**Brief Report**

Assessing the Driving Performance of a Person With Epilepsy Presurgery and Postsurgery

Alexander M. Crizzle, Sherrilene Classen, Christina LaFranca, Sandra M. Winter, Steven N. Roper, Stephan Eisenschenk

Occupational therapists and certified driving rehabilitation specialists are uniquely skilled to assess functional abilities underlying driving performance. However, little information exists on the utility of clinical assessments to determine driving performance in people with epilepsy. This case study demonstrates how an occupational therapy evaluation battery was used to examine differences in visual and cognitive abilities and simulated driving performance before and after epilepsy surgery. Specifically, a 43-yr-old White man with right anterior lobe epilepsy underwent temporal lobectomy and had his driving-related abilities and simulated driving performance assessed pre- and postsurgery. The occupational therapy evaluation indicated improvements in executive skills, attention, and information processing speed postsurgery. Visuospatial abilities worsened after surgery, likely contributing to the modest increase in vehicle position errors on the driving simulator. Nevertheless, simulated driving performance improved after temporal lobectomy. Reductions in the number of visual scanning, lane maintenance, and speed regulation errors were recorded.


**MeSH TERMS**
- anterior temporal lobectomy
- automobile driving
- epilepsy
- postoperative period
- preoperative period
- task performance and analysis

**Alexander M. Crizzle, PhD,** is Postdoctoral Associate, Institute for Mobility, Activity and Participation, College of Public Health and Health Professions, University of Florida, Gainesville.

**Sherrilene Classen, PhD,** is Associate Professor and Director, Institute for Mobility, Activity and Participation, College of Public Health and Health Professions, University of Florida, PO Box 100164, Gainesville, FL 32610-0164; sclassen@phhp.ufl.edu

**Christina LaFranca, BHS,** is Honors Student, Institute for Mobility, Activity and Participation, College of Public Health and Health Professions, University of Florida, Gainesville.

**Sandra M. Winter, PhD,** is Coordinator, Institute for Mobility, Activity and Participation, College of Public Health and Health Professions, University of Florida, Gainesville.

**Steven N. Roper, MD,** is Professor, Department of Neurosurgery, College of Medicine, University of Florida, Gainesville.

**Stephan Eisenschenk, MD,** is Associate Professor, Department of Neurosurgery, College of Medicine, University of Florida, Gainesville.
anterior temporal lobectomy has increased in frequency over the past 2 decades. To our knowledge, however, no study has examined the effects of temporal lobectomy on the performance components and driving outcomes for PWE.

Given that driving (and community mobility) is an emerging practice area and included in the domain of occupational therapy (American Occupational Therapy Association [AOTA], 2008) and in the profession’s Scope of Practice (AOTA, 2010), practitioners must understand the effects of medical interventions on occupational performance, including driving performance of PWE. Additionally, because CDRSs have insight into the driving impairments that influence driving, clinicians should consult with a CDRS before approving PWE to drive. Thus, in this case study, our primary objective was to determine whether any differences would be found in clinical tests and driving performance after epilepsy surgery. Because temporal lobectomy has shown success in reducing or eliminating seizures, we anticipated that PWE would have improved performance on clinical tests and when driving on a simulator postsurgery.

Method

Design

Ethics approval was obtained from the institutional review board at the University of Florida. Our case participant (L. S.) provided informed consent before the study. We used a case study design to determine whether temporal lobectomy can improve driving performance on clinical tests and on a simulator. This case study is part of a larger study examining the simulated driving performance of PWE that has been ongoing since 2010. Because L. S. wanted to resume driving postsurgery and was one of the few study participants to have undergone temporal lobectomy over the study period (2010–2012), he was an ideal candidate to have his driving and clinical test performance reassessed postsurgery.

Participant History

L. S. is a 43-yr-old White man who owns a moving and delivery service company. He was a frequent long-distance driver and was dependent on driving as part of his occupation. In 1991, L. S. had a hemorrhagic stroke involving the right anterior temporal lobe. Soon after, he developed recurrent complex partial seizures characterized by staring and nonresponsiveness for 1 to 2 min followed by diaphoresis (profuse sweating). He occasionally noted a “weird” internal feeling immediately before the event. He had postictal confusion (altered state of consciousness after having a seizure). Rarely, these symptoms would develop into secondarily generalized tonic–clonic convulsions. Their frequency varied from every few weeks to several months.

