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Which operation for trigeminal

The right trigeminal nerve from above in a patient with right trigeminal neuralgia (autopsy photograph). The nerve is retracted laterally revealing a deep groove caused by the superior cerebellar artery resting on the surface of the pons medial to the nerve. This is the typical configuration of the superior cerebellar artery in relation to the trigeminal nerve in patients with trigeminal neuralgia.

Trigeminal neuralgia?

INTRODUCTION

Trigeminal neuralgia is a severe, debilitating facial pain disorder that has driven some to suicide when unable to obtain relief. Afflicted patients often describe the pain as 'shocking', 'lightning', or 'electric'. If a patient describes pain in the face with words such as these, the diagnosis of trigeminal neuralgia should be at the top of the differential diagnosis.

Historically, treatment has ranged from poultices and salves to injecting boiling water into the cheek to kill the nerve. The introduction of carbamazepine brought successful medical management to many, but adverse effects, and gradual development of refractory pain, mean that some patients still require invasive procedures to achieve pain control. The goal is to identify the point at which surgical intervention should be considered, and then to guide the choice of procedure.

MEDICAL MANAGEMENT

First line therapy for trigeminal neuralgia is carbamazepine (Tegretol). If the patient cannot tolerate carbamazepine, other anticonvulsants such as gabapentin, phenytoin or valproic acid or baclofen can be tried, but they are not very effective (Wiffen *et al.* 2000). Generally, the failure of carbamazepine to eliminate pain without tolerable adverse effects will signal the need to consider surgical therapy in the near future.

WHAT THE SURGEON THINKS AND DOES

When asked to assist in the treatment of trigeminal neuralgia, the surgeon must first confirm the diagnosis. We use three criteria: the character of the pain, its location and its response to carbamazepine. At least at its onset the pain should have been described in terms such as 'electric', 'shock like' or a 'bolt of lightning'. It should be brief, lasting seconds to minutes, although longer lasting series of repeated brief pains can occur. Later in its course, some patients describe a longer lasting burning or aching component, but this should not be a major part of the complaint.

The pain must be restricted to the distribution of one trigeminal nerve. Bilateral trigeminal neuralgia does occur, but is asynchronous in onset and the involvement of the two sides can easily be separated. Pain that crosses from side to side, extends to the back of the head or into the neck must be regarded with great suspicion.

The initial response to medication confirms the diagnosis. One occasionally encounters a patient with typical trigeminal neuralgia who has never tolerated a medication long enough to determine its effectiveness, and so one may have to make a clinical judgement without this criterion, but this is rare.

Having clinically confirmed the diagnosis, the surgeon will generally request an MRI if one

has not already been done. While the association with structural lesions is rare, the surgeon about to undertake an invasive procedure must avoid being surprised by an unexpected structural lesion such as a tumour or vascular anomaly (Barker *et al.* 1996).

Surgical options

There are five widely available invasive options for treating trigeminal neuralgia that are currently used: radiofrequency rhizotomy, balloon compression, glycerol injection, radiosurgery and microvascular decompression. The first four are considered 'minimally invasive' but still involve the controlled application of some form of destructive energy to partially injure the nerve. Microvascular decompression requires craniotomy and microsurgery, but does not add any injury to the trigeminal nerve. The choice of procedure is based on the patient's ability to undergo general anaesthesia, patient preference, and which division of the nerve is affected. The classic procedure of injection of absolute alcohol into the Gasserian ganglion or peripheral branches of the nerve has an unacceptable risk of painful dysaesthesiae when compared to the more modern procedures and should be abandoned (Fardy & Patton 1994).

Radiofrequency rhizotomy is the most commonly used percutaneous procedure. A small insulated electrode is placed in the foramen ovale through a nick in the cheek. Most electrodes have a curved tip that allows some manipulation of direction depending on the distribution of pain. V3 pain is treated with the tip curved down, while V1 pain is treated with the tip curved up. Second division pain is treated with the straight electrode. Placement is confirmed with a lateral X-ray image. With a radiofrequency generator, the needle tip is then heated to approximately 40 degrees centigrade for a short period while the patient is sedated with an ultra short acting sedative such as propofol or methohexital. After heating the nerve, the patient is aroused and the area in question tested. The goal is to achieve pain relief, but with light touch and pinprick preserved. However, patients need to be aware of the potential for significant numbness in the area treated. If the nerve is heated too much or too long, complete anaesthesia can be reached. If treating V1 pain, the most significant risk is of corneal anaesthesia and resultant corneal ulceration and keratitis. Motor function is nearly always left intact with this technique. Other rare but important

problems are cranial nerve deficits, intracranial abscess, meningitis and puncture of the carotid artery or cavernous sinus (Taha & Tew 1996).

