

15. The Effects on Language of Ventral Lateral Thalamotomy for Treatment of Movement Disorders

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The relationship between language and thalamic function has been investigated in cases of naturally occurring and surgically created thalamic lesions, and during electrical stimulation of the thalamus. Although the exact role of the dominant thalamus in language is unclear, empirical evidence suggests that it is instrumental in generating, relaying, arousing, processing, and integrating language (Horenstein, Chung, & Brenner, 1978; Ojemann, 1975; Penfield & Roberts, 1959; Riklan, Levita, Zimmerman, & Cooper, 1969). The specific thalamic nuclei for which a role in language has been proposed are the ventral anterior nucleus, the pulvinar, and the ventral lateral (VL) nucleus. The effects of surgical lesions of the VL thalamus on language abilities were of primary interest in the current study.

Evidence supporting a role in language for the VL thalamus comes from several sources. Electrical stimulation of the VL thalamus has produced alterations in speech and language behavior (Ojemann, 1975). Numerous clinical reports describe alterations in language and other communicative behaviors as a result of vascular lesions of the VL thalamus (e.g., Alexander & LoVerme, 1980; Cappa & Vignolo, 1979; Ciemins, 1970; Crosson et al., 1986; Graff-Radford, Eslinger, Damasio, & Yamada, 1984; McFarling, Rothi, & Heilman, 1982; Mohr, Watters, & Duncan, 1975; Reynolds, Turner, Harris, Ojemann, & Davis, 1979; Robin & Scheinberg, 1990; Wallesch, Kronhuber, Kunz, & Brunner, 1983). In addition, and most germane to our study, are the results of surgical lesions designed to control intractable movement disorders, such as tremor in Parkinson's disease. Aphasia or aphasic-like deficits, as well as speech disturbances, have been reported after VL thalamotomy, with the expected higher incidence of aphasia following lesions of the left VL thalamus (Allen, Turner,

& Gadea-Ciria, 1966; Bell, 1968; Cooper et al., 1968; Darley, Brown, & Swenson, 1975; Riklan et al., 1969; Samra et al., 1969; Selby, 1967; Vilkki & Laitinen, 1974).

Stereotactic computer-assisted VL thalamotomies have been performed at the Mayo Clinic for several years (Kelly et al., 1987) and have provided us with an opportunity to study their effects on speech and language. Computer-assisted stereotactic thalamotomy allows smaller and more accurately placed lesions than have been possible in the past. Because of this, the procedure's effects on speech and language can be more confidently attributed to VL dysfunction, or to its remote effects. We have been able to obtain adequate preoperative and postoperative examinations on substantial numbers of patients and have also been able to monitor speech and language intraoperatively. Intraoperative monitoring has permitted us to observe changes at the time of lesion placement and to relate their nature and severity to postoperative speech and language abilities. In this report we address the effects of VL thalamotomy on language ability. The effects of the surgical procedure on motor speech will be reported elsewhere.

We addressed two primary questions:

1. What are the effects of VL thalamotomy on language?
2. What are the relationships among preoperative, intraoperative, and postoperative language abilities in patients who undergo VL thalamotomy?

METHOD

Subjects

From September 1984 to November 1989, 65 patients underwent computerized stereotactic VL thalamotomy at the Mayo Clinic. Fifty of the 65 patients had preoperative, intraoperative, and postoperative and/or follow-up speech and language evaluations. These 50 patients represent the subject sample for this study.

Thirty-seven patients were male, 13 female. Mean age was 50.4 years ($SD = 14.6$; range = 18–72). Mean educational level was 13.3 years. Forty-four patients were right handed, five were left handed, and handedness was unrecorded for one patient.

The etiology of the movement disorder treated by the surgery was Parkinsonism for 32 patients, multiple sclerosis for three, vascular for one, traumatic for one, and unknown for the remaining 13 patients.

Thirty-seven patients underwent left VL thalamotomy and 11 underwent right VL thalamotomy. Two patients had a second thalamotomy at a later date in the opposite hemisphere.

