Cerebral structural lesions are found in approximately 30% of patients with medically intractable epilepsy.1 In patients undergoing resective surgery for intractable temporal lobe epilepsy (TLE), low-grade tumors have been identified in 10-20% of cases.2,3 The concordance of focal structural lesion, interictal and ictal electroencephalogram (EEG) abnormality, and neuronal dysfunction may offer good seizure control postoperatively.4 Magnetic resonance imaging (MRI) can detect such lesions in a high percentage of patients with TLE. However, the presence of a structural lesion in a patient with TLE does not always localize the epileptogenic zone. The temporal lobe lesions can induce secondary epileptogenicity in the mesiotemporal structures. The incidence of extra-hippocampal tumor and mesiotemporal sclerosis ranges from 8% to 22%.5-8 Different surgical approaches have variable seizure control outcomes.

**Background.** Structural lesions are found in about 30% of surgical specimens resected for intractable temporal lobe epilepsy (TLE). Detailed presurgical evaluations can identify the epileptogenic foci, the structural lesions and their correlation. Different surgical approaches have variable seizure control outcomes.

**Methods.** The preoperative investigations for the intractable TLE consisted of serial electroencephalogram (EEG) recordings, long-term EEG/video monitoring with sphenoidal electrodes, magnetic resonance imaging (MRI), magnetic resonance spectroscopy (MRS), positron emission tomography with fluorodeoxyglucose (FDG-PET) and neuropsychological assessment. Among the 217 patients who underwent anterior temporal lobectomy (ATL) for TLE at Taipei Veterans General Hospital between 1987 and 1998, 47 (21.7%) had structural lesions in the resected specimen. The patients were divided into neoplastic (n = 35) and vascular (n = 12) groups, based on the pathological findings.

**Results.** In the neoplastic group, the interictal scalp-sphenoidal EEG recordings were abnormal in all 35 cases and lateralizing in 30 (85.7%). MRI revealed tumor growth within the temporal lobe in 26 patients (74.3%). FDG-PET was performed on 17 patients. Fifteen (88.2%) of them revealed unilateral mesial temporal lobe hypometabolism. In the vascular group, the interictal EEG tracings revealed unilateral mesial temporal lobe spikes in 11 patients (91.6%). MRI revealed abnormal enhanced lesions within the temporal lobes in all 12 patients. FDG-PET was available for 7 patients, 6 (86%) of whom had unilateral mesial temporal lobe hypometabolism. At the last follow-up (range 2-10 years, with a mean period of 4.2 years), 25 patients (73%) in the neoplastic group became and remained seizure-free postoperatively, 3 (9%) had fewer than 3 attacks per year. Among the vascular group, all 12 patients became and remained seizure-free after surgery.

**Conclusions.** For intractable TLE with structural lesions, detailed presurgical evaluations are mandatory to identify the concordance of the lesions and the epileptogenic foci. Standard ATL with removal of the lesion may offer good seizure control postoperatively.
approaches, such as en bloc resection, and lesionectomy with or without amygdalo-hippocampectomy, have variable outcomes of seizure control.\textsuperscript{9-12} The authors present a retrospective study of intractable TLE patients present with structural lesions within the temporal lobe.

MATERIALS AND METHODS

Patient selection

 Among 217 patients undergoing anterior temporal lobectomy (ATL) for intractable TLE at Taipei Veterans General Hospital between 1987 and 1998, 47 (21.7%) had structural lesions in the resected specimen. Their preoperative charts and data on postoperative outpatient correspondence were reviewed. All had suffered from chronic and intractable complex partial seizures (CPS) (mean duration 9.4 years, range 1 to 43 years) since a mean age of 23.1 years (range 8 to 58 years). The age at operation ranged between 16 and 64 years (mean 32.5 years). None of them presented with clinical evidence of raised intracranial pressure or focal neurological deficit.

Preoperative investigations

 The preoperative investigations consisted of serial EEG recordings, long-term EEG/video monitoring with sphenoidal electrodes, MRI, magnetic resonance spectroscopy (MRS), positron emission tomography with fluorodeoxyglucose (FDG-PET), neuropsychological assessment and Wada test.

Surgical procedures

 Under general anesthesia, 24 patients underwent a nondominant-sided 5.5 cm and 23 underwent a dominant-sided 4.5 cm en block ATL. The lateral cortex of the temporal lobe was removed in one piece to expose the temporal horn. To obtain a second specimen, the mesial temporal structures were removed under microscope. The hippocampus was preserved for histological examination.

Postoperative follow-up study

 Scalp EEG recordings were obtained 12 months after surgery. Patients were reviewed at regular one-month intervals by neurologists. All patients maintained their preoperative doses of anticonvulsants for 2 years postoperatively. Slow drug withdrawal was then offered to seizure-free patients. Postoperative seizure control was divided into four grades according to the classification proposed by Engel\textsuperscript{13}: (I) seizure-free or auras only; (II) rare seizures (fewer than three attacks per year); (III) worthwhile improvement (more than 50% reduction of seizure frequency); and (IV) no worthwhile improvement. The mean follow-up period was 3.5 years (range 1-10 years).