The client maintained his driver’s license and would periodically be granted driving privileges. In the past year, the frequency of his seizures had increased, with a resulting imbalance in many of his daily occupations. He was admitted to the Epilepsy Monitoring Unit (EMU) at the University of Florida to assess his candidacy for epilepsy surgery, specifically right temporal lobectomy. On admission, he was taking lamotrigine (100 mg) and oxcarbazepine (750 mg) twice a day. L. S. consented to participate in an occupational therapy driving study, completing a clinical battery of tests and simulated drives using a DS–250 fixed platform driving simulator (DriveSafety, Murray, UT; Figure 1). As stated previously, 6 mo before his surgery, he also participated in the driving study, completing the same battery of tests and driving the same simulator scenarios.

Neurology Report

Video electroencephalograph (EEG) monitoring captured two typical complex partial seizures with localization to the right anterior temporal lobe. Multiple auras (warning signs of an oncoming seizure) occurred without definitive electrographic changes. Interictal (period between seizures) EEG demonstrated sharp waves with maximal amplitude at electrode T8, demonstrating localization to the right anterior temporal lobe. L. S.’s magnetic resonance imaging (MRI) study demonstrated evidence of hemosiderin (iron-storage complex often formed after bleeding) and gliosis (glial cells accumulating in areas in which the neurons have been damaged) within the right anterior temporal lobe consistent with developmental venous anomaly (vascular insufficiency). There was a small encephalomalacic defect (softening of brain tissue, usually caused by vascular insufficiency or degenerative changes) along the anterior–inferior surface of the right temporal lobe adjacent to the area of hemosiderin deposition. Additionally, some hemosiderin appeared to be located along the margins of the lateral ventricle, probably from previous intraventricular blood products.

Instruments

The clinical battery included an assessment of vision using the Optec 2500...
Table 1. Clinical Test Scores and Driving Performance Errors

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMSE</td>
<td>30/30</td>
<td>28/30</td>
</tr>
<tr>
<td>Trails B, min</td>
<td>1.24</td>
<td>1.03</td>
</tr>
<tr>
<td>Visuospatial, min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Letter H Time 1</td>
<td>0.51</td>
<td>1.03</td>
</tr>
<tr>
<td>Letter H Time 2</td>
<td>0.53</td>
<td>1.06</td>
</tr>
<tr>
<td>Visual perception</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MVT Spatial Closure</td>
<td>17/17</td>
<td>16/17</td>
</tr>
<tr>
<td>MVT Spatial Construction</td>
<td>5/5</td>
<td>5/5</td>
</tr>
<tr>
<td>Visual attention, ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UFOV 1 (speed of processing)</td>
<td>16.7</td>
<td>16.7</td>
</tr>
<tr>
<td>UFOV 2 (divided attention)</td>
<td>76.7</td>
<td>16.7</td>
</tr>
<tr>
<td>UFOV 3 (selective attention)</td>
<td>113.3</td>
<td>59.9</td>
</tr>
<tr>
<td>Risk Index (global rating)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Vision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual acuity</td>
<td>20/20</td>
<td>20/20</td>
</tr>
<tr>
<td>Contrast sensitivity</td>
<td>Intact</td>
<td>Intact</td>
</tr>
<tr>
<td>Depth perception</td>
<td>Intact</td>
<td>Impaired</td>
</tr>
<tr>
<td>Motor, s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finger to nose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>4.19</td>
<td>4.44</td>
</tr>
<tr>
<td>Left</td>
<td>3.93</td>
<td>5.22</td>
</tr>
<tr>
<td>Foot tap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>4.88</td>
<td>3.50</td>
</tr>
<tr>
<td>Left</td>
<td>4.22</td>
<td>3.29</td>
</tr>
<tr>
<td>Driving performance (no. errors)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual scanning</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Lane maintenance</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Speed regulation</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Vehicle position</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Adjustment to stimuli</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total driving errors</td>
<td>21</td>
<td>5</td>
</tr>
</tbody>
</table>

Note. MMSE = Mini-Mental State Examination; MVT = Motor-Free Visual Perceptual Test; UFOV = Useful Field of View.

(Stereo Optical Inc., Chicago) to assess visual acuity (binocular and monocular), contrast sensitivity, depth, and color perception. Cognitive status was assessed using the following measures:

- The Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), composed of 11 questions that cover domains of orientation, registration, attention, calculation, recall, language, and visuospatial perception requiring approximately 10 min to complete.
- The Trail Making Test Part B (Trails B), administered in a few minutes, which is a measure of executive function and visual–conceptual and visual–motor tracking (Reitan, 1958).
- The Letter H Cancellation test (Uttl & Pilkenton-Taylor, 2001), a test of visual scanning and visual search that can be completed in ≤1 min.