A motor speech evaluation and the Mayo Clinic Procedures for Language Evaluation (unpublished), short or long versions, were conducted pre- and postoperatively, and on follow-up. The Mayo language evaluation examines a variety of language skills in verbal comprehension, speaking, reading, and writing. The long version of the test contains a number of subtests from the *Minnesota Test for the Differential Diagnosis of Aphasia* (Schuell, 1972), the *Word Fluency Test* (Wertz, Keith, & Custer, 1971), the *Token Test* (DeRenzi & Vignolo, 1962), and some tasks from the *Boston Diagnostic Aphasia Examination* (Goodglass & Kaplan, 1972). Patients' verbal responses during these evaluations were frequently audiorecorded.

The intraoperative examination was, of necessity, brief. Patients were generally asked to prolong a vowel, perform speech AMRs and SMRs, repeat a few words and sentences, spell and define a few words, and answer a few orientation questions. The adequacy of their spontaneous comments and answers to questions from the surgeon was also noted. These intraoperative tasks were conducted (a) prior to any lesion, (b) following a test or temporary lesion, and (c) following the permanent surgical lesion or lesions.

Preoperative speech and language evaluations were performed approximately 1 week prior to surgery. Postoperative evaluations were performed on an average of 4 days following surgery, with a range of 1 to 15 days. Follow-up evaluations were performed on an average of 4 months following surgery, with a range of 2 to 14 months.

Reliability

Pre- and postoperative speech and language data were obtained by review of clinical reports, test forms, and audio recordings. Interjudge reliability (percentage of point-to-point agreement) was assessed by comparing (a) independent chart reviews by the two authors on 26 relevant research variables for five randomly selected patients (10% of the patient sample); (b) diagnostic judgments from preoperative audio recordings with preoperative reports of language diagnosis; and (c) the authors' judgments about changes and severity of impairment from intraoperative, postoperative, and follow-up audio recordings.

Reliability for the chart review data for 5 patients averaged 91% (range = 85–100%). Interjudge agreement was 100% for the following judgments: (a) the presence of normal versus abnormal versus aphasic language for 31 patients' preoperative performance; (b) the presence

versus absence of change in language performance following the surgical lesion, intraoperatively, for 40 patients; and (c) the presence of normal versus abnormal versus aphasic language for 5 patients seen in the immediate postoperative period and for 12 patients seen later for follow-up assessment.

RESULTS

Preoperative Language Status—Left Thalamotomy

Among the 37 patients who underwent left VL thalamotomy, 30 (81%) had normal language and 7 (19%) had difficulty on language tasks. Of the 7 patients who had difficulty on language tasks, 6 had problems with attention/concentration, short-term memory, or other nonspecific problems that influenced performance on language tasks. The remaining patient had a generalized intellectual impairment. The language difficulties of these 7 patients were rated as mild and did not significantly impair functional communication. No subject was diagnosed as aphasic preoperatively.

Preoperative Language Status—Right Thalamotomy

Among the 11 patients who underwent right VL thalamotomy, 9 (82%) had normal language and 2 (18%) had difficulty on some language tasks. One of the 2 subjects with abnormal language performance had a generalized intellectual impairment. No patient was aphasic.

Results of Left Thalamotomy

Intraoperative. The results for patients who underwent left VL thalamotomy are summarized in Table 15.1. Thirty of the 37 patients (81%) had intraoperative monitoring. Among the subjects with normal language preoperatively, 14 (58%) did not develop problems with verbal language intraoperatively. Ten (42%) did develop problems that were most often characterized by decreased alertness; hesitancy during verbal expression; delayed responses; word-finding, spelling, or counting difficulties; and perseveration.

Of the subjects who did have language difficulty preoperatively, 4 (67%) worsened intraoperatively and had problems similar to those

TABLE 15.1. INTRAOPERATIVE, POSTOPERATIVE, AND FOLLOW-UP LANGUAGE PERFORMANCE OF PATIENTS WITH LEFT VL THALAMOTOMY, RELATIVE TO PREOPERATIVE LANGUAGE STATUS

| <i>Time</i> | <i>Preoperative Status</i> | | | | | |
|---------------------------|----------------------------|----|--------------------------|-----|----------|----|
| | NORMAL | | ABNORMAL (NONAPHASIC) | | TOTAL | |
| | <i>n</i> | % | <i>n</i> | % | <i>n</i> | % |
| Intraop. (<i>n</i> = 30) | | | | | | |
| Unchanged | 14 | 58 | 2 | 33 | 16 | 53 |
| Worse | 10 | 42 | 4 | 67 | 14 | 47 |
| Postop. (<i>n</i> = 35) | | | | | | |
| Unchanged | 15 | 54 | 5 | 71 | 20 | 57 |
| Worse | 11 | 39 | 1 | 14 | 12 | 34 |
| Aphasic | 2 | 7 | 1 | 14 | 3 | 9 |
| Postop. (<i>n</i> = 13) | | | | | | |
| Unchanged | 10 | 83 | — | — | 10 | 77 |
| Worse | 1 | 8 | 1 | 100 | 2 | 15 |
| Aphasic | 1 | 8 | — | — | 1 | 7 |

