**A Team Treatment Approach After Major Brain Surgery: Rehabilitation Post–Functional Hemispherectomy**

Jeffrey Bolek, PhD, BCB
Cleveland Clinic Children’s Hospital for Rehabilitation, Cleveland, OH

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Difficult medical cases are often best addressed by a team approach where the expertise of several disciplines can be brought to bear on multiple challenges. This article reviews the team approach at the Motor Control Program at the Cleveland Clinic Children’s Hospital for Rehabilitation. In the case of a school-age child, in addition to medical issues there are social, family, educational, and scheduling issues that affect the progress of the patient. This case describes how quantitative surface electromyographic (QSEMG) biofeedback was one part of an overall treatment plan to help restore a child to health after major brain surgery.

**Introduction**

Epilepsy is most common in children and includes a variety of seizure types. Patients are diagnosed with epilepsy when they have seizures that occur more than once without a specific cause. In most cases, about 7 out of 10, the cause of the seizures cannot be identified. Epilepsy can begin at any time of life, but it is most common in children under 5 years. Although epilepsy varies from person to person, children with epilepsy generally have seizures that are responsive to medication about 70% to 80% of the time, and they enjoy a normal and active childhood.

With the failure of two or three antiepileptic medications over a span of 2 or 3 years, surgery becomes a consideration. In the best case, a focal or epileptogenic area of the brain is identified and removed. If the lesion is extensive, a bigger or multilobar resection is done. The most extreme surgery is full removal of half the brain, a hemispherectomy. About 20% of patients who have had a functional hemispherectomy experience residual seizures (Mittal et al., 2001). The most striking instance of cerebral reorganization is seen in children who have undergone removal of the left hemisphere and whose everyday language functions are spared (Curtiss, de Bode, & Mather, 2001). In tests of language and verbal intelligence, the highest level of performance was achieved by patients with a right hemispherectomy of postnatal origin compared to those with a left hemispherectomy (Liegeois, Cross, Polkey, Harkness, & Vargha, 2008). While the side of surgery made no difference in general intelligence, both left and right hemispherectomy patients typically scored 30 points below normal on both verbal and nonverbal measures (Curtiss et al., 2001). Some (Gott, 1973) have found that memory is impaired to a greater extent by removal of the left than removal of the right hemisphere.

**Case Study: Darren**

This case study reviews the rehabilitation progress of an 8-year-old boy after surgery to alleviate intractable seizures due to Rasmussen encephalitis.

**Medical History**

“Darren,” age eight, came to the Cleveland Clinic with many daily seizures and progressive motor, language, cognitive, and behavioral deficits. His right hemiparesis (weakness on one side of the body) was pronounced and MRIs showed progressive left hemisphere cortical atrophy consistent with a diagnosis of Rasmussen syndrome. Rasmussen syndrome is an autoimmune process that causes one hemisphere of the brain to become inflamed and deteriorate. It is associated with intractable unilateral seizures, progressive hemiparesis, and intellectual dysfunction. Seizures are often the first symptom to appear. Despite treatment with seven antiepileptic medications there was no change in the seizure frequency. After these medication trials he underwent a total left hemispherectomy or incomplete removal of the left side of his brain. Functional hemispherectomies produce a better outcome than complete removal of the hemisphere (Devlin, Cross, Chong, Harding, & Neville, 2003).
A Collaborative Treatment Plan

Darren was admitted to the Cleveland Clinic Children’s Hospital for Rehabilitation (CCCHR) for intensive rehabilitation five days after surgery. A team of physicians, therapists, social workers, and psychologists developed a rehabilitation plan to address his very dense right hemiparesis, oral dysphagia (difficulty in swallowing), noncompliance with tasks asked of him, and change of handedness (he was originally right handed, now left handed). During the initial occupational therapy sessions he was resistant to following directions and noncompliant with tasks asked of him. There were no active or trace movements with the right upper extremity or movement noted with attempts to facilitate grasp. Adding to his frustration were decreased memory and word finding difficulties. Treatment sessions in occupational, physical, and speech therapy were scheduled for 3 hours per day over a 6-day week. He also participated in the in-house school and recreational therapy programs.

At the time of admission and throughout the inpatient stay, weekly team meetings allowed collaboration among all disciplines involved in the patient’s care including nursing, medicine, therapy services, school, nutrition, psychology, and social work. A major goal of the team is the transition to home for out of town patients like Darren. Often services need to be put into place such as modifications to the home for access, continued outpatient physical and/or occupational therapy and the development of an individualized education plan.

