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ABNORMAL NEUROVASCULAR COUPLING DURING STATUS EPILEPTICUS MIGRAINOSUS IN STURGE-WEBER SYNDROME

Sturge-Weber syndrome is a rare, sporadic, neurocutaneous disorder classically characterized by a facial nevus in the trigeminal distribution (port wine stain), leptomeningeal angiomas, and glaucoma, although intracranial changes can be present without cutaneous involvement.¹ Seizures occur in up to 75% of individuals, are often associated with headache, and stroke-like episodes causing prolonged neurologic deficits are also described.^{1,2}

Headache meeting criteria for migraine attack in association with electrographic status epilepticus has previously been reported as status epilepticus migrainosus.³ We report clinical, electrophysiologic, and functional imaging findings in a patient with occipital Sturge-Weber syndrome without facial nevus during a prolonged episode of headache, visual field deficit, and focal occipital status epilepticus.

Case report. An 18-year-old intellectually normal man with a history of focal seizures and episodes of nonconvulsive status epilepticus was admitted to our epilepsy monitoring unit for characterization and consideration for surgery. He was born at term after an uneventful pregnancy and had normal early childhood development. Seizures started at age 2 years and comprised flashing lights in the right visual field, right arm clonic movements, tinnitus, and postictal dysphasia. Seizures lasted up to 20 minutes, and were often accompanied by severe throbbing global headache that persisted for hours to days. There was no history of headache unrelated to seizures. Neuroimaging was typical of Sturge-Weber syndrome (figure, A–C) and baseline fluorodeoxyglucose (FDG) PET showed hypometabolism over the left occipital cortex (figure, E). Visual fields were normal on perimetry.

At admission, EEG showed normal background rhythms and infrequent left occipital spike-wave epileptiform discharges. After gradual withdrawal of routine medications (topiramate, levetiracetam, and lamotrigine) over 72 hours, frequent focal seizures occurred. Episodes of flashing lights with distorted vision in the patient's right visual field were

reported and these were inconsistently associated with focal spiking and evolving theta rhythms over the left occipital region (figure, D). Technetium-99m ethyl cysteinate dimer was injected during a clinical seizure followed by a SPECT scan, and this revealed ictal hypoperfusion over left occipital cortex (figure, F).

Over the next 24 hours, the patient developed a severe throbbing headache lateralized to the left side, nausea requiring antiemetic medications, a right visual field defect on bedside confrontation testing, and continued reporting of intermittent flashing lights in the right visual field. During this period, the EEG showed persistent left occipital polymorphic delta slowing without epileptiform discharges (figure, D). Due to uncertainty whether the persistent symptoms were migrainous or epileptic, an FDG-PET scan was obtained, which showed remarkable hypermetabolism over the left occipital region compared to baseline (figure, F).

The patient was treated for status epilepticus with IV benzodiazepines and his usual antiepileptic medications were recommenced. IV chlorpromazine was administered for treatment of "migraine" headache. There was resolution of headache and visual field deficits over the next 24 hours and EEG returned to baseline.

Discussion. The etiology of Sturge-Weber syndrome is not known but it is suggested that there is failure of regression of primitive cephalic venous plexus affecting the ectoderm destined to become the upper facial skin and scalp as well as the parieto-occipital area of the brain.² Somatic mosaic mutations have long been suspected as the likely cause, and recently, mutations in the *GNAQ* gene have been found in affected brain and skin tissue.⁴ Whether headaches are a consequence of the epileptic activity or due to shared underlying pathology in the trigeminovascular system remains a mystery. Children with Sturge-Weber syndrome show functional imaging abnormalities that evolve over time. SPECT and PET studies in infants demonstrate interictal hyperperfusion and hypermetabolism, which changes to interictal hypoperfusion of the involved cortex after infancy.^{5,6} Increased metabolic demand during epileptic activity in the presence of reduced perfusion, i.e., abnormal neurovascular coupling, is

(A) CT shows intraparenchymal calcifications in the left occipital region. (B) Susceptibility-weighted MRI shows abnormal vasculature (arrowhead) and areas of signal loss over the left occipital region (arrow). (C) T1-weighted postcontrast image shows leptomeningeal enhancement, volume loss over the left occipital pole (black arrowhead), and an enlarged choroid plexus on the left (white arrowhead). (D) Five-second EEG epochs show focal spikes and rhythmic slowing over the left occipital region during a focal seizure (top panel) and polymorphic delta slowing over the left posterior quadrant without epileptiform discharges during the prolonged "ictal" period (bottom panel). (E) Interictal (left) and ictal (right) FDG-PET axial views show hypometabolism of the left occipital cortex during the interictal period (arrow) and hypermetabolism (arrowhead) during the prolonged "ictal" state. (F) Interictal (left) and ictal (right) SPECT axial views show relative hypoperfusion of the left occipital cortex during the ictal state (arrowheads).

