Hypoglycemia and Safe Driving

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Hypoglycemia and hypoglycemia unawareness is a real issue for diabetic patients and a real challenge for their health care providers. This review addresses the issue of road traffic accidents and drivers with Type 1 diabetes mellitus (T1DM) exploring the effects of hypoglycemia, its awareness state and the appropriate response by the driver and the doctor under such circumstances. The regulations surrounding this issue are also briefly discussed.

This is a simulation of a diabetologist's evidence in court.
A diabetologist had been called to be an expert witness in a trial of a young man with T1DM who was accused of causing death by dangerous driving. Give a short but clear outline of the physiological and psychological effects of hypoglycemia linking it to the relevant literature. This paper addresses hypoglycemia, medico-legal aspects and looks into the legislation in different countries in relation to diabetes and driving. It presents itself as a pocket manual for giving evidence in court.

Recently the effects of hypoglycemia on mental status and the issue of relationship between diabetes and driving have been raised for discussion. Investigations into the effect of glucose on the performance have been conducted in humans. Some studies explored the effect of glucose on learning, memory and mood in school children, attention, memory and decision making in college students, and memory in adults.

Benton et al. provided a useful overall review of the effect of blood glucose on cognitive functioning.[1] They discussed the widely accepted view that hypoglycemia causes physical and psychological symptoms associated with disruption of cognitive function.[1] Hypoglycemia has been found to induce adrenergic symptoms such as nervousness and tremor as well as CNS such as tiredness, confusion and slowed mental function.[2] The first signs and symptoms of low blood sugar can begin to occur below 70 mg/dl, although this varies from person to person. While driving, subjects need integration of their mental function to drive safely (visual and auditory processing or motor skill, reasoning, logic or problem solving). Comi stated that complete cognitive recovery may lag for 30 – 45 minutes behind restoration of normal blood glucose levels.[3]

In terms of sensory processes, certain visual functions were affected at low blood glucose levels e.g. detection of visual change and movement and the reaction time to visual stimuli.[4] Performance of visual tasks requiring more involved processing are adversely affected at low blood glucose levels. Also, the ability for decision making based on auditory processes has been likewise impaired at low blood glucose levels.[5]

The aspects of attention were affected at low blood glucose levels, hence speed of performance on attention tasks was reduced when blood glucose levels were low and subjects then become slower in their reaction response.[6]
Reaction time performance vigilance tasks, detection of auditory or visual tones and a tracking task was significantly lower at low blood glucose levels.[7]

With respect to judgement and decision making, planning performance was slower and mental flexibility and tracking were impaired at low blood glucose levels.[8]
Low blood glucose levels significantly impaired complex task performance, assessed by driving simulation.[9] Steering, speed control and braking were negatively affected at low blood glucose levels. Accuracy of performance was preserved at the expense of speed on these tasks with very slow driving being demonstrated. Interestingly, patients with hypoglycemia are not always aware of their impairments.[10]

There is no evidence of risks associated with driving for T1DM patients, randomized controlled studies (provide the strongest evidence) exist. Sophisticated driving simulator studies with demanding scenarios showed that driving itself is a significant stressor that is associated with greater autonomic symptoms, higher epinephrine levels and higher glucose needs.[11] Cox et al. found that the actual act of driving was associated with higher dextrose infusion rate (p=0.02), more autonomic symptoms (p<0.05), increased heart rate (p<0.001), a trend of greater epinephrine release (p=0.09) and more frequent hypoglycemic self treatment (p<0.001).[11]

Driving puts T1DM patients at increased risk of hypoglycemia.[11]

Simulator performance studies also showed that during hypoglycemia (even if mild with BG between 4.0 and 3.4 mmol/l), T1DM persons engage in some form of less safe driving (driving across the midline, speeding and/or inappropriate breaking).[2] The exact BG range at which driving is impaired and the exact driving parameters disrupted were found to be idiosyncratic.[10] Depression of CNS activity (evidenced by increased theta wave activity in EEG) occurs at moderate hypoglycemia (3.3-2.8 mmol/l).[10] Moreover, such studies revealed that 23-43% of T1DM patients with impaired hypoglycemia awareness (based on epinephrine level and symptoms score assessed by various neuropsychological tests) failed to decide not to drive during hypoglycemia, thus increasing the chance of dangerous driving.[12,13]

