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Forebrain Commissurotomy for Epilepsy

Review of 20 Consecutive Cases

By

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With 1 Figure

Summary

During the past 10 years, 20 patients with intractable generalized, generalized and partial, and partial seizures have been treated here by surgical division of one or more of the forebrain commissures. Modifications in the operative technique and extent of operation have resulted in continued good results in seizure control with decreased morbidity. The present operation, a two-stage division of the corpus callosum and underlying hippocampal commissure, is demonstrated to be effective in controlling intractable seizures. Good or excellent results account for more than 80 per cent of the series. Historical background, indications for operation, criteria for patient selection, operative technique, results, complications, and the value of forebrain commissurotomy as a research tool are presented.

Keywords: Commissurotomy; corpus callosum; epilepsy; seizures.

Introduction

The Dartmouth series of forebrain commissurotomies for intractable epilepsy began in 1972 [26–29]. The first three patients underwent a "complete" commissurotomy—division of one fornix, the anterior commissure, the hippocampal commissure, and the entire corpus callosum. The next five patients were treated by "frontal" commissurotomy with one fornix, the anterior commissure, and the rostral half of the corpus callosum being sectioned. However, the morbidity associated with these procedures—hydrocephalus, aseptic and bacterial meningitis, persistent neurological deficits, and one post-

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operative death, was too high. The operation was therefore modified to a single stage "central" commissurotomy—division of only the corpus callosum and underlying hippocampal commissure—for the next six patients. The last six patients have undergone central commissurotomy in two stages, which ameliorates the acute disconnection syndrome seen in single stage operations.

Staged central commissurotomy has proved to be effective for seizure control with fewer and less debilitating complications. The surgical technique and results of this procedure as well as criteria for patient selection are discussed. Case reports demonstrating the full potential of commissurotomy for intractable seizures are presented.

Case Reports

Case 1. T. O. was noted to have a mild left hemiparesis shortly after birth. He was, however, doing well until the age of six years when be began having atonic seizures and generalized tonic-clonic convulsions. By the age of seven, his seizures had increased to more than 10 per day despite various combinations of anticonvulsants. An electroencephalogram (EEG) done at that time showed continuous spike-wave discharges from the right hemisphere with minimal spread to the left. Carotid angiography was normal, and pneumoencephalography revealed a slightly dilated right lateral ventricle.

By the age of nine the patient was totally incapacitated by 30 generalized seizures daily and lived on a mattress on the floor. EEG now showed bilaterally synchronous spike-wave discharges. His neurological exam was unremarkable except for a mild spastic left hemiparesis. A complete commissurotomy was done on 25 January 1972 as an alternative to hemispherectomy. The ventricular system was opened for division of the right fornix.

Postoperatively the patient demonstrated mutism, increased left hemiparesis, and fever. Cerebrospinal fluid examination following numerous lumbar punctures was consistent with aseptic meningitis. His steroid dose was increased, and he improved rapidly. At discharge on 8 February 1972 his routine neurological examination was unchanged from admission, and he had had no seizures since surgery. Inadvertently, he left hospital without anticonvulsants.

On 26 February 1972 he presented with papilloedema, projectile vomiting, and excruciating headache. Ventriculography revealed hydrocephalus, and a ventriculoperitoneal shunt resulted in rapid resolution of symptoms.

With the possible exception of a single nocturnal seizure the patient has remained seizure-free for more than 10 years since operation. His mild left hemiparesis persists unchanged. Postoperative EEGs show seizure discharges, again confined to the right hemisphere. He has recently graduated from high chool, and is gainfully employed.

Case 16. As an infant S. A. was seen to have a mild spastic left hemiparesis. Focal motor seizures initially involving the left hand were first noted at the age of 10 years. These were not incapacitating, and the patient did well until the age of 15 when absence attacks and generalized tonic-clonic convulsions began. Generalized seizures progressed despite aggressive anticonvulsant management, and at the age of 17 a right temporal lobectomy was done at another institution. His seizures continued postoperatively.

By the age of 20 the patient was incapacitated by frequent generalized seizures, and was evaluated for commissurotomy. Only a mild spastic left hemiparesis was found on neurological examination. Computed tomographic brain scan showed a dilated right lateral ventricle. Preoperative EEG revealed bilaterally synchronous polyspike and wave activity.

