Cortical activation in patients with functional hemispherectomy

Introduction

Hemispherectomy is performed in patients with a grossly damaged hemisphere and medically intractable epilepsy originating in this hemisphere. Anatomical hemispherectomy with complete removal of the affected hemisphere was first performed in the late twenties [7] in patients with glioma and was introduced for the therapy of epilepsy in 1938 [14, 16]. Owing to the high mortality and complications such as hydrocephalus and superficial cerebral hemosiderosis the technique was later modified to a functional hemispherectomy. The most recent technique, also called “functional hemispherectomy” or “hemispherical deafferentation”, includes removal of the anterior temporal lobe and the hippocampus and complete dissection of all white matter of the frontal, parietal, temporal and occipital lobes leaving the dissected hemisphere in place as a physical counterbalance [21]. Complete seizure control can be

Abstract

Functional hemispherectomy, a safe and effective therapeutical procedure in medically intractable epilepsy, offers the chance to investigate a strictly unilateral cortical activation in ipsilateral limb movement. We assessed the pattern of cortical activation in a group of patients following functional hemispherectomy. We measured regional cerebral blood flow (rCBF) in 6 patients postoperatively and 6 normal subjects with positron emission tomography using 15\(^{\text{O}}\)H\(_2\)O as a tracer. Brain activation was achieved by passive elbow movements of the affected arm. Analysis of group results and between-group comparisons were performed with statistical parametric mapping, (SPM96). In normal subjects brain activation was found contralaterally in the cranial sensorimotor cortex and the supplementary motor area and ipsilaterally in the inferior parietal cortex. In patients significant rCBF increases were found in the inferior parietal cortex, caudal sensorimotor cortex and the supplementary motor area ipsilaterally. The activation was weaker than in normal subjects. Compared with normal subjects patients showed additional activation in the premotor cortex, caudal sensorimotor cortex and the inferior parietal cortex of the remaining hemisphere. Less activation compared with normal subjects was found in the cranial sensorimotor cortex and the supplementary motor area. A functional network connecting the inferior parietal cortex, premotor cortex and the supplementary motor area as well as the existence of ipsilateral projections originating from these regions may explain why these areas are predominantly involved in reorganization confined to a single hemisphere.

Key words Corticofugal projections · Ipsilateral · Passive elbow movements · Positron Emission Tomography · Reorganization
achieved in 60–80% of hemispherectomized patients [8].

Postoperatively, hemispherectomy and control subjects performing the same paradigm has not been carried out so far. The objective of this present study was to assess the pattern of cortical activation in a group of patients with hemispherectomy and compare them with control subjects. All normal subjects and patients gave written informed consent. The study was approved by the local ethics committee.

Subjects

Six patients (3 female, 3 male) aged 19 to 52 years participated in this study. They fulfilled the following inclusion criteria: (1) adult, (2) ability to perform elbow flexion and extension against gravity and moderate resistance, (3) ability to walk at least with help, (4) able to give written informed consent. The underlying brain lesions (ischemia, n = 4; penetrating trauma, n = 1; brain abscess, n = 1) had occurred between one month and two years of age. Functional hemispherectomy was performed at ages 15 to 47 years because of intractable severe focal epilepsy despite therapy with all available standard anticonvulsive substances at maximum doses. Surgery was performed according to the technique introduced by Schramm [21]. Functional hemispherectomy was complete in all but one patient in whom a small area of the frontal cortex, probably the supplementary motor area, was not dissected (patient 6). The interval between surgery and PET scanning varied from 2 to 8 years.

Presurgical evaluation and surgery were performed at the University of Bonn, Departments of Epileptology and Neurosurgery, and the patients were followed-up at the Department of Neurology, University of Essen. Postoperative neurological status and seizures were assessed regularly during outpatient visits and during the study.

Preoperatively all patients had a moderate to severe paresis of the contralateral arm and a mild to moderate paresis of the contralateral leg. Postoperatively the neurological status was unchanged in three patients, two patients improved partially and one patient deteriorated due to perioperative complications. All patients could flex and extend the forearm and perform movements such as opening the door or holding a bag at the time of this study. Purposeful hand and finger movements were only possible in two patients. In all patients pain sensation was intact throughout the whole arm, light touch sensation was impaired in the hand and fingers. Joint position sense of the elbow was intact. At the time of this study all patients were free of seizures and one patient was no longer on anticonvulsive medication. We could not find an association between age at brain lesion or age at time of hemispherectomy and the results of the neurologic examination.

Demographic and clinical data of each patient are summarized in Table 1.

PET data acquisition

The subjects lay supine in the scanner with the eyes closed. To ensure correct head position the orbito-mental line of the subjects were adjusted to a laser beam parallel to the transaxial planes of the scanner. The bridge of the nose was adjusted to a laser beam parallel to the scanner axis. During PET scanning the affected arm (i.e. contralateral to the hemispherectomy and ipsilateral to the hemisphere under investigation) was abducted at the shoulder level to 70° and placed in a forearm brace which was connected to a torque motor (Jace SYSTEMS, Mülheim, Germany). The torque motor generated passive movements of the brace resulting in flexion and extension of the elbow between 80° and 170° at a frequency of 0.75 Hz. Complete extension of the elbow was avoided. Patients and control subjects were investigated in exactly the same way using the same apparatus.

Methods