

Driving Mishaps Among Individuals With Type 1 Diabetes

A prospective study

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OBJECTIVE — Hypoglycemia-related neuroglycopenia disrupts cognitive-motor functioning, which can impact driving safety. Retrospective studies suggest that drivers with type 1 diabetes experience more collisions and citations than their nondiabetic spouses. We present the first prospective data documenting the occurrence of apparent neuroglycopenia-related driving performance impairments.

RESEARCH DESIGN AND METHODS — We completed the initial screening of 452 drivers from three geographically diverse centers who then reported monthly occurrences of driving “mishaps,” including collisions, citations, losing control, automatic driving, someone else taking over driving, and moderate or severe hypoglycemia while driving.

RESULTS — Over 12 months, 52% of the drivers reported at least one hypoglycemia-related driving mishap and 5% reported six or more. These mishaps were related to mileage driven, history of severe hypoglycemia, and use of insulin pump therapy.

CONCLUSIONS — Many individuals with type 1 diabetes report hypoglycemia-related driving events. Clinicians should explore the recent experiences with hypoglycemia while driving and the risk of future events.

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Hypoglycemia is the major barrier to type 1 diabetes intensive insulin therapy (1), in part because of its disruptions on cognitive-motor functioning (2). One practical implication is its adverse effect on vehicular driving performance, resulting in collisions and citations (3,4). These potential disruptive effects are made further problematic because some individuals with diabetes decide to drive when they know that their blood glucose is low (5).

Retrospective studies (6) have documented that individuals with type 1 diabetes compared with those with type 2 diabetes have more collisions and citations. The current study presents the first prospective data documenting the occur-

rence of different types of hypoglycemia-related driving mishaps.

RESEARCH DESIGN AND METHODS

Drivers with type 1 diabetes (48% male) from three geographically diverse clinical regions (central Virginia, $n = 121$; Boston, MA, $n = 165$; Minneapolis, MN, $n = 166$) completed all data collection (out of a total of 515 who consented) in a study investigating factors that promote driving safety among individuals with diabetes. Subjects were recruited through newspaper, diabetes media, and radio advertisements and were compensated \$250 for their participation. Inclusion criteria were type 1 diabetes >12 months, legal driver's license,

driving >5,000 miles per year, and blood glucose measurement performed ≥ 2 times per day. Mean \pm SD demographics were as follows: age 42.4 ± 12.5 years, duration of disease 25.9 ± 12.9 years, and estimated A1C $7.8 \pm 0.8\%$ (7); the average number of miles driven per year was $16,000 \pm 10,000$ miles. At screening, 21% retrospectively reported being involved in collisions and 15% reported receiving a moving vehicle citation in the previous 2 years. This is similar to the 19% collision and 15% violation rates reported in our multinational retrospective study of consecutive patients attending diabetes clinics (6), suggesting that the current data are representative of the diabetes community in general.

After signing an institutional review board–approved consent form, subjects were instructed on the definition of the seven different types of hypoglycemia-related driving mishaps listed in Table 1. Subjects were then asked how often such events had occurred in the past 2 years, how often they carried fast-acting glucose in their car, and at what blood glucose threshold they would choose not to drive. For prospective data collection, subjects were given data sheets to record whether and/or when any of the seven types of hypoglycemia-related driving mishaps occurred, whether they measured their blood glucose within 30 min of starting to drive, and what that blood glucose reading was. For the next 12 months, subjects were contacted monthly by either e-mail or telephone to report their mishaps.

RESULTS — Over 12 months, 52% of the drivers reported at least one hypoglycemia-related driving mishap, 32% reported two or more, and 5% reported six or more. Table 1 displays the percentage of subjects reporting each type of mishap and the means and range of such mishaps for those subjects who reported their events. On average, 35% of the time drivers performed self-monitoring of blood glucose within 30 min of initiating their drive when a mishap occurred; 78% of the time self-monitoring of blood glucose was ≤ 90

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Table 1—Seven different hypoglycemia-related driving mishaps: percentage of drivers reporting each type of mishap, the mean and range of each mishap for those subjects reporting them, and predictors of hypoglycemia-related mishaps

	Events reported (n)	Subjects reporting events (%)	Events for involved subjects (mean/range)	SMBG within 30 min of starting the drive (%)	SMBG <90 mg/dl (%)
Since your last entry, while driving how many times					
1. Did you experience severe hypoglycemia where it was impossible to treat yourself because of low blood glucose?	31	5.1	1.3/1–6	40	87
2. Did you experience disruptive moderate hypoglycemia where you could still treat yourself but you could no longer drive safely?	503	41	2.7/1–26	43	78
3. Did you experience automatic driving due to hypoglycemia where you became disoriented, got lost, or arrived at your destination with no memory of driving there?	198	18	2.4/1–14	21	52
4. Did you hit something with your vehicle due to hypoglycemia?	11	2.4	1/1–1	30	67
5. Were you stopped by the police for reckless driving or speeding due to hypoglycemia?	6	1.3	1/1–1	38	100
6. Did you lose control of your car, but did not hit anything, due to hypoglycemia?	11	2.4	1/1–1	34	67
7. Did someone else take over control of your car due to hypoglycemia?	199	18	2.5/1–32	36	82