On 14 September 1979 a posterior division of the corpus callosum was done. The patient recovered promptly from surgery with diminished frequency of seizures. Anterior corpus callosum section was performed on 4 December 1979, and again he recovered promptly from surgery without complications. He has had no seizures for almost three years since commissurotomy, and his routine neurological examination is unchanged from preoperatively. His most recent EEG shows random slow-wave activity only. He is independent, and is enrolled in a vocational technical school.

Materials and Methods

All patients considered for commissurotomy had to be incapacitated by seizures for at least four years despite aggressive medical management. "Incapacitated" was defined as an average of one or more seizures per day and the inability to lead a reasonably normal life because of these seizures. Patients were initially admitted to the medical neurology service, and evaluated with an extensive history and physical examination, neurological examination, anticonvulsant blood levels, skull roentgenography, electroencephalography, and neuropsychological testing. Cerebral angiography and pneumoencephalography, done early in the series, were replaced by computed tomographic scanning when this became available.

As previously indicated, the operative technique has evolved significantly in the last 10 years. The present technique of staged central commissurotomy is presented here. Glucocorticoid coverage is used in the perioperative period starting the night before surgery. Though not required for the operation, scalp electrodes are placed outside the surgical field on the morning of surgery, and continuous intraoperative EEG recordings are done. General endotracheal anaesthesia is used.

The patient is placed in a sitting position with his head fixed in a skeletal clamp. The scalp is clipped and shaved, and then cleansed with an iodophor soap and solution. A mannitol infusion (0.5 g per kg body weight) is started. A 9 to 10 cm linear incision is made in the right parietal area (Fig. 1). The incision must cross the midline to assure proper placement of the trephine. Cerebellar retractors maintain separation of the wound while a two-inch d'Errico trephine is used to remove a bone disc [25]. The medial edge of the bone disc must be over the sagittal sinus. The anterior edge is 5 cm behind the midpoint of the nasion to inion distance. Under loupe magnification the dura is opened, and bridging veins are

coagulated and divided as necessary. The right parietal lobe is gently retracted from the falx, and arachnoid adhesions are sharply divided until the stark white splenium of the corpus callosum is seen. At this point a self-retaining retractor is placed, and the operating microscope with a 300 mm focal length lens replaces loupe magnification. Small vessels on the surface of the splenium are coagulated and divided. A thin sucker is used to divide the fibres of the corpus callosum and hippocampal commissure until the bluish, translucent, ependymal lining of the ventricles is first seen. Fibres abutting the

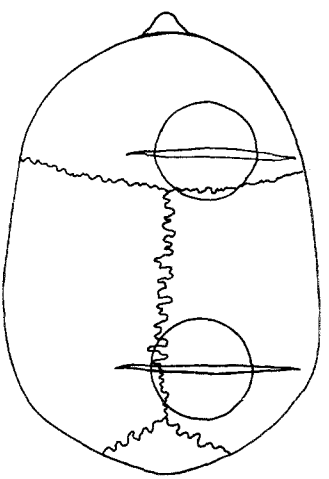

Fig. 1. Placement of scalp incisions and trephinations for anterior and posterior corpus callosum section

ependyma are bluntly divided with a Krayenbühl micro-dissector to avoid entering the ventricle. Division of all fibres to the ependymal surface assures division of callosal fibres as well as the fibres of the adjacent hippocampal commissure. Dissection is carried posteriorly until the arachnoid overlying the vein of Galen and cerebellum is encountered, and then anteriorly as far as possible. A silver clip is placed at the anterior limit of the dissection. The dura is closed, the bone disc is replaced, and the scalp is apposed. Postoperatively, the patient's anticonvulsants are continued. Glucocorticoid coverage is maintained for three days, then rapidly tapered and discontinued.

A recovery period of at least one month is allowed before the second stage division. The patient is placed in a supine position for anterior corpus callosum section. A linear incision is made 9 cm behind the nasion, and a bone disc is removed with its medial edge

over the sagittal sinus and its posterior edge on the coronal suture (Fig. 1). Commissurotomy is done as described above, with dissection continuing posteriorly until the previously placed silver clip is retrieved. Anteriorly, the genu of the corpus callosum is divided until it tapers into the rostrum. Postoperatively, anticonvulsants are continued at preoperative levels initially then tapered and discontinued as tolerated.

