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Association between Glaucoma and At–fault Motor Vehicle Collision Involvement among Older Drivers

A Population-based Study

MiYoung Kwon, PhD,[1] Carrie Huisingh, MPH,[1] Lindsay A. Rhodes, MD,[1] Gerald McGwin, Jr., MS, PhD,[1,2,3] Joanne M. Wood, PhD,[4] Cynthia Owsley, PhD, MSPH[1]

Objective: To examine the association between glaucoma and motor vehicle collision (MVC) involvement among older drivers, including the role of visual field impairment that may underlie any association found.

Design: A retrospective, population-based study.

Participants: A sample of 2000 licensed drivers aged ≥70 years who reside in north central Alabama.

Methods: At-fault MVC involvement over the 5 years before enrollment was obtained from state records. Three aspects of visual function were measured: habitual binocular distance visual acuity, binocular contrast sensitivity (CS), and the binocular driving visual field constructed from combining the monocular visual fields of each eye. Poisson regression was used to calculate crude and adjusted rate ratios (RRs) and 95% confidence intervals (CIs).

Main Outcomes Measures: At-fault MVC involvement over the 5 years before enrollment.

Results: Drivers with glaucoma (n = 206) had a 1.65 times higher MVC rate (95% CI, 1.20–2.28; $P = 0.002$) compared with those without glaucoma after adjusting for age, and mental status. Among those with glaucoma, drivers with severe visual field loss had higher MVC rates (RR, 2.11; 95% CI, 1.09–4.09; $P = 0.027$), whereas no association was found among those with impaired visual acuity and CS. When the visual field was subdivided into 6 regions (upper, lower, left, and right visual fields; horizontal and vertical meridians), we found that impairment in the left, upper, or lower visual field was associated with higher MVC rates, and an impaired left visual field showed the highest RR (3.16; $P = 0.001$) compared with other regions. However, no association was found in deficits in the right side or along the horizontal or vertical meridian.

Conclusions: A population-based study suggests that older drivers with glaucoma are more likely to have a history of at-fault MVC involvement than those without glaucoma. Impairment in the driving visual field in drivers with glaucoma seems to have an independent association with at-fault MVC involvement, whereas visual acuity and CS impairments do not. *Ophthalmology 2015;■:1–8 © 2015 by the American Academy of Ophthalmology.*

Although driving is the preferred means of travel among older adults in the United States,[1–3] older drivers have a greater risk of motor vehicle collision (MVC)–related fatal injury than other age groups, and MVC rates in the United States show a sharp increase among drivers aged ≥70.[4] Vision is a critical component of safe driving, and the link between visual impairment and driving has been well-documented in many studies.[5,6]

Among many aging-related eye disorders, glaucoma is a leading cause of irreversible vision loss among the elderly in the United States, characterized by optic nerve damage and associated visual field defects. It has been shown that individuals with more severe visual field loss from a range of causes tend to report difficulty driving.[7] To enhance public safety, it is imperative to understand whether glaucomatous visual field loss puts an elderly driver at a greater risk for MVC involvement. However, there is conflicting evidence regarding the association between visual field loss and MVC rates.

For instance, a California study of 10 000 drivers[8] showed that drivers with severe binocular field loss had MVC and conviction rates twice as high as those with normal fields, and also reported that glaucoma was among the leading causes of visual field loss within their sample. A prospective, population-based study of older drivers in Maryland showed that visual field loss as measured by a screening test was associated with MVC involvement, whereas visual acuity (VA) and contrast sensitivity (CS) were not.[9] A similar association between visual field loss and MVC rates has been also reported in a recent retrospective, population-based study of older drivers in Alabama where visual field testing focused on the area of the visual field used while driving.[10] Simulated binocular visual field studies[11,12] demonstrated that restricted visual fields result in poor driving performance, suggesting a possible linkage between visual field loss and a higher MVC rate. They found that restriction of the binocular visual field to ≤90° significantly

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decreased the ability to identify road signs correctly and avoid obstacles, and considerably increased reaction times. Although the findings from these studies are consistent with studies of drivers with visual field impairment specifically owing to glaucoma (McGwin GJ, Wood JM, Owsley C. Motor vehicle collision involvement among persons with hemianopia and quadrantanopia. Under review.),[13–15] several other studies have reported no association between MVC involvement and visual field loss.[16–19] It is possible that the failure to find an association might be related to the way visual field impairment and/or MVC involvement has been defined or the use of nonstandard instruments for visual field testing.