RESULTS

Preoperative investigations

 In the neoplastic group, the interictal scalp-sphenoidal EEG recordings were abnormal in all cases and lateralizing in 30 patients (85.7%). Twenty-three patients (65.7%) had unilateral mesial temporal lobe spikes and 7 (20%) had bilateral mesial temporal lobe spikes with unilateral predominance. Five patients with inconclusive interictal recordings and unclear ictal onsets from telemetry underwent surgery according to MRI and PET findings. Scalp-sphenoidal telemetry demonstrated the unilateral onset of seizure activity during an ictus in 9 patients (25.7%). In the vascular group, the interictal EEG tracings revealed unilateral mesial temporal lobe spikes in 11 patients (91.6%). Five patients (41.6%) had unilateral onset of seizures recorded from telemetry.

 High resolution, thin-cut (3 mm) slices, MRI was performed in all cases. In the neoplastic group, tumor growth within the temporal lobe was seen in 26 patients (74.3%) (Figs. 1 and 2). Seven of them also had mesial temporal sclerosis (MTS). MRI detected MTS only in 5 patients. Four patients had normal MRI. The pathology of these 9 patients revealed low-grade astrocytomas. In them, proton MR spectroscopy (MRS) was performed to evaluate the biochemical and metabolic condition of bilateral temporal lobes. Reduction of N-acetyl-aspartate (NAA) and decreased ratio of NAA/creatine (Cr) + choline complex (Cho) indicated relative dysfunction of the brain in this area (Fig. 3). In the vascular group, all 12 patients had abnormally enhanced lesions within the
temporal lobes.

In the neoplastic group, FDG-PET was performed in 17 patients with low-grade glioma. Fifteen (88.2%) of them revealed unilateral mesial temporal lobe hypometabolism. In the vascular group, FDG-PET was available in 7 patients, and 6 (86%) revealed unilateral mesial temporal lobe hypometabolism. Overall, three patients (whose pathology pointed to astrocytoma, pilocytic astrocytoma, and oligodendroglioma, respectively) demonstrated unilateral temporal lobe hypermetabolism.

Fig. 1. A patient presented with left temporal pilocytic astrocytoma. (A) The axial T2-weighted MRI showed a high signal space occupying lesion in the left lateral temporal lobe. (B) The high resolution oblique coronal T2-weighted MRI showed the lesion arising from subcortical white matter of the left lateral temporal lobe and displacing the middle temporal gyrus upward and inferior temporal gyrus downward.

Fig. 2. A patient presented with right temporal anaplastic astrocytoma. (A) The high resolution coronal T2-weighted MRI showed a large space occupying lesion with marginal high signal and central iso-signal to gray matter involving right side amygdala, hippocampus, parahippocampal gyrus and pyriform gyrus. (B) The post-contrast axial T1-weighted MRI showed evidence of heterogeneous contrast enhancement in the mass lesion.
Pathological analysis

Neoplastic lesions were observed in 35 patients. In this group, 28 (80%) had low-grade gliomas, of which 23 were low-grade astrocytomas. Three oligodendrogliomas and 2 gangliogliomas were found (Table 1). Seven additional patients had anaplastic astrocytomas. Among the 28 patients with low-grade gliomas, 12 (43%) had hippocampal sclerosis. None of the patients with anaplastic astrocytoma had hippocampal sclerosis. Vascular malformations were identified in 12 patients. This vascular group comprised 7 arteriovenous malformations (AVMs) and 5 cavernous hemangiomas. Among 11 specimens in which the hippocampus was adequately represented, hip-

Table 1. Pathology in 47 patients

<table>
<thead>
<tr>
<th>Lesion Type</th>
<th>No. of Patients</th>
<th>HS</th>
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<tbody>
<tr>
<td>Neoplastic group</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Low grade glioma</td>
<td>28</td>
<td>12 (43%)</td>
</tr>
<tr>
<td>- low grade astrocytoma</td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>- oligodendroglioma</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>- ganglioglioma</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Anaplastic astrocytoma</td>
<td>7</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Vascular group</td>
<td>12</td>
<td>8 (73%)</td>
</tr>
<tr>
<td>Arteriovenous malformation</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Cavernous hemangioma</td>
<td>5</td>
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*Among 11 specimens in which the hippocampus was adequately represented, hippocampal sclerosis was found in 8 cases (73%). HS = hippocampal sclerosis.
Pocampal sclerosis was found in 8 cases (73%) (Table 1).

Seizure control
At the last follow-up review, 25 patients (73%) in the neoplastic group became and remained seizure-free (Grade I) after the operation, 3 patients (9%) had fewer than 3 attacks per year (Grade II) and 5 patients (15%) achieved a Grade III outcome with worthwhile improvement. Only one patient (3%) did not benefit from surgery (Grade IV). One patient with anaplastic astrocytoma died of the disease one year after the operation. Among the vascular group, all 12 patients became and remained seizure-free after surgery (Table 2). The mean follow-up period was 4.2 years (range: 1-10 years).