Note: % = percentage of subjects in preoperative subgroup at a particular time.

described for the preoperatively normal patients. Two (33%) did not develop new problems intraoperatively. Altogether, a total of 14 (47%) of the patients with left VL thalamotomy who were monitored intraoperatively developed some language difficulties intraoperatively.

Postoperative. Thirty-five patients were evaluated postoperatively. Among those with normal language preoperatively, 15 (54%) remained normal. Eleven (39%) had difficulties on language tasks similar to those exhibited intraoperatively. Two (7%) were diagnosed as aphasic; 1 was rated as mild in severity, the other moderate.

Two of the 7 patients with abnormal language preoperatively had worsening of language postoperatively. One of these patients was diagnosed as having a mild aphasia.

Altogether, a total of 43% of the patients had changes postoperatively, and 3 demonstrated aphasia. These postoperative difficulties with language were rated as mild in all cases except for the 1 patient who developed a moderately severe aphasia.

Follow-Up. Thirteen patients were assessed on follow-up. Two (16%) of the 12 patients with normal language preoperatively who had postoperative problems continued to have language difficulties on follow-up;

TABLE 15.2. INTRAOPERATIVE, POSTOPERATIVE, AND FOLLOW-UP LANGUAGE PERFORMANCE OF PATIENTS WITH RIGHT VL THALAMOTOMY, RELATIVE TO PREOPERATIVE LANGUAGE STATUS

| <i>Time</i> | <i>Preoperative Status</i> | | | | | |
|---------------------------|----------------------------|----|--------------------------|-----|----------|----|
| | NORMAL | | ABNORMAL (NONAPHASIC) | | TOTAL | |
| | <i>n</i> | % | <i>n</i> | % | <i>n</i> | % |
| Intraop. (<i>n</i> = 7) | | | | | | |
| Unchanged | 4 | 80 | 2 | 100 | 6 | 86 |
| Worse | 1 | 20 | — | — | 1 | 14 |
| Postop. (<i>n</i> = 9) | | | | | | |
| Unchanged | 6 | 86 | 2 | 100 | 8 | 89 |
| Worse | 1 | 14 | — | — | 1 | 11 |
| Follow-up (<i>n</i> = 7) | | | | | | |
| Unchanged | 5 | 80 | 1 | 100 | 6 | 86 |
| Worse | 1 | 20 | — | — | 1 | 14 |

Note: % = percentage of subjects in preoperative subgroups at a particular time.

one of these was aphasic. One patient with abnormal language preoperatively continued to have language difficulties on follow-up. Altogether, 23% of the left VL thalamotomies who were seen for follow-up continued to have language difficulties relative to preoperative language status. These problems remained mild and in most instances were improved relative to performance in the immediate postoperative period.

Results of Right Thalamotomy

Intraoperative. The results for patients who underwent right VL thalamotomy are summarized in Table 15.2. Obviously, the percentages in Table 15.2 should be interpreted cautiously because of the small number of patients.

Of the 11 patients who underwent right VL thalamotomy, 7 had intraoperative monitoring. One of the 5 patients with normal language preoperatively had language problems intraoperatively; these consisted of spelling difficulties and hesitancy during verbal expression. Neither of the 2 patients who had trouble with language tasks preoperatively developed further problems intraoperatively.

Postoperative. Postoperatively, 9 patients were evaluated. One with normal language preoperatively demonstrated mild problems postopera-

TABLE 15.3. RELATIONSHIP BETWEEN INTRAOPERATIVE AND POSTOPERATIVE CHANGE IN LANGUAGE STATUS FOR 28 PATIENTS WITH LEFT VL THALAMOTOMY

| | <i>Postoperative Status</i> | | | |
|-----------|-----------------------------|----|-----------|----|
| | WORSE | | UNCHANGED | |
| | <i>n</i> | % | <i>n</i> | % |
| Intraop. | | | | |
| Worse | 9 | 32 | 5 | 18 |
| Unchanged | 4 | 14 | 10 | 36 |

tively and none of the patients with preoperatively abnormal language had problems postoperatively.

