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Clinical Development of Corpus Callosotomy in Treating Refractory Seizure

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1. Introduction

For those patients with refractory seizures who are not candidates for focal respective surgery, corpus callosotomy can decrease the severity and attacking rate, but its outcome, complications and indications are still worrying the clinical doctors. In this text, we review the history, development and recent progress of corpus callosotomy in treating the refractory seizure.

The corpus callosum serves to integrate the activity of the two hemispheres and permits them to communicate with each other. The primary purpose of the corpus callosum may be to equalize the activity of both hemispheres to permit optimal integration of cortical responses. The purpose of this article is to provide a comprehensive review of clinical and practical aspects of callosotomy including rations, beneficial effects, adverse effects and prognostic factors for surgery success.

2. Anatomy and physiology of corpus callosum

The corpus callosum is a large bundle of mostly myelinated and some nonmyelinated fibers, the great white commissure, that cross the longitudinal cerebral fissure and interconnect the hemispheres. The body of the corpus callosum is arched; its anterior curved portion, the genu, continues anteroventrally as the rostrum. The thick posterior portion terminates in the curved splenium, which lies over the midbrain (Waxman, 2003).

The corpus callosum is topographically organized with anterior fibers connecting frontal regions of the two hemispheres and posterior fibers connecting posterior cortical structures. This anterior-to-posterior organization results in modality-specific regions of the corpus callosum. For example, the rostrum transfers higher cognitive information; the anterior midbody transfers motoric information by connecting fibers from the premotor, motor, anterior insular, and anterior cingulate cortical areas; the posterior midbody transfers somatosensory information; the isthmus transfers auditory signals; and the splenium transfers visual information (Wong et al., 2006; Funnell et al., 2000). Thus, the fiber tract in the anterior half of the corpus callosum is essential for the generalization of tonic and tonic–clonic convulsions, as well as atonic seizures (Wong et al., 2006). The corpus callosum is the major anatomical substratum for seizure bilateralization and bisynchronization (Reeves & Roberts, 1995).

3. Surgery rationale of corpus callosotomy

There are six midline commissural structures connecting the cerebral hemispheres, including the corpus callosum, anterior commissure, posterior commissure, hippocampal commissures, massa intermedia, and fornix. Of these, the most significant is the corpus callosum, which covers the most part of cortex (Wyllie, 1993). Curtis found that cortical stimulation of one hemisphere evoked potential on the opposite hemisphere (Curtis, 1940). Crowell and Ajmone reported that experimentally induced cortical epileptic activities of one hemisphere were also found in the homotonic area of the opposite hemisphere. Therefore, they suggested that a cortical epileptic discharge in one hemisphere is transferred to the other to induce epileptic synchronization (Crowell & Ajmone, 1972). Erickson's experimental report revealed that the corpus callosum was a major pathway for interhemispheric generalization of seizures in monkeys (Erickson, 1940). The rationale underlying the amelioration of seizures by corpus callosotomy is based on the hypothesis that the corpus callosum is the most important pathway for interhemispheric spread of epileptic activity (Reeves & Roberts, 1995).

4. Application of corpus callosotomy in refractory seizure

4.1 History

The history of corpus callosotomy began with a publication by Dandy (Dandy, 1936) in 1936 of patients who had partial callosal resection during surgeries of pineal tumors. Dandy reported that there were no resultant gross neurologic deficits in his patients. Corpus callosotomy as a treatment of epilepsy was first described in a series of 10 patients by Van Wagenen and Herren (Van & Herren, 1940) in 1940. The authors had observed that patients with tumors of the corpus callosum initially presented with generalized seizures. As the tumors grew and destroyed more of the corpus callosum, the seizures became less frequent and were more often unilateral. Their results at the time were variable and the follow-up period was brief. Interest in callosotomy remained stagnant until the 1960s when Bogen and Vogel (Bogen & Vogel, 1963) published their articles on the clinical and neuropsychological outcome of the surgery. Luessenhop (Luessen et al., 1970) reported the corpus callosotomy could replace the hemispherectomy. Adding with the report from Wilson (Wilson & Reevesm, 1978), the corpus callosotomy has earned widespread consideration.

