Neurologic Conditions: Assessing Medical Fitness to Drive

Steven H. Yale, MD, *Department of Internal Medicine, Marshfield Clinic, Marshfield, Wisconsin*
Phiroze Hansotia, MD, *Emeritus Physician, Department of Neurology, Marshfield Clinic, Marshfield, Wisconsin*
Dawn Knapp, OTR, *Department of Occupational Therapy, Saint Joseph's Hospital, Marshfield, Wisconsin*
John Ehrfurth, PhD, *Department of Neuropsychology, Marshfield Clinic, Marshfield, Wisconsin*

REPRINT REQUESTS:

Steven Yale, MD
Department of Internal Medicine
Marshfield Clinic
1000 North Oak Avenue
Marshfield, WI 54449
Telephone: 715-387-5436
Fax: 715-389-3808
Email: yale.steven@marshfieldclinic.org

KEYWORDS:

Driving restrictions; Seizures;
Parkinson's disease; Dementia

RECEIVED:

FEBRUARY 14, 2003

REVISED AND ACCEPTED:

JUNE 6, 2003

Clinical Medicine & Research

Volume 1, Number 3: 177-188
©2003 Clinical Medicine & Research
www.mfldclin.edu/clinmedres

ABSTRACT

Clinicians are often asked to make an assessment on whether a patient is medically fit to drive, even though few have been formally trained in this area. Driving is a complex task that requires having adequate operational, cognitive and higher executive functions that work together. These functions can be compromised to a greater or lesser extent in neurological disorders, such as stroke, traumatic brain injury, peripheral neuropathy, dementia, Parkinson's disease and epilepsy. There is insufficient standardized information relating to impaired function at this time. Because of this, state laws vary in their assessment of medical conditions as they relate to driver licensing. Wisconsin laws are reviewed as an example. There are numerous assessment tests for various functions, but they lack a validated correlation with actual driving performance. These and other factors, as well as practical recommendations for the practicing physicians, are the subjects of this review.

INTRODUCTION

The decision to recommend licensure for driving after a stroke, cerebral brain injury, or seizure is important. For the patient it signals independence, the ability to care for themselves and the freedom to travel when they wish. For the general public the issues are safety and risk assessment. Risk assessment is the ability to assess if a patient is able to control a motor vehicle at all times. To drive with a crash risk comparable to that of the healthy general population.

For this type of assessment to occur, physicians need:

- Information about the functional capability of the driver in addition to the medical diagnosis(es).
- Knowledge of the minimum functional requirements for safe driving.
- Knowledge and ability to correlate the assessment of the driver's functional level with his risk of crashes as a driver.

In clear-cut or extreme cases of ill health, assessment is not a problem. For those who fall in between, careful evaluation and informed judgment on the part of the physician is required.

Both primary care and subspecialty physicians often lack basic knowledge and formal training to make a recommendation on who can safely operate a motor vehicle.¹ Furthermore, despite published guidelines for assessing driving competency, many physicians are often unaware of the laws in their state.² Physicians unaware of state regulations may be held liable if they do not report necessary information to state authorities and provide counseling to patients.

This article is restricted to reviewing neurologic conditions that affect driving fitness to operate a motor vehicle. State laws for professional drivers operating commercial vehicles will not be discussed. This review is undertaken with the aim of guiding the practicing physician in evaluating their patients for driving safety and automobile licensure.

COGNITIVE AND MOTOR SKILLS

Driving is a complex task that requires possessing sufficient cognitive, visual and motor skills. The driver must have adequate motor strength, speed and coordination. Perhaps more importantly, higher cognitive skills including concentration, attention, adequate visual perceptual skills, insight and memory need to be present. Higher cortical functions required for driving include strategic and risk taking behavioral skills, including the ability to process multiple simultaneous environmental cues in order to make rapid, accurate and safe decisions. The task of driving requires the ability to receive sensory information, process the information, and to make proper, timely judgments and responses.³

Wisconsin laws require that drivers “retain consciousness and the ability to have bodily control of a motor vehicle.” Factors affecting consciousness (e.g., seizures, syncope, hypoglycemia and sleepiness), perception (e.g., visual acuity and field of vision), mental functioning (e.g., dementia), neuromuscular and musculoskeletal function (e.g., adequate manipulation of vehicle controls), and behavior (e.g., self and impulse control) may limit safe driving.⁴ How to best assess and monitor driving ability in each of these conditions has not been completely elucidated.

One example of a method that has been established to determine acceptable risk are the laws pertaining to blood alcohol concentration and calculations (driving under the influence/driving while intoxicated). Federal and state governments have set blood alcohol concentration levels that determine drunkenness. A comparable method to establish acceptable risk in most neurological disorders does not exist. Studies that have been conducted to define a method to determine acceptable risk are lacking in quality, mainly because of the absence of control groups, inadequate recording of the severity of disease, secondhand reporting, or insufficient sample size.

METHODS FOR ASSESSING DRIVING SKILLS IN THE COGNITIVELY IMPAIRED PATIENT

No single measurement used can best predict driving performance.

Neuropsychological tests, simulators, protected courses, or on-the-road tests can be used to assess cognitive function and driving performance. Driving performance depends on a driver's experience with street signs, road conditions, time of day and familiarity with the route of travel. Assessment of fitness is often subjective. An acceptable level of performance depends upon each evaluator's judgment and threshold.⁵

NEUROPSYCHIATRIC ASSESSMENT

Detailed neuropsychologic tests have been developed to assess the integrity of a wide range of higher cognitive and perceptual abilities associated with driving safety. Commonly used neuropsychologic measures are listed in table 1. This list is by no means exhaustive.

Neuropsychologic tests vary in their ability to predict driving performance.

Standardized measures of higher cognitive and perceptual abilities are useful tools for screening and detection of deficits that may not be apparent on limited mental status examination, and for assessing the severity of these deficits. Clinicians often use results from neuropsychologic tests to make recommendations regarding driving fitness. Interpretation of results of studies designed to assess the utility of neuropsychologic tests in predicting actual driving performance is confounded by the fact that studies vary widely in terms of the specific psychometric tests and outcome measures employed.

Psychometric examination should not serve as the sole assessment of driving competency.

Research indicates that several neuropsychologic measures are useful in identifying individuals at risk due to central nervous system dysfunction, but the clinician must use caution in selecting neuropsychologic tests relevant to the assessment of driving competency. While useful in identifying patients at risk, standardized neuropsychologic tests are not considered fully reliable predictors of risk for traffic collisions or violations.

OFF- AND ON-ROAD ASSESSMENTS

On-road assessment, although considered the reference standard, is limited and often failing to detect subtle deficits in psychological and psychomotor skills.⁹

Off-road testing may be useful for screening functional ability and determining which patients should proceed to additional on-road testing.⁶ These tools are also useful in patients with disabilities for evaluating their need for adaptive equipment prior to proceeding to on-road assessment.⁶

The on-road test has proven safe, reliable and valid in assessing driving skills.^{7,8} Road test skills measure both the basic operational (handling) and cognitive (decision making) aspects of driving. Systematic performance based on the on-road tests should include standards for qualitative, as well as observational scoring, which has internal validity, reliability and reproducibility.

