Trigeminal neuralgia treated by differential percutaneous radiofrequency coagulation of the Gasserian ganglion

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The authors describe surgical and anesthetic techniques for the treatment of trigeminal neuralgia by radiofrequency coagulation. Using radiographic landmarks derived from a stereotaxic study of 54 cadaver skulls, they delineate lateral and anteroposterior guidelines which aid in the percutaneous penetration of the foramen ovale. Controlled lesions can be made selectively in any division of the trigeminal nerve. The procedure has been effective in abolishing pain usually with preservation of touch sensation in the face. The percutaneous operation has the added advantage of a short hospitalization, usually 2 days. Of the 65 patients treated, only one still has the pain of trigeminal neuralgia. In six instances the procedure had to be repeated because insufficient sensory deficit was produced by the initial lesion. Three patients have developed anesthesia dolorosa; however, none has developed facial paralysis.

Key Words: trigeminal neuralgia · radiofrequency coagulation

In 1970, Sweet and Wepsic described a method for treatment of trigeminal neuralgia with radiofrequency lesions using a percutaneous approach to the Gasserian ganglion. Their very promising results in treating 73 patients stimulated further interest in this method and improvements in the technique.

In this paper we present the results of this treatment in 65 patients.

Materials and Methods

To develop an improved radiographic method for the placement of the electrode we first made measurements of the target site in 54 cadaver skulls. Using this data we then developed a technique for making retrogasserian radiofrequency lesions with the same electrode and needle used for the percutaneous radiofrequency cordotomy.

Cadaver Skull Studies

A small lead oval was fixed to the site of Meckel’s cave in 54 cadaver skulls. Each skull was then placed in the Todd-Wells stereotaxic frame and the center of the oval brought into the central beam of the x-ray. This target site on the lateral film was consistently located at the angle or junction of the shadows produced by the clivus and the petrous ridge (Fig. 1). In some cases a less dense shadow was observed somewhat above the shadow of the petrous ridge; then
FIG. 1. Left: Lateral view of cadaver skull in stereotaxic frame showing target site at junction of shadows produced by the clivus and petrous ridge. Right: Line drawing of lateral projection showing target site at vertex of lines produced by the clivus and petrous ridge.

the target site was at the angle produced by this upper shadow and the clivus.

On the anteroposterior projection, the center of the target site was found to lie a mean distance of 18 mm from the midline (S.D. ± 0.23 mm). In the anteroposterior projection the target site could be identified on a horizontal line transecting the middle of the internal auditory meatus as visualized through the petrous ridge, with the midpoint of the target site at a mean distance of 6.1 mm medial to the lateral edge of the internal auditory meatus (S.D. ± 1.3 mm). These two measurements are actual values determined stereotaxically. Since the electrode usually passes proximal to the ganglion and lies in the retrogasserian rootlets, and taking into account the usual magnification obtained in anteroposterior x-rays, we deduced that the electrode passes, on an average, 9.0 mm medial to the lateral edge of the internal auditory meatus.

In this same anteroposterior projection there was frequently a depression in the medial petrous ridge produced by the fifth cranial nerve as it crossed this area. The most medial edge of this depression was usually in the line with the center of the ganglion (Fig. 2).

Anesthesia

Our present clinical technique is to use, without any premedication, droperidol

FIG. 2. Left: Cadaver skull showing lead oval at site of ganglion in line with internal auditory canal and at the medial point of "dip" in superior aspect of petrous ridge. Right: Line drawing of this projection defining ganglion in relation to lateral wall of internal auditory meatus.
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(0.15 mg/kg) or diazepam 5 mg intravenously at the start of the procedure. After waiting about 10 minutes for the tranquilizer to take effect, the narcotic fentanyl is given slowly intravenously in three doses of 0.05 mg each about 5 minutes apart. More fentanyl is then given, as needed, 1 ml (0.05 mg) at a time. In some instances an additional 5 or 7 ml has been required. These agents are administered by an anesthesiologist.

Initially we used droperidol and fentanyl in combination as Innovar but found that some patients were too confused to permit careful clinical testing because this fixed combination contained too much droperidol.