4.2 Evolution of corpus callosotomy

Since the 1960s numerous studies regarding the indication and outcomes of corpus callosotomies have been published (Bogen & Vogel, 1963; Luessen et al., 1970; Wilson & Reevesm, 1978). The goal of a callosotomy procedure is to reduce the frequency and severity of seizures by interrupting common seizure spread pathways. Traditionally anterior two-third corpus callosotomy has been performed with great success. Different series have reported 50% or more reduction in seizure frequency in 55–100% of patients following this procedure (Wong et al., 2006; Maehara & Shimizu, 2001).

As a result of these data, corpus callosotomy has been increasingly utilized to control intractable generalized epilepsy. However, no standardized guidelines have been universally accepted for the selection of callosotomy patients for anterior two-third versus total callosotomy. In the past it had been thought that anterior two-third callosotomy would prevent postoperative neurologic deficits such as the disconnection syndrome marked by

mutism, hemiataxia, and/or alexia (Harbaugh et al., 1983). Thus many neurosurgeons preferentially performed anterior two-third callosotomy initially with completion of the callosotomy during a second procedure if seizures were not properly controlled. Results of a second procedure for completion of the callosotomy were not impressive along with the associated increased morbidity with a second craniotomy procedure (Wyllie, 1993). Maxwell reported a modified surgical approach, using a more anterior interhemispheric approach, which decreased the surgical complications (Engel, 1993). Wyler suggested sectioning the corpus callosum between the bilateral pericallosal arteries (Wyllie, 1993).

4.3 Contemporary concept of corpus callosotomy

With the evolution of the operation technique and concept of corpus callosotomy, this procedure has been used more frequently and for a wider range of epilepsy disorders. It can be considered that decreasing the surgical complications and the seizure incidence rate, improving the cognitive and psychology function is much important to younger patients.

4.3.1 Surgical complications

Permanent serious complications are rare after callosotomy; most adverse effects are temporary. These include acute epidural hematoma, hydrocephalus, subdural cerebrospinal fluid accumulation, and infections (e.g., meningitis, osteomyelitis) (Wong et al., 2006; Maehara & Shimizu, 2001; Nei et al., 2006), possibly because of brain retraction and trans-ventricular approach. Disconnection syndrome is more common with total section than anterior callosotomy (Maehara & Shimizu, 2001; Kim et al., 2004; Rossi et al., 1996). Objects presented solely to the hemisphere that is not dominant for language may not be verbally reported by the patient. For example, rapid presentation of visual stimuli in the non-dominant visual field is not reported by the patient, as the language-dominant hemisphere has no access to the information. The nondominant hand no longer responds reliably to verbal commands, because the dominant hemisphere may not readily transfer information to the nondominant motor cortex (Kim et al., 2004; Reeves & Roberts, 1995). Most patients are unaware of the deficit (Kim et al., 2004). Transient postoperative apathy is sometimes observed and is probably related to mesial and convexity frontal lobe disconnections. The symptoms usually diminish with time, but are permanent to some extent and may fluctuate over the years. There remains debate over the extent of callosal damage necessary to produce disconnection syndrome (Geschwind, 1995). It typically appears in the setting of a complete disconnection (callosotomy), but we have rarely observed it after an anterior callosal section as well. It is quite unlikely to occur in patients with significant unilateral cerebral injury, for example, porencephaly, prior to surgery.

4.3.2 Overall daily function and behavioral consequences

In recent years, the implications of corpus callosotomy on the cognitive status of epilepsy patients have been emphasized. In one study, overall daily function, as assessed by families, improved in 62% of patients. Changes included improvement in hyperactivity (93%), emotional well-being (42%), social contacts (36%), speech function (21%), and memory function (17%) (Maehara & Shimizu, 2001). In another study, nearly three-fourths of the parents appreciated improvements in behavior and attentiveness of their children (Turanli et al., 2006). Activities of daily living including level of self-care, family life, and even school attendance may improve significantly (Turanli et al., 2006). Intelligence quotient scores do

not usually change significantly after callosotomy. However, in some patients with marked impairment of cognitive and language functions in whom a favorable seizure outcome has been achieved, an improvement in overall intelligence and language abilities has been observed (Maehara & Shimizu, 2001; Turanli et al., 2006; Rathore et al., 2007). This improvement is probably due to the decrease in seizure frequency or consequent decrease in antiepileptic drug load, or both. In one study, a close relationship was observed between improvement in quality of life and seizure relief regardless of the age and operation and psychological status (Rougier et al., 1997). Improvement in quality of life is more common in children (>70%) than in adults (>45%). One possible explanation for the better functional outcome in children is that a child's brain is more flexible and has better compensatory mechanisms to make up for the disconnected corpus callosum (Maehara & Shimizu, 2001). No association has been found between the extent of callosotomy and changes in Intelligence Quotient score or neuropsychological outcome in one study (Mamelak et al., 1993).