When used to predict driving performance, a poor correlation exists between on- or off-road driving tests and neuropsychological tests.^{10,11}

The variability in outcome among these studies can be accounted for by different experimental designs (on- vs. off-road testing), variable outcomes of interest, study size, heterogeneity of study groups, degree of premorbid functional impairment and the type of predictive test (on- or off-road, simulators, neuropsychological tests).^{12,13}

Table 1. Commonly used neuropsychological tests.^{4,9,13,14,35,38,52,55,60,97-100}

General intellectual function
Wechsler Adult Intelligence Scale-III (WAIS-III)
Kaufman Brief Intelligence Test (K-BIT)
Language
Controlled Oral Word Association (COWAT)
Boston Naming Test (BNT)
Aphasia screening exam
Token Test
Attention and scanning
Visual
Trailmaking Test
Symbol Digit Modality Test
Cancellation tasks
Tests of Variable Attention (TOVA)
Symbol Search (WAIS-III)
Useful Field of View (UFOV)
Verbal
Serial Verbal Learning
Digit Span (WMS/WAIS-III)
Letter-Number sequencing (WMS/WAIS-III)
Paced Auditory Serial Addition Test (PASAT)
Memory
Wechsler Memory Scale (WMS-III)
California Verbal Learning Test-II (CVLT)
Selective Reminding Test
Benton Visual Retention Test
Memory for Designs Test
Tactual Performance Test (TPT)
Rivermead Behavioral Memory Test (RBMT)
Visuospatial reasoning and constructional ability
Block Design (WAIS-III)
Rey-Osterrieth Complex Figure (ROCF)
Tactual Performance Test (TPT)
Judgment of Line Orientation Test (JLO)
Ravens Progressive Matrices
Hooper Visual Organization Test (HVOT)
Executive function
Wisconsin Card Sorting Test® (WCST)
Halstead Category Test
Porteus maze test
Proverb interpretation (e.g., Proverbs test)
Similarities (WAIS-III)
Abstract word tests
Stroop (color word test)
Motor speed and dexterity
Finger Oscillation Test
Grooved Pegboard Test
Psychomotor speed
Assorted reaction time tasks
(simple vs. recognition vs. choice)
Brief screening measures/batteries
Mini-Mental State Exam (MMSE)
Mattis Dementia Rating Scale
Blessed Dementia Rating Scale (BDRS)
Neurobehavioral Cognitive Status Exam (CogniStat)
Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)

NEUROLOGICAL CONDITIONS

Stroke

Deficits resulting from stroke or cerebral brain damage are determined by the location and size of injury. These injuries can affect all aspects of higher cortical sensory and/or motor functioning. All patients with a previous stroke or traumatic brain injury should receive a thorough evaluation for driving. Between 30% and 42% of patients with these conditions are able to resume driving safely.¹⁴⁻¹⁶

RIGHT, LEFT AND FRONTAL LOBE STROKES

Patients with right hemispheric injuries have disturbances in higher cortical processing of visual information.⁸ There is often left-sided visual neglect with visuospatial and perceptual defects, poor insight regarding these defects and a prolonged reaction time.^{17,18} These patients tend to have poorer driving skills, are more difficult to train and frequently do not pass their re-licensing examination.^{3,19} Despite these deficiencies, with appropriate adaptations, patients with right hemispheric involvement can do as well as those with left hemispheric strokes.²⁰ Thus, diagnosis alone appears to be a poor marker for driving ability.

Patients with left or right hemispheric strokes typically develop some degree of paresis or paralysis on the contralateral side of the injury. Left hemispheric injuries may result in deficits in understanding language, speaking and visual fields. Depending upon the location there may also be problems related to reading and writing.

Damage to the prefrontal cortex may cause impairment in the areas of exercising appropriate judgment and regulation of behavior. Patients typically demonstrate a lack of insight, apathy, liability and self-confidence. These behavioral features can cause the most devastating limitations to safely resume driving.²¹⁻²³

VISUAL PATHWAYS

A variety of visual pathway and/or visual cortical deficits may also occur in stroke, varying with both the type and severity of damage as determined by the location of the injury. Unlike patients with visual neglect, patients with visual pathway defects resulting in hemianopsias or quadrantanopsias, are often able to compensate for their visual field defect by placing their head in a certain position. Binocular visual field deficits, such as complete bitemporal or homonymous hemianopsia or homonymous quadrantanopsia extending to fixation, may be a restriction to driving.^{8,24}

Stroke, transient ischemic attacks and traumatic brain injury involving paralysis of the extraocular muscles can result in diplopia. In patients with a stroke or head injury, visual fields should be screened with confrontation testing of the quadrants. In cases of diagnostic uncertainty, a quantitative perimetric examination is required. In the United States, diplopia following head injury is regarded as a restriction to driving unless this can be treated with either a

prism or frosted eyeglass, or by wearing a patch over the affected eye while driving.⁸ Reduced visual fields, color vision and stereoptic visual field deficits are not associated with an increased rate of motor vehicle collisions.²⁴

DRIVING AFTER STROKE GUIDELINES

A 15% incidence of unprovoked seizures has been reported to occur within 5 years after an ischemic stroke. Although seizures occurred early in 12% of patients, long-term risk for recurrent seizures is relatively low.²⁵ The Joint Commission on Driving Licensing of the International Bureau of Epilepsy and International League Against Epilepsy consensus statement, recommends that a person who has had a seizure as a result of a stroke should not have driving privileges withheld. This guideline is based on the caveat that there has been full clinical recovery with the expectation that no relapse will occur.²⁶ The American Medical Association recommends that persons with cerebrovascular accidents that result in disturbances in higher cortical function should cease driving.²⁷ They did not specifically address which particular impairment would warrant revocation of driving privileges.

Traumatic brain injury

Approximately one-half of all patients with cerebral damage resume driving. Patients driving before the cerebral event are more likely to become re-licensed than those who were not driving before the injury. The data must be interpreted with skepticism because of the potential for selection biases and lack of comparable control group.^{18,28,29}

Patients with traumatic brain injury typically require more time to complete certain tasks because of delays in information processing, impairment in the perception of spatial relationships and inattentiveness to a series of multiple simultaneous events.^{3,30} The extent of slowing is dependent upon the severity of injury, duration since the injury and complexity of the task.³¹ Once the speed of performance is adjusted to control for slowness of information processing, patients with traumatic brain injuries can often successfully complete assigned tasks.³¹⁻³³

CONCUSSION

Under simulated driving conditions, Stokx and Gaillard showed that patients who sustained a severe head concussion had both a slower reaction time and poorer driving skills. Unlike previous investigators, they were unable to show that this type of brain injury affects any particular stage of information processing.³⁴ In general, patients with serious concussions appear slower in all time related tests of cognitive function.³⁵

ASSESSMENTS AND REHABILITATION

Some suggest that only patients with traumatic brain injury who show signs of visuomotor slowness, visuospatial or behavioral disorders be referred for driving assessment.³¹ Driving training programs for patients with brain injury, stroke, or other handicaps cannot only assess driving capabilities, but also help one overcome driving difficulties.

Occupational therapy examination is a valuable source for evaluation of cognitive and perceptual functioning through neuropsychiatric and on- and off-road testing.