presumed to contribute to neuronal injury during prolonged seizures in childhood, although this has not been demonstrated directly.^{2,6} Evidence of such altered neurovascular coupling has also been found during invasive monitoring in patients with aneurysmal subarachnoid haemorrhage and likely contributes to neuronal injury.⁷

Our patient with Sturge-Weber syndrome concurrently developed focal occipital status epilepticus and a prolonged headache that met criteria for migraine headache attack.⁸ PET showed markedly increased cortical metabolism consistent with ongoing epileptic activity, whereas ictal SPECT showed reduced perfusion of the involved cortical region. This provides neuroimaging evidence for abnormal neurovascular coupling in an adult with Sturge-Weber syndrome during status epilepticus migrainosus. From a clinical perspective, this case also highlights the role of functional imaging in determining the underlying etiology of a patient's

symptoms as epileptic in the absence of scalp EEG discharges, thus guiding appropriate treatment.

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Study funding: No targeted funding reported.

Disclosure: The authors report no disclosures relevant to the manuscript. Go to Neurology.org for full disclosures.

Received July 18, 2016. Accepted in final form September 22, 2016.

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TEN-YEAR RESULTS OF PALLIDAL STIMULATION FOR CRICOPHARYNGEAL DYSTONIA WITH SPASMODIC DYSPHONIA

Focal dystonias are the most common and can occur in any body part, including the neck skeletal muscles and muscles of the larynx and pharynx. Laryngeal dystonia includes spasmodic dysphonia, a disabling vocal disorder characterized by involuntary vocalization disruption.¹ Pharyngeal dystonias that impair swallowing and phonation have been reported less frequently.^{2,3} In cases of combined laryngeal and pharyngeal dystonia, swallowing, speech, and respiration may be drastically impaired. We report a case with wide-ranging dystonic symptoms, including cricopharyngeal dystonia (CPD) and spasmodic dysphonia, effectively treated for 10 years by deep brain stimulation (DBS) of the globus pallidus internus (GPi).

Classification of evidence. This single case without controls provides Class IV evidence.

Case report. A 53-year-old man had oromandibular and tongue dyskinesia, resulting in dysarthria, involuntary vocalization disruption, and laryngeal tightness during vocalization. These symptoms became progressively more severe and made it nearly impossible to communicate verbally (video 1 at Neurology.org). A videofluoroscopic swallowing study (VFSS) on admission demonstrated pooling in the valleculae, pyriform sinuses, and hypopharynx; inappropriate opening of the epiglottis; failure of upper esophageal sphincter relaxation; and aspiration into the larynx (figure, video 2). Esophagoscopy showed no mechanical abnormality and cricopharyngeal muscle relaxation failure. Our diagnosis was segmental dystonia encompassing the oromandibular, tongue, laryngeal, pharyngeal, and neck muscles. Because of the wide-ranging dystonic muscles, we planned to perform bilateral GPi-DBS. Quadripolar DBS electrode (Model 3387; Medtronic, Langhorne, PA)

implantation was performed under local anesthesia. The target was defined on stereotactic frame-based magnetic resonance and CT images of the GPi borders and optic tract. Stereotactic coordinates of the bilateral GPi were 2 mm anterior to the midcommissural point, 4 mm below the anterior commissure–posterior commissure line, and 20 mm lateral to the midline. An implantable pulse generator (IPG) (Soletra; Medtronic) was inserted under general anesthesia 3 weeks after the first operation. DBS commenced on the day of IPG implantation. All dystonic symptoms were markedly alleviated by GPi-DBS (video 1). Laryngoscopy revealed normal movement of the tongue, larynx, pharynx, and vocal cords and showed no pooling in the valleculae, pyriform sinuses, or hypopharynx. Postoperative VFSS demonstrated smooth swallowing with appropriate epiglottis opening and cricopharyngeal muscle relaxation (video 2). Initially, we started GPi stimulation at an amplitude of 2.5 V, a frequency of 185 Hz, and a pulse width of 210 μ s (bipolar stimulation: contact 0 positive, contact 1 negative) on both sides. Optimal stimulation parameters were 3.5 V, 210 μ s, and 185 Hz (bipolar stimulation: contact 1 and 2 negative, contact 3 positive) on both sides for the last 5 years. Three IPG replacements were required over the 10-year follow-up to maintain these improvements. No hardware-related complications occurred during follow-up.

Discussion. Cricopharyngeal muscles normally maintain a tonic contraction to prevent regurgitation of food into the pharynx and passage of air into the esophagus during inspiration. During deglutition, cricopharyngeal muscles relax to allow the passage of the food bolus. Cricopharyngeal dysfunction, which is attributed mainly to the disordered opening of the cricopharyngeal muscles, can lead to dysphagia and aspiration.⁴ Cricopharyngeal dysfunction etiologies are diverse, including anatomic, neuromuscular, iatrogenic, inflammatory,

Supplemental data
at Neurology.org