Surgical outcomes and seizure control rates after resection of dysembryoplastic neuroepithelial tumors

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Object. In this study the authors review the outcomes in pediatric patients who presented with seizures and underwent resection of dysembryoplastic neuroepithelial tumors (DNETs). The authors focus on the diagnostic evaluation and surgical techniques that facilitate gross–total tumor resection and subsequent freedom from seizures.

Methods. Eighteen patients between the ages of 1 month and 13 years who presented with seizures underwent resection of DNETs between January 1992 and December 2004. Preoperative evaluation included magnetic resonance (MR) imaging and interictal scalp electroencephalography (EEG) in all patients, functional MR imaging in eight patients, video monitoring with ictal scalp EEG in 12 patients, interictal single-photon emission computerized tomography (SPECT) scanning in one patient, and ictal SPECT scanning in two patients. Thirteen patients underwent one-stage procedures, whereas five underwent two-stage procedures (implantation of monitoring electrodes followed by tumor resection), either for functional language mapping (three patients) or due to inconclusive preoperative data (two patients). Intraoperative electrocorticography (ECoG) was performed in 17 patients and led to resection of the cerebral cortex beyond the tumor margins in 10 of them. According to operative reports, gross–total tumor resections were achieved in all patients, but one child had minimal residual tumor on postoperative MR images that has remained stable. The only surgical complication was a transient third cranial nerve palsy. Over a median follow-up duration of 1.6 years, all patients are seizure free and without radiographically detected tumor recurrence.

Conclusions. Dysembryoplastic neuroepithelial tumors are a highly treatable cause of epilepsy in children. Excellent rates of complete tumor resection and seizure control with minimal morbidity can be attained using intraoperative ECoG and two-stage surgical procedures when appropriate.

KEY WORDS • dysembryoplastic neuroepithelial tumor • seizure • surgical technique • children

First described in 1988 by Daumas-Duport, et al.,2 DNETs are pathologically distinct lesions that are commonly associated with seizures and presentation in childhood. Neuroimaging findings typically include single lesions that are hyperintense on T₂-weighted and hypointense on T₁-weighted MR images.3,7,9,11,13 Lesions characteristically lack surrounding edema, and only a few enhance with addition of contrast material.13 Dysembryoplastic neuroepithelial tumors are characterized as benign lesions that rarely recur after resection. Reported rates of complete freedom from seizures after resection range from 58% to more than 80%.1,2,6,10,12 The presence of residual tumor is a significant risk factor for poor long-term seizure outcome.10

The objective of this study was to review the outcomes in a series of children who presented with seizures and were noted to have tumors that were identified as DNETs when resected and samples studied for pathological features. The authors specifically focused on the diagnostic evaluation and surgical techniques that not only facilitate gross–total tumor resection but enhance the probability of complete seizure control.

CLINICAL MATERIAL AND METHODS

After Institutional Review Board approval was obtained, a patient database maintained at the Comprehensive Epilepsy Center of Miami Children’s Hospital was searched. We identified 18 patients who presented with seizures between January 1992 and December 2004 and were found to have brain tumors that were resected and pathologically confirmed as DNETs. Clinical information was obtained from the database as well as office and hospital charts, EEG reports, imaging study reports, and operative reports.
Clinical features in the patients we treated are listed in Table 1. Ten patients were boys and eight were girls. The median age at seizure onset was 7.2 years, and the range was 1 month to 13 years. The median age at tumor resection was 9.6 years, and the range was 6 months to 19 years. Seizure types included complex partial (10 of 18), simple partial (four of 18), complex partial with secondary generalization (three of 18), and both complex partial and simple partial (one of 18). Before surgery, seizures occurred at least daily in seven patients, at least weekly in six, at least monthly in two, and less than monthly in three patients. In 16 of 18 patients, neurological examinations yielded completely normal results before surgery, and the other two had mild left hemiparesis.

The results of diagnostic evaluation prior to surgery are detailed in Table 2. In each patient an MR imaging study demonstrated a lesion, and the most common tumor location was the temporal lobe (61.1%). Ten of 18 lesions were located on the right side, and the other eight were located on the left. Figure 1 demonstrates a typical lesion identified in one patient. Functional MR images were obtained in eight of 18 patients based on the surgeon’s concern about the tumor’s location within or adjacent to eloquent cerebral cortex. Each patient underwent routine interictal scalp EEG, and 16 of 18 patients had abnormal results. Video monitoring with ictal EEG recordings was obtained in 12 of 18 patients, 11 of whom demonstrated focal spiking, and one of whom had multifocal spiking. An interictal SPECT scan was obtained in one of 18 patients, and an ictal SPECT scan was obtained in two others.

Based on the diagnostic evaluation, surgical procedures were performed in these 18 patients as outlined in Table 3. Thirteen of 18 patients underwent one-stage and five of 18 underwent two-stage procedures, which included implantation of monitoring electrodes (subdural grid and/or depth) followed by tumor resection at a later date. Two-stage procedures were performed for functional language mapping before resection of left-sided lesions in three patients. In the other two patients, two-stage procedures were performed to clarify EEG data that were inconclusive or did not con-
Surgical outcomes and seizure control rates after DNET resection

verge with MR imaging findings. Intraoperative ECoG was performed in all but one patient, and additional cerebral cortex beyond the tumor margins was resected in 10 patients based on ECoG findings. In five of these patients the ECoG data that led to additional resection were obtained from extraoperative monitoring using previously placed electrodes, which were inserted in the first stage of a planned two-stage procedure (electrode implantation followed by resection). In the other five patients the ECoG data that led to additional resection were obtained during a single-stage procedure.

