Quantitative analysis of lesion parameters in radiofrequency trigeminal rhizotomy

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A series of 144 lesions made during 32 radiofrequency rhizotomies was reviewed. The parameters of each lesion were compared with the sensory change resulting from the lesion. One-half of the lesions resulted in no sensory change, but 16.7% produced numbness in a division not predicted by stimulation. This was a barely detectable sensory change in 6% of lesions and more dense in 10%. The first lesion in a series was particularly likely to result in sensory deficit, and accounted for half of the more dense lesions not predicted by stimulation. When the threshold at which stimulation was perceived was 0.2 volts or less, a lesion was likely to produce numbness, and when it was 0.5 volts or greater, marked sensory loss did not occur. There was no apparent relationship between the likelihood of sensory change and lesion temperature or duration. Analysis of lesion temperature was made more difficult by the use of low temperatures when numbness should be easy to obtain. With careful technique, radiofrequency rhizotomy can be performed with acceptable risk of unpredicted sensory loss. Particular care should be taken during the first lesion in each procedure and when stimulation thresholds are 0.2 volts or less.

KEY WORDS □9 trigeminal nerve □9 trigeminal neuralgia □9 rhizotomy □9 radiofrequency lesion

PERCUTANEOUS radiofrequency trigeminal rhizotomy is an effective way to control pain in trigeminal neuralgia. Although it is relatively safe and reliable, there are occasional undesirable sequelae. These include a disagreeable quality to the operatively induced facial numbness (rarely seen without complete loss of sensation), and unwanted sensory loss in another division. Stimulation and heating parameters which will secure sufficient numbness to control pain but avoid these complications have been recommended, but no detailed report of the effect of variations in these parameters is available. In this report, we review a series of 144 lesions made during 32 radiofrequency rhizotomies, and compare the lesion parameters with the sensory changes resulting from the lesion.

Clinical Material and Methods

Radiofrequency trigeminal rhizotomy was performed using a needle that was insulated except at its tip. This was placed through the foramen ovale so that the tip was among trigeminal rootlets. Stimulation through the needle was assumed to be perceived in the portion of the face supplied by rootlets closest to the needle tip. The needle was moved until its tip was near the rootlets supplying the symptomatic part of the face. To make a lesion, the patient was anesthetized for 2 to 3 minutes and the rootlets were damaged by heating the needle tip with a radiofrequency current. A thermistor in the needle tip allowed its temperature to be measured. A Radionics RFG-3AV lesion generator was used for each procedure.* When the patient awakened sensation was assessed and, if sensory loss was insufficient, another lesion was made.

During a 24-year period, the details of each lesion were tabulated. These included the following parameters: stimulation division (trigeminal division to which sensation elicited by stimulation was referred), stimulation threshold (threshold at which stimulation was perceived), sequence of each lesion in the procedure, needle temperature, current duration, and degree of numbness in each division before and after the lesion. Repetitive, negative-pulsed square waves at 25

*Radionics RFG-3AV lesion generator manufactured by Radionics, Inc., 76 Cambridge Street, Burlington, Massachusetts.
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FIG. 1. Frequency of sensory deficit in one or more divisions.

Hz and 1-msec duration were used for stimulation, and a needle insulated to within 5 mm of its tip was used to create the lesions. If sensation was elicited without electrical stimulation, presumably due to the physical presence of the needle touching trigeminal rootlets, the stimulation threshold was considered to be 0.0 volts (no stimulation). Sensation was assessed with the same pin (sterilized for each case) before the first lesion and after each successive lesion. Facial sensation was graded as normal, slightly hypalgesic, moderately hypalgesic, densely hypalgesic, analgesic, or anesthetic.

The patient population included 14 females and 15 males, all with trigeminal neuralgia. The average age was 67 years. An average of 4.5 lesions were required for each procedure. Thirty-two procedures (144 lesions) were available for analysis. All of the patients were relieved of their pain, although two patients required two procedures separated by a few days and one underwent repeat rhizotomy for recurrent pain 1½ years after an initially successful procedure.

Results

There was no change in sensation after approximately one-half of the lesions (Fig. 1). The great majority of the remainder produced a sensory change in a single division. There were a few episodes of electrode heating which produced sensory change in two divisions and, on three occasions, electrode heating with a V2 stimulation division resulted in some degree of sensory loss in all three trigeminal divisions. The likelihood of numbness in one or more divisions was the same for each of the three stimulation divisions, with the exception that sensory change in all three divisions occurred only when stimulation had been perceived in V2.

There was an unquestionable relationship between the sequence of electrode heating and the likelihood of producing a sensory deficit (Fig. 2). The first lesion in a series was particularly likely to produce sensory loss in two divisions. After the seventh attempt, lesions were less likely to be accompanied by any sensory change at all, probably because only patients in whom numbness was difficult to obtain required more than seven lesions.

There was not a clear relationship between lesion temperature and the likelihood of sensory change (Fig. 3). There was a suggestion that lesions made at 85°C might be slightly less effective than lower-temperature lesions, but this could be accounted for by the use of high temperatures only when numbness was difficult to obtain. The relationship between temperature and the likelihood of sensory change may have been masked by the selection of low lesion temperatures for episodes of electrode heating in which the stimulation threshold was low and numbness should be easier to obtain.