Balloon compression is a recently developed technique performed under general anaesthesia. A 14 gauge needle and a blunt tipped guiding stylet (Cook Inc., Bloomington, IN, USA) is advanced through the cheek to the foramen ovale under X-ray control – lateral, antero-posterior and 'down-the-barrel' views are used to achieve the correct approach. Once the foramen is engaged, the guiding stylet is removed and a no. 4 French fogarty balloon catheter (Cook Inc.) is advanced and positioned with continuous X-ray control. When in the correct position, the balloon is inflated with 2 cc of omnipaque 300 (Amersham Health, Princeton, NJ, USA). Brown *et al.* (1996) recommend leaving the balloon inflated for 1 min at a pressure of 1200 mmHg when patients undergo their first compression. Repeat procedures for recurrence are often treated with compression for 1.5 min. Because this procedure is done under general anaesthesia, the advantage of being able to speak to the patient is lost. Clinical signs of successful placement and compression are significant bradycardia, hypertension, and a very classic pear-shape during inflation on lateral X-ray. The bradycardia and hypertension resolve spontaneously once the balloon is deflated. However, the bradycardia can be significant enough to warrant placing an external pacemaker on the patient preoperatively for use during the procedure. Blood pressure monitoring is recommended with either an arterial line or continuous cuff measurements. After the compression, the needle and balloon are removed and the cheek is compressed for 5 min to prevent haematoma formation. A sticking plaster is applied and the patient observed for a few hours. Many patients go home the same day if the general anaesthesia is well tolerated (Abdennebi *et al.* 1997).

Notable adverse effects are ipsilateral masseter weakness that resolves over a few days, and mild numbness in the affected region. There is a very low risk of corneal anaesthesia. Carotid-cavernous fistula has been reported with malposition of the introducing needle (Kuether *et al.* 1996).

Glycerol rhizolysis. As with balloon compression and radiofrequency rhizotomy, glycerol rhizolysis starts with a spinal needle placed through the cheek and into the foramen ovale (Fig. 1). Free flow of CSF must be seen at this

Figure 1 (a) A modified X-ray view demonstrating the foramen ovale (arrow). Lateral to the mandible, medial to the maxilla, and above the petrous ridge. (b) Submentovertex view of the skull. Needle enters right foramen ovale. (c) AP view of skull. The needle rests in the left Meckle's Cave which has been filled with contrast. (d) Lateral view of the skull. The needle rests in the left Meckle's Cave which has been filled with contrast.

point to guarantee proper placement. X-ray imaging guides the needle to the correct location in the trigeminal cistern. Iohexol is injected into the cistern as the table is tilted upwards, outlining Meckel's cave. The inferior edge of the Gasserian ganglion can be seen as the superior edge of the outlined space. The amount of iohexol to fill the cistern is measured by injecting until the dye overflows into the posterior fossa. The iohexol is withdrawn and anhydrous glycerol is injected into the same area filling the cistern. The glycerol has a neurotoxic effect on the nerve fibres and this effects the pain relief. After the cistern is filled, the patient is kept upright for about 2 h to keep the glycerol in the correct position. Pain relief is usually felt within a few hours and patients usually go home the same day (Jho & Lunsford 1997).

Complications of this procedure are similar to those of the other percutaneous procedures. Incorrect needle placement can cause CSF leaks, carotid-cavernous fistula, and haematoma formation. Corneal anaesthesia is a relatively uncommon adverse effect but has been reported.

Radiosurgery has been advocated as an even less invasive option for the treatment of trigeminal neuralgia but does still involve the application of a stereotactic frame. A very small (4 mm) target in the trigeminal root just anterolateral to the brainstem receives a precisely aimed single dose of 60–90 Gray. A mild sedative may be given to help the patient hold completely still during the therapy (Kondziolka 1999). This treatment has had some initial reports of success rates as high as 85% in the first year, but the definition of success used by radiosurge-

ons includes patients with only partial pain relief, a criterion not used in evaluating other procedures (Kondziolka *et al.* 2002). Recurrence, however, is somewhat high at 55% at five years. Most series indicate success rates (i.e. pain control sufficient to eliminate requests for additional procedures) just above 50%. It may take days to months to achieve relief. While there is great patient appeal in a procedure that requires no injection or operation, radiosurgery has the lowest rate of initial success of any of the currently available procedures and is not free of complications. Adverse effects seem to be directly related to the radiation dosage. Patients treated with dosages at 90 Gray have longer lasting pain relief but a higher risk of painful dysaesthesia and corneal numbness than those treated with 70 Gray (Pollack *et al.* 2002). Treatment with 90 Gray is not therefore recommended. The procedure appears not to be a good choice for first surgical therapy, but as an alternative for patients who have failed previous surgical interventions, had a recurrence, or refuse any surgical intervention.