Postoperatively, all patients were followed by members of the sections of neurosurgery and neurology, and were evaluated by clinical and research psychologists. The effect of commissurotomy on the severity and frequency of seizures was graded by a modification of Crandall's criteria [5].

Results

The operative results and complications for each patient in the series are shown in Table 1. Results of surgery were determined at the latest follow-up visit which was greater than one year in all but one case. Excellent results are defined as seizures reduced to three or less per year. Good results are a reduction of seizures by greater than 50 per cent and a change in seizures to a less debilitating type. A fair result is a definite decrease in the frequency and severity of seizures, but less than 50 per cent, and a poor result is seizures unchanged or worse.

Of the 19 patients available for follow-up 5 have had excellent results. Anticonvulsants have been stopped completely in two of these patients without recurrent seizures. An additional 11 patients have shown a marked reduction in seizures and a change in the type of seizures—a good result. Two patients have had fair results, and one patient, though now lost to follow-up, was not improved three years postoperatively. Good or excellent results in seizure control thus comprise about 84 per cent of the patients in this series.

Of the 20 patients operated upon, 7 (35 per cent) had postoperative complications—an unacceptably high figure. However, modification of the procedure to a central commissurotomy appears to have reduced the incidence and severity of complications while maintaining the efficacy of the procedure (Table 1).

Though all patients treated by complete commissurotomy had good or excellent seizure control postoperatively, two patients developed meningitis and hydrocephalus, and one was left with a significant neurological deficit.

Five patients were treated by frontal commissurotomy with good ar excellent results obtained in three of the four patients available

Table 1. *Forebrain Commissurotomy:*

Case no.	Age (years)	IQ	Neurologic findings	Radiologic findings	Seizure types	
1	9	74	left hemiparesis	dilated right lateral ventricle	generalized:	tonic-clonic, atonic
2	21	84	normal	normal	generalized:	tonic-clonic
3	16	81	normal	normal	generalized: partial:	tonic-clonic motor complex
4	35	74	normal	normal	generalized: partial:	tonic-clonic, atonic complex
5	29	112	normal	dilated right temporal horn	partial:	complex
6	24	84	normal	S/P right temporal lobectomy	generalized: partial:	tonic-clonic complex
7	24	< 70	normal	normal	partial:	complex
8	40	not available	normal	normal	generalized: partial:	tonic-clonic complex
9	15	82	left hemiparesis	dilated right lateral ventricle	generalized: partial:	atonic complex
10	15	89	left hand apraxia	normal	generalized: partial:	tonic-clonic, atonic complex
11	23	83	normal	dilated left frontal horn	generalized: partial:	tonic-clonic, absences complex
12	16	80	normal	normal	generalized: partial:	tonic-clonic, absences complex
13	19	76	normal	normal	generalized: partial:	tonic-clonic, absences, atonic complex
14	21	60	dysphasia	normal	generalized: partial:	tonic-clonic, absences, atonic complex
15	25	91	normal	normal	generalized: partial:	tonic-clonic, absences motor

Patient Profiles, Results, Complications

Operation	Results (seizure control)	Complications	Acute disconnection syndrome	Follow up (years)
complete commissurotomy + VP shunt 01-25-72	excellent	aseptic meningitis and hydrocephalus	+	10
complete commissurotomy, 12-12-72	good	aseptic and bacterial meningitis, hydrocephalus, memory dysfunction, left hemiplegia	+	9
complete commissurotomy, 01-09-73	good	none	+	9
frontal commissurotomy, 02-06-73	good	none	+	9
frontal commissurotomy, 02-20-73	excellent	none	+	9
frontal commissurotomy, 03-02-73	good	none	+	9
frontal commissurotomy, 05-01-73	poor	aseptic meningitis and hydrocephalus	+	3
frontal commissurotomy, 02-15-74	—	died 12th postoperative day with right frontal haemorrhagic infarction	+	—
central commissurotomy, 07-18-75	good	none	+	6
central commissurotomy, 01-23-76	good	aseptic meningitis, ? bacterial meningitis	+	6
central commissurotomy, 04-23-76	good	none	—	6
central commissurotomy, 12-30-76	excellent	none	+	5
central commissurotomy, 06-24-77	excellent	none	+	5
central commissurotomy, 09-22-78	fair	wound infection	+	3
central commissurotomy, 2 stages, 09-14-79/10-16-79	good	none	—	2