We examined visual–perceptual abilities with the Motor-Free Visual Perceptual Test (Colarusso & Hammill, 2002). The Useful Field of View™ (UFOV) was used to assess central vision, information processing speed, and divided and selective attention using a touch-screen computer (Ball & Owsley, 1993). The first UFOV task assesses information processing speed by centrally presenting a single object (either a car or a truck) that must be identified. Task 2 (divided attention) requires the participant to identify a peripheral target while still attempting to correctly identify the central target (car or truck). The third task (selective attention) involves the same procedure as Task 2, with the exception of distracter triangles surrounding the peripheral target. After completion, threshold scores for each subtest (not to exceed 500 ms) were provided along with a risk index (low, moderate, or high probability of being crash susceptible) for all tasks. Higher scores indicate poorer performance. The UFOV requires approximately 15–20 min to administer. Last, motor coordination and dexterity were assessed using the finger-to-nose and foot-tap tests.

As shown in Figure 1, driving performance was assessed using a fixed-base, high-fidelity simulator modeled after a Ford Focus passenger car with automatic transmission (DriveSafety CDS–250, DriveSafety, Murray, UT). The simulator consisted of three high-resolution displays (1,024 pixels × 768 pixels), placed 44 in. away from the eyes of the participant. L. S. was only required to control the steering wheel, accelerator, and brake pedal. He completed three acclimation scenarios (5 min each) for comfort and confidence before completing a 35-min drive. The simulated conditions represented daylight and included rural, residential, city, and freeway sections with light to moderate traffic. Driving errors recorded were consistent with those observed in our on-road studies and included visual scanning, lane maintenance, vehicle position, speed regulation, yielding, gap acceptance, and adjustment to stimuli (Justiss, Mann, Stav, & Velozo, 2006; Shechtman, Classen, Awadzi, & Mann, 2009). The drive also included three scripted events that required the driver to avoid collisions: a train crossing and two scenarios in which a car enters the driving lane from a parked position. The full protocol is described elsewhere (Crizal et al., 2012).

Procedures

L. S. was admitted to the University of Florida EMU to determine candidacy for temporal lobectomy. In his inpatient room, he completed a clinical battery of tests and had his driving assessed on a simulator while being continuously monitored for seizure activity via EEG and video recordings. Six months after having a right temporal lobectomy, L. S. (as an outpatient) completed the same clinical battery of tests and had his driving assessed, using the same scenarios on the driving simulator. Both
pre- and post–epilepsy surgery assessments were conducted by a trained researcher on the EMU.

**Data Collection**

Two PhD-level driving researchers executed the protocol after training by an occupational therapist–CDRS (intraclass correlation = .98, p = .05). We collected demographic information (e.g., age, occupation), general driving habits and history (postsurgery), clinical test scores, and performance on the driving simulator.

**Data Analysis**

All data were entered into SPSS Version 20.0 (IBM, Armonk, NY) for comparison purposes. Scores on clinical tests and simulated driving errors were compared pre- and postassessment and are shown in Table 1 as descriptive data.

**Results**

**Surgery Report**

L. S. underwent a right anterior temporal lobectomy with microdissection (dissection of tissues under magnification, such as a microscope). Pathology revealed a vascular malformation consistent with cavernous angioma with evidence of remote hemorrhage. There was reactive gliosis in the brain tissue surrounding the cavernous angioma. Pathology within the hippocampus demonstrated no specific pathologic alterations. The client remained seizure free with no auras expressed as Engel class 1 for 6 mo after surgery. Follow-up MRI was performed 3 mo after surgery. Figure 2 demonstrates the brain before the surgery (left) and the visible right anterior lobectomy (axial view; right).

**Clinical Battery of Tests**

After epilepsy surgery, L. S. was seizure free and resumed one of his main occupations: driving. He maintained his usual medication regimen post-surgery (lamotrigine and oxcarbazepine). He consented to have his clinical and driving performance reassessed on the simulator. His pre- and postsurgery clinical test scores are shown in Table 1.

