Neurosurgical techniques in the management of chronic pain

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Abstract
Neurosurgical treatment for pain can be classified into three categories: treatment of the cause, neuro-ablative techniques and neuromodulation. Treatment of the cause is exemplified by microvascular decompression for trigeminal neuralgia.

All of these treatments are now delivered in a multidisciplinary context, with other adjunctive treatments including cognitive techniques and pain management programmes. There is increasing emphasis on outcome measurement in all categories, using both condition-specific and generic assessment tools such as the EuroQuol-5D.

Keywords  Neuromodulation; neurosurgery for chronic pain; stimulation; trigeminal neuralgia

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Learning objectives
After reading this article, you should be able to:
- classify neurosurgical techniques for pain management
- compare lesioning techniques used to treat trigeminal neuralgia
- list neuromodulation options and describe their limitations
- give an overview of the management of trigeminal neuralgia.

General principles
Surgical treatments are best for focal problems and are often highly effective. By contrast medical management is necessarily systemic, so even if a drug agent is efficacious side effects can be problematic. Often invasive surgical interventions are only considered after the failure of conventional medical management. This approach is enshrined in the WHO pain ladder, which is arguably unfounded and by inhibiting the uptake of effective surgical options can be positively harmful. Logically it may be better to consider surgical techniques earlier, especially where a focal problem can be identified. Patients have a right to be provided with balanced information and told of the existence of surgical options at an early stage so that they can make informed treatment choices (Box 1).

Treatment for the cause
Lumbar microdiscectomy
In this example, pain radiating down the patient’s leg associated with surgically significant lumbar disc prolapse and without neurological deficit is considered. A surgical patient group and a conservatively managed group have similar outcomes when assessed at 5 years. Surgery offers a reduction in pain immediately at the expense of surgical morbidity and procedural risk. The morbidity of simple microdiscectomy is low; it can be performed as a day case, and rarely involves hospital stay of more than 24 hours postoperatively. These factors must be compared with the conservative option, which involves loss of function due to pain, side effects from analgesic use and time for pain to settle.

Spinal fusion with or without instrumentation
There is little controversy over the need for spinal fixation in cases of deformity — for example scoliosis, spondylolysisis or trauma — as a means of alleviating pain. The situation has until recently been much less clear regarding metastatic tumour, or degenerative low-back pain.

Spinal metastatic tumour: recent evidence from a prospective randomized controlled trial shows that improvements in mobility, survival and pain control can be achieved by decompression and stabilization.

Fusion for low-back pain associated with degenerative lumbar spine disease: When surgical fusion is compared to an intensive functional restoration program, both groups performed better than the reported natural history. However, there was significant morbidity to the surgery. A recent National Institute for Health and Care Excellence guidance stated that there was a limited role for surgery. ‘Failed back surgery syndrome’ (FBSS) is a reasonably frequent condition following this type of surgery.

Microvascular decompression for trigeminal neuralgia
In a large proportion of cases trigeminal neuralgia is associated with an artery or vein in contact with the trigeminal nerve at its root entry zone. Classically the compressing vessel is the superior cerebellar artery. The operation involves moving this vessel away via a small craniectomy in the posterior fossa. The vessel is mobilized from the trigeminal nerve and held away with pieces of Teflon.

Outcome evidence comprises observation data from large numbers of patients, in some cases for over 20 years. These series show that long-term pain relief is achieved in about 75% of cases and that this pain relief is permanent. Risks are low, but they can be serious. A mortality and serious morbidity (e.g. stroke) rate exists (0.1%), and there is a risk of ipsilateral hearing impairment (2%). This surgery is safe even in elderly patients, provided they are selected for fitness for anaesthesia. This rate of efficacy is unsurpassed in any other area of pain medicine. It should be noted and recognized that the most difficult part of the whole procedure is making a clear diagnosis, and this can often be difficult.

