Hypoglycemia and Driving Performance

Driving is an activity that demands complex psychomotor skills, good visuospatial functions, rapid information processing, vigilance, and satisfactory judgment. Driving ability can be impaired by fatigue, drowsiness, and drugs and alcohol, all of which have been implicated in causing road traffic accidents. Acute hypoglycemia, the most common side effect of insulin therapy, may also compromise driving skills. Modest degrees of neuroglycopenia can provoke cognitive dysfunction without necessarily producing symptomatic awareness of hypoglycemia (1). Because hypoglycemia is a causal factor in some motor vehicle accidents, most national authorities who regulate the issue of driving licenses, period-restrict licenses for applicants who have insulin-treated diabetes, with renewal at varying intervals being subject to reassessment of medical fitness to drive (2). This restrictive approach has been criticized as being discriminatory, and its justification has been questioned on the basis that insufficient evidence exists to show that diabetic drivers have higher accident rates (3,4). However, glycemic control can be unstable, with some individuals experiencing periods of recurrent and unpredictable hypoglycemia. In addition, complications of diabetes, such as sight-threatening retinopathy, may progress with time, so that diabetes is usually designated a “prospective” disability for driving (2).

One acquired complication of insulin therapy that increases in prevalence with duration of diabetes is impaired awareness of hypoglycemia (5,6). Although its development does not invariably result in revocation of the driving license, it is considered to be a major risk for driving by most licensing authorities. This diminished ability to perceive the onset of hypoglycemia affects ~25% of people with type 1 diabetes (7,8). Reduced intensity of the symptoms of hypoglycemia is associated with an altered symptom profile, in which neuroglycopenic symptoms predominate, and a rate of severe hypoglycemia exists that is sixfold higher than that observed in people who retain normal awareness of hypoglycemia (9,10). While impaired awareness of hypoglycemia may be associated temporarily with periods of very strict glycemic control (11), in many patients with long-standing diabetes, it appears to be an established disability, and the increased frequency of severe hypoglycemia can dominate and disrupt everyday life. Impaired awareness of hypoglycemia is associated with more profound cognitive dysfunction, which takes longer to recover after acute hypoglycemia than is experienced by individuals with normal awareness (12).

Studies of cognitive function during hypoglycemia have demonstrated that complex tasks are affected more than simple ones, that there is considerable inter-individual variation, and that accuracy is preserved at the expense of speed. Cognitive function does not return to normal until 40–90 min after normoglycemia has been restored (13,14). Functions that are most affected by hypoglycemia include rapid decision-making, sustained attention, analysis of complex visual stimuli, “mental flexibility,” memory of recently learned information, and hand–eye coordination (15). While intact cognitive function is important for safe driving, it is unclear how complex psychological tests, performed under artificial experimental conditions, relate to everyday activities in which many other factors may cause distraction and influence performance. In addition, hypoglycemia diminishes speed of visual information processing and affects contrast sensitivity (a greater problem in poor visibility) (16,17) and promotes mood changes, including increased irritability and anger (15), which may be relevant to driving performance.

Objective evidence of the direct effects of hypoglycemia on driving performance was lacking until the seminal studies of Cox et al. (18), who used a driving simulator to examine the driving ability of 25 drivers with type 1 diabetes while using a stepped glucose clamp to lower blood glucose. Driving performance over a period of 4 min was significantly disrupted in nine subjects (36%) at an arterialized blood glucose of 2.6 mmol/l and mainly affected steering. Increased swerving and spinning of the vehicle, poor road positioning, and compensatory slowing were also observed. One disconcerting observation was that approximately half of the affected drivers did not experience warning symptoms of hypoglycemia and said that they felt competent to drive despite their blood glucose being low (18). A longer period of test driving might have affected more subjects. These studies have been refined and extended using a more sophisticated driving simulator and a different research design so that the development of hypoglycemia was more representative of that experienced in the daily life of people treated with insulin. Using an insulin infusion technique, hypoglycemia was induced progressively in 37 drivers with type 1 diabetes, half of whom had impaired awareness of hypoglycemia. Their driving ability was examined over a 30-min period, with frequent subjective assessment of their symptom perception and judgment of driving ability. The results are published in this issue of Diabetes Care in the article by Cox et al. (19).

