On-road Driving Performance of Patients With Bilateral Moderate and Advanced Glaucoma

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• PURPOSE: To compare on-road driving performance of patients with moderate or advanced glaucoma to controls and evaluate factors associated with unsafe driving.
• DESIGN: Case-control pilot study.
• METHODS: A consecutive sample of 21 patients with bilateral moderate or advanced glaucoma from Washington University, St Louis, Missouri and 38 community-dwelling controls were enrolled. Participants, aged 55–90 years, underwent a comprehensive clinical evaluation by a trained occupational therapist and an on-road driving evaluation by a masked driver rehabilitation specialist. Overall driving performance of pass vs marginal/fail and number of wheel and/or brake interventions were recorded.
• RESULTS: Fifty-two percent of glaucoma participants scored a marginal/fail compared to 21% of controls (odds ratio [OR], 4.1; 95% CI, 1.30–13.14; $P = .02$). Glaucoma participants had a higher risk of wheel interventions than controls (OR, 4.67; 95% CI, 1.03–21.17; $P = .046$). There were no differences detected between glaucoma participants who scored a pass vs marginal/fail for visual field mean deviation of the better ($P = .62$) or worse ($P = .88$) eye, binocular distance ($P = .15$) or near ($P = .23$) visual acuity, contrast sensitivity ($P = .28$), or glare ($P = .88$). However, glaucoma participants with a marginal/fail score performed worse on Trail Making Tests A ($P = .03$) and B ($P = .05$), right-sided Jamar grip strength ($P = .02$), Rapid Pace Walk ($P = .03$), Braking Response Time ($P = .03$), and identifying traffic signs ($P = .05$).
• CONCLUSIONS: Patients with bilateral moderate or advanced glaucoma are at risk for unsafe driving—particularly those with impairments on psychometric and mobility tests. A comprehensive clinical assessment and on-road driving evaluation is recommended to effectively evaluate driving safety of these patients. (Am J Ophthalmol 2016;166:43–51. © 2016 Elsevier Inc. All rights reserved.)

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GLAUCOMA PATIENTS, PARTICULARLY THOSE with more advanced disease, have a greater risk of a motor vehicle collision[1–4] and of being at fault or injured in a motor vehicle collision[1,2] than drivers without glaucoma. Many of these unsafe drivers pass state licensing examinations and continue to drive, possibly posing a significant public health risk and financial burden to society and themselves. Conversely, potentially safe drivers with glaucoma not meeting the state-mandated vision requirements for driving may be forced to relinquish their license and unduly suffer from the negative sequelae of driving cessation.[5–7] A better understanding of factors associated with driving safety in glaucoma patients, particularly those with more advanced disease, is clearly needed.

An on-road driving assessment provides a valid,[8–10] objective, and standardized method of assessing driving performance. Although it is considered the gold standard in driving assessment, relatively few on-road driving studies have been conducted in patients with glaucoma.[11–14] To our knowledge, there are no studies that have comprehensively evaluated clinical factors and on-road driving performance in a high-risk sample of patients with bilateral moderate and advanced glaucoma. The purpose of this pilot study is to compare driving performance of patients with moderate or advanced glaucoma to age-matched controls using a validated on-road driving evaluation. This study also investigates the association between a comprehensive panel of vision and non-vision factors and unsafe driving.

METHODS

THIS IS A CASE-CONTROL PILOT STUDY IN ACCORDANCE with the Declaration of Helsinki and approved by the Human Research Protection Office at Washington University School of Medicine in St Louis, Missouri. A written informed consent was obtained from all eligible participants prior to study participation.

• **PARTICIPANTS:** Patients, aged 55–90 years, with bilateral moderate or advanced glaucoma and age range–matched individuals with no ocular disease participated in this study. Glaucoma patients were recruited during their regularly scheduled clinic visits at Washington

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University School of Medicine. Individuals with no ocular disease were recruited from the volunteer database of healthy community-dwelling older adults maintained by Washington University Medical School and community centers and were screened for any major comorbidities. All participants completed their visits between March 31, 2010 and August 23, 2011.

Patients with glaucoma were determined based on glaucomatous optic nerve cupping and reproducible visual field defects on the Humphrey Visual Field (VF) Analyzer II (Carl Zeiss Meditec, Dublin, California, USA) equipped with the Swedish Interactive Threshold Algorithm (SITA) obtained within 6 months of the study. All glaucoma patients were required to have visual field defects in *both eyes* that met the criteria for the Glaucoma Staging System[15] for stage 2 or worse (criteria including mean deviation of −6.01 or lower). Normal participants had no self-reported ocular disease. All study participants were required to be currently driving with a valid driver's license, have a visual acuity of 20/70 or better in at least 1 eye in compliance with Missouri and Illinois licensure requirements for visual acuity, speak English, and have at least 10 years of driving experience.