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Classification of neurosurgical techniques

Treatment of the cause

- Once the cause is removed, then pain should and usually does immediately resolve: example is microvascular decompression for trigeminal neuralgia and lumbar microdiscectomy for sciatica

Lesioning of pain pathways

- Lesioning for pain control is still performed for trigeminal neuralgia, for focal pain of malignant origin (cordotomy) and brachial plexus avulsion

Neuromodulation

- Neuromodulation includes two groups of therapies: electrical modulation, by stimulation of the central or peripheral nervous system, and drug delivery systems

Techniques alleviating the cause are preferred over those treating symptoms. Non-lesional techniques (e.g. spinal cord stimulation or drug delivery systems) are preferred over lesional techniques, yet each has its place

Box 1

Lesioning for pain control

Trigeminal neuralgia

The trigeminal nerve can be lesioned using a percutaneous approach to the foramen ovale. The procedure involves a needle introduced from a point 2.5 cm lateral to the angle of the mouth, lined up in the plane of the mid-pupillary point and the root of the zygoma, so as to pass in the direction of the foramen, with the position confirmed using fluoroscopy. Anaesthesia dolorosa is a rare but serious side-effect. Paraesthesia is common and in up to 8% this may be unpleasant. Statistical analysis has found no difference in efficacy amongst these techniques:

Radiofrequency lesioning — positioning of the needle is usually performed under general anaesthesia. The patient is then woken, and the electrode is stimulated until paraesthesia is obtained in the division of the nerve corresponding to the location of the pain. The patient is then re-anaesthetized and a thermal lesion made by heating the tip of the electrode with a radiofrequency technique. The patient is then woken again and tested for analgesia. If this is inadequate then the whole process is repeated. The wake—sleep process may be difficult to tolerate especially in elderly patients. The technique is more difficult to use for the first division and carries a risk of corneal anaesthesia, leading to ulceration.

Glycerol injection — once the needle is in position the patient sits up and a mixture of glycerol in contrast is injected until Meckel’s cave is filled. It is awkward to sit the patient up with the needle in situ, and cranial nerve palsies can occur if material leaks from the intended position.

Balloon microcompression — is carried out under general anaesthetic, with a larger-gauge needle. When the needle is in position a catheter with a balloon at the tip is introduced and inflated, compressing the nerve against the wall of the foramen ovale. The larger-gauge needle does increase the risk of damage to nearby vessels (internal carotid, jugular vein and complex).

Radiosurgery — a dose of radiation is delivered to the root entry zone or the Gasserian ganglion. The effect is usually not immediate. The efficacy is dose-related, as is the side effect of dysaesthesia. In some analyses the pain relief is not as good as the other lesioning techniques.

For comparison, at 5 years the proportion of patients off medication is approximately 80% for microvascular decompression, 50% for the foramen ovale techniques and around 30–40% for radiosurgery. To put this in context up to 75% of cases will find medical treatment alone unsatisfactory.

Cordotomy

Cordotomy is performed almost exclusively for malignant pain — classically for infiltrating pain from Pancoast’s syndrome. It is a highly effective and under-used method of pain control in these patients but pain relief will last for only a few months.

Methods — cordotomy can be performed either percutaneously or at open operation. The aim is to cut the anterior spinothalamic tract on the contralateral side to the pain. The much more commonly performed percutaneous method involves a lateral puncture between C1 and C2 under fluoroscopic control. Stimulation is carried out to confirm pain relief in the desired area and then a lesion can be made in the spinothalamic tract.

The open method requires a general anaesthetic and a laminectomy (now rarely performed) and is performed for bilateral pain (one side is done percutaneously the other open), for technical failure of percutaneous cordotomy and when there is metastatic disease within the cervical spinal canal. It maybe more effective than the percutaneous technique for pain in the sacral region, though is of greater morbidity being an open procedure. Some practitioners wake the patient at this point to carry out functional testing. The procedure is simple and of much lower morbidity than the description might suggest.