Driving skills were impaired even during modest hypoglycemia (blood glucose range 3.4–4.0 mmol/l), and in all three ranges of low blood glucose tested, less than one-quarter of the diabetic drivers were aware that their ability to drive was impaired. During this longer period of test driving, the abnormalities included inappropriate braking in the open road, driving too fast, and driving across the midline or off the road. Many of these problems occurred simultaneously and more than one-third of the drivers demonstrated serious driving deficiencies during hypoglycemia. Some subjects failed to halt at stop signs and many were involved in crashes, usually caused by stopping the vehicle suddenly.

The most alarming observation in this study was that only one-third of the drivers treated their hypoglycemia and/or stopped driving and, in most instances, not until their blood glucose had declined to <2.8 mmol/l. Some of the most severely affected subjects took no corrective action. This reluctance to stop or self-treat has been noted previously in anecdotal reports, with some drivers describing a compulsion to keep driving despite experiencing symptomatic hypoglycemia (20). Whether this impaired judgment and loss of rational decision-making can progress to a form of automatism while driving has yet to be
determined. Cox et al. (19) have shown that progressive neuroglycopenia while driving, demonstrated by electroencephalograph changes, was associated with increasing delays to initiate self-treatment. Perception of a dangerously low blood glucose level became dulled by more profound neuroglycopenia and interfered with the ability to take corrective action. Appropriate corrective behavior during hypoglycemia required simultaneous subjective awareness that blood glucose was low and that driving ability was impaired.

The inability to recognize deteriorating driving ability, which was evident in many drivers, did not appear to be a feature of impaired awareness of hypoglycemia per se (19). Indeed, attempts to identify which subjects were most at risk of hypoglycemia-induced driving disabilities also failed to implicate a history of recent severe hypoglycemia, exposure to low blood glucose in the preceding 48 h, or the insulin regimen being used. It may be necessary to evaluate a much larger population of insulin-treated diabetic drivers to allow such predictive factors to emerge. The inter-individual variability in the severity of cognitive dysfunction induced by hypoglycemia was evident also with driving performance. Cerebral adaptation occurs in patients with strict glycemic control, in whom normal uptake of glucose by the brain is maintained during hypoglycemia (20). Although this capacity to maintain, and even increase, cerebral blood glucose uptake during hypoglycemia protects the brain, it is considered to be a maladaptive response because it suppresses normal warning symptoms and risks the development of profound neuroglycopenia. It is possible that such a cerebral adaptive mechanism preserves driving performance in some diabetic drivers, but the hesitation to take corrective action would suggest that the judgment of most subjects is impaired during hypoglycemia.

Diabetic drivers are advised to test their blood glucose regularly on long journeys, to stop for regular meals and snacks, to avoid drinking alcohol, and to desist from driving until at least 45 min after effective treatment of hypoglycemia (21), should be a fundamental part of the education of all insulin-treated diabetic drivers. Blood glucose-awareness training in drivers with impaired awareness of hypoglycemia is reputed to reduce the number of subsequent road traffic accidents (22), suggesting an indirect benefit of improving recognition of blood glucose fluctuations.

The authors are pained to comment that their findings have no direct relevance to determining driving privileges for people with diabetes. However, it is naive to believe that the results of this study will be ignored by driving licensing authorities and their medical advisors, for whom public safety is paramount. While hypoglycemia is responsible for only a very small percentage of road traffic accidents, it can undoubtedly affect driving performance adversely and must be avoided by all diabetic drivers when they are behind the wheel. Diabetic drivers who are at high risk of developing unpredictable disabling hypoglycemia will have difficulty retaining their driving licenses as a consequence of the results of this important study (19).

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References

Editorial