The above regimen has proved quite satisfactory and most patients state that they would be very willing to have the operation repeated should this be necessary.

**Technique of Electrode Placement**

Most surgeons approach the Gasserian ganglion through the foramen ovale by some modification of the technique described by Härtil.² This approach has been reviewed by White and Sweet.¹¹

A point 2 to 3 cm lateral to the lateral angle of the mouth is infiltrated with local anesthesia; a thin-walled No. 18 lumbar puncture needle, 10 cm in length, is then introduced and aimed at a point on the zygoma 2.5 cm anterior to the anterior edge of the external auditory meatus and, in the anteroposterior plane, the center of the pupil. A gloved finger is placed in the mouth to prevent penetrating the oral cavity. The needle is advanced beneath the maxilla close to the base of the skull. At this point fluoroscopy or Polaroid radiographs in the lateral projection are used to assure that the needle is aiming directly at the angle created by the clivus and petrous ridge, the target determined by our cadaver studies. An anteroposterior projection is then used to visualize the target site through the orbit. In this projection, the needle should be directed toward a point about 9 mm medial to the lateral wall of the internal auditory meatus or at the medial-most aspect of the dip on the petrous ridge. Making the necessary corrections, the needle is further introduced to the base of the skull. If the foramen ovale is not penetrated the films are repeated and appropriate corrections made. At this point it is frequently possible to “walk” the needle around the base of the skull until the foramen is entered. At this time the needle is advanced using the lateral roentgenogram to identify the relationship of the needle tip to the clivus (Fig. 3 left), and, in the anteroposterior view, the relationship to the internal auditory meatus (Fig. 3 right). Cerebrospinal fluid (CSF) is usually obtained at this point.

**Creation of the Lesion**

To create the lesion we have used a longer version of the electrode with a Teflon insulated stylet 0.016 in. in diameter used.
by Lin, et al.,\textsuperscript{5} for percutaneous cordotomy. The tip is exposed 3 mm rather than the 2 mm for cordotomy. The tip of the electrode is usually set to extend 5 mm beyond the tip of the lumbar puncture needle. The somewhat larger needle (0.02 in. in diameter) used by Rosomoff, et al.,\textsuperscript{6} for percutaneous cordotomy can also be used with the same lumbar puncture needle. We have preferred the smaller electrode primarily because the electrode tip can be bent to allow some deviation of the electrode and therefore a little more flexibility in the placement of the lesion. The electrode can be used repeatedly.

Most important for ascertaining proper placement of the electrode is the response evoked to low voltage stimulation. About 0.2 to 0.4 volts are applied to the tip of the electrode using the hub of the needle as an indifferent electrode. A lesion can usually be made at low current settings when the threshold for a sensory response to stimulation is 0.2 volts or less. The patient is instructed beforehand in identifying the area of the face in which he will feel sensations produced by the stimulation. If the electrode is in the proximity of the motor root, low frequency stimulation will evoke muscle contractions. The pain or discomfort sometimes produced in the division in which the lesion is being made further assists in localization.

The electrode may quite consistently be placed in any one of the three divisions merely by adjusting the depth of penetration. Since the electrode traverses the retrogasserian sensory rootlets, deepest penetration involves the first division fibers and lesser penetration, the second and still less the third division rootlets (Fig. 4).

When treating second division pain, one should attempt to achieve a response to stimulation in the upper lip or side of the nose rather than in the upper cheek because in the latter location the lesion may also involve the fibers to the cornea.

When the electrode has been properly positioned, a radiofrequency lesion is made using the A mode and the same current parameters that are used with this electrode for percutaneous cordotomy. We usually use between 50 and 110 mA and 12 to 20 V as read on the meters of the Radionics generator. A 10-second lesion is made initially and enlarged in increments of 3 to 5 seconds until the desired degree of sensory deficit is created, the point at which pinprick loses or almost loses its sharp and pricking quality. At this time light touch is usually preserved. If sensory deficit is not produced in 30 seconds, more power is usually required. The amount of current required to produce lesions varies, probably due to the fact that the electrode may be located either in the rootlets or in the adjacent cerebrospinal fluid.