Functions that are mainly affected by hypoglycemia include rapid decision-making, sustained attention, analysis of complex visual stimuli and hand–eye coordination.[14] In patients with T1DM and repeated hypoglycemia, there is marked deterioration of performance in tests of short-term, delayed, and working memory for both verbal and nonverbal material.[15]

The issue of whether there is an increased risk of accidents among T1DM drivers has been controversial, but a recent retrospective study showed that significantly more T1DM drivers experienced at least one auto crash over the preceding 2-year period as compared to T2DM drivers or non-diabetic spouses (19% vs 12% vs 8% respectively, $p<0.001$).[7] Also, significantly more of those T1DM drivers reported episodes of mild symptomatic hypoglycemia, hypoglycemic stupor and requiring assistance while driving due to the development of hypoglycemia than the T2DM drivers and non-diabetic drivers.[16] T1DM drivers also reported twice as many crashes as their non-diabetic spouses.[16] T1D drivers who did not self-treat had almost three times the crash rate. The three main factors that significantly contributed to an increased probability of crashes were: experiencing more episodes of hypoglycemic stupor while driving, less frequent Self Monitoring Blood Glucose (SMBG) before driving and taking insulin by sc injections rather than an insulin pump.[16]

The question of whether it is possible to ascertain that the T1DM patient in this case was suffering from a hypo attack cannot be ascertained, but may put the possibility forward. Clues found to significantly increase the possibility of a hypoglycemic stupor while driving in T1DM include; accepting a lower BG as a threshold for deciding not to drive and suffering more frequent episodes of mild symptomatic hypoglycemia while driving.[16] However, a diabetic on tight glycaemic control (evidenced by his HbA1c) is at more risk of hypoglycemia. The presence of hypoglycemia unawareness may indicate the occurrence of previous severe hypoglycemia and raises the possibility that this patient suffered an attack while driving. One must look into the patient's BG in relation to driving and the time factor for development of events (in view of the recommendations) to judge further.

Hypoglycemia unawareness can be described when a subject is unaware of an early fall in their plasma glucose concentration and lose the warning neuroglycopaenic symptoms and fail to compensate by eating to prevent progression to severe hypoglycemia. The syndrome is the result of deficient sympathetic neural and adreno-medullary responses to falling glucose levels.

Hypoglycemia unawareness can occur in long standing diabetic patients who have defects in secretion of counter-regulatory hormones. It is developed if there are frequent bouts of hypoglycemia (level below 3.0 mmol/l).[17] By definition, a patient with hypoglycemia unawareness cannot recognize this state. Hence full assessment can be completed by interviewing the people close to the patient in everyday life. Health education, SMBG can help especially after exercise and during sleep.[17]

For hypoglycemia unawareness to be considered, it requires recurrent bouts of hypoglycemic attacks.[18] luckily, this can be reversed by scrupulous avoidance of hypoglycemia in daily life. At least a 3 week period of meticulous avoidance of hypoglycemia could be attempted with the goal of encouraging a return to awareness to hypoglycemia.[19]

Hypoglycemia promotes mood changes, including increased irritability and anger.[19, 20] Long term consequence can include a pattern of fear of hypoglycemia with negative impact on patients' health related quality of life.[6] Patients with type 2 diabetes may experience feelings of depression and anxiety which may affect their driving performance.[21]

Acute hypoglycemia causes a progressive, reversible deterioration in cognitive function that becomes detectable with glucose below 3 mmol/l.[20,22,23]

A cognitive function does not return to normal until 40–90 minutes after normoglycaemia has been restored.[14,24]

There should be specific obligations and recommendations that the T1DM driver should abide to and these should be discussed by their physician and other members of the diabetic team treating the patient. In this case, the T1DM driver should measure his BG before driving and not drive if it is below 5 mmol/l.[16,25] Moreover, the driver should frequently recheck their BG during long journeys driving,[16,25] a 2-hour interval has been suggested by some.[7] The driver should discontinue driving and consume a rapid-acting carbohydrate if they develop hypoglycemia.[16,25] They should not continue driving until 30-45 minutes after restoration of BG as studies have shown that cognitive function may not recover until then.[16] A study where participants undertook BG Awareness Training (BGAT) showed a two third reduction in crashes and

motor vehicle violations at long-term follow up.[25] T1DM drivers should be urged to the wear potentially life saving diabetes alert identification, that will save their life and identify their blood sugar level at the moment of the accident by rescue teams.