L. S. performed substantially better on UFOV Subtests 2 and 3, indicating improved visual attention and the ability to process visual information more quickly. He also performed better on the Trails B, a measure of executive function, specifically mental flexibility. However, he performed worse on the MMSE, a global measure of cognitive function. On the MMSE, he particularly performed worse on memory word recall and visuospatial aspects (i.e., drawing the intersecting polygon). Additionally, he performed worse on tests of visual scanning, taking on average 12 s longer to complete the Letter H test. Moreover, his depth perception, assessed via the stereopsis slides on the Optec 2500 Visual Analyzer machine, changed from within functional limits to impaired. L. S.’s motor performance was intact, and no large differences were observed pre- and postsurgery. Perhaps most interesting was that his driving performance improved after surgery. He made fewer errors of visual scanning, lane maintenance, and speed regulation (Table 1). However, he did make more vehicle position errors (vehicle’s position in relation to lane markings, other traffic, or road users).

**Discussion**

The findings from this case study show that an occupational therapy assessment battery can produce valuable information related to driving performance pre- and postsurgery in PWE. Specifically, in doing so, occupational therapists can play a distinct role in assessing clients with epilepsy and can be instrumental in making decisions about underlying abilities and fitness-to-drive competency for such clients. In particular, L. S.’s executive function (measured by Trails B) and divided and selected attention (measured by the UFOV) were all improved, consistent with the findings of another study (Martin et al., 2000). However, L. S. performed more poorly on tests of visual scanning (assessed by the Letter H test) and on the visuospatial construction task (intersecting polygons).

Right anterior temporal lobectomy has been associated with deficits in identifying objects in a visual scene, or objects in space, and in recognizing and recalling visual patterns and designs (Pigott & Milner, 1993). These factors may collectively have contributed to L. S.’s worsened visuospatial and visuoconstruction abilities. L. S. also had impaired depth perception after surgery, which is worse after right temporal lobectomy (Pitto, Zatorre, Larson, & Tosoni, 1991). These findings partially suggest that some skills related to driving are improved after right anterior temporal lobectomy and others are more impaired. Specifically, these deficits can be captured through our occupational therapy clinical battery of tests and assessment of simulated driving performance.

L. S.’s simulated driving performance was improved postsurgery: he made fewer errors and performed better on tasks of visual scanning and lane maintenance. It is possible that L. S.’s improved simulated driving performance was the result of a learning effect. However, the interval
between pre- and postoperative simulated drives was >6 mo, and medications were unchanged over that period. In regard to L. S.’s resumption of driving, his self-reported driving frequency was the same immediately before the initial preoperative simulated driving assessment and the postoperative testing.

Implications for Occupational Therapy Practice

The results of this study have the following implications for occupational therapy practice:

- In a single case, temporal lobectomy improved lane maintenance and speed regulation but affected vehicle positioning negatively.
- Clinical tests of cognition and visuospatial abilities can be used to determine changes in those abilities to better understand the mechanisms for change in simulated driving performance pre- and postsurgery.
- An occupational therapist may make a substantive contribution in assessing fitness to drive in PWE pre- and post-temporal lobectomy surgery.
- Use of the CDS-250 driving simulator is a safe and efficient method to detect changes in the driving errors of PWE before and after temporal lobectomy surgery.

Conclusion

Our study demonstrates a case for using an occupational therapy approach and procedure to measure driving performance. Clinical tests of cognitive and visual performance identified skills directly related to driving that were affected after epilepsy surgery. Our case study also shows that an occupational therapy assessment can determine the improvement in visual, cognitive, and driving performance after epilepsy surgery (i.e., right anterior temporal lobectomy), indicating that the occupational therapy practitioner has an emerging role in neurology, specifically as it pertains to PWE who are undergoing surgery, in helping to determine fitness to drive. Just as some underlying skills used in driving may be improved postsurgery, others may be compromised, making it critical for a clinical and performance-based assessment. Moreover, recent literature has shown that inferences can be drawn between the transferability of simulated errors and real-world errors (Bédard, Parkkari, Weaver, Riendeau, & Dahlquist, 2010; Shechtman et al., 2009), indicating that the simulator can be used as a proxy measure of actual driving ability.

Information contributed by this case study should be confirmed with a larger group of PWE who undergo such surgeries and who are then assessed via simulator or, if safe, on-road assessment. Clinical trials in which participants are evaluated both on the simulator and via on-road tests are needed before recommendations regarding fitness to drive can be determined. ▲

Acknowledgments

We acknowledge the Wayne Densch Epilepsy Research Endowment Fund and the Institute for Mobility, Activity and Participation at the University of Florida for providing infrastructure and support.

References


Martin, R. C., Sawrie, S. M., Edwards, R. R., Roth, D. L., Faught, E., Kuzniecky, R. I., ... Gilliam, F. G. (2000). Investigation of executive function change following...