Training should be focused on further developing and refining tactile and strategic planning skills in order to compensate for deficiencies in slow information processing. Patients with physical impediments may be able to partially compensate for those deficits by using vehicle adaptations or limiting driving in particular situations.³⁶

DRIVING AFTER TRAUMATIC BRAIN INJURY GUIDELINES

There is no obligatory regulation for re-licensing after a severe brain injury. Patients are encouraged to voluntarily report to their licensing agency when they have a condition that might influence their fitness to drive. The role of the physician is to encourage and convince patients with severe neurologic impairment to self-report to the licensing bureau in cases where there is doubt about driving such that accommodations can be made for car adjustments and retraining.

Peripheral Neuropathy

Peripheral neuropathy may affect the ability to drive. Patients with sensory neuropathy may have difficulty with the use of the accelerator and brake pad. They may be unaware of how much pressure to apply to the brake and gas pedals, or how far to turn the steering wheel.³⁷ There is insufficient research in this area to make any formal recommendations regarding driving.

Dementia

Senile dementia of the Alzheimer's type, the most common form of dementia, is an acquired progressive degenerative neurologic disease resulting in impairment in the areas of memory, language, visuospatial skills, decision making and other higher aspects of executive cognitive functioning. There is often a fluctuating variability in forgetfulness and a progressive, but variable rate of decline in cognitive functioning. The rate of progression and clinical features present at a particular stage vary among persons with Alzheimer's disease. Patients may be unaware of and lack sufficient insight into their actual degree of functional impairment. Therefore, patients with Alzheimer's disease may drive longer than they actually should.

EARLY DEMENTIA

Driving performance may be affected even in the early stages of Alzheimer's disease.^{38,39} It can be difficult to distinguish Alzheimer's disease from the normal age-related decline in cognitive functioning. Instability of judgment and insight may not be obvious and recognizable. In addition, this stage is characterized by a decline in recent memory and difficulty in processing simultaneously competing auditory stimuli.⁴⁰ Persons may be unaware or not fully comprehend their limitation and severity of cognitive deficit.

There is an insufficient amount of evidence, particularly early in the disease, to make firm recommendations regarding whether patients should continue to drive because standard-

ized measures of cognitive and behavioral function in relation to driving skills are lacking. The diagnosis alone is insufficient to determine driving fitness.^{41,42} Individual assessment and examination of physical and cognitive skills necessary for driving should be thoroughly evaluated. A driving recommendation should be made if deficits are found in these component areas.

Therefore, early in the disease course when insight remains intact, it may be possible to set certain driving parameters or limit their driving distance in order to maintain driving privileges.⁴³ As the disease progresses, there is increased dependency and inability to perform activities of daily living, which means that over time all persons with Alzheimer's disease will become incapable of driving.

METHODS OF ASSESSMENT

Studies focusing on driving and dementia are limited because of failure to control for the amount of mileage driven, small sample size, methodological reporting, lack of a control group and retrospective data collection.^{44,45} In the early stages of mild cognitive impairment, neuropsychiatric testing may be useful in determining those specific deficits that may affect the ability to drive safely, particularly the more subtle aspects of cognitive function. These tests are poor predictors of future risk for crashes or violations.⁴⁶ Thus, neuropsychological assessment should be used only in conjunction with a standardized road evaluation.

The Clinical Dementia Rating (CDR) scale is one objective tool used both in clinical and research settings to assess driving competence.^{41,47} The CDR is scored from 0 to 2. Higher scores reflect a greater impairment in cognitive functional abilities of daily living.⁴⁷ Alzheimer's patients with a CDR score of >1.0 have been shown to have a higher risk of collisions and should be advised not to drive. Patients with a score of 0.5 should be evaluated every 6 months and undergo a formal driving examination.⁴⁷ Up to 50% of these patients progress to the next or higher stage of cognitive dysfunction within 1 year.⁴⁸

Visuospatial impairment tests, especially the applicable sub-sections of the Mattis Dementia Rating Scale and Folstein Mini-Mental Status Examination (MMSE), have been used to identify patients considered safe to drive.⁴⁹ In some small studies, the MMSE has not been found to be a reliable method of predicting driving performance.^{44,50} Since this tool was not originally designed to assess cognitive function with respect to driving, the MMSE as a measure to assess driving performance lacks validity when used to assess patients falling between the extremes of cognitive impairment.^{7,51}

The Useful Field of View (UFOV) is a computer-administered test that measures and detects abnormalities in the speed of visual processing and sensory function. UFOV also measures skills in selective and divided attention.⁵² Compared to other visual and cognitive tools, there is a poor correlation using the UFOV with driving ability to predict collision rates.⁵³⁻⁵⁵

LICENSE REVOCATION

The most challenging aspect of this disease is determining when the individual needs to give up driving privileges. Despite the diagnosis, most patients with Alzheimer's disease continue to drive for as long as 4 years.^{44,51} Given the heterogeneity among patients with widely ranging cognitive dysfunction, it is important to assess patients systematically and to individualize recommendations.⁵⁶

COLLISION RATE

The collision rate in the first several years after disease onset, or in patients with mild dementia, is similar to age-matched controls.^{45,46,56-58} These studies may be confounded because of the failure to control for the amount of mileage actually driven, lack of control groups, small sample size, method of reporting and avoidance of high risk driving situations.^{44-46,51,59} Overall, the evidence does support an increased risk of motor vehicle collisions in patients with dementia even with restrictions attached to driving, such as driving distance or location.^{51,60-62}

DRIVING WITH DEMENTIA GUIDELINES

The American Academy of Neurology Quality Standards Subcommittee recommends that all patients with a CDR stage 1, or greater should refrain from driving. Patients with a CDR stage 0.5 may be at an increased risk of having a motor vehicle collision. These patients require evaluation by neuropsychiatric testing and possible driving performance evaluation.⁶³

The neuropsychologist is a useful resource in educating the patient and family regarding management of cognitive deficits and also in assisting the patient and family in discussions regarding safety (to themselves and others). As well as, financial ramifications which may occur if the patient continues to drive against medical advice.

It is recommended that physicians take an accurate driving history from both the patient and informant. An assessment of cognitive function should be routinely performed in evaluating patients with suspected Alzheimer's disease. Patients with cognitive impairment need to be assessed over time to determine whether there is evidence for progression in the decline of cognitive functioning and driving skills. A history from the patient or informant of near misses, collisions, becoming lost while driving, or cognitive errors in judgment, as well as difficulties with visuospatial skills, attention, or memory, should determine the necessity of a recommendation for a formal on-road driving review from the Department of Transportation (DOT). Competency to drive may be impaired in patients with mild to moderate dementia. The following tests should be considered when making a formal evaluation on the competency to continue to drive: cognitive, psychomotor and on-road.^{41,60,64}

Parkinson's Disease

Parkinson's disease and other neurodegenerative diseases are slowly progressive disorders resulting in abnormalities in motor and cognitive function. Driving assessment in patients with Parkinson's disease is often difficult given the complex

and often unpredictable nature of both the cognitive and motor functions that may fluctuate daily (table 2). Driving performance may fluctuate depending on the severity of the tremor, dyskinetic and the “on-off phenomenon” related to medication. Not unexpectedly, there is a correlation between the severity of disease and motor vehicle accident rate.⁶⁵