Postoperative scalp electroencephalography
Twelve months after the operation, scalp EEG tracings indicated abnormal recordings in 4 patients (17.4%), with unilateral focal epileptogenic discharges over the operative site. Three of them were in the seizure-free group. No significant correlation could be found between the abnormal postoperative EEG and the worse seizure-control outcome.

DISCUSSION
Structural lesions within the temporal lobe comprise 20-30% of patients who received ATL for intractable TLE.1-3 In most cases, surgical treatment is associated with good outcomes - up to 80-90% turned seizure free.4,8,10 Wolf et al. reported a series of 216 cases with intractable TLE, in which 75 (34.7%) were tumors. The most common ones were gangliogliomas (34 patients) and astrocytomas (23 patients).16 In our series, neoplastic lesions comprised 16% (35/217) of ATL patients. Among them, astrocytoma was the most common tumor (23 patients) encountered.

Hamer and colleagues14 reported that the patient group with hippocampal sclerosis (HS) showed a significantly higher percentage of ipsilateral epileptiform discharges (Eds) (median, 97.0%), compared with the group with medial temporal lobe tumor (median, 72.1%). Those restricted epileptiform discharges suggest a smaller irritative zone in HS compared with medial temporal lobe tumors.14 In our series, the vascular group showed significantly higher percentage of ipsilateral Eds (91.6%), as compared with the neoplastic group (65.7%). This result reflects the higher incidence (73%) of HS in the vascular group than in the neoplastic group (34%, 12/35). Among the 28 patients with low-grade gliomas, 12 (43%) had hippocampal sclerosis. However, no patients with anaplastic astrocytoma presented with hippocampal sclerosis.

The sensitivity of MRI in detecting the structural lesions in refractory epileptic patients approaches 100%, with a reported specificity of 87%.3,5 In our series, MRI detected the lesions in all 12 patients in the vascular group, and in 12 patients with neoplasms other than low-grade astrocytomas in the neoplastic group. However, MRI detected the lesions in only 61% (14/23) patients with low-grade astrocytoma. MRS should be performed in the remaining 9 patients to evaluate the biochemical and metabolic condition of bilateral temporal lobes.

Won et al.15 reported that among MRI, PET and single photon emission computerized tomogram (SPECT) in lateralizing epileptogenic foci, PET is the most sensitive tool. With the pathologic diagnosis as the standard of reference, PET correctly lateralized the epileptogenic foci in 85% of patients.15 In our series, PET correctly lateralized the epileptogenic foci in 88.2% of patients in

<table>
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<th>Table 2. Postoperative outcome of seizure control</th>
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<tr>
<td>Outcome grade13</td>
</tr>
<tr>
<td>Grade I Seizure free</td>
</tr>
<tr>
<td>Grade II Rare seizures</td>
</tr>
<tr>
<td>Grade III Worthwhile improvement</td>
</tr>
<tr>
<td>Grade IV No improvement</td>
</tr>
<tr>
<td>Total</td>
</tr>
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</table>

a One patient with anaplastic astrocytoma died of disease one year after the operation. ATL = anterior temporal lobectomy.
the neoplastic group and 86% of patients in the vascular group. In 3 patients with low-grade glioma, PET revealed unilateral temporal lobe hypermetabolism. PET may be used as a complementary tool in cases of inconclusive lateralization with other presurgical evaluations.

In this series, all patients in the vascular group became and remained seizure-free after the operation. Eight had hippocampal sclerosis, as shown on MRI and pathological findings. Removal of both the epileptic zone and the pathological lesion will lead to a favorable surgical outcome. The possible mechanisms of epileptogenesis in TLE patients with vascular lesions are remote hemorrhage, mass effect or a vascular steal phenomenon. However, in the absence of hippocampal sclerosis, lesionectomy alone may be effective in the control of seizures. In our series, 25 patients (73%) in the neoplastic group became and remained seizure-free postoperatively. Twelve of them had hippocampal sclerosis. These results confirm the importance of epileptic zone removal in the presence of dual pathologies. It is more likely for a tumor on the surface of the temporal lobe to kindle the mesiotemporal structures than an intrahippocampal tumor to kindle the temporal cortex. However, in the absence of hippocampal sclerosis, complete removal of the lesion seems unlikely because of the tumor’s infiltrative nature. Further delineation of the epileptogenic zone using intracranial electrodes should be performed. In the author’s previous report, among 210 ATL patients followed for more than 2 years, 171 (81%) were seizure-free, 26 (12%) had rare seizures, 12 (6%) had worthwhile improvement and 1 (0.5%) had no improvement. The outcome for seizure control showed no significant difference between the patients with structural lesions and those without structural lesions.

In summary, in dealing with the intractable TLE patients with structural lesions, detailed presurgical evaluations should be performed. The concordance of the epileptogenic foci and the structural lesions is a favorable indicator of postoperative outcome for seizure control.

REFERENCES

15. Won HJ, Chang KH, Cheon JE, Kim HD, Lee DS, Han MH, et