The Motor Control Program

Included in his therapy was participation in the Motor Control Program, a unique program based on a variant of surface electromyography called Quantitative Surface Electromyography (QSEMG; Bolek 2013a, 2013b). In QSEMG, the focus is to internalize the correct muscle pattern recruitment within the constellation of muscles rather than relying on only one or two muscles. When this constellation of muscle groups is on target (i.e., the thresholds met), positive feedback in the form of a video reward is activated. Typically, some muscles need to be activated and some relaxed. For example, upright sitting may be enhanced by targeting the lower trapezius to be active with minimal use of the upper trapezius and pectoralis major were rewarded along with minimal use of the upper trapezius and left arm. This provided him a stable base of support so he was able to produce swipes with his right arm for the first time. He continued to demonstrate compensation through the trunk and back but this decreased as sessions progressed. Typically, a session started out with overall poor behavior but as the session progressed he displayed much improved participation and effort. It was at the end of the first session that he displayed the most active right arm movement to date since surgery. Although he quickly learned to maintain an upright sitting sites. The thresholds were set based on information from the physical/occupational therapist. However, as we will see, the program appears deceptively simple. Figure 1 shows the electrode placement. All thresholds were met if he sat in an upright, evenly based sitting posture while performing a reach across his body as if to grasp a cup about shoulder level on his left side.

Intrasession progress was tracked by calculating the percentage of time he was able to sit with all thresholds met for any given session. Inter- or between-session progress was obtained by plotting a series of sessions on a graph. In this way, an objective measure of progress was obtained.

He was seen in the Motor Control Program for ten 1-hour sessions where activity (as measured in microvolts or μV via SEMG) of the lower bilateral trapezius and right pectoralis major were rewarded along with minimal use of the upper bilateral trapezius and left arm. This provided him a stable base of support so he was able to produce swipes with his right arm for the first time. He continued to demonstrate compensation through the trunk and back but this decreased as sessions progressed. Typically, a session started out with overall poor behavior but as the session progressed he displayed much improved participation and effort. It was at the end of the first session that he displayed the most active right arm movement to date since surgery. Although he quickly learned to maintain an upright sitting
Children who have an extensive medical history may not have had the life exposure to learn that “good” and “bad” behavior may have different outcomes. Parents, faced with a child with life-altering medical issues, may be reluctant to use firm consequences with behavior that is unacceptable. The refusal to complete a task (such as putting toys away) may be viewed as a result of fatigue from medical treatments and instead of allowing more time for the child to complete the task or offer assistance, the parent may excuse the child from completing the task altogether. A pattern then emerges where no firm limits are set. As a consequence, developmental milestones involving natural consequences are missed.

A unique advantage of the Motor Control Program is, by design, that target behavior (meeting the thresholds) is immediately rewarded and noncompliant behavior is not. For some children this is their first exposure to an inevitable life lesson; that is, behavior has consequences.

Figure 2 shows the percentage success for 10 sessions spanning November 2 through December 6. Of note is the irregular pattern of success typical of patients with a brain injury. Overall, Darren showed a dramatic improvement, with an initial success of 13% increasing to 71% on the last session. This was the beginning of the performance of a functional movement that he could use to help dress himself. There were occasional setbacks due to labile moods. At the time of discharge he was able to bring his right arm across his body in a swiping motion. Active shoulder flexion was now 100°. Functionally he was able to brush his teeth independently as well as don and doff his shirt using both arms to assist. He was discharged after two months at CCCHR. A follow-up report from his home school 2 months post discharge placed him in the low average range on a test of fine motor skills.

**The Devil in the Details**

Darren’s treatment protocol described earlier appears to be a simple case of using a biofeedback modality (in this case SEMG) to change behavior. However, how the biofeedback is applied contributes to the success or failure of the treatment. Knowledge of results (KR) is augmented by extrinsic information about task success (Winstein, 1991).

This is feedback such that performing A results in B: for example, reaching to touch a switch activates a toy. During Darren’s treatment, the monitor readout of muscle activity was gradually reduced until he was able to perform the movement with at least 85% accuracy by movement awareness alone. The reason for this is summarized well in research by a variety of authors (Shea, Shebilske, & Worchel, 1993; Winstein & Schmidt, 1990). In this research, one group received feedback on every trial; the other group was given KR early in practice followed by a reduction later in practice. Performance was the same for both groups but the reduction group performed better on a delayed retention task. This is exactly what needs to be considered for biofeedback to be effective. The patient may perform well in the clinic but unless consideration is given to future performance as in the studies above, the treatment may not generalize to other settings.

**Some Closing Observations**

Interventions with patients with complex medical issues are multifaceted, and the information comes from a variety of sources. Some of it is factual, some of it is based on an interpretation of the data, and some is very subjective. Psychophysiology data, in this case SEMG data, can serve as a benchmark to monitor progress in one area objectively. This is especially important with the changes in managed care where payment for services is linked to patient outcomes.

**References**


Correspondence: Jeffrey E. Bolek, PhD, BCB, Cleveland Clinic Children’s Hospital for Rehabilitation, Motor Control Program, Cleveland, OH 44104, email: bolekj@ccf.org.