METHODS OF ASSESSMENT

There is currently no standardized method that can be applied to establish driving capacity in patients with Parkinson’s disease. There is a poor correlation between patient questionnaires and disease severity scales in determining medical fitness to drive.^{64,65} The cognitive impairment seen in patients with Parkinson’s disease includes short term working memory, non-verbal recognition memory, attention and visuospatial deficits.^{66,67} Slowness in cognitive functions including processing, choice reaction times, visual perception and memory have been identified as key factors that affect driving in patients with Parkinson’s disease.⁶⁴

It is important to assess both the motor and cognitive function when performing a medical assessment to determine fitness to drive. Patients with Parkinson’s disease may show evidence of reduced power, speed and accuracy of movement. They may have visuospatial and motor perception difficulties.⁶⁸ Simulator assessments have shown that Parkinson’s disease patients have attention abnormalities, directional errors, reduced strength and speed of movement, as well as an increased reaction time.⁶⁹

MEDICATION RELATED EFFECTS

Excessive daytime sleepiness has been reported to occur in 15% of patients with Parkinson’s disease compared to only 1% of healthy age-matched controls.⁷⁰ The dopamine agonists, bromocriptine, and pramipexole, as well as L-dopa, have been reported to cause excessive daytime sleepiness.^{71,72} Patients should be informed of the potential sedative side effects of dopaminergic medication and its implication on safe driving.

Table 2. Factors affecting driving in patients with Parkinson’s disease.

Motor disorders
Tremor
“On-off” phenomenon
Dyskinesia
Akinesia
Cognitive disorders
Hallucinations
Confusion
Dementia
Sleep disorders
Increased daytime sleepiness
Antiparkinsonian medications
Increased daytime sleepiness
Orthostatic hypotension
Reduced concentration

Epilepsy

Seizures account for 11% of all motor vehicle collisions in patients with epilepsy, but are only responsible for 1% of all motor vehicle collisions.^{73,74} In persons compliant with local driving restrictions for seizures, little to no increased risk of car collisions occurs.⁷⁴⁻⁷⁶ Evaluating the relationship between driving and epilepsy is difficult because of the failure to control for the amount of mileage driven, retrospective nature of the studies and severity of the disease.

Minimum requirements for length of seizure-free time before a person is allowed to drive varies between states. The lack of a uniform standard for driving restriction after a seizure is compounded by the fact that there is lack of agreement regarding the relative risk of recurrent seizures in patients whose disease is medically controlled. Patients who are seizure-free for at least 1 year and are compliant with driving restrictions pose little or no increased risk of motor vehicle collisions.^{74,76}

RISK FACTORS

The risk of recurrent seizures is difficult to determine because it is influenced by the cause of the initial event and the type of prescribed anti-epileptic drugs (AEDs). Risk factors for motor vehicle collisions in patients with seizures include age, marital status, gender, history of multiple seizures, psychiatric disorders, alcohol abuse, generalized or complex seizures, partial complex seizures, noncompliance with AEDs, or history of drug intoxication.^{74,77-79} When discussing risk, it is important to distinguish between high and low risk groups. Other factors associated with an increased risk include idiopathic cases, the presence of neurologic findings, and the duration since the previous seizure.⁸⁰

Seizures due to a known precipitating factor such as physical injury, vascular insult, or a metabolic or toxic disorder are unlikely to reoccur once the underlying factor is corrected. If the precipitating factor cannot be corrected, then consideration for initiating AEDs should be made. These decisions often need to be individualized and discussed with the patient, weighing both the risks and benefits of treatment and potential risk in driving.

UNPROVOKED SEIZURES

In patients with previous unprovoked seizures there is a 14% to 66% probability of recurrence in the first 12 months.⁸¹⁻⁸⁴ Some of the discrepancy in patients with first unprovoked seizure is due to study methods and types of prognostic factors included in these studies.

RECURRENT SEIZURES

Hauser found that an electroencephalogram showing a generalized spike and wave abnormality, history of previous unprovoked seizure and a sibling with seizures, increased the risk of recurrent seizures.⁸¹ The greatest risk of recurrence is in patients with previous neurologic injuries. Other factors including age of first seizure, seizure type, episode of status epilepticus, or abnormality on neurological examination did not affect the risk of recurrent seizure.⁸¹

Factors that decrease the probability of a seizure-related motor vehicle collision include a long seizure-free interval, reliable aura, a good driving record prior to seizure and physician directed reduction in the numbers of AEDs. In addition to using the least sedative, but most effective medications.⁸⁵

DRUG-RELATED EFFECTS

It is important to assess all patients for side effects related to their AEDs. The ability to drive can be impaired by these medications that can cause drowsiness, impaired concentration, ataxia, dizziness and psychomotor slowing. Drug-related side effects can be minimized by measuring therapeutic drug levels, prescribing single agents, changing to an alternative medication and using, if possible, nonsedating AEDs.

WITHDRAWAL OF AEDS

There are no specific laws regulating driving restrictions while an AED is withdrawn. This is a potential vulnerable period for seizures. Patients should be advised to avoid driving for at least the first 4 months after the start of AED withdrawal, and in the 6 months following discontinuation of an AED.⁸⁶ This period does not apply if an alternative AED is being used simultaneously.²⁶ There are currently no state laws mandating these recommendations. Approximately one-third of patients tapering an AED will have a recurrent seizure within 1 year. If a seizure reoccurs driving should cease. Patients with a history of epilepsy often choose to continue their medications regularly, rather than temporarily suspend their driving privileges.

LICENSE REVOCATION REGULATIONS

The requirements for license revocation following a seizure varies among states, ranging from 3 months to 2 years. Current Wisconsin state law mandates a 3 month period in which driving be temporarily suspended following any loss of consciousness. It does not distinguish the etiology for that loss of consciousness or distinguish between provoked and unprovoked seizures. Patients must be free of recurrent episodes in order to be allowed to resume driving.

DRIVING AFTER SEIZURE REQUIREMENTS

What is the evidence supporting the 3-month, seizure-free time period before a patient can resume driving in Wisconsin? A 3-month interval was 85% reliable in predicting seizure control for up to 1 year.⁸⁷

A retrospective cohort study in Marshfield, Wisconsin, (Wood County) and surrounding counties showed no difference in the motor vehicle collision rate between patients who had been seizure-free for 3 versus 6 months.⁷⁴ A recent consensus statement on driving after a seizure adapted by the American Academy of Neurology, the American Epilepsy Society and the Epilepsy Foundation of America, recommends at minimum, a 3 month seizure-free interval before driving is resumed.⁸⁸ The trend has been for states to shorten the minimum duration in which patients must be seizure-free before they can resume driving. The 3-month period when

a driving license is suspended after a seizure has been established as an observational period. The greatest risk of reoccurrence is immediately after the seizure.

Although complex partial seizures have been associated with a higher risk of driving collisions than nocturnal or idiopathic seizures, no distinction is made in the law regarding this seizure type. This type of potential epilepsy is difficult to determine after a single seizure.