Follow-Up. Seven patients were seen on follow-up. One of the 6 subjects with normal language preoperatively had language difficulties on follow-up. The 1 patient with preoperative difficulty on language tasks who was seen for follow-up was unchanged relative to preoperative performance. Only 1 subject demonstrated mild language difficulties intra- and postoperatively and on follow-up; this patient was left-handed and therefore may have had right-hemisphere or mixed hemispheric dominance for language.

Relationship Between Intraoperative and Postoperative Language Difficulty

To what degree did the detection of intraoperative language change predict the presence of postoperative language change? This question can be addressed most meaningfully by looking at those patients in the left thalamotomy group who had intraoperative and postoperative assessments. These data are summarized in Table 15.3. Nine patients or 32% of the sample of 28 patients had problems intraoperatively *and* postoperatively. Ten patients or 36% of the sample with no intraoperative changes had no postoperative changes. In other words, postoperative change or stability was correctly predicted by intraoperative monitoring for 68% of the patients. This is significant at the .10 level of confidence on a chi-square test.

SUMMARY AND DISCUSSION

The results of this study can be summarized as follows:

1. The frequency of preoperative language difficulty was similar between groups of patients who underwent right and left VL thalamotomy. Slightly less than 20% of the patients in each group had difficulty on language tasks preoperatively and none were aphasic.
2. A substantial percentage of patients who underwent VL thalamotomy exhibited difficulty on language tasks intraoperatively. Such difficulties occurred more frequently during left than right thalamotomy.
3. Postoperative language difficulties did not usually lead to a diagnosis of aphasia, but patients who had changes in language status did have difficulty with the accuracy, completeness, and organization of language expression and comprehension.
4. The frequency of aphasia following VL thalamotomy was low (9%) relative to that seen in many other studies. Aphasia occurred only in patients who had left thalamotomy.
5. Postoperative language and other cognitive-communication difficulties were nearly always mild in severity.

What are the clinical and possible theoretical implications of these results? It is clear that patients who undergo left VL thalamotomy are at greater risk for postoperative language difficulty than are those who have right thalamotomy. This result is consistent with findings reported in numerous studies of VL thalamotomy (Allen et al., 1966; Almgren, Andersson, & Kullberg, 1972; Cooper et al., 1968; Darley et al., 1975; Samra et al., 1969; Selby, 1967; Shapiro, Sadowsky, Aenderson, & Van Buren, 1973; Vilkki & Laitinen, 1974; Wallesch, Kronhuber, Kunz, & Brunner, 1983).

Intraoperative monitoring demonstrated that intraoperative deficits tend to predict the presence of deficits postoperatively. Therefore, intraoperative monitoring appears to be a valuable intraoperative procedure. It is also very helpful in identifying changes in speech and language following test lesions placed before a permanent lesion. We have been involved in a number of cases in which a permanent lesion was not made on the basis of the speech and language changes that occurred following a test lesion. In fact, left VL thalamotomies in our institution are not done without intraoperative speech-language monitoring.

The incidence of postoperative aphasia in our study (9%) was lower than that often reported in the literature. Perhaps the discrete lesioning produced by computerized stereotactic surgery, the intraoperative mon-

itoring of speech and language, and/or our criteria for diagnosing aphasia were contributing factors to this lower incidence.

Nonaphasic language difficulty found among our patients was typically mild and associated with reduced accuracy, completeness, and organization of language expression. These behaviors are similar to those described by Darley et al. (1975) in their study of thalamotomy for Parkinsonian tremor. Like us, Darley et al. did not generally use the term *aphasia* to describe these patients' postoperative language difficulties.

We do not believe that our data resolve the issue of the role of the dominant VL thalamus in language. The low incidence of aphasia in our study argues against a role that is similar or as important as that of the dominant perisylvian cortex for language-specific functions, at least in most cases. But the relatively high incidence of difficulty on language tasks does support the views of Luria (1977), Ojemann (1975), and Wallesch and Papagno (1988), who see a role for the dominant VL thalamus in focusing attention and maintaining the vigilance and alertness necessary for processing and organizing activities that are specifically verbal in character.

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