

# Flight and diabetes

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## ABSTRACT

Although safe and fast, air travel can cause problems in diabetic passengers and pilots. In fact, most diabetes-related emergencies can be prevented during the flight. Diabetic passengers and pilots can fly safely with proper control and planning. In this review, we have discussed in detail the negativities caused by flights in diabetic passengers and pilots and some issues to be considered during and after the flight.

**Keywords:** diabetes, flight, aviation

## Introduction

Diabetes mellitus (DM) is a chronic metabolic disease that requires constant medical care, in which an individual cannot benefit from carbohydrates, fats, and proteins because of insulin deficiency or problems in the use of insulin. Continuous education of healthcare professionals and patients is essential to reduce the risk of acute complications of the disease and to prevent its chronic sequelae, which have a long-term and expensive treatment regimen. Treatment and follow-up of diabetes should not only reduce the complications of the disease from a medical perspective but also focus on the obstacles that may occur in the professional life of diabetic patients. In recent years, it is estimated that diabetic individuals travel as often as any other healthy individuals, attributed to the rapid increase in diabetes prevalence and increasing popularity of air travel (1). The issuance of flight certificates under certain conditions to pilots with diabetes has also made this issue important for flight personnel. Complications that may develop in diabetic passengers and pilots during the flight may threaten the safety of both passengers and pilots. Therefore, guidelines for diabetic passengers and pilots during a flight have become increasingly important in the recent years.

Air travel results in encountering a hypobaric situation. During a flight, the height is usually around 10,000 to 13,000 m (~30,000 to 42,000 feet), and the cabin pressure is at a level of 0.75 atm, which is 75% of the pressure measured at sea level. Some glucometers have been reported to be affected by changes in altitude, and it was determined that glucose levels were

calculated approximately 1%–2% lower against each 300 m/1000 feet rise (2). Lower oxygen pressure leads to the detection of lower glucose values than actual and incorrectly the risk of monitoring hypo- or normoglycemic values. The reason is that many glucometers use the glucose oxygenase method, which is dependent on oxygen in the environment (3). Although this does not cause a serious problem in patients using oral antidiabetic medications; on long-duration travel, additional medication needs may arise, especially in patients using insulin. The relationship between diabetes and aviation is a controversial issue.

There is a conflict between individual rights and aviation security. Pilots, whose diabetes is under control only with diet and exercise, usually get flight clearance (4-6). Over time, some diabetic pilots, whose diabetes is controlled with oral antidiabetics, also began to be given flight certificates. Traditionally, although aviation and insulin use are considered incompatible with each other, diabetic pilots who have been using insulin in recent years, even in a small number, have been actively working, and this number is increasing around the world (7, 8). The most important concern for diabetic pilots is the effects of hypoglycemia, which may occur during flight, on flight performance (9). This can lead to difficulty in decision-making, orientation disorder, deterioration of cognitive functions, confusion and even loss of consciousness.

In pilots with type 2 DM whose diabetes is controlled only with diet and exercise, the risk of hypoglycemia is no greater than in non-diabetic individuals. However, this risk increases significantly in diabetic pilots using sulfonylurea group oral antidiabetics or insulin. In addition, the risk of hypoglycemia is tri-



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**Table 1. Blood glucose monitoring protocol during a flight**

When should the pilot measure BG	BG	What should the pilot do in this situation
30 minutes before the flight	< 90 mg/dL	A light meal containing 15 g glucose must be eaten, and BG should be re-measured after 30 minutes.
	90–270 mg/dL	Can operate the flight
	> 270 mg/dL	Must cancel the flight
A light meal including glucose 30 minutes after eating (if the first measurement is < 90 mg/dL)	< 90 mg/dL	A light meal containing 15 g glucose must be eaten, and BG should be re-measured after 30 minutes.
	90–270 mg/dL	Can perform the flight
	> 270 mg/dL	Must cancel the flight
During the first 30 minutes of flight, every successive hour of the flight and 30 minutes before landing	< 90 mg/dL	A light meal containing 30 g glucose must be eaten, and then plane should be landed at the nearest convenient airport. When the BG can be kept within the range of 90–270 mg/dL, the flight should be continued.
	90–270 mg/dL	No additional intervention is required.
	> 270 mg/dL	The flight should be landed at the nearest convenient airport, and the flight should be continued when the BG can be kept within the range of 90–270 mg/dL.