Glaucoma patients and controls were excluded if they had a driving evaluation within 12 months prior to the study or comorbidities or conditions that may affect driving, including advanced cardiopulmonary disease, severe orthopedic or neuromuscular impairments, clinically diagnosed dementia, psychiatric illness, substance abuse, use of potentially sedating medications (eg, narcotics, anxiolytics), visually significant nonglaucomatous ocular conditions (eg, macular degeneration, cataracts), or neovascular, uveitic, or acute angle-closure glaucoma. Visually significant cataracts for the glaucoma patients were based on chart review and defined as the presence of a posterior subcapsular or nuclear sclerotic cataract graded 2 or greater. Glaucoma patients were excluded if they used a low vision driving aid or underwent ocular incisional surgery within 3 months prior to the study visit.

Study eligibility for glaucoma patients was determined by chart review of consecutive patients from selected glaucoma clinics. Potentially eligible patients were approached and, if currently driving, asked to participate. Individuals with no ocular disease (ie, controls) were contacted by telephone to confirm study eligibility. All potential participants underwent a telephone interview in which they were screened for dementia using the Alzheimer Disease-8 questionnaire[16] and Short Blessed Test.[17] Patients declining participation for the on-road driving study were asked the reason and later contacted for participation in the questionnaire-only part of the study.

• **DRIVING EVALUATION:** All consenting glaucoma patients and controls completed a comprehensive clinical assessment and an on-road driving evalution based at the DrivingConnections outpatient clinic located in The Rehabilitation Institute of St Louis at Washington University Medical Center. Clinical assessments were conducted on the same day and just prior to the on-road evaluation.

Clinical Assessments. The clinical assessments took approximately 90 minutes to complete and were administered by a registered occupational therapist who was not masked to the vision status of the participant. The following measures, except for visual field testing, were administered by the occuptional therapist in the DrivingConnections clinic:

Vision: All vision measures were assessed with the participant's normal corrective lenses. Monocular and binocular distance and near visual acuity (VA) were measured with the Early Treatment Diabetic Retinopathy Study and Sloan near VA tests, respectively, and recorded with per-letter scoring.[18] Contrast sensitivity (CS) and glare testing were measured binocularly with per-letter scoring using the Pelli-Robson CS chart[19,20] and the Vector Vision chart, respectively. Visual field tests were conducted by trained ophthalmic technicians in the eye clinic using standard automated perimetry (Humphrey VF 24-2 with SITA standard program). Mean deviation (MD) was used as the main global index of visual field impairment. Two glaucoma participants (n = 3 eyes) completed Goldmann VF tests for their most recent visit; therefore, the mean deviation of their last Humphrey VF test (obtained within 1 year prior to the study visit) was recorded. Two participants (n = 2 eyes) were unable to perform a VF test in their worse eye owing to poor vision and were assigned a −30 decibel MD value.

Psychometrics: The Short Blessed Test was administered to screen for cognitive impairment and the Clock Drawing Test[21] and the Snellgrove Maze Task measured executive function and visuospatial abilities. Additional assessments included Trail Making Test A[22] (attention, psychomotor speed, and visual scanning) and B (alternating attention and executive function). Two subtests from the Driving-Health Inventory were administered: Subtest 2 of the Useful Field of View[23] (divided visual attention, visual memory, and processing speed) and the Motor-Free Visual Perceptual Test[24] (visual closure). For all psychometric tests, except for the Clock Drawing Test, higher scores indicate greater impairment.

Mobility: Standard goniometric techniques were used to measure cervical range of motion. The Jamar grip dynamometer[25] measured grip strength for each hand in pounds, averaging the sum of 3 trials. Motor speed and coordination were evaluated in seconds using the 9-Hole Peg Test[26] and the Rapid Pace Walk.[27] The Braking Response Time Monitor measured brake reaction time of the right lower extremity.

Medical and driving questionnaires: Additional assessments included the Geriatric Depression Scale,[28] the Epworth Sleepiness Scale,[29] a written driving test and road sign recognition test (ie, sign name and function),[30] and the Driving Habits Questionnaire.[31] In order to assess the