Blood Glucose Awareness Training Helps Return Insulin-Treated Aviators to the Cockpit

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DIABETES MELLITUS (DM) was found to be one of the major causes for permanent disqualification from flying duties in a study performed among USAF pilots and navigators who were permanently disqualified from flying duties in the years 1995–1999 (15). The incidence of this disease has been estimated at 0.47 cases per 1000 aviator-years per year and a study published in 1995 found that 78% of diabetic aviators were removed from flying duties (14). Our growing understanding of type 1 DM has permitted the identification of subgroups of diabetics with an acceptable aeromedical risk and, therefore, a greater proportion of diabetics were removed from flying duties (14). Published in 1995 found that 78% of diabetic aviators were removed from flying duties.

CASE REPORTS

Patient A

A 29-yr-old C-130 navigator presented to the IAF Aeromedical Center on April 1999 with complaints of polyuria, nocturia, and polydipsia. Blood glucose was 323 mg% and glycosylated hemoglobin (HgbA1C) was 8.5%. Type 1 DM was diagnosed and treatment with insulin Lispro (Humalog, Eli Lilly, IN) and NPH was started. Insulin NPH was later replaced with Glargine turned to the cockpit. Two such cases are presented and discussed in detail.

Hyperinsulinemic Clamp Technique

After an overnight fast, insulin treatment was withheld. Subjects were admitted in the morning and two intravenous catheters were placed using a local anesthetic cream. The first catheter, for infusion of glucose and insulin, was inserted in a large vein in the non-dominant hand. The second, for sampling of arterialized venous blood, was inserted retrograde into the distal wrist or a hand vein of the same arm and kept patent with a slow saline infusion. At the beginning of the study, a primed continuous infusion of regular insulin (Human Actrapid, Novo Nordisk, Bagsvaerd, Denmark) was started at a maintenance rate of 1.5 mU kg⁻¹ min⁻¹ and infused for 180 min. Glucose was maintained at 90 mg% for 10 min, and then reduced in successive steps to 70, 60, and 50 mg%, before being restored to 90 mg% after 140 min. Each glucose plateau lasted 25 min in total. At the end of each study, subjects received lunch. Glucose monitoring was continued until stable euglycemia was maintained, after which all intravenous lines were withdrawn.

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(Aventis Pharmaceuticals, Bridgewater, NJ) insulin in an attempt to further minimize the chances of hypoglycemia. On a 5-yr follow-up, his diabetes was well controlled with HgbA1c values in the range of 6–7.9%. Annual ophthalmologic examination and microalbumin were within normal limits. Two hypoglycemic insulin clamp studies were performed.

In the first study, paresthesias appeared after 70 min when glucose level was measured at 94 mg·dL⁻¹. The patient reported a feeling of fatigue after 145 min when plasma glucose measured 71 mg·dL⁻¹. During a second study, he reported a ‘funny feeling’ at a glucose level of 115 mg·dL⁻¹. He learned that the earliest symptoms of his hypoglycemia were paresthesias and a ‘funny feeling.’ He was returned to flight in a multicrew aircraft (C-130 as a navigator) under limiting conditions which included a requirement to measure his blood glucose levels prior to every flight and during flight on long-distance missions, and the need to be equipped during flight with a glucometer, a glucagon vial, and glucose oral tablets. A diabetic control team including an endocrinologist and his attending flight surgeon has followed him. There have been no hypoglycemic episodes that required exogenous treatment and no in-flight episodes.

Patient B

A 28-yr-old Apache AH pilot presented to the IAF Aeromedical Center on March 2001 with complaints of polyuria, polydipsia, and weight loss. Glycosylated hemoglobin values were 14.48% and fasting glucose was 330 mg%. Anti-GAD antibodies were positive and he was diagnosed with type 1 DM. Insulin reserve was evaluated through C-peptide measurement following glucagon administration; C-peptide rose to 1.8 μmol·L⁻¹, attesting to a low insulin reserve. Treatment with insulin Lispro (Humalog) and NPH was begun. Insulin NPH was later replaced with Glargine insulin in an attempt to further minimize the chances of hypoglycemia. Statin therapy was instituted due to dyslipidemia. During follow-up, his glycosylated hemoglobin values were in the range of 6–8.5%. Annual ophthalmologic examination and microalbumin testing were within normal limits. A hypoglycemic insulin clamp study was performed.

He reported hunger after 100 min when his plasma glucose level was 91.2 mg·dL⁻¹. After 160 min, at a plasma glucose level of 57 mg·dL⁻¹, he reported dizziness, after which his blood sugar dropped to 35 mg·dL⁻¹. He learned that hunger was the preliminary symptom of impending hypoglycemia. He was returned to flight in a multicrew aircraft (Apache AH which is operated by two crewmen) under limiting conditions which included a requirement to measure his blood glucose levels prior to every flight, and the need to be equipped during flight with a glucometer, a glucagon vial, and glucose oral tablets. He has been followed for 3 yr with no hypoglycemic episodes requiring exogenous treatment, and no episodes occurring in flight.