The radiofrequency lesion may be rather suddenly enlarged by small increases in time and/or current. In three cases this has caused unintentional anesthesia in the first division. If the radiofrequency generator loses current flow it may be difficult to make an adequate lesion; this can be corrected more quickly by repositioning the electrode than by attempting to increase the current.

It is usually wise, when more than one division is to be treated, to coagulate the most inferior division first because the lesion may spread to involve the upper division. The most satisfactory results have been obtained when the lesion was made in the presence of a free flow of cerebrospinal fluid. If repeated lesions cause severe pain in the face without creating a sensory deficit, the electrode should be replaced as it is probably not in the retrogasserian rootlets. Occasionally a referred pain in the forehead may be noted during the creation of a lesion or sensory deficit in the first division.
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TABLE 1

<table>
<thead>
<tr>
<th>Electrode Tip Relation</th>
<th>1st Div Lesions (mm)</th>
<th>2nd Div Lesions (mm)</th>
<th>3rd Div Lesions (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>electrode tip to clivus, lateral view:†</td>
<td>4.4 post.</td>
<td>3.1 post.</td>
<td>0.2 post.</td>
</tr>
<tr>
<td>mean</td>
<td>5 ant., 13 post.</td>
<td>6 ant., 13 post.</td>
<td>10 ant., 12.5 post.</td>
</tr>
<tr>
<td>range</td>
<td>5 ant., 13 post.</td>
<td>6 ant., 13 post.</td>
<td>10 ant., 12.5 post.</td>
</tr>
<tr>
<td>electrode tip to petrous ridge, AP view:‡</td>
<td>2.1 sup.</td>
<td>0.9 inf.</td>
<td>3.4 inf.</td>
</tr>
<tr>
<td>mean</td>
<td>8 sup., 2 inf.</td>
<td>8 sup., 11 inf.</td>
<td>8 sup., 12 inf.</td>
</tr>
<tr>
<td>range</td>
<td>8 sup., 2 inf.</td>
<td>8 sup., 11 inf.</td>
<td>8 sup., 12 inf.</td>
</tr>
</tbody>
</table>

* The mean distance of the electrode medial to the lateral wall of the internal auditory meatus at mid canal for all lesions was 9.0 mm.
† Tube to plate distance was 36 in.
‡ Tube to plate distance was 40 in

Experience indicates that, for some reason, first division lesions can often be made at much lower current settings than those required for second and third division lesions. Thus, these lesions may be made without any discomfort in the face during the creation of the lesion. This must be kept in mind when treating first division pain.

As the lesion is being enlarged the cilial and corneal reflexes are regularly examined. The cilial reflex is usually impaired before the corneal reflex if the first division is involved, so careful monitoring of the cilial reflex is necessary if the first division is to be spared. First division trigeminal neuralgia may be successfully treated by enlarging the lesion until the cilial reflex is lost but the corneal reflex spared.

Radiographic Localization of Lesions

The relationship of the electrode tip to the clivus and petrous ridge for lesions in the three divisions are tabulated in Table 1. However, the response to low voltage stimulation is more important for accurate placement than the relationship of the electrode to the clivus.

In our first 17 patients we also obtained submento-vertex views to localize the electrode tip. The mean depth of penetration of the electrode beyond the posteromedial edge of the foramen ovale for first division lesions was 15 mm, for second division lesions 13 mm, and for third division lesions 11 mm.

Results

We have performed 72 operations in 65 patients, 33 men, with an average age of 61 years, and 32 women, whose age averaged 69 years. Six patients had to have a second operation because insufficient sensory deficit was obtained at the first operation and the pain recurred. In another patient, the neuralgia extended to a division not involved at the time of the first operation. Three of our recurrences occurred within days of the initial procedure whereas the other three had return of pain approximately 6 months later.

Our follow-up averages 13 months with a range from one to 41 months.

Previous treatment had included Tegretol or Dilantin, 92%; alcohol blocks, 48%; and 57% had had either alcohol block, nerve avulsion or a decompressive procedure. We have successfully treated 10 patients who had previously had a subtemporal decompressive procedure. All patients but one are currently free of the pain of trigeminal neuralgia; this one patient has a minimal degree of pain that requires no treatment.