Complications of both methods include ipsilateral muscle weakness. If performed bilaterally, then loss of bladder function will almost always occur. The risk to respiration, particularly if performed at the cervical level, is important. If performed for chest pain in lung carcinoma, the respiratory function on the side of the pain may already be compromised; therefore, the production of weakness on the ‘good’ side may be significant. If bilateral cervical lesions are performed ‘Ondine’s curse’ may develop. To avoid this risk, open, high-thoracic cordotomy is preferred for the second side. The level of cordotomy should be carefully judged: a lower level will preserve function, but since fibres discussate over as many as eight levels, too low will impair efficacy. The usual ‘mistake’ is to be too conservative with the lesion. The results are as that about 50% of patients are satisfied with pain relief at 12 months. There is a risk of development of post-lesioning dysaesthesias, so the technique is solely reserved for pain of malignant origin.

DREZ lesion

‘Microsurgical selective posterior rhizotomy’ or radiofrequency lesioning in the dorsal root entry zone (DREZ) has been used for pain control since the 1970s. The logic of the treatment in avulsion-related pain is that the DREZ cells are hyperactive following deafferentation.
Syndromes — the only clear indication for this technique is for brachial plexus avulsion injuries, although it has been tried for pain resultant from many other central and peripheral nerve lesions.

Operation — DREZ lesion is an open neurosurgical procedure requiring a laminectomy. A lesion is created affecting Rexed laminae I–IV; the lesion can be made microsurgically or by radiofrequency thermal coagulation. Laser lesionising has been used in the past. The DREZ can be difficult to identify when roots have been avulsed so intraoperative neurophysiological techniques can be necessary to aid identification of the correct anatomy.

Risks — some ipsilateral loss of sensation and/or weakness may occur in as many as 60% of cases and be significant in up to 10%. Rarely loss of bladder control can occur. For these reasons DREZ lesion is often attempted only as a last resort.

Outcomes — for brachial plexus lesions success rates of 70% are reported, with long-term follow-up of between 1 and 8 years. Rates of 50–70% are found for other indications; where relief is obtained it seems to be maintained, but relapse can occur with time.7

Neuromodulation

Spinal cord stimulation
See Implantable technologies for pain management on pages 520–523 of this issue.

Peripheral nerve stimulation: early complications with electrode migration reduced application, although this is less problematic now. Currently, the best-known solution is the vagal nerve stimulator, which is used for epilepsy. Occipital nerve stimulation is used for occipital neuralgia and is being trialled in refractory cases of migraine and cluster headache. Both surgically implanted leads and percutaneous techniques are used.

Deep brain stimulation
Indications — deep brain stimulation can be used in cases of central post-stroke pain and some facial pains. The procedure carries a risk of stroke and death (<2%). It has replaced historical techniques of thalamotomy.

Methods — under local anaesthesia a burr-hole is made in the skull and an electrode passed stereotactically to the intended target, normally within the sensory thalamus and/or the periaqueductal/periventricular grey — from which area the endogenous opioid based pain inhibitory system is thought to arise. More recent interest is in the cingulate gyrus as a target. The patient is left with the sensation of pain but no longer regards it as unpleasant. A trial of stimulation is performed to confirm positioning. Following a successful trial, a permanent device is implanted and connected to the electrode.

Outcomes — 50% of patients may respond and have a device implanted, which is a good outcome in a highly refractory group of patients, though the data are entirely observational.6

Motor cortex stimulation
Indications — the main indication is for central post-stroke pain, where the referred area of pain is the upper limb or face, and also for refractory facial pain.

Methods — a craniotomy is performed and electrodes are placed over the motor cortex using intraoperative neurophysiology and/or image guidance with functional magnetic resonance imaging.

Outcomes — have not been uniformly encouraging though some have found good results, so currently the method should be regarded as unproven. There is controversy over whether the pre-motor cortex is a more effective target region. Transcranial magnetic stimulation systems may help evaluate this therapy.

Intrathecal drug delivery systems
These can be used for pain and spasticity control (see Implantable technologies for pain management on pages 520–523 of this issue).

REFERENCES

FURTHER READING