Herein we report results from a retrospective, population-based study of older drivers. In this study, we asked the following questions: (1) Do older drivers with glaucoma have a higher MVC rate compared with those without glaucoma? (2) If that is the case, is glaucomatous visual field loss associated with at-fault MVC involvement among drivers with glaucoma after controlling for other types of visual impairment such as VA or CS? (3) Is region-specific visual field loss associated with increased at-fault MVC involvement among drivers with glaucoma as reported in previous studies of populations with field loss from a range of causes?[9,10]

Huisingh et al[10] used the same population-based study of older drivers to examine the association between MVC involvement and driving visual field, regardless of the etiology of field loss. In the current study we focused specifically on older drivers with glaucoma and their MVC rate as compared with nonglaucomatous drivers, as well as investigated how the characteristics of their field loss related to MVC involvement.

Methods

The study was based on a population-based sample of 2000 licensed drivers aged ≥70 years who reside in north central Alabama. Potential participants were identified from contact information available through a list of persons in this geographic region obtained from a direct marketing company (Pinpoint Technologies, Tustin, CA). Potential participants were selected randomly from the final list, driver licensure in the state of Alabama was verified, and they were then contacted by letter, followed by a phone call. Individuals who confirmed that they had a current Alabama license and had driven within the past 3 months, were ≥70 years old, and spoke English were invited for a single study visit. The final sample consisted of 2000 drivers enrolled between October 2008 and August 2011. A detailed description of the enrollment procedure is given elsewhere.[20]

Informed consent was obtained from participants in accordance with procedures approved by the institutional review board of the University of Alabama at Birmingham and complying with the Declaration of Helsinki. Trained research assistants confirmed demographic information (age, gender, race/ethnicity) and administered all vision tests along with a general health questionnaire.[18] General cognitive status was assessed with the Mini-Mental Status Examination.[21] An estimate of driving exposure (i.e., miles driven in a typical week) was obtained from administering the Driving Habits Questionnaire[22]; previous research indicates that drivers can provide these estimates reliably.[23] Information about participants' MVC involvement occurring within 5 years before enrollment was obtained through accident reports made available to the study by the Alabama Department of Public Safety. At-fault status was indicated on the report by the police officer at the scene who investigated the collision.

Glaucoma was confirmed through medical records using the following protocol, as described previously.[20] A copy of each participant's most recent comprehensive eye examination by an ophthalmologist or optometrist was obtained after the participant completed a signed medical record release authorizing the study to access these records. An experienced coder of eye medical records recorded whether the participant had a diagnosis of glaucoma as indicated in the section of the chart where diagnoses are listed by the ophthalmologist; participants with a diagnosis of ocular hypertension or who were categorized as a glaucoma suspect were not included in the glaucoma category. The coder was masked to all other data collected on the participant, including MVC involvement. Agreement with a second coder was high (91.4%).[20] There were a total of 206 drivers with confirmed glaucoma in the study sample after excluding 101 drivers for whom we were unable to obtain the medical record from the most recent eye examination.

Measures of visual function included binocular distance VA, binocular CS, and the driving visual field.[10] Participants wore whatever spectacles or contact lenses they normally wore when driving for acuity and CS testing. Binocular VA was assessed using the Electronic Visual Acuity system[24] and expressed as logarithm of the minimum angle of resolution (logMAR). Contrast sensitivity was measured using the Pelli-Robson CS chart[25] and scored using the letter-by-letter method and expressed as log sensitivity.[26]

Measurement procedures for the binocular driving visual field have been described previously[10] and are summarized herein. Visual field sensitivity of each eye was measured with a custom test designed for the Humphrey Field Analyzer (HFA) Model II-I (Carl Zeiss Meditec, Dublin, CA). The selection of test target locations was based on the visual field area relevant when a driver gazes toward the roadway environment through a vehicle's windshield[27] or at the vehicle's dashboard. The selection and description of the driving visual field test are provided in detail by Huisingh et al.[10] Briefly, we selected test target locations in the HFA that covered the widest possible horizontal extent of the field that could be tested for each eye (≤60°), with targets extending out to 15° superiorly and 30° inferiorly, consistent with a previous analysis of the driving visual field and our own measurements of a series of vehicles. The number of target locations was chosen so that the protocol covered the visual field area relevant to driving safety while minimizing the testing duration to make the test practical for assessing visual fitness to drive. Each monocular visual field consisting of 20 target locations was assessed with the HFA's full-threshold procedure using a white stimulus size III target. Best correction for the HFA test distance was provided with trial lenses when testing targets within the 30°-radius field, and were removed for targets outside the 30° field. The duration of the test was approximately 5 minutes per eye. As shown in Figure 1A, the binocular visual field was then constructed by combining the monocular visual fields based on the more sensitive of the 2 eyes at each visual field location. The binocular field thus comprised a total of 21 test target locations, spanning 60° to the right and left, 15° to the superior field, and 30° to the inferior field.

Impairment of VA was defined as <20/40 (0.3 logMAR) because this threshold is the commonly used VA standard for licensure in the United States.[28] Quartiles for CS were calculated; participants were defined as having impaired CS if their CS fell in the lowest quartile (≤1.6 log sensitivity). Similarly, quartiles for