Deep touch sensation (pinprick appreciated as touch) was preserved in all three divisions in 58 (89%) of the 65 patients; 42 (65%) had preservation of light touch (twisted corner of facial tissue) in all three divisions. The sensory deficits produced are summarized in Table 2.

To prevent recurrence in an adjacent
Facial sensory deficit following treatment by radiofrequency lesion

<table>
<thead>
<tr>
<th>Deficit</th>
<th>In No Divisions</th>
<th>In One Division</th>
<th>In Two Divisions</th>
<th>In Three Divisions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Cases</td>
<td>%</td>
<td>No. of Cases</td>
<td>%</td>
</tr>
<tr>
<td>anesthesia</td>
<td>58</td>
<td>89</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>analgesia</td>
<td>30</td>
<td>46</td>
<td>24</td>
<td>37</td>
</tr>
<tr>
<td>light touch lost</td>
<td>42</td>
<td>65</td>
<td>14</td>
<td>21</td>
</tr>
</tbody>
</table>

In three patients who had first division pain the result must be considered poor even though the pain of trigeminal neuralgia has been eliminated; early in our experience we intentionally produced anesthesia in the eye to treat the pain. These three patients have developed anesthesia dolorosa affecting the eye in two and the eye and upper second division in one. In one patient this problem could be called tolerable but in the other two it is severe and intolerable. We now attempt to preserve corneal sensation when the first division is involved. This was accomplished in eight of 10 patients treated later in the series.

The motor branch has been impaired to the extent that it was readily apparent in eight patients. In 20 others the jaw barely deviated to the treated side when opened against resistance, suggesting some involvement of the motor root. Follow-up examination indicates that the motor deficit improves with time. Seven patients, three with readily apparent deficits, recovered from the immediate postoperative motor loss in periods varying from 1 to 9 months. Adequate follow up was not available on the remainder. Recovery might be anticipated from a lesion-in-continuity distal to the nucleus.

A pterygo-alar bar in two of our patients prevented penetration of the foramen ovale. This anatomical feature was noted in 7% of skulls by Chouké and Hodès; the anatomy of the foramen ovale and adjacent structures has been reviewed by Sondheimer.

The most serious complication is injury to the internal carotid artery. The older literature reports five deaths from carotid thrombosis or injury probably related to diathermy electrocoagulation, which may produce larger and less well controlled lesions than the radiofrequency technique.

We have punctured the carotid artery four times. In one of these the electrode was in proper position radiographically but in the other three the needle was placed too medial. Adjustment of the needle in two of these cases allowed correct placement of the electrode in the rootlets, clear CSF was obtained and the patients were successfully treated. More cautious attention to the radiographic landmarks defined above would have prevented these errors and we no longer attempt to penetrate the foramen ovale without an anteroposterior x-ray.

One frail and debilitated 87-year-old man with severe pain died from acute bilateral necrotizing pneumonia 2 days after an attempt was made to treat him with a radiofrequency lesion. He was one of the patients whose carotid artery was punctured but no lesion made, and appeared to have no ill effects whatever from the carotid puncture.

Conclusions

Our results thus far indicate that this is an excellent method of treating trigeminal neuralgia and is superior to the open surgical procedure for the following reasons:
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1. The mortality and morbidity is decreased; the patient leaves the hospital the day after the procedure.
2. Lasting relief, if not a cure, is possible with preservation of touch sensation in the face in most cases.
3. The procedure is tolerated better by the elderly; our oldest patient was 92 years old.
4. Control of the lesion is usually possible so that by gradually enlarging the lesion, varying degrees of sensory deficit can be created.
5. There is no danger of facial paralysis.
6. With the technique described the submentovertex radiographic projection which is cumbersome and uncomfortable for the patient can be avoided; we have used this projection only once in our last 51 patients.
7. With the neuroleptanalgesia described it should be possible to treat the patient with a tolerable degree of discomfort.

References

7. Seeger W: (Trigeminal neuralgia in space-occupying intracranial processes.) Zbl Neurochir 23:152–165, 1963 (Ger)

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