Physicians have a duty to familiarize drivers with the risk of hypoglycemia and recognition of its signs and symptoms.[26] Drivers should perform SMBG especially when long journeys are planned. Drivers should be strongly advised against risk taking behavior. This should be correlated with meals. If the history is suggestive of hypoglycemic unawareness, the driver should be advised to stop driving until the condition is reversed, by scrupulously avoiding further hypoglycemia for at least two weeks.[27,28]

The diabetic driver on insulin has a duty to inform the authorities about their diabetes. If they are on diet and/or oral hypoglycemic and are free of complications such as hypoglycemic unawareness, there is no need to inform the authorities. Generally, insulin treated patients are not allowed to drive heavy goods vehicles, certain passenger vehicles like buses. Approvals may be sought for exceptional cases.[29]

Although the duty is on the driver to inform, the doctor may on grounds of public interest inform the authorities if they conclude that there is a risk, and the driver cannot be persuaded to notify the authorities or to stop driving. This intention must be communicated to the patient. The Driver and Vehicle Licensing Agency (DVLA) also recommend discussing with the next of kin, but the patient is unlikely to agree. A second opinion may be sought, but until this is resolved, the patient should also refrain from driving.[29]

The obligation seems to rest largely on the individual patient, after due advice and discussion has taken place. The legal position of the physician who fails to notify the authorities about a recalcitrant driver in the event of an accident is still untested.[29]

There is insufficient evidence to prove that diabetic drivers have higher accident rates. [30,31] However, some researches support the idea that hypoglycemia significantly compromises driving performance resulting in longer response times and lower scores in cognitive tests which may lead to traffic violations and accidents.[10]