Intraoperative frameless stereotactic navigation was used in seven of 18 patients to assist with tumor localization. Gross–total tumor resections were achieved in all 18 patients according to the surgeons’ operative reports. Postoperative MR images confirmed an absence of residual tumor in 13 patients, revealed a small amount of residual tumor in one, and were not available for review in the remaining four.

RESULTS

Outcomes are listed in Table 4. The only surgical complication was a transient postoperative third cranial nerve palsy, which eventually resolved completely. Over a median follow-up duration of 1.6 years (range 1 week–10.5 years), all 18 patients have been completely seizure free and none has had a radiographically confirmed tumor recurrence. Ten of these patients have been followed for more than 1 year, and eight have been followed for less than 1 year. As noted previously, in one patient a small amount of residual tumor was noted on postoperative MR images; this has remained unchanged on serial imaging studies obtained over 2.5 years.

DISCUSSION

The clinical features of the patient population presented in this series are similar to those in previous studies. That is, DNETs most commonly present with seizures in childhood, and the majority of patients are neurologically intact at presentation. Despite the fact that DNETs can remain indolent for years, these lesions represent a curable cause of seizures and are typically resected if they arise in an accessible location. Tumors located within areas of eloquent cortex, particularly if seizures are infrequent or well controlled with medications, are occasionally followed with serial imaging studies and resected only in cases of radiographically confirmed progression or poor seizure control.

Preoperative evaluation typically includes standard interictal scalp EEG in addition to MR imaging studies. If the EEG demonstrates focal spiking that converges with MR imaging data in terms of location, and the lesion is not located in cerebral cortex potentially associated with language function, then the next logical step is a one-stage tumor resection in the majority of cases. Functional MR images obtained before tumor resection can be useful in

Fig. 1. Preoperative (A–C) and postoperative (D–F) coronal T\textsubscript{2}-weighted MR images and coronal and sagittal T\textsubscript{1}-weighted MR images with Gd contrast obtained in a 4-year-old boy who presented with seizures. He underwent craniotomy for implantation of subdural electrode grids and functional language mapping followed by tumor resection with the aid of ECoG. The patient has been free of seizures for 2 years since his surgery.
TABLE 4
Outcomes in 18 children with DNETs and seizures who underwent resection

<table>
<thead>
<tr>
<th>Factor</th>
<th>Value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>surgical complications</td>
<td></td>
</tr>
<tr>
<td>none</td>
<td>17</td>
</tr>
<tr>
<td>transient 3rd cranial nerve palsy</td>
<td>1</td>
</tr>
<tr>
<td>follow up range</td>
<td>1 wk–10.5 yrs</td>
</tr>
<tr>
<td>median</td>
<td>1.6 yrs</td>
</tr>
<tr>
<td>tumor recurrence yes</td>
<td>0 (0)</td>
</tr>
<tr>
<td>no</td>
<td>18 (100)</td>
</tr>
<tr>
<td>seizure free yes</td>
<td>18 (100)</td>
</tr>
<tr>
<td>no</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

determining the anatomical relationship between the tumor and adjacent eloquent cerebral cortex to guide the surgical approach. Ictal and interictal SPECT scans are typically not obtained in patients with a single lesion.

If the interictal scalp EEG demonstrates multifocal spiking or abnormalities that are not concordant with MR imaging findings, subsequent evaluation is warranted. In the current series, 12 of 18 patients were admitted for video monitoring with ictal scalp EEG. Once again, if the data are convergent and conclusive and the lesion is not located near or within cortex associated with language function, then a single-stage resection is planned. If language function is potentially threatened by resection, then two-stage procedures are typically performed to map language preoperatively, because awake craniotomies for speech mapping are not feasible in many children. Two-stage procedures may also be performed if scalp EEG data are inconclusive or do not converge with MR imaging findings. In these cases, implantation of a subdural grid and/or cortical depth electrodes may confirm that the lesion visualized on MR images corresponds to the location of abnormalities on EEG studies.

At our center, intraoperative ECoG is routinely performed during craniotomies for tumor resection when patients present with seizures. Although some authors contend that intraoperative ECoG does not yield higher seizure control rates than lesionectomy alone,9 others have reported that higher seizure control rates can be obtained if resection of adjacent epileptogenic cortex as determined based on ECoG readings is performed.8 In previous studies, researchers have demonstrated that epileptogenic foci are typically present in the cortex surrounding the DNET.3 In our series, use of intraoperative ECoG resulted in resection of additional cortex beyond the tumor margins in 10 of 17 patients in whom it was used. Currently, all patients in this series are completely free of seizures (Engel Class I).3 Nevertheless, the median follow-up duration of 1.6 years in this series is relatively short and several outliers have extremely limited follow-up periods (as short as 1 week). In a previous report on 26 children, freedom from seizure 1 year after DNET resection was reported in 22 children, but only 16 remained free of seizures after a longer follow-up duration.10 Thus, long-term follow-up review is needed to prove definitively our hypothesis that extensive preoperative evaluation, including possible invasive monitoring as well as intraoperative ECoG, leads to improved seizure control in this patient population.

CONCLUSIONS

Dysembryoplastic neuroepithelial tumors are a highly treatable cause of epilepsy in children. Excellent rates of tumor resection as well as seizure control can be obtained with minimal morbidity with the aid of intraoperative ECoG as an adjunctive surgical tool in all cases and with two-stage procedures when appropriate. Longer follow up is needed to confirm the durability of both tumor and seizure control rates in this series.

References


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