Table 1 *(continued)*

Case no.	Age (years)	IQ	Neurologic findings	Radiologic findings	Seizure types	
16	20	80	left hemiparesis	S/P right temporal lobectomy	generalized:	tonic-clonic, absences
					partial:	motor
17	25	94	normal	normal	generalized:	tonic-clonic, absences, atonic
					partial:	complex
18	20	< 70	normal	normal	generalized:	tonic-clonic,
					partial:	complex
19	16	71	left hemiparesis	right frontal porencephaly	generalized:	absences, atonic
					partial:	adversive
20	20	83	normal	normal	generalized:	tonic-clonic, absences atonic

Complete commissurotomy—corpus callosum, hippocampal commissure, anterior
Frontal commissurotomy—rostral corpus callosum, anterior commissure, one
Central commissurotomy—corpus callosum and hippocampal commissure

for follow-up. However, one patient died of a right frontal lobe haemorrhagic infarction postoperatively, and one patient developed aseptic meningitis and hydrocephalus.

Twelve patients have now undergone central commissurotomy in either one stage (first six patients) or two stages (second six patients). Ten have had good or excellent results. One patient developed a transient aseptic meningitis, and two patients have had extradural infections. None of these patients has suffered any neurological injury other than the subtle deficits created by commissurotomy [7, 9] and the reversible changes of the acute disconnection syndrome, and there have been no deaths.

Discussion

Sir Victor Horsley [13] in 1886 reported that division of the forebrain commissures in dogs and monkeys limited the spread of epileptic discharges to one cerebral hemisphere. However, this work was largely forgotten, and in 1940 Erickson [6] reported a series of similar though more extensive experiments which demonstrated the

Operation	Results (seizure control)	Complications	Acute disconnection syndrome	Follow up (years)
central commissurotomy, 2 stages, 09-14-79/12-04-79	excellent	none	—	2
central commissurotomy, 2 stages, 05-27-80/06-17-80	good	none	+	2
central commissurotomy, 2 stages, 05-06-80/07-25-80	fair	none	+	> 1
central commissurotomy, 2 stages, 06-20-80/10-07-80	good	wound and bone disc infection	—	> 1
central commissurotomy, 2 stages, 11-21-80/05-01-81	good	none	—	< 1

commissure, one fornix divided.
fornix divided.
divided.

primary role of the corpus callosum in the propagation of seizures. Like Horsley, he showed that electrical stimulation of one cerebral hemisphere resulted in generalized tonic-clonic convulsions in intact animals, while the same stimulus resulted in hemiconvulsions after corpus callosum section.

Van Wagenen and Herren [23] observed amelioration of seizures in epileptic patients who subsequently had infarction or tumour involving the corpus callosum. They reasoned that division of the commissural pathways in the corpus callosum might confine seizure discharges to one cerebral hemisphere. Seizures thus confined should be less severe without loss of consciousness, generalized convulsive movements, or incontinence.

In 1940 they published a series of ten patients treated by division of various portions of the corpus callosum and other forebrain commissures [23]. The results were variable and follow-up brief, but this work documented that patients could survive the operation without obvious neurological deficit [1].

Bogen and his associates revived interest in cerebral commissurotomy [2–4, 11]. Both complete and frontal commissurotomies were

performed, and the results were encouraging. Luessenhop and colleagues subsequently reported a small series of commissurotomies in children [15, 16]. They found the operation to be very effective in cases with primary unilateral origin of seizure discharge. Commissurotomy was suggested as an alternative to hemispherectomy in such cases.

Despite these positive reports, cerebral disconnection never gained general acceptance. The Dartmouth series of commissurotomies began as an alternative to hemispherectomy (case 1). Despite a stormy postoperative course, complete cessation of seizures following commissurotomy demonstrated the full potential of the operation. However, the morbidity of the procedure early in the series was prohibitively high (Table 1). Following the death of patient 8 commissurotomies were stopped and the previous cases analyzed. It was felt that the problems of aseptic meningitis and subsequent hydrocephalus might be minimized if the ventricular system were not violated. However, a completely extraventricular division of one fornix and the anterior commissure was difficult.