PATIENT AND PHYSICIAN RESPONSIBILITIES

Recurrent seizures in patients with epilepsy are often preventable and can be divided into patient- and physician-related factors. Patients should be counseled that it is important to take their medications as prescribed and avoid the consumption of alcohol. Healthcare providers must be notified of the prescribed AEDs, in order to avoid potential drug interactions that could cause fluctuating drug levels.⁸⁹

Clinician-related causes include prescribing inadequate doses of AEDs or failure to monitor drug levels. It is important that physicians advise patients to avoid factors thought to increase the likelihood of recurrent seizures, including sleep deprivation, alcohol, emotional excitement and excessive fatigue. Unfortunately, patients with epilepsy often continue to drive illegally, fail to notify the driving and vehicle licensing bureau (Wisconsin Division of Motor Vehicles) and are not fully informed of the current state laws regarding driving restrictions.⁸⁹⁻⁹⁴ This may be due in part to the lack of knowledge physicians have regarding the state regulations concerning the failure to inform patients of the need to curtail their driving.

In the state of Wisconsin, it is the legal responsibility of the physician to inform the patient of the state's statutes on driving after any loss of consciousness and the minimum required seizure-free time before driving is resumed. Physicians are also required to provide documentation that patient seizures have been controlled during this time; the patient does not pose an unreasonable risk to public safety. The basis for determining risk to public safety must consider factors such as recurrent motor vehicle collisions related to seizures and seizure frequency.

REPORTING DUTIES AND RESPONSIBILITIES

Based on the 1999 report, "Impaired Drivers and Their Physicians," in 2000 the American Medical Association (AMA) Council on Ethical and Judicial Affairs released an opinion, the purpose of which,

...is to articulate the physician's responsibility to recognize impairments in patient's driving ability that pose a strong threat to public safety and which may ultimately may need to be reported to the Department of Motor Vehicles. It does not address the reporting of medical information for the purpose of punishment or criminal prosecution.¹⁰¹

The opinion has been included in the AMA's "Code of Medical Ethics" (E-2.24 Impaired Drivers and Their Physicians) and is available from the AMA Web site. The opinion is as follows:¹⁰¹

1. Physicians should assess patients' physical or mental impairments that might adversely affect driving abilities. Each case must be evaluated individually since not all impairments may give rise to an obligation on the part of the physician. Nor may all physicians be in a position to evaluate the extent or the effect of an impairment (e.g., physicians who treat patients on a short-term basis). In making evaluations, physicians should consider the following factors:
 - (a) the physician must be able to identify and document physical or mental impairments that clearly relate to the ability to drive;
 - (b) the driver must pose a clear risk to public safety.
2. Before reporting, there are a number of initial steps physicians should take. A tactful but candid discussion with the patient and family about the risks of driving is of primary importance. Depending on the patient's medical condition, the physician may suggest to the patient that he or she seek further treatment, such as substance abuse treatment or occupational therapy. Physicians also may encourage the patient and the family to decide on a restricted driving schedule. Efforts made by physicians to inform patients and their families, advise them of their options, and negotiate a workable plan may render reporting unnecessary.
3. Physicians should use their best judgment when determining when to report impairments that could limit a patient's ability to drive safely. In situations where clear evidence of substantial driving impairment implies a strong threat to patient and public safety, and where the physician's advice to discontinue driving privileges is ignored, it is desirable and ethical to notify the Department of Motor Vehicles.
4. The physician's role is to report medical conditions that would impair safe driving as dictated by his or her state's mandatory reporting laws and standards of medical practice. The determination of the inability to drive safely should be made by the state's Department of Motor Vehicles.
5. Physicians should disclose and explain to their patients this responsibility to report.
6. Physicians should protect patient confidentiality by ensuring that only the minimal amount of information is reported and that reasonable security measures are used in handling that information.
7. Physicians should work with their state medical societies to create statutes that uphold the best interests of patients and community, and that safeguard physicians from liability when reporting in good faith.

It is highly recommended that all physicians seek out the reporting rules legally required in the state in which they practice. Wisconsin State Law mandates that physicians:

- Inform their patients of the nature of their medical condition and recommend to them that they refrain from driving until medical clearance has been obtained.
- Document in the medical records that this information was conveyed to the patient.
- Report medical impaired drivers to the law enforcement agency if they believe that the patient will persist in driving despite recommendations to cease.
- Inform the patient regarding their legal requirement to report their medical condition to the DOT.

It is important that the physician recommend to the patient, preferably with his or her family members present, to refrain from driving. It is also recommended that physicians provide a patient with a written letter regarding driving recommendations.

Physicians are not required to confirm fitness to drive. Their role is strictly to advise and determine whether patients have met the recommended medical standards for driving. These standards are determined through an examination documenting the presence and degree of impairment in the areas of cognitive, sensory and motor function. If a physician believes that further assessment is necessary, patients should be referred for evaluation to an occupational therapist, psychiatrist, neurologist, or neurophysiologist.

As part of the duty to report, physicians should release only the minimal amount of pertinent information and should ensure that confidentiality of the information is secure. The provider must complete and submit a driver's condition or behavior report.

Failure to notify may potentially result in liability damages for negligence to anyone harmed by patient noncompliance. The physician should inform the patient both verbally and in writing of their recommendation and obligation to notify the DOT if the patient continues to drive. The physician should record the same information in the medical record. Confidentiality of the report to the family and the medical record is maintained.

Family members or other private citizens may also report concerns regarding a patient's ability to safely drive regardless of the decision of the provider. In Wisconsin, if a private citizen files a report with the DOT, due to the State open records law, confidentiality becomes secondary and is not maintained. A physician may also decide to file a report to the DOT, if despite medical advice, it is believed that the patient will continue to drive. This again would override the patient's right to confidentiality.

MEDICAL QUALIFICATIONS FOR DRIVING LICENSE RECOMMENDATIONS

Physicians are commonly required to make a recommendation regarding a patient's fitness to drive, despite the relative absence of well-defined screening tools that allow them to adequately assess driving capacity. It is the physician's responsibility to assess driving capacity that includes a thorough evaluation of cognitive, motor and affective functions. It is difficult to assess fitness to drive because of the multiple and confounding variables that are involved, as well as the subjective nature of the evaluation. Evaluating cognitive status alone is insufficient in determining driving performance. Behavioral and functional assessments need to be included in order to identify unfit drivers. The physician's decision to recommend that a patient stops driving is often subjective due to the lack of precise standards and a valid driving competency test.

A physician should base the decision to allow a patient to continue to drive based on current guidelines and legal requirements. Currently, there are few clear and consistent guidelines available by which this topic is addressed. Thus, the physician is often in a dilemma when called on to determine a patient's fitness to drive. Ultimately, considerable judgment and professional obligation to personal and public interest must be exercised.

Assessing medical fitness to drive should include a physical examination assessing physical limitation and screening for cognitive function (table 3). The history should focus on physical disabilities and activities of daily living that may affect a patient's ability to safely enter and exit the vehicle, in addition to the ability to safely operate the vehicle. The history should include questions on whether the patient has had traffic collision violations, near misses, or become lost in familiar areas. A driving history from family members or other acquaintances may be informative.

An assessment of activities of daily living (e.g., meal preparation, money management) is important given its association to driving ability.⁹⁵ There is a good correlation between activities of daily living and returning to driving in patients with stroke, Parkinson's disease and traumatic brain injury.^{15,96} It is particularly important to assess and review

with the patient, current and over-the-counter medications that may cause drowsiness and potentially increase motor vehicle collision rates.⁶² Patients should be reminded not to consume alcohol while driving.

