Deep brain stimulation for the alleviation of post stroke neuropathic pain

Introduction

Intractable neuropathic pain affects 2-8% of patients after a stroke. Typically, a burning hyperaesthesia and aching affect areas that are rendered numb after a stroke. Such pain usually resists medical therapy leaving these patients with no symptom alleviation. In the UK, an estimated 28,000 people will suffer from this predicament.

Although motor cortex stimulation has been reported as a mode of therapy for this condition the published literature quotes extremely variable results. Therefore, deep brain stimulation has been the preferred mode of therapy for neuropathic pain at Oxford since 1999. During this period, 15 post stroke patients with neuropathic pain were treated with deep brain stimulation. Here we present the clinical results.

Patient population and surgery

Of the 15 patients in the study the average age was 58.6 years, there were 3 female and 12 male patients, 5 had cortical and 10 subcortical strokes of which 8 were thalamic, 1 pontine, and 1 in the internal capsule. Average duration of pain prior to surgery was 5.2 years. The most disabling aspect of the pain syndrome was a burning hyperaesthesiain the area of numbness that affected 7 of the 15 patients. Also described was a severe cramping or crushing sensation.

Provided there were no over riding medical or psychological contraindications, deep brain stimulation of the periventricular area and sensory thalamus were offered to these patients. Both targets were chosen after existing literature by different authors quoted both as being effective. Also there was no indication of any superiority of one target over another. Preoperatively they filled in pain charts using a visual analogue scale and the McGill questionnaire. They also underwent a comprehensive neuropsychological assessment. Deep brain stimulation for neuropathic pain has approval of the local ethics committee.

All patients had a T-1 weighted axial MRI scan prior to surgery, and a CRW base ring was applied to the patients’ head under local anaesthesia. A stereotactic CT scan was then performed and using the Radionics Image Fusion, and Stereoplan, programme the MRI scan is volumetrically fused to the stereotactic CT scan. This is a technique that has been adopted since 1995 to eliminate the errors of using MRI stereotaxy alone that arise from the spatial distortions intrinsic to magnetic fields. The co-ordinates for the PVG and VPL were then calculated. Patients with strokes in the sensory thalamus were only implanted in the PVG/PAG with a Medtronic 3387. The VPL was implanted with a Medtronic 3387 electrode where stimulation induced parasthesia in the area of pain and the PVG/PAG with a Medtronic 3387 electrode where stimulation induced relief of pain or a sensation of warmth in the area of pain. The deepest electrode was noted to be in a satisfactorily well position if eye bobbing was induced at an intensity of stimulation at least twice that required for sensory effects. The electrodes were fixed to the skull with a miniplate prior to externalisation.

In all patients the electrodes were externalised for a week of trial stimulation. Pain was assessed before surgery and during stimulation by a self-rated visual analogue scale. Post stroke pain during the trial period responded better to stimulation of the PVG compared to the VPL. If the patients were satisfied with the degree of pain relief, full implantation of a Medtronic pulse generator was performed in the following week under general anaesthesia.

Results

During a trial period of one week following surgery, 3 patients did not feel there was significant pain relief to proceed to full implantation of the pacemaker and the electrodes were removed under local anaesthesia. The 12 remaining underwent full implantation of the extension cables and the pacemaker (SYNERGY, Medtronic Inc). Although dual channel, all patients were implanted with a SYNERGY because of the longer battery life, if one channel is used a plug is used to close off the inactive channel. The patients were then reviewed a month later to optimise the settings for maximum pain relief and were reviewed 6 monthly thereafter.

Follow up

Average follow up was 15 months. Nine patients preferred chronic stimulation of the PVG, one in the VPL and three preferred both electrodes to be activated. The results are summarised in Table 1. Overall the reduction in pain scores was 48.8% (SD 2.2, p<0.001). The average reduction in the cortical strokes subgroup was 42% (SD 2.7, p=0.023) and in the sub cortical stroke group was 54% (SD 1.9, p<0.001). If burning hyperaesthesia was present this was markedly reduced. An analysis of the McGill questionnaire was also performed, by looking at pain scores in the four word groups sensory, affective, evaluative and miscellaneous. In each group the average pain score was reduced postoperatively as follows: sensory from 8.5 to 8.0, affective from 9.1 to 7.3, evaluative from 4.6 to 4.3 and miscellaneous from 11.2 to 6.5. Of the 12 patients, 7 stopped all analgesics (of these 4 were on opiates, 3 on Gabapentin) and 5 changed from regular opiate analgesia to as...
required non-opiates. There was one complication in this series. One patient struck the top of his head against a lintel and a few hours later the neuropathic pain returned, as the lead had fractured which required surgical revision with return of pain relief.

Discussion

This prospective study demonstrates that deep brain stimulation of the PVG/PAG and sensory thalamus may have a useful role in the management of post-stroke central pain. In our experience, those patients who symptomatically suffer from severe burning hyperaesthesia appear to respond best. In this series the average pain relief is of the order of 48.8% which is of the region of 50% relief often quoted as the bench mark for useful pain relief. The site of the stroke may be of relevance as we have observed that cortical stroke patients had less relief than sub-cortical strokes but given the small numbers there was no statistical difference. One disadvantage put forward against deep brain stimulation is the onset of tolerance. In our experience the effect is not that of tolerance but that once patients lose the intolerable burning hyperaesthesia, the background crushing aching sensation becomes more noticeable. Nevertheless, the effectiveness of the procedure can be confirmed in an N of 1 study in which the patient records pain scores and the stimulator is randomly turned on or off. The mechanism of the effects are still unclear. There is some evidence to suggest that PVG/PAG stimulation has an inhibitory effect on the sensory thalamus. However, the analgesic effects of deep brain stimulation can last for over 24 hours after a period of stimulation. This confounds on/off studies but does support studies that indicate that that PVG/PAG stimulation results in the release of endogenous opiates. Deep brain stimulation has been tried with success in the past but due to overall poor results and poor patient recruitment into two trials in the 1980s this technique was largely abandoned. However, with the resurgence of functional surgery for movement disorders the use of MRI scans for stereotactic target localisation, safer electrodes than those used in the early days (internaised stylet), more reliable pacemakers, the knowledge gained from some early studies does mean that this important indication should be revisited.

### Table 1: Changes in VAS scores

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<th>Pre-op VAS</th>
<th>Post-op VAS</th>
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<th>SD</th>
<th>P value</th>
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<td>2.7</td>
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<td></td>
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<td>1.2</td>
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<tr>
<td>Mean</td>
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<td>3.6</td>
<td>54</td>
<td>1.9</td>
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<td>Total Mean</td>
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<td>4.1</td>
<td>49</td>
<td>2.2</td>
<td>&lt;0.001</td>
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References


**Figure 1:** An axial MRI scan showing electrodes in the VPL (lateral) and PVG (medial) nuclei.