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References

1. Benton D, Parker PY, Donohoe RT. The supply of glucose to the brain and cognitive functioning. J Biosoc Sci 1996 Oct;28(4):463-479.
2. LJaE JA. Beating the blood sugar blues: American Diabetes Association 2001.
3. Comi RJ. Approach to acute hypoglycemia. Endocrinol Metab Clin North Am 1993 Jun;22(2):247-262.
4. Blackman JD, Towle VL, Lewis GF, Spire JP, Polonsky KS. Hypoglycemic thresholds for cognitive dysfunction in humans. Diabetes 1990 Jul;39(7):828-835.
5. McCrimmon RJ, Deary IJ, Frier BM. Auditory information processing during acute insulin-induced hypoglycaemia in non-diabetic human subjects. Neuropsychologia 1997 Dec;35(12):1547-1553.
6. Lobmann R, Smid HG, Pottag G, Wagner K, Heinze HJ, Lehnert H. Impairment and recovery of elementary cognitive function induced by hypoglycemia in type-1 diabetic patients and healthy controls. J Clin Endocrinol Metab 2000 Aug;85(8):2758-2766.
7. Fruehwald-Schultes B, Born J, Kern W, Peters A, Fehm HL. Adaptation of cognitive function to hypoglycemia in healthy men. Diabetes Care 2000 Aug;23(8):1059-1066.
8. Hoffman RG, Speelman DJ, Hinnen DA, Conley KL, Guthrie RA, Knapp RK. Changes in cortical functioning with acute hypoglycemia and hyperglycemia in type I diabetes. Diabetes Care 1989 Mar;12(3):193-197.
9. Cox DJ, Gonder-Frederick L, Clarke W. Driving decrements in type I diabetes during moderate hypoglycemia. Diabetes 1993 Feb;42(2):239-243.
10. Cox DJ, Gonder-Frederick LA, Kovatchev BP, Julian DM, Clarke WL. Progressive hypoglycemia's impact on driving simulation performance. Occurrence, awareness and correction. Diabetes Care 2000 Feb;23(2):163-170.
11. Cox DJ, Gonder-Frederick LA, Kovatchev BP, Clarke WL. The metabolic demands of driving for drivers with type 1 diabetes mellitus. Diabetes Metab Res Rev 2002 Sep-Oct;18(5):381-385.
12. Weinger K, Kinsley BT, Levy CJ, Bajaj M, Simonson DC, Cox DJ, et al. The perception of safe driving ability during hypoglycemia in patients with type 1 diabetes mellitus. Am J Med 1999 Sep;107(3):246-253.
13. Stork AD, van Haeften TW, Veneman TF. The decision not to drive during hypoglycemia in patients with type 1 and type 2 diabetes according to hypoglycemia awareness. Diabetes Care 2007 Nov;30(11):2822-2826.
14. Blackman JD, Towle VL, Sturis J, Lewis GF, Spire JP, Polonsky KS. Hypoglycemic thresholds for cognitive dysfunction in IDDM. Diabetes 1992 Mar;41(3):392-399.
15. Sommerfield AJ, Deary IJ, McAulay V, Frier BM. Short-term, delayed, and working memory are impaired during hypoglycemia in individuals with type 1 diabetes. Diabetes Care 2003 Feb;26(2):390-396.
16. Cox DJ, Penberthy JK, Zrebiec J, Weinger K, Aikens JE, Frier B, et al. Diabetes and driving mishaps: frequency and correlations from a multinational survey. Diabetes Care 2003 Aug;26(8):2329-2334.
17. Cryer PE. The barrier of hypoglycemia in diabetes. Diabetes 2008 Dec;57(12):3169-3176.
18. Turner BC, Jenkins E, Kerr D, Sherwin RS, Cavan DA. The effect of evening alcohol consumption on next-morning glucose control in type 1 diabetes. Diabetes Care 2001 Nov;24(11):1888-1893.
19. Dagogo-Jack S, Fanelli CG, Cryer PE. Durable reversal of hypoglycemia unawareness in type 1 diabetes. Diabetes Care 1999 May;22(5):866-867.
20. Deary IJ. Symptoms of Hypoglycaemia and Effects on Mental Performance and Emotions. In: Frier BM, editor. Hypoglycaemia in Clinical Diabetes: John Wiley & Sons, Ltd; 2007.
21. R.R ABJR. Practical Psychology for Diabetes Clinicians: Amer Diabetes Assn; 2002.
22. McAulay V, Deary IJ, Ferguson SC, Frier BM. Acute hypoglycemia in humans causes attentional dysfunction while nonverbal intelligence is preserved. Diabetes Care 2001 Oct;24(10):1745-1750.
23. Warren RE, Allen KV, Sommerfield AJ, Deary IJ, Frier BM. Acute hypoglycemia impairs nonverbal intelligence: importance of avoiding ceiling

effects in cognitive function testing. Diabetes Care 2004 Jun;27(6):1447-1448.
24. Lindgren M, Eckert B, Stenberg G, Agardh CD. Restitution of neurophysiological functions, performance, and subjective symptoms after moderate insulin-induced hypoglycaemia in non-diabetic men. Diabet Med 1996 Mar;13(3):218-225.
25. Graveling AJ, Warren RE, Frier BM. Hypoglycaemia and driving in people with insulin-treated diabetes: adherence to recommendations for avoidance. Diabet Med 2004 Sep;21(9):1014-1019.
26. Distiller LA, Kramer BD. Driving and diabetics on insulin therapy. S Afr Med J 1996 Aug;86(8)(Suppl):1018-1020.
27. Fritsche A, Stumvoll M, Häring HU, Gerich JE. Reversal of hypoglycemia unawareness in a long-term type 1 diabetic patient by improvement of beta-adrenergic sensitivity after prevention of hypoglycemia. J Clin Endocrinol Metab 2000 Feb;85(2):523-525.
28. In the Driver's Seat: Managing Hypoglycemia When Driving [database on the Internet]2009.
29. Drivers Medical Group DaVLA. For Medical Practitioners. At a Glance: Guide to the Current Medical Standards of Fitness to Drive In: DVLA, editor. Swansea: Drivers Medical Group, DVLA; 2007.
30. MacLeod KM. Diabetes and driving: towards equitable, evidence-based decision-making. Diabet Med 1999 Apr;16(4):282-290.
31. Songer TJ. Drivers with diabetes. Innocent until proven guilty. Diabetes Care 1989 Mar;12(3):233-234.