A thorough neurologic assessment should be performed, including a Mini-Mental examination. In some cases, neuropsychiatric testing may be useful in determining the extent and type of cognitive impairment.

In patients who show signs of cognitive impairment, additional assessments should include neuropsychiatric, and on- and off-road testing, depending on the tools available at your facility. General screening tests that are relatively easy to administer include the Motor Free Visual Perception Test, Trial Making Test, and Benton Visual Retention Test. These tests are useful for assessing visual attention, visual perception and visuomotor abilities. Patients who perform normally on neuropsychological and physical motor skills may be eligible for a driver's license without proceeding to on-road testing. Patients who do not pass one of these or other similar neuropsychiatric tests should be considered for on-road testing after consultation with an expert in automotive adaptations. Considerable expertise and informed judgment on the part of the physician should be exercised before making any formal recommendation.

While guidelines are not currently available for making objective medical determinations of a patient's competence to drive in the face of the neurological disorders discussed, applying the recommended assessment tools combined with best clinical judgments should aid in counseling patients in their driving abilities or restrictions.

CONCLUSION

It is widely recognized that physicians do not have the proper training to make a legal determination about whether a patient is fit to drive. Driving is a privilege granted by the state, not a right issued by a physician. The current accepted reference standard to determine fitness-to-drive is an on-the-road test administered by a qualified driving performance examiner. These tests evaluate driving skills in a controlled environment and thus may not equate to all possible driving conditions. After the occurrence of certain specified medical conditions, testing of driving abilities may be legislatively

Table 3. Pre-driving assessment tools.

History to determine previous motor vehicle accidents, number of miles driven, psychosocial aspects, medical conditions and current level of psychological functioning
Physical examination to identify subtle physical conditions
Assess joint mobility of neck, shoulders, wrists, hips, knees and ankles
Assess upper and lower muscle strength manually
Assess upper and lower coordination through finger-nose, heel to shin and rapid alternating motion
Current medication
Visual fitness
Mental status
Neuropsychiatric testing
Off-road driving testing (simulator)

controlled by some states. For instance, some states require periodic evaluation and retesting after a traumatic brain injury. In other instances, despite their lack of professional training in this arena, physicians are frequently asked to make assessments and recommendations to their patients with regard to whether they should drive or not based on an existing or incipient medical condition.

While physicians are not trained to judge whether a patient *is* legally fit to drive, a physician may be able to determine that an individual *is not* functionally fit to drive based upon published findings of neuropsychological tests in groups of people with neurological illnesses. Even so, neuropsychiatric testing alone is inadequate to be used alone to determine fitness to drive. In light of the rarity of motor vehicle collisions in patients with neurodegenerative disease or traumatic brain injury, the predictive value of neuropsychiatric tests, actual collision rate and the risk related to allowing a patient to resume driving is currently unknown. In lieu of such studies; however, neuropsychological and off-road testing should be utilized by physicians to make valid decisions as to whether to refer patients to the appropriate legal authority for on-the-road fitness-to-drive evaluation.

ACKNOWLEDGMENTS

The authors wish to thank Marshfield Clinic Research Foundation for providing assistance in the preparation of this manuscript through the services of Graig Eldred and Alice Stargardt.

REFERENCES

- King D, Benbow SJ, Barrett JA. The law and medical fitness to drive—a study of doctors' knowledge. *Postgrad Med J* 1992;68:624-628.
- Drickamer MA, Marottoli RA. Physician responsibility in driver assessment. *Am J Med Sci* 1993;306:277-281.
- Waller JA. Physician's role in highway safety. Functional impairment in driving. *N Y State J Med* 1980;80:1987-1991.
- Galski T, Bruno RL, Ehle HT. Prediction of behind-the-wheel driving performance in patients with cerebral brain damage: a discriminate function analysis. *Am J Occup Ther* 1993;47:391-396.
- Bloedow RA, Adler G. Driving and dementia: perspectives from an outpatient clinic. *Soc Work Health Care* 1992;17:31-43.
- Gianutsos R, Campbell A, Beattie A, Mandriota F. The driving advisement system: a computer-augmented quasi-simulation of the cognitive prerequisites for resumption of driving after brain injury. *Assist Technol* 1992;4:70-86.
- Odenheimer GL, Beaudet M, Jette AM, Albert MS, Grande L, Minaker KL. Performance-based driving evaluation of the elderly driver: safety, reliability and validity. *J Gerontol* 1994;49:M153-M159.
- Shute RH, Woodhouse JM. Visual fitness to drive after stroke or head injury. *Ophthalmic Physiol Opt* 1990;10:327-332.
- Galski T, Ehle HT, Williams JB. Off-road driving evaluations for persons with cerebral injury: a factor analytic study of predriver and simulator testing. *Am J Occup Ther* 1997;51:352-359.
- Galski T, Ehle HT, Bruno RL. An assessment of measures to predict the outcome of driving evaluations in patients with cerebral damage. *Am J Occup Ther* 1990;44:709-713.
- Korteling JE, Kaptein NA. Neuropsychological driving fitness tests for brain-damaged subjects. *Arch Phys Med Rehabil* 1996;77:138-146.
- Sivak M, Olson PL, Kewman DG, Won H, Henson DL. Driving and perceptual/cognitive skills: behavioral consequences of brain damage. *Arch Phys Med Rehabil* 1981;62:476-483.
- Galski T, Bruno RL, Ehle HT. Driving after cerebral damage: a model with implications for evaluation. *Am J Occup Ther* 1992;46:324-332.
- Priddy DA, Johnson P, Lam CS. Driving after a severe head injury. *Brain Inj* 1990;4:267-272.
- Fisk GD, Owsley C, Pulley LV. Driving after stroke: driving exposure, advice and evaluations. *Arch Phys Med Rehabil* 1997;78:1338-1345.
- Legh-Smith J, Wade DT, Hewer RL. Driving after a stroke. *J R Soc Med* 1986;79:200-203.
- Sundet K, Goffeng L, Hofft E. To drive or not to drive: neuropsychological assessment for driver's license among stroke patients. *Scand J Psychol* 1995;36:47-58.
- Kaizer F, Korner-Bitensky N, Mayo N, Becker R, Coopersmith H. Response time of stroke patients to visual stimulus. *Stroke* 1988;19:335-339.
- Quigley FL, DeLisa JA. Assessing the driving potential of cerebral vascular accident patients. *Am J Occup Ther* 1983;37:474-478.
- Jones R, Giddens H, Croft D. Assessment and training of brain-damaged drivers. *Am J Occup Ther* 1983;37:754-760.
- Nouri FM, Tinson DJ, Lincoln NB. Cognitive ability and driving after stroke. *Int Disabil Stud* 1987;9:110-115.
- American Medical Association. American Medical Association guides to the evaluation of permanent impairment. 4th ed, third printing. 1995.
- New South Wales Motor Accidents Authority. Guidelines for the assessment of permanent impairment of a person injured as the result of a motor accident. March, 2000. Available at http://www.maa.nsw.gov.au/pdfs/impairment_assess.pdf. Accessed June 20, 2003.
- Schulte T, Strasburger H, Muller-Oehring EM, Kasten E, Sabel BA. Automobile driving performance of brain-injured patients with visual field defects. *Am J Phys Med Rehabil* 1999;78:136-142.
- Hauser WA, Ramirez-Lassepas M, Rosenstein R. Risk for seizures and epilepsy following cerebrovascular insults. *Epilepsia* 1984;25:666.
- Fisher RS, Parsonage M, Beaussart M, Bladin P, Masland R, Sonnen AE, Remillard G. Epilepsy and driving: an international perspective. Joint Commission on Drivers' Licensing of the International Bureau for Epilepsy and the International League Against Epilepsy. *Epilepsia* 1994;35:675-684.
- Doege TC, Engelberg AL, editors. Medical conditions affecting drivers. Chicago: American Medical Association;1986.
- Brooke MM, Questad KA, Patterson DR, Valois TA. Driving evaluation after traumatic brain injury. *Am J Phys Med Rehabil* 1992;71:177-182.
- van Zomeren AH, Brouwer WH, Minderhoud JM. Acquired brain damage and driving: a review. *Arch Phys Med Rehabil* 1987;68:697-705.
- Brouwer WH, Ponds RW, Van Wolffelaar PC, van Zomeren AH. Divided attention 5 to 10 years after severe closed head injury. *Cortex* 1989;25:219-230.
- Brouwer WH, Withaar FK, Tant ML, van Zomeren AH. Attention and driving in traumatic brain injury: a question of coping with time-pressure. *J Head Trauma Rehabil* 2002;17:1-15.
- Brouwer W, Verzendaal M, van der Naalt J, Smit J, van Zomeren E. Divided attention years after severe closed head injury: the effect of dependencies between the subtasks. *Brain Cogn* 2001;46:54-56.