Relative risk of a hypoglycemia-related event (above) occurring associated with demographic and clinical variables adjusted for the number of miles driven per year*

	Adjusted relative risk (95% CI)	χ^2	P
Age (years)	1.00 (0.99–1.01)†	1.66	0.20
Sex	1.09 (0.91–1.32)	0.87	0.35
Female (52%)			
Male			
Duration of disease (years)	1.00 (0.99–1.01)†	0.71	0.40
Total insulin units/day	1.00 (0.99–1.01)†	0.06	0.81
Use of insulin pump therapy	1.35 (1.12–1.64)	9.77	0.002
No (52%)			
Yes			
Estimated A1C	1.02 (0.91–1.13)†	0.08	0.78
Awareness of low blood glucose by symptoms	1.14 (0.80–1.64)	0.55	0.46
No (32%)			
Yes			

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Table 1—Continued

Relative risk of a hypoglycemia-related event (above) occurring associated with demographic and clinical variables adjusted for the number of miles driven per year*	Adjusted relative risk (95% CI)	χ^2	P
History of severe hypoglycemia in past year	1.06 (1.03–1.08)†	20.92	<0.001
Blood glucose threshold for treatment <59 mg/dl vs. 26% >60 mg/dl	1.20 (0.89–1.62)	1.50	0.22
Blood glucose threshold for not driving <59 mg/dl vs. 82% >60 mg/dl	1.11 (0.84–1.48)	0.53	0.47
Carbohydrates available in car No (6%) Yes	0.98 (0.66–1.46)	0.1	0.93
Collisions in past 2 years, regardless of cause (n)	1.20 (1.07–1.34)†	10.31	0.001
Hypoglycemia-related driving mishaps in past 2 years (n)	1.06 (1.05–1.08)†	70.47	<0.001
Mild symptomatic hypoglycemia while driving in past 6 months (n)	1.03 (1.01–1.05)†	12.33	<0.001

*The demographic questionnaire is available upon request. †The odds ratio for a continuous predictor is estimated for a 1 unit difference in that exposure. SMBG, self-monitoring of blood glucose.

mg/dl, and 48% of the time it was <70 mg/dl. Disruptive moderate hypoglycemia that impaired driving was the most common event and was reported by 41% of the subjects. While 22% of the subjects prospectively reported some type of collision during the year, only 2.4% reported a collision attributed to hypoglycemia.

Modified Poisson regression (8) analyses were used to estimate the relative risk of the occurrence of hypoglycemia-related driving mishaps. To correct for exposure, all relative risk ratios were adjusted for the reported total number of miles driven during the 12-month study. The occurrence of future driving mishaps was significantly associated with using insulin pump therapy and with a history of severe hypoglycemia, vehicular collisions, and hypoglycemia-related driving mishaps. Participants using pump therapy to manage their blood glucose were 35% more likely to experience a hypoglycemia-related driving mishap than those using insulin injections. Having one retrospectively reported episode of severe hypoglycemia, collision, hypoglycemia-related mishap, or mild symptomatic hypoglycemia while driving increased the risk of a driving mishap in the

next 12 months by 6, 20, 6, and 3%, respectively. Risk increased exponentially with additional reported episodes; e.g., if two episodes of severe hypoglycemia occurred in the previous 12 months, risk would increase by 12%, or if two collisions occurred in the previous 2 years, risk would go up 40%.

CONCLUSIONS— Hypoglycemia is a common (when monitored prospectively) and unique risk factor for driving mishaps among some drivers with type 1 diabetes that is not found among the general population. In this prospective study, these mishaps were not related to sex, duration of disease, A1C, self-reported hypoglycemic awareness, availability of fast-acting glucose in the car, or blood glucose thresholds for when to treat or when not to drive. Mishaps were related to the use of insulin pumps, history of collisions, severe hypoglycemia, and hypoglycemia-related driving mishaps. Therefore, it would be prudent to routinely query patients about recent experiences concerning hypoglycemia and driving mishaps. If such events have occurred, steps to avoid hypoglycemia while driving

should be encouraged, such as measuring blood glucose before driving, encouraging a higher blood glucose threshold for when not to begin driving (e.g., >90 mg/dl), and, when hypoglycemia is detected while driving, safely ceasing driving, eating fast-acting carbohydrates, and not resuming driving until blood glucose and cognitive-motor functioning have recovered. Despite the consistency of findings in this and our multinational retrospective study (6), similar to that in the Diabetes Control and Complications Trial, a limitation of this study is its subject selection/dropout and reliance on the subjects' attributions as to whether hypoglycemia caused their mishaps, which could contribute to an over- or underestimation of hypoglycemia-related driving mishaps.

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