4.3.3 Patient selection

Corpus callosotomy is a palliative procedure for patients with medically un- controllable seizures not amenable to focal resection. Clinically, ictal EEG with bilateral synchronization has been associated with good outcome in some studies. In one study, ictal EEG was important as a predictive factor for outcome after callosotomy. The patterns with generalized slow spike–wave, electrodecrement, or nonevolving low–amplitude fast activity were associated with absence seizures, tonic and atonic seizures, or axial spasms, all of which can cause drop attacks. Patients with these patterns demonstrated a marked reduction in seizure frequency, and 10 of 11 (91%) demonstrated a 90% or greater decrease in their seizure frequency. The ictal EEG can efficiently identify patients with drop attacks who have a likelihood of good outcome after callosotomy (Hanson et al., 2002).

Most epilepsy patients, especially in children, have light or seriously lower Intelligence Quotient score. Although this is not the surgery contraindication, it exerts important implication on the outcome of patients. Rathore (Rathore et al., 2007) reported that those who with serious lower Intelligence Quotient score had a significant improve in cognitive function and social psychological status, in spite of not good control of seizure as expected. Therefore, it is thought that to improve the quality of life of patients after surgery is more important and meaningful, compared to sheer control of seizure attack.

5. Conclusion

Corpus callosotomy is a reasonably safe and effective palliative surgical procedure for some patients with intractable seizures who are not amenable to focal resection. This is a feasible and cost-effective treatment for some patients, even those in developing countries and with limited resources (Asadi-Pooya & Sperling, 2008). New imaging techniques may serve to further understanding of the role of callosal connections in generating and propagating seizures. Other areas for research include development of a reliable prognostic and outcome scoring system, development and evaluation of new techniques for surgery (e.g., gamma knife or endoscopic surgery), better characterization of specific deficits after surgery, and implementation of surgical and medical preventive measures to prevent postoperative complications.

In conclusion, the corpus callosotomy can be viewed as a feasible alternative to the standard surgical procedure in patients with refractory seizures. When physicians, patients, and their families choose a treatment for seizure control, several factors should be considered, including the control of seizure frequency and severity, patient expectations, and relative risk of the procedure.

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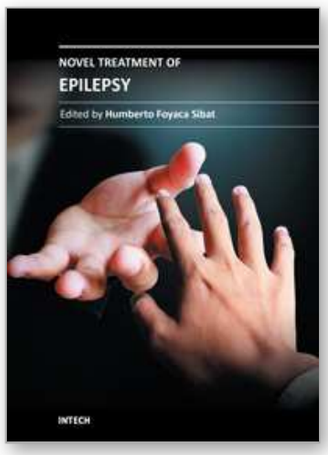

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Epilepsy continues to be a major health problem throughout the planet, affecting millions of people, mainly in developing countries where parasitic zoonoses are more common and cysticercosis, as a leading cause, is endemic. There is epidemiological evidence for an increasing prevalence of epilepsy throughout the world, and evidence of increasing morbidity and mortality in many countries as a consequence of higher incidence of infectious diseases, head injury and stroke. We decided to edit this book because we identified another way to approach this problem, covering aspects of the treatment of epilepsy based on the most recent technological results â€œin vitroâ€ from developed countries, and the basic treatment of epilepsy at the primary care level in rural areas of South Africa. Therefore, apart from the classic issues that cannot be missing in any book about epilepsy, we introduced novel aspects related with epilepsy and neurocysticercosis, as a leading cause of epilepsy in developing countries. Many experts from the field of epilepsy worked hard on this publication to provide valuable updated information about the treatment of epilepsy and other related problems.

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