33. Khan F, Baguley IJ, Cameron ID. 4: Rehabilitation after traumatic brain injury. *Med J Aust* 2003;178:290-295.
34. Stokx LC, Gaillard AW. Task and driving performance of patients with a severe concussion of the brain. *J Clin Exp Neuropsychol* 1986;8:421-436.
35. van Zomeren AH, Brouwer WH, Rothengatter JA, Snoek JW. Fitness to drive a car after recovery from severe head injury. *Arch Phys Med Rehabil* 1988;69:90-96.
36. Kumar R, Powell B, Tani N, Naliboff B, Metter EJ. Perceptual dysfunction in hemiplegia and automobile driving. *Gerontologist* 1991;31:807-810.
37. Poser CM. Automobile driving fitness and neurological impairment. *J Neuropsychiatry Clin Neurosci* 1993;5:342-348.
38. Fitten LJ, Perryman KM, Wilkinson CJ, Little RJ, Burns MM, Pachana N, Mervis JR, Malmgren R, Siembieda DW, Ganzell S. Alzheimer and vascular dementias and driving. A prospective road and laboratory study. *JAMA* 1995;273:1360-1365.
39. Hunt LA, Murphy CF, Carr D, Duchek JM, Buckles V, Morris JC. Reliability of the Washington University Road Test. A performance-based assessment for drivers with dementia of the Alzheimer type. *Arch Neurol* 1997;54:707-712.
40. Gates GA, Karzon RK, Garcia P, Peterein J, Storandt M, Morris JC, Miller JP. Auditory dysfunction in aging and senile dementia of the Alzheimer's type. *Arch Neurol* 1995;52:626-634.
41. Drachman DA. Who may drive? Who may not? Who shall decide? *Ann Neurol* 1988;24:787-788.
42. Parasuraman R, Nestor PG. Attention and driving skills in aging and Alzheimer's disease. *Hum Factors* 1991;33:539-557.
43. Ott BR, Mernoff ST. Driving policy issues and the physician. *Med Health R I* 1999;82:428-431.
44. Fox GK, Bowden SC, Bashford GM, Smith DS. Alzheimer's disease and driving: prediction and assessment of driving performance. *J Am Geriatr Soc* 1997;45:949-953.
45. Drachman DA, Swearer JM. Driving and Alzheimer's disease: the risk of crashes. *Neurology* 1993;43:2448-2456.
46. Trobe JD, Waller PF, Cook-Flannagan CA, Teshima SM, Bieliauskas LA. Crashes and violations among drivers with Alzheimer disease. *Arch Neurol* 1996;53:411-416.
47. Dubinsky RM, Stein AC, Lyons K. Practice parameter: risk of driving and Alzheimer's disease (an evidence-based review): report of the quality standards subcommittee of the American Academy of Neurology. *Neurology* 2000;54:2205-2211.
48. Hunt LA. Evaluation and retraining programs for older drivers. *Clin Geriatr Med* 1993;9:439-448.
49. Logsdon RG, Teri L, Larson EB. Driving and Alzheimer's disease. *J Gen Intern Med* 1992;7:583-588.
50. Lucas-Blaustein MJ, Filipp L, Dungan C, Tune L. Driving in patients with dementia. *J Am Geriatr Soc* 1988;36:1087-1091.
51. Friedland RP, Koss E, Kumar A, Gaine S, Metzler D, Hasby JV, Moore A. Motor vehicle crashes in dementia of the Alzheimer type. *Ann Neurol* 1988;24:782-786.
52. Rizzo M, Reinach S, McGehee D, Dawson J. Simulated car crashes and crash predictors in drivers with Alzheimer disease. *Arch Neurol* 1997;54:545-551.
53. Sims RV, Owsley C, Allman RM, Ball K, Smoot TM. A preliminary assessment of the medical and functional factors associated with vehicle crashes by older adults. *J Am Geriatr Soc* 1998;46:556-561.
54. Owsley C, Ball K, Sloane ME, Roenker DL, Bruni JR. Visual/cognitive correlates of vehicle accidents in older drivers. *Psychol Aging* 1991;6:403-415.
55. Duchek JM, Hunt L, Ball K, Buckles V, Morris JC. Attention and driving performance in Alzheimer's disease. *J Gerontol B Psychol Sci Soc Sci* 1998;53:P130-P141.
56. Carr DB, Duchek J, Morris JC. Characteristics of motor vehicle crashes of drivers with dementia of the Alzheimer type. *J Am Geriatr Soc* 2000;48:18-22.
57. Graca JL. Driving and aging. *Clin Geriatr Med* 1986;2:577-589.
58. Stutts JC, Stewart JR, Martell C. Cognitive test performance and crash risk in an older driver population. *Accid Anal Prev* 1998;30:337-346.
59. Dubinsky RM, Williamson A, Gray CS, Glatt SL. Driving in Alzheimer's disease. *J Am Geriatr Soc* 1992;40:1112-1116.
60. Hunt L, Morris JC, Edwards D, Wilson BS. Driving performance in persons with mild senile dementia of the Alzheimer type. *J Am Geriatr Soc* 1993;41:747-753.
61. Gilley DW, Wilson RS, Bennett DA, Stebbins GT, Bernard BA, Whalen ME, Fox JH. Cessation of driving and unsafe motor vehicle operation by dementia patients. *Arch Intern Med* 1991;151:941-946.
62. Freedman ML, Freedman DL. Should Alzheimer's disease patients be allowed to drive? A medical, legal, and ethical dilemma. *J Am Geriatr Soc* 1996;44:876-877.
63. Dubinsky RM, Stein AC, Lyons K. Practice parameter: risk of driving and Alzheimer's disease (an evidence based review): report of the quality standards subcommittee of the American Academy of Neurology. *Neurology* 2000;54:2205-11.
64. Heikkila VM, Turkka J, Korpelainen J, Kallanranta T, Summala H. Decreased driving ability in people with Parkinson's disease. *J Neurol Neurosurg Psychiatry* 1998;64:325-330.
65. Dubinsky RM, Gray C, Husted D, Busenbark K, Vetere-Overfield B, Wiltfong D, Parrish D, Koller WC. Driving in Parkinson's disease. *Neurology* 1991;41:517-520.
66. Bradley VA, Welch JL, Dick DJ. Visuospatial working memory in Parkinson's disease. *J Neurol Neurosurg Psychiatry* 1989;52:1228-1235.
67. Sullivan EV, Sagar HJ. Nonverbal recognition and recency discrimination deficits in Parkinson's disease and Alzheimer's disease. *Brain* 1989;112:1503-1517.
68. Sandyk R, Iacono RP. Rapid improvement in visuoperceptive functions by picoTesla range magnetic fields in patients with Parkinson's disease. *Int J Neurosci* 1993;70:233-254.
69. Lings S, Dupont E. Driving with Parkinson's disease. A controlled laboratory investigation. *Acta Neurol Scand* 1992;86:33-39.
70. Tandberg E, Larsen JP, Karlsen K. Excessive daytime sleepiness and sleep benefit in Parkinson's disease: a community based study. *Mov Disord* 1999;14:922-927.
71. Frucht S, Rogers JD, Greene PE, Gordon MF, Fahn S. Falling asleep at the wheel: motor vehicle mishaps in persons taking pramipexole and ropinirole. *Neurology* 1999;52:1908-1910.
72. Olanow CW, Schapira AH, Roth T. Waking up to sleep episodes in Parkinson's disease. *Mov Disord* 2000;15:212-215.
73. van der Lugt PJ. Traffic accidents caused by epilepsy. *Epilepsia* 1975;16:747-751.
74. Hansotia P, Broste SK. The effect of epilepsy or diabetes mellitus on the risk of automobile accidents. *N Engl J Med* 1991;324:22-26.
75. Gislason T, Tomasson K, Reynisdottir H, Bjornsson JK, Kristbjarnarson. Medical risk factors amongst drivers in single-car accidents. *J Intern Med* 1997;241:213-219.
76. Taylor J, Chadwick D, Johnson T. Risk of accidents in drivers with epilepsy. *J Neurol Neurosurg Psychiatry* 1996;60:621-627.
77. Hansotia P, Broste SK. Epilepsy and traffic safety. *Epilepsia* 1993;34:852-858.
78. Hansotia P. Seizure disorders, diabetes mellitus, and cerebrovascular disease. Considerations for older drivers. *Clin Geriatr Med* 1993;9:323-339.
79. Gastaut H, Zifkin BG. The risk of automobile accidents with seizures occurring while driving: relation to seizure type. *Neurology* 1987;37:1613-1616.

