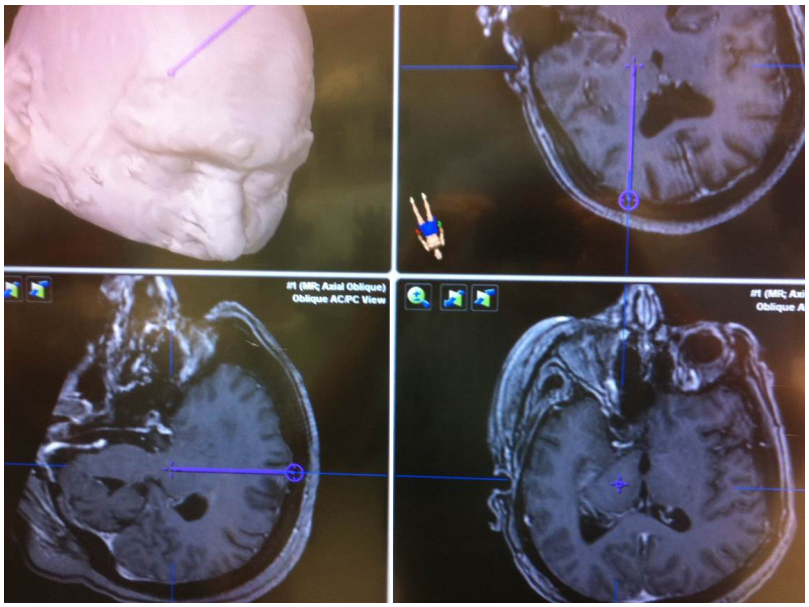

Fig. 1. MR guided planning in deep brain stimulation. Snapshot from planning station demonstrating target, entry, and trajectory for a DBS insertion on T1 weighted MR with gadolinium.

however, the neurosurgical treatment of pain has far transcended lesion-inducing procedures and also incorporates site-specific neuromodulation. Neurostimulators may be placed at virtually any site in the nervous system from the cerebral cortex, deep nuclei of the brain, spinal cord, and/or cranial/peripheral nerves. Despite the fact that neurostimulatory devices have been used for 50 years, our understanding of how stimulation works is still in its infancy. Melzack and Wall's gate theory of pain is most commonly referenced, typically for spinal cord stimulation [1].

Stimulatory devices can be placed at a variety of levels in the nervous system and proper location is essential to achieving adequate pain relief. In the majority of cases, the electrode should be placed "above" the level of pain involvement. For example, if patients suffer a nerve root injury after back surgery, a spinal cord stimulator (SCS) is generally the first neuromodulatory strategy attempted for refractory pain. Placing the device above allows the descending pathways to be targeted rather than the interneurons and cells at the level of injury, i.e. the very same pain transmission cells one is trying to inhibit [1]. An antidromic as well as an orthodromic activation of the dorsal column fibers may also play a role. In this article, we intend to better elucidate outcomes based on disease process by focusing on supraspinal stimulation (SSS) for treatment of pain and discussing off-label uses of deep brain stimulation (DBS) and motor cortex stimulation (MCS) for specific pain conditions to that avail. It is our hope, that stratifying outcomes by disease process will better guide future clinical-neuroscientific decisions.

2. Deep brain stimulation

DBS is the most invasive form of neuromodulation. Specifically, it involves targeting a deep structure in the brain. In order to do this effectively, thin cut T1 with gadolinium and T2 weighted MRIs must be obtained (Fig. 1). Stereotaxy must be used, which involves putting the location in the MRI into vector space. This entails obtaining imaging in a stereotactic frame. The MRI may either be obtained in advance and a CT done the day of surgery with the frame in place or the MRI may be done the day of surgery with the frame in place. After planning the target and entry site to avoid blood vessels and critical structures, a burr hole is made and DBS lead is placed into the target region (Fig. 2). Microelectrode recording and macrostimulation is often performed intra-operatively to ensure that no adverse effects are seen at parameters commonly used in the clinic.

DBS has been used in a selection of pain syndromes (Table 1). Overall, percent success is 61% for nociceptive pain, 54% for neuropathic pain, 71% for phantom limb, 36% for central pain, and 71% for chronic cluster headache. Certain pain etiologies seem to have better treatment outcomes than others for DBS; speculation as to why this occurs may arise from maladaptive plasticity development in central based etiologies. DBS targets CNS

Fig. 2. Intra-operative photograph of DBS surgery. Demonstration of burrhole based on entry point chosen on MRI. The photograph shows the stereotactic frame that allows for determination of vector coordinates and the microdrive which allows for electrode implantation.