**DISCUSSION**

One of the major aeromedical concerns in insulin-treated diabetics is the potential risk of hypoglycemia. Hypoglycemia results in cognitive impairment that may manifest as emotional changes, visual impairment, or auditory dysfunction. A study performed in diabetic subjects revealed that these patients were more prone to motor vehicle accidents depending on the method of insulin treatment (higher among those on intensive insulin therapy as compared with pump therapy), the frequency of blood glucose monitoring before driving, and the rate of hypoglycemic episodes. Another study revealed that a narrow window exists between a patient’s decision to treat self-detected hypoglycemia and the appearance of neuroglycopenia that may lead to driving impairment. It is thus not surprising that the decision to return insulin-treated diabetics to the cockpit relies largely on the risk of hypoglycemia. Features that characterize a low risk of hypoglycemia include an educated awareness of the disease with an established pattern of stable glycemic control based on sustained compliance to a diabetic diet and exercise program.

Neither adults nor children are particularly adept at identifying hypoglycemia-associated symptoms or estimating blood glucose values reliably. One early study noted that 76% of adults with type 1 diabetes overestimated their blood glucose values during experimentally induced hypoglycemia. Gold et al. found that insulin-treated diabetics with hypoglycemia unawareness exhibited more profound cognitive dysfunction during acute hypoglycemia that persisted for longer periods following blood glucose recovery than non-diabetics. These studies indicate that many diabetic subjects fail to estimate their glucose levels accurately and are thus at risk for severe complications from this phenomenon. The development of hypoglycemia unawareness in diabetic subjects exposes them to recurrent episodes of hypoglycemia, these being increasingly more severe. Avoidance of hypoglycemia restores hypoglycemia unawareness even in those with established unawareness, primarily by increasing β-adrenergic sensitivity. In addition, military aviation is a task that certainly increases metabolic demands and increases the chances of hypoglycemia, as has been demonstrated in drivers. It is thus clear that insulin-treated diabetics face a significant risk of in-flight hypoglycemia, especially those who are well controlled. This phenomenon may affect the aviator’s cognitive performance and may lead to in-flight incapacitation.
Every effort should thus be made to recognize those patients at high risk of developing hypoglycemia and to educate those returning to the cockpit of the early signs of this phenomenon in order to minimize the chances of in-flight incapacitation.

The insulin infusion test is a safe and reproducible method and can reliably predict which patients with type 1 diabetes are at risk of developing severe hypoglycemia during intensive insulin therapy (1). This test also exposes the patient to controlled hypoglycemia, thus educating him to recognize its early symptoms and can aid in the decision to return a certain aviator to the cockpit. Although this test cannot eliminate the risk of hypoglycemia, it can decrease the frequency and severity of such episodes. Such a program exists for the early recognition of hypoxia, another dreaded complication of modern aviation (2). This training program exposes the aviators to gradual hypoxia in an altitude cabin and teaches them to recognize the early signs of this phenomenon in order to avoid persistent hypoxia that may lead to loss of consciousness.

Blood glucose awareness training has been advanced as a strategy to avoid hypoglycemia by teaching individuals to use the appearance of autonomic and neuroglycopenic symptoms as indicators of decreasing blood glucose levels (7). The insulin-glucose clamp study is certainly a major tool in this aspect, as it enables the clinician to gradually lower the subject’s blood glucose levels and monitor the appearance of symptoms at various glucose levels. The patient will learn to recognize the earliest signs and symptoms of hypoglycemia and respond appropriately, so preventing a further decrease in blood glucose values. The competence of an individual to decrease his risk of severe hypoglycemia after participation in a formal blood glucose awareness-training program is variable, depending partially on psychological factors (16). These patients may be returned to the cockpit with greater assurance, as their ability to recognize the early signs of hypoglycemia may aid them in avoiding in-flight incapacitation. We believe that these aviators should be permitted to fly with a co-pilot as the risk of hypoglycemia is significantly lower than in untrained individuals, but is still certainly higher than in the general population. We also believe that since the use of a blood glucose awareness program does not eliminate the risk of in-flight hypoglycemia, all those returned to the cockpit should measure their blood glucose levels prior to flight and during flight, particularly during long flights.

CONCLUSIONS

Insulin-treated diabetics may be returned to the cockpit in a multicrew aircraft provided they are aware of the risks of hypoglycemia and are able to recognize this complication at an early stage, so as to avoid in-flight incapacitation. This may be achieved through a formal blood glucose awareness-training program, such as an insulin glucose clamp study. This program follows similar principles as the altitude chamber-training program performed by most aviators worldwide. Future developments such as continuous blood glucose monitoring and closed loop insulin delivery systems may enable aeromedical examiners to further eliminate present restrictions placed on diabetic aviators.

REFERENCES