80. Spudis EV, Penry JK, Gibson P. Driving impairment caused by episodic brain dysfunction. Restrictions for epilepsy and syncope. *Arch Neurol* 1986;43:558-564.
81. Hauser WA, Anderson VE, Loewenson RB, McRoberts SM. Seizure recurrence after a first unprovoked seizure. *N Engl J Med* 1982;307:522-528.
82. Hauser WA, Rich SS, Annegers J, Anderson VE. Seizure recurrence after a 1st unprovoked seizure: an extended follow-up. *Neurology* 1990;40:1163-1170.
83. Bora I, Seckin B, Zarifoglu M, Turan F, Sadikoglu S, Ogul E. Risk of recurrence after first unprovoked tonic-clonic seizure in adults. *J Neurol* 1995;242:157-163.
84. Berg AT, Shinnar S. The risk of seizure recurrence following a first unprovoked seizure: a quantitative review. *Neurology* 1991;41:965-972.
85. Krauss GL, Krumholz A, Carter RC, Li G, Kaplan P. Risk factors for seizure-related motor vehicle crashes in patients with epilepsy. *Neurology* 1999;52:1324-1329.
86. Practice parameter: a guideline for discontinuing antiepileptic drugs in seizure-free patients—summary statement. Report of the Quality Standards Subcommittee of the American Academy of Neurology. *Neurology* 1996;47:600-602.
87. Kuhl V, Kiorboe E, Lund M. The prognosis of epilepsy with special reference to traffic safety. *Epilepsia* 1967;8:195-209.
88. Consensus conference on driving licensing and epilepsy: American Academy of Neurology, American Epilepsy Society, and Epilepsy Foundation of America. Washington, D.C., May 31-June 2, 1991. *Proceedings. Epilepsia* 1994;35:662-705.
89. Stanaway L, Johnson RH, Lambie DG. Epilepsy and driving. *N Z Med J* 1983;96:525-528.
90. Kelly R, Warke T, Steele I. Medical restrictions to driving: the awareness of patients and doctors. *Postgrad Med J* 1999;75:537-539.
91. Long L, Reeves AL, Moore JL, Roach J, Pickering CT. An assessment of epilepsy patients' knowledge of their disorder. *Epilepsia* 2000;41:727-731.
92. Dickey W, Morrow JL. Epilepsy and driving: attitudes and practices among patients attending a seizure clinic. *J R Soc Med* 1993;86:566-568.
93. McLachlan RS, Jones MW. Epilepsy and driving: a survey of Canadian neurologist. *Can J Neurol Sci* 1997;24:345-349.
94. Berg AT, Vickrey BG, Sperling MR, Langfitt JT, Bazil CW, Shinnar S, Walczak TS, Pacia S, Spencer SS. Driving in adults with refractory localization-related epilepsy. Multi-Center Study of Epilepsy Surgery. *Neurology* 2000;54:625-630.
95. Cameron ID, Kurrle SE. 1: Rehabilitation and older people. *Med J Aust* 2002;177:387-391.
96. Lyman JM, McGwin G Jr, Sims RV. Factors related to driving difficulty and habits in older drivers. *Accid Anal Prev* 2001;33:413-421.
97. Kapust LR, Weintraub S. To drive or not to drive: preliminary results from road testing of patients with dementia. *J Geriatr Psychiatry Neurol* 1992;5:210-216.
98. Akinwuntan AE, Feys H, DeWeerd W, Pauwels J, Baten G, Strypstein E. Determinants of driving after stroke. *Arch Phys Med Rehabil* 2002;83:334-341.
99. Mazer BL, Korner-Bitensky NA, Sofer S. Predicting ability to drive after stroke. *Arch Phys Med Rehabil* 1998;79:743-750.
100. Lezak MD. *Neuropsychological Assessment*. 2nd ed. New York: Oxford University Press; 1983.
101. American Medical Association. Code of Medical Ethics. "E-2.24 Impaired Drivers and Their Physicians." Available at <http://www.ama-assn.org/ama/pub/category/2503.html>. Accessed June 22, 2003.