Because of evidence that the corpus callosum is the primary pathway for the spread of seizures discharges [6, 17–19, 21, 22, 24] the operation was subsequently modified to a division of only the corpus callosum and, of necessity, the underlying hippocampal commissure. Restricting the operation to a central commissurotomy would, it was thought, mahe the procedure safer without sacrificing seizure control. In addition, by dividing only the corpus callosum and hippocampal commissure, data could be collected on the role of these structures in seizure propagation and information transfer.

We have found central commissurotomy to be a safer procedure than complete or frontal commissurotomy with comparable effectiveness in seizure control. All patients treated by central commissurotomy derived some benefit in seizure control, and no patient died or suffered significant neurological injury.

Central commissurotomy has been further refined to a two-stage procedure. This has resulted in decreased severity and duration of the postoperative acute disconnection syndrome. This syndrome may persist for days or weeks following commissurotomy. Mutism, left-sided apraxia, left visual field agnosia, alternating focal seizures, confusion, and childish behaviour may be seen [10, 20, 29]. This transient array of signs and symptoms is thought to result from deficits in interhemispheric information transfer [10, 20, 29]. Staging has reduced the severity and duration of this syndrome in the last six patients. Activation of alternative pathways for information transfer following partial commissurotomy may be responsible for the more rapid recovery, though this remains unproven.

Analysis of these cases may yield better criteria for patient selection. Severely retarded patients (cases 7, 14, and 18) derived the least benefit from commissurotomy. If these patients (with IQ scores less than 70) are deleted from the series, good or excellent results in seizure control were obtained in all patients available for follow-up.

Atonic seizures have responded dramatically to commissurotomy. Cases 1, 4, 9, 10, 13, 17, 19, and 20 had complete or nearly complete cessation of atonic seizures postoperatively and good or excellent overall results. Though case 14 achieved only fair results, there have been no postoperative atonic seizures. Why this particular type of seizure responds so well to commissurotomy remains unknown.

Those patients with unequivocal neurological or radiological evidence of unilateral hemispheric injury (cases 1, 5, 9, 10, 11, 16, 19) all had good or excellent results following commissurotomy. This is similar to Luessenhop's observations in children [15, 16].

The value of commissurotomy as a research tool should also be stressed. Great insight regarding hemispheric specialization and the role of the corpus callosum in interhemispheric information transfer has been gained from the study of "split brain" patients [1, 7–9, 11, 14, 20]. For epileptology, forebrain commissurotomy yields new data on the origin and spread of seizure discharges [3, 12]. A separate report has been prepared based on the change in seizure patterns and EEG records following commissurotomy [12].

Many questions remain unanswered. How does commissurotomy inhibit not only generalized seizures but in some patients focal seizures as well? Why does staging diminish the severity of the postoperative disconnection syndrome, and what alternative pathways function in interhemispheric information transfer? Should surgical intervention be undertaken earlier in the course of intractable seizures before additional brain injury may occur? Why do atonic seizures show a dramatic response to commissurotomy even when other seizures are not diminished? None of these questions has been adequately answered though work is proceeding in all these areas.

As other centres are beginning to perform commissurotomy for intractable epilepsy, data should soon be available to confirm or contradict our findings. At present our data suggest the following conclusions:

1. Forebrain commissurotomy has been shown to be effective for control of intractable seizures in a selected group of patients. It should be stressed that commissurotomy is not a substitute for aggressive anticonvulsant treatment of epilepsy but is to be used with medical therapy in selected cases.

2. Indications for commissurotomy are intractable, incapacitating seizures despite aggressive medical management in patients who are not candidates for standard resection of an epileptogenic focus.

3. Patients with obvious unilateral hemispheric injury have had good or excellent results in seizure control following commissurotomy whereas severely retarded patients have benefited least. Atonic seizures respond dramatically to commissurotomy.

4. Division of only the corpus callosum and underlying hippocampal commissure may be safer than more extensive operations without sacrificing seizure control.

5. Commissurotomy done in two stages reduces the severity and duration of the acute disconnection syndrome seen after corpus callosum section.

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