Microvascular decompression, using an operating microscope, was popularized in the

Figure 2 Intraoperative exposure of the trigeminal nerve during right trigeminal microvascular decompression. (a) After placement of a Teflon felt pledget. There is a typical caudally looping superior cerebellar artery that has been moved from its position between the trigeminal nerve and the pons to rest entirely lateral to the nerve, separated from it by the pledget. The trigeminal nerve is completely hidden by the pledget. (b) The dissector elevates the trigeminal nerve revealing an unusual loop of the anterior inferior cerebellar artery compressing the nerve from below.

1960s by Peter Jannetta. This procedure is performed, with the patient under general anaesthesia, through a small craniotomy just behind the sigmoid sinus. The subarachnoid space is entered supero-laterally to the cerebellum. The dissection continues medially towards the brainstem until the fifth cranial nerve is identified as it exits the pons. Once identified, the area is explored to discover any vascular structures (usually arterial) that may be compressing, dividing or lying on the nerve (Fig. 2). Pledgets of shredded Teflon (DeRoyal, Powell, TN, USA) are placed in order to permanently separate the vessel and nerve, completing the procedure. Sometimes a venous structure may be coagulated and divided if necessary. The patient is observed in hospital for 1–3 days after surgery. Complications range from CSF leaks, infection and meningitis to rare, severe problems such as cranial nerve deficits (1%), stroke (0.1%) and intracranial bleeding (0.02%).

CHOOSING A SURGICAL PROCEDURE

With such a varied armamentarium, and notwithstanding the lack of randomised trials, the surgeon is in an excellent position to help the patient choose a procedure best for his or her individual circumstances. However, we believe that one consideration takes precedence: minimizing injury to the trigeminal nerve itself. The more injury to the nerve, the more likely are the most devastating complications of keratitis

leading to blindness and anaesthesia dolorosa, a condition even worse than trigeminal neuralgia itself (see below). The management of craniotomy for microvascular decompression in experienced hands has advanced to the point that the risk of serious complications approaches that of the other invasive procedures. Moreover, it is the only procedure that does not add injury to the trigeminal nerve. It is also less likely that the patient will require a subsequent procedure. We consider it the procedure of choice in patients without medical contraindications to general anaesthesia, and also in virtually everyone with first division pain, because the risk of corneal involvement is especially high when these patients are treated with nerve injuring procedures.

The immediate initial success rate for microvascular decompression is as high as 98% (Barker *et al.* 1996) and is advocated by many as first line therapy for those who can tolerate general anaesthesia. (See Table 1.)

For medically fragile patients with second or third division pain, glycerol rhizolysis is probably the quickest procedure with the least physiological stress and lowest risk of severe anaesthesia or dysaesthesia. However, it should be clear that the three procedures performed by needle access to the Gasserian ganglion have similar profiles of success and risk and so the surgeon's experience should be the primary determining factor in the choice.

Radiosurgery remains a secondary alternative, less successful than any of the other procedures.

Table 1 Results of surgical treatments for trigeminal neuralgia (adapted from Taha & Tew 1996).

	RADIOFREQUENCY RHIZOTOMY	BALLOON COMPRESSION	GLYCEROL INJECTION	MICROVASCULAR DECOMPRESSION
Total number of patients treated	500	759	1217	1417
Initial pain relief	98%	93%	91%	98%
Recurrence rate	20%	21%	54%	15%
Facial numbness	98%	72%	60%	2%
Anaesthesia dolorosa	0.2%	0.1%	1.8%	0%
Corneal anaesthesia	3%	1.5%	3.7%	0.05%
Perioperative morbidity	0.6%	1.7%	1%	10%

We reserve it for patients who have failed invasive procedures and we cannot justify it as the first invasive procedure for any patient on the basis of current evidence (Pollack *et al.* 2002).

ANAESTHESIA DOLOROSA

The most feared complication of the treatment of trigeminal neuralgia is persistence of pain, usually with severe dysaesthesiae, in the presence of facial anaesthesia and analgesia. This form of deafferentation pain is amongst the most horrible and most difficult to treat in human experience. It has been associated with a high rate of suicide.

There is no satisfactory surgical treatment for anaesthesia dolorosa that can be routinely recommended. However, advances in surgical neuromodulation are raising hopes that such a solution may become available in the foreseeable future. Dorsal root entry zone ablation (Bullard & Nashold 1997) and motor cortex stimulation (Gouda & Brown 1997) are probably the most popular procedures at the moment. However, these techniques are not part of the standard neurosurgical armamentarium. The techniques are innovative and require an investigative mindset on the part of both surgeon and patient. The management of these patients is complex, requiring much attention to non-surgical issues. The rare and very unfortunate patient with anaesthesia dolorosa should not be referred to just any neurosurgeon, but to a team investigating the treatment of facial deafferentation pain.

SUMMARY

The neurosurgeon has a number of procedures with differing risks and benefits available for the treatment of trigeminal neuralgia in patients who have failed or cannot tolerate pharmacological control of their disease. This allows the surgeon and patient to choose the procedure

best suited for the patient's individual situation, and with a high likelihood that pain control can be achieved with safety.

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