\*\*Adapted from the reference #12

pled in pilots, in whom a strict control was targeted for the prevention of diabetes complications (10, 11). Loss of consciousness or confusion caused by severe hypoglycemia during a flight could be catastrophic (12). Hyperglycemia is another problem that pilots should pay attention to in terms of flight safety. It causes serious complications that may affect the pilot's flight ability in the long run. Short-term issues in the form of visual impairments, refractive changes, and frequent urination could also be a complication of hyperglycemia. There is also a risk of developing ketoacidosis and progressing to coma, if left untreated (10, 13). Furthermore, long-term complications such as ischemic heart disease, diabetic retinopathy, diabetic nephropathy, and diabetic neuropathy may also affect the pilot's flight health (8).

Today's aviation conditions impose additional problems on diabetic pilots. In particular, pilots who operate commercial flights often experience serious fatigue, irregular daily programs, and irregular nutrition away from home. In addition, the pilots need to make changes in their insulin treatment on flights with meridian changes (14). As a result, certification is quite a complicated process for pilots with both type 1 and type 2 DM. Pilots who have the ability to perceive low glucose levels and control this situation appropriately can obtain a flight certificate medically with some absolute limitations. After this process is completed and the flight certificate is obtained, pilots can perform their flight duties under certain guidelines.

### Required procedures during flight in pilots with type 1 and type 2 diabetes mellitus treated with insulin

To ensure a safe flight, pilots with type 1 and type 2 DM treated with insulin should keep with them a glucometer that can

measure and record blood glucose (BG) values, a sufficient number of glucose measuring sticks for the evaluation of blood samples and, if necessary, sufficient amount of glucose (glucose tablets, sugar cubes) that can be absorbed quickly, throughout the flight (15). The BG monitoring protocol during flight is shown in Table 1. The information presented in Table 1 is the ideal procedure to be followed when there is no element that can threaten flight safety. However, regarding the determination of BG concentrations and other interventions during flight, pilots should be very careful when deciding whether the relevant situation or the measurement of the BG concentration because of environmental factors such as bad weather conditions that may threaten flight safety is of top priority. In a situation where they decide that it is a priority situation that may threaten flight safety, the pilots should take a meal containing 10 g glucose and measure BG concentration after 1 hour. If it is not suitable owing to conditions to measure BG concentration at that time, they should take another snack including 10 g glucose and should land at the nearest airport for measuring BG concentration (16, 17).

### Flight in passengers with diabetes mellitus

Most diabetic patients treated with insulin or oral antidiabetics can travel safely under acceptable glycemic control, following some important rules during flight. The passengers should keep all their medications with them during the flight. These medicinal liquids, such as insulin, are permitted in quantities above the 100 mL limit, providing that being subjected to identity verification. However, the passengers should inform the relevant airline company about this before traveling. In addition, passengers should keep a document from a specialist physician that reports their medical condition (18). Patients using insulin pumps and/or continuous glucose monitoring (CGM) devices should also contact the airline they will travel with regarding the rules

**Table 2. Safety measures that a diabetic passenger should pay attention to during a flight**

- Frequent glucose monitoring
- When plasma glucose is > 250 mg/dL, ketones in urine should be measured and if positive, extra insulin should be used.
- As it can affect hypoglycemia awareness and diabetes control, avoiding using v
- The nature of the travel:
  - No need to change the timing of insulin or oral antidiabetics if traveling to North or South.
  - If the patient is traveling to the West or East, but the mentioned change is less than 5 hours, patients do not need to change the treatment regimen they are receiving.
  - However, if the change involves 6–12 time zones, the patient may experience problems with meals and the medication dosage schedule (traveling to the West means that the day will be longer, and the person may need more insulin; traveling to the East means that the day will be shorter, and the person may need less insulin). This situation can be resolved by close communication between the patient and physician.

for the use of such devices during flight. Insulin pumps can interact electromagnetically with some safety systems used in the airport. As the metal detector at the airport will not damage the device, the insulin pump and CGM system may remain on the person when passing through such security systems. However, these devices should never be passed through an X-ray machine. When passing through the body scanner at the airport, the pump or CGM system should be removed or a different passing security assessment should be requested. In other words, patients carrying this system should definitely warn the security at the airport. The relevant airline company should be asked to have suitable diabetic meals during the flight. Diabetic passengers should keep their relevant equipment (glucometer, lancet, battery, insulin pump reservoir, insulin pump infusion set, ketone strip, and medical ID card) and medications (oral antidiabetics and insulin) in their hand luggage. They should keep simple carbohydrates, such as glucose tablets or sugar, and foods containing long-acting carbohydrates in their hand luggage against the possibility of delayed meals. Passengers should also keep insulin, which they will not use during flight, in their hand luggage against the possibility of exposure to temperatures that can lead to insulin deterioration (usually freezer) and loss. Glucagon