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Do drivers with epilepsy have higher rates of motor vehicle accidents than those without epilepsy?

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ABSTRACT

Objective: We sought to understand the magnitude of the risk that drivers with epilepsy (DWE) contribute to motor vehicle accidents (MVAs) compared to other drivers.
Methods: We performed an evidence-based, systematic review using the American Academy of Neurology (AAN) guideline methodology.
Results: Contributory evidence consisted of six Class II studies and one Class III study. Two articles reported a trend toward a decreased rate of overall MVA rates for DWE when compared with the general population with a relative risk (RR) of 0.86 (95% CI: 0.65–1.14) (Class III) and a RR of 1.00 (95% CI: 0.95–1.06) (Class II); both studies used patient report to ascertain MVA rates. Three Class II studies reported either a trend toward or an increased risk of MVA rates for DWE when compared with the general population with a RR of 1.62 (95% confidence interval (CI): 0.95–2.76), as ascertained by insurance, emergency department, and physician reporting databases, a RR of 1.73 (95% CI 1.58–1.90), as ascertained by police reports, and a RR of 7.01 (95% CI 2.18–26.13), as ascertained by casualty department visits. One Class II study showed that, compared to fatal crashes with DWE, fatal crashes were 26 times more likely to occur because of other medical conditions and 156 times more likely to occur because of alcohol abuse. Motor vehicle accident crashes due to seizures in DWE occurred in one out of every 2800 MVAs, as reported in another Class II study.
Conclusions: The evidence for the difference in MVA rates in DWE compared to the general population is inconsistent, and no conclusion can be made. Important methodological differences across the studies contribute to the imprecision. Future research should be performed using objective measures rather than self-reporting of MVAs by DWE and "miles driven" as the denominator to calculate MVA rates.

1. Introduction

Drivers with epilepsy (DWE) are subject to driving restrictions throughout the United States. The recommended duration of driving restriction after seizure occurrence for DWE is inconsistent, and the evidence to support any restriction is obscure. The quality of life for persons with epilepsy (PWE) is adversely affected when seizure severity and frequency limit social activities and independence, including driving [1]. We sought to begin to understand how to formulate an appropriate driving restriction by determining the magnitude of the risk that DWE contribute to highway accidents compared to drivers with or without other medical conditions.

2. Methods

We performed a systematic, evidence-based review using the American Academy of Neurology (AAN) guideline methodology. We searched PubMed for all articles published from 1996 to the present, limiting the search to articles available in English. The search strategy included the Boolean operator AND between the parenthetical statements "(epilepsy OR seizure OR seizure disorder OR loss of consciousness)" and "(driving OR motor vehicle accident OR driving accident OR driving risk)." This search yielded 494 abstracts, which were each reviewed by two authors for relevance. Twenty-eight papers met criteria for further review and were classified according to the AAN prognostic criteria. After review by all four authors, eight papers were classified as having

Abbreviations: DWE, drivers with epilepsy; MVA, motor vehicle accidents; PWE, persons with epilepsy.

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contributory Class I, II, or III data. Other papers were rejected because of the lack of addressing the question or lack of an appropriate comparator arm. Estimated rates of epilepsy prevalence were applied in two papers [2,3].

3. Results

The evidence for rates of MVAs in DWE compared to the general population consisted of one Class I study, four Class II studies, and one Class III study. The Class I study by Sillanpaa and Shinnar [4] suggested that DWE do not have an increased risk of MVAs. However, this study had a small sample size of 81 DWE and 96 comparator drivers and a one-year assessment period; therefore, the results are imprecise and, overall, not contributory. Two articles showed a trend towards decreased risk of overall MVA rates in DWE when compared with the general population: Taylor et al. [5], a Class III study which used self-report questionnaires from drivers with epilepsy and utilized the denominator of 1000 driver-years, reported a relative risk (RR) of 0.86 (95% CI: 0.65–1.14); and McLachlan et al. [6], a Class II study, reported a RR of 1.00 (95% CI: 0.95–1.06) and used self-reported questionnaires from DWE who were identified through physician report to the transportation registry, with a denominator of MVAs per year.

However, the three additional Class II studies showed that DWE have increased MVA rates compared to the general population. Kwon et al. [7] reported a RR of 1.62 (95% CI: 0.95–2.76) and used medical and insurance databases to determine the occurrence of crashes in persons with epilepsy, with a denominator of 1000 person-years. Vernon et al. [8] reported a RR of 1.73 (95% CI: 1.58–1.90 for "unrestricted" drivers) and a RR of 1.47 (95% CI: 1.06–2.03 for "restricted drivers"). Drivers were categorized as "restricted" based on a physician evaluation of the severity of their medical condition and whether it caused impairment in driving ability. Driver's licenses with restrictions were divided into twelve levels in which driving was restricted to a certain speed, area, and/or time of day; privileges may have also been completely denied based on this evaluation. This study determined MVA rates using police reports in persons with driver's licenses that had previously registered medical conditions, with a denominator of 10,000 license-days. Lings [9] reported a RR of 7.01 (95% CI: 2.18–26.13) for DWE compared to the general driving population. In this study, the MVA rates were determined by reports from the casualty departments with a denominator of 1000 person-years. This study also had fewer outcomes than the other reports, as evidenced by the wide confidence interval (see Table 1).