There was also no apparent relationship between the duration of electrode heating and the likelihood of change in sensation (Fig. 4). The possible tendency for lesions of very long duration to be ineffective could be accounted for by the use of these long durations only when numbness was difficult to obtain.

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The only statistically significant correlation between a lesion parameter and sensory change was with stimulation threshold \((p < 0.05, \text{Fig. } 5)\). When patients could appreciate stimulation of 0.2 volts or less, there was a high likelihood of producing sensory change. Lesions with these very low stimulation thresholds were particularly likely to produce numbness in more than one division. Stimulation thresholds of greater than 0.6 volts were rarely accompanied by numbness, and when these higher stimulation threshold lesions did produce numbness it was never profound. Even following lesions at 0.5 volts and 0.6 volts, the sensory deficits were never more than slight hypalgesia.

In 24 of the 144 lesions (17%), a sensory change occurred in a division not predicted by stimulation. Nine of these inappropriate lesions were in the \(V_1\) distribution, six were in \(V_2\), six in \(V_3\), and three were in both \(V_1\) and \(V_3\) (and accompanied \(V_2\) stimulation). Fortunately, only 15 of these inappropriate sensory deficits resulted in moderate hypalgesia or worse, the rest being barely detectable sensory loss. Also, 10 patients had pain in two divisions, and the inappropriate lesion was in a painful division requiring a sensory deficit during the procedure, although not in the stimulation division of the lesion being tabulated. Seventeen of these 24 lesions (and all but one of the accidental \(V_1\) lesions) resulted from electrode heating with a \(V_2\) stimulation division. The first lesion in a series was particularly likely to result in unanticipated deficit, and accounted for seven of the more dense inappropriate lesions.

**Discussion**

Most authors advise that low stimulation thresholds are optimal; however, thresholds from 2 to 7 volts have been reported to be acceptable.\(^6\) The present study suggests that this is not the case; it indicates that thresholds above 0.6 volts are so unlikely to be accompanied by significant numbness at the time of electrode heating that, when these thresholds are obtained, the needle should be repositioned.

When the stimulation threshold is less than 0.5 volts, the needle tip is likely to be sufficiently close to the trigeminal rootlets to produce numbness following an episode of electrode heating. It is also important to insure that the smallest effective lesion is created, since this will maximize the chance that numbness will be confined to the desired trigeminal division. The lack of correlation of lesion temperature and duration with the likelihood of sensory deficit in this series may be misleading. Low temperature lesions of brief duration were used when stimulation thresholds were low and the rootlets were presumably in close proximity to the needle tip. This may have biased the study and obscured a relationship that would have been demonstrated if stimulation threshold, lesion temperature, and lesion duration had been independent variables. It is logical to assume that a very low temperature lesion of brief duration is less likely to injure the trigeminal rootlets. Maximum safety should be obtained by a gradual approach to lesion generation, beginning with a very low temperature lesion and gradually increasing the temperature of successive lesions until the desired sensory deficit has been secured.\(^6\) In the present study, this technique allowed identification of unwanted sensory change before it became more than barely detectable in nine lesions. A facial flush sometimes develops as a portion of the face becomes numb, and the occurrence of this flush has been suggested as a means of identifying the development of numbness in an unwanted division.\(^4\) This was not found to be helpful in this study, since the facial flush often did not occur and when it did develop it was at the end of the episode of electrode heating. Other authors have recommended trigeminal rhizotomy with the patient awake, so that clinical sensory testing can be carried out during electrode heating.\(^3\)

Numbness in a division unaffected by neuralgia is a particularly serious problem when the first division

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**Fig. 4.** Relationship between lesion duration and likelihood of sensory deficit in one or more divisions.

**Fig. 5.** Relationship between stimulation threshold and likelihood of sensory deficit in one or more divisions.

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is affected. Of the 24 lesions not predicted by stimulation, 12 were in the V₁ distribution. Eleven of these occurred with lesions accompanied by stimulation of the V₂ divisions. Five of these accidental V₁ lesions included a more than barely perceptible sensory deficit. Corneal ulceration did not occur. Other authors have recorded unintentional V₁ sensory deficits occurring in 5% to 10% of procedures, and unintentional and intentional deficits in 28% of rhizotomies.³-⁷ In every patient with V₁ hypalgesia, there is corneal hypalgesia, and in every patient with V₁ analgesia there is corneal anesthesia.¹² Despite corneal anesthesia, corneal ulceration is unusual after rhizotomy.²,⁶,⁷ Assessment of its frequency requires periodic reexamination since corneal ulceration can occur months after rhizotomy.

Careful attention to lesion parameters can reduce the risks of radiofrequency rhizotomy. Low stimulation thresholds (produced by the mechanical presence of the needle without electrical current or with up to 0.1 volt) are very likely to be associated with numbness in the stimulation division, but are also likely to be followed by sensory change in a division not suggested by stimulation. Lesions at these low stimulation thresholds should begin with very low lesion temperatures, particularly if the lesion is the first in the procedure. Subsequent lesions with higher stimulation thresholds can be made with higher temperatures. There is little likelihood of a successful lesion when stimulation threshold is greater than 0.6 volts. The duration of lesioning seems relatively unimportant.

References


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