Two other Class II studies provided information on comparative MVA rates but were more specific in their scope: one addressed seizure-related crashes in DWE, and one addressed fatal crashes. From the first of these Class II studies, seizure-related crashes in DWE are rare, occurring in one out of every 2800 MVAs [2]. This study used crashes reported by law enforcement agencies with a denominator of one billion miles driven. From the remaining Class II study, DWE are at least 50% less likely to be involved in fatal crashes than other drivers [3]. Fatal crashes due to alcohol abuse and alcoholism occurred 156 times more often than those in DWE, and overall, drivers with other medical conditions cause fatal accidents 26 times more than DWE [3]. These medical conditions included cardiac conditions, diabetes, and conditions related to alcohol use. This study used US death certificates provided by the National Center for Health Statistics of the Centers for Disease Control and Prevention, with a denominator of 100,000 person-years [3].

4. Discussion

The overall rates of MVAs in DWE from one Class I study, four Class II studies and one Class III study that included case-control and retrospective cohort study designs were not consistent, prohibiting the formulation of any conclusions. However, the study methods reveal reasons for the inconsistent results as well as sources of potential bias. For example, the short period of driving restriction from the study of Vernon et al. [8] may have influenced the results toward reports by DWE with more poorly controlled seizures who may have had more MVAs.

The ascertainment methods used in these studies would also contribute to the bias. The two publications showing the lowest risk utilized self-reported questionnaire surveys for the occurrence of MVAs [5,6]. This methodology could bias the results toward an underestimation of risk. The three publications showing the greatest risk were by Kwon et al. [7], Vernon et al. [8], and Lings [9]. These studies used police reports, hospital records, and medical databases to capture MVA events. These methods are likely more objective, complete, and accurate than self-report questionnaires.

In the study of McLachlan et al. [6] and Kwon et al. [7], the amount of time spent driving and the distance driven by PWE was not captured. In other studies, license-days [8], driving-years [5], and person-years with epilepsy [9] were used as denominators to calculate MVA rates. The varied denominators almost certainly preclude consistent results, but it is unclear if there is a bias associated with any of these approaches. It is likely, however, that the use of license-days or holding a license as a denominator does not accurately represent the amount of miles DWE are actually driving, since drivers with medical conditions including epilepsy drive less than unaffected drivers [10]. Motor vehicle accident rates in future studies should be adjusted from miles driven; we suggest that the use of billions of miles driven, derived using roadway sensor data and fuel taxes by Drazkowski et al. [2], is a more accurate methodology for deriving the denominator.

Seizure-related crashes appear to be rare, occurring in one out of every 2800 MVAs [2]. However, the strength of evidence for this is low, based on one Class II study. The strength of evidence is also low that fatal crashes for DWE are markedly less frequent than fatal crashes due to alcohol abuse or alcoholism and other medical conditions. Drivers with epilepsy are at least 50% less likely to be involved in fatal crashes than other drivers [3].

The role of antiepileptic drugs (AEDs) as a factor in the occurrence of MVAs is complex. Consistent information from two large studies shows that AED nonadherence doubles the MVA risk [11], the risk of MVAs due to seizures, and the risk of losing driving privileges [12]. However, the adverse cognitive effects of taking AEDs, such as impaired attention and limited visual scanning, may increase the risk of driving errors, as suggested by Mills et al. [13].

Limitations of the reports used as evidence include the following: there was no indication as to who was at fault for the accident and it is not clear whether MVAs occurred in the setting of adverse weather, mechanical failure, or cellphone usage including texting. This review also points out what is well known; other medical conditions such as cardiac disease, diabetes, and conditions related to alcohol have an increased risk of MVAs even compared to epilepsy, and they should be evaluated under a critical lens.

5. Conclusions

Our systematic review does not strongly support or refute an increased risk of MVA for DWE. However, the evidence does reveal how the 'truth' regarding this risk could be ascertained in future studies. First, studies with more objective ascertainment methods showed slightly increased risk compared to those with self-reported methods and are likely more accurate. Second, the MVA occurrences should be obtained with a denominator of 'miles driven' which would increase the accuracy of the evidence and would probably show an even further increased risk. Important factors which have already been shown to increase MVA risk in DWE should be accounted for when comparing DWE to the general population. These include an objective assessment of AED adherence and the relative MVA risk imparted by taking AEDs known to have adverse cognitive or sedative effects. Finally, the seizure frequency should be accounted for, at least by adjusting for the minimum seizure-free period used to permit driving in the states of the study populations. More information on MVA risk for DWE compared to

Table 1
Prognostic classification of selected articles comparing MVA rates in DWE.

Author and Year	Method	Location and sample size	Source of data	MVA rates	Completeness	Classification for prognostic accuracy
Drazkowski et al. [2]	Retrospective cohort study Motor vehicle crashes related to seizures versus other medical conditions and other crashes for people without medical conditions after driving restriction for DWE for three months[a]	Arizona, USA 136 seizure-related crashes 614,000 total crashes	Arizona traffic crash report forms provided by law enforcement agencies	1.1 per billion miles driven for DWE 2800 per billion miles driven for drivers without epilepsy RR = 3.9×10^{-4} (confidence interval could not be calculated)	100%	Class II
Kwon et al. [7]	Retrospective cohort study	Alberta, Canada 10,240 DWE 40,960 controls	Alberta Health Care Insurance Plan Registry (includes >99% of the population); Hospital discharge abstract database, ER visit database and physicians' claim database and "vital statistics" database	1.86 MVAs per 1000 person-years for DWE 1.15 MVAs per 1000 person-years for drivers without epilepsy RR = 1.62 (95% CI 0.95–2.76)	100%	Class II
Lings [9]	Retrospective cohort study	Odense, Denmark 159 DWE 559 controls	Danish Central Person Register, Patient Register at Odense University Hospital, Accident Analysis Group's Register at Odense University Hospital, Central Register of Driving Licenses at the National Commissioner of the Danish Police, and the Odense Police Driving Register	9.4 MVAs per 1000 person-years for DWE 1.34 MVAs per 1000 person-years for drivers without epilepsy RR = 7.01 (95% CI: 2.18–26.13)	100%	Class II
McLachlan et al. [6]	Retrospective cohort study	Alberta and Ontario, Canada 425 people with epilepsy responded 375 controls responded	Ontario: Ministry of Transportation registry (physician-required reporting) Alberta: physician-discretionary reporting (no registry) Subjects were selected from epilepsy clinics located in Ontario and Alberta Self-completion surveys sent to people with history of epilepsy and controls	0.09 MVA in DWE in the past year 0.09 MVA in drivers without epilepsy in the past year RR = 1.00 (95% CI: 0.95–1.06) MVA in lifetime 0.6 MVA in drivers with epilepsy per lifetime 0.6 MVA in drivers without epilepsy per lifetime RR = 0.99 (95% CI: 0.82–1.19)	80%	Class II
Sheth et al. [3]	Case control Annual totals and disease-specific risk for fatal crashes associated with seizures and other medical conditions[a]	USA 86 seizure-related fatal crashes 44,027 total fatal crashes	US death certificates provided by the National Center for Health Statistics of the Centers for Disease Control and Prevention	8.6 fatal seizure-related crashes per 100,000 person-years 22.51 fatal crashes in general population per 100,000 person-years RR = 0.38 (95% CI 0.3–0.5)	100%	Class II
Sillanpaa and Shinnar [4]	Prospective cohort study	Turku, Finland 81 DWE 96 persons without epilepsy	Patient records in hospitals, institutions, day care centers, special schools, private surgeons, and National Health Service records	0 MVAs in 81 DWE over one year 0 MVAs in 96 drivers without epilepsy over one year RR = 0	100%	Class I
Taylor et al. [5]	Retrospective cohort study	United Kingdom 16,958 DWE 8888 controls	Driver and Vehicle Licensing Agency and associated medical department records Self-completion surveys sent to people with history of epilepsy and controls	83 MVAs per 1000 driving-years for DWE 96 MVAs per 1000 driving-years for drivers without epilepsy RR = 0.86 (95% CI 0.65–1.14)	71%	Class III
Vernon et al. [8]	Case control Comparison of rates of MVAs experienced by DWE (in medical conditions licensing program) versus controls	Utah, USA 2709 DWE 1,750,918 total licensed drivers	Police crash reports obtained from the Utah Department of Transportation as well as death certificate data from the Utah Department of Health	2.69 MVAs (unrestricted DWE) per 10,000 license-days 1.55 MVAs (unrestricted controls) per 10,000 license-days Unrestricted: RR = 1.73 (95% CI 1.58–1.9) 2.67 MVAs (restricted DWE) per 10,000 license-days 1.81 MVAs (restricted controls) per 10,000 license-days Restricted: RR = 1.47 (95% CI 1.06–2.03)	100%	Class II

[a] Population estimates of epilepsy cases used.

the general population could inform the formulation of appropriate and perhaps individualized driving restrictions.

Disclosures

Dr. Harden has been a speaker for UCB, has received royalties from "Up-to-Date" and "Wiley", and has received research support from the NINDS. Drs. Naik, Bhatia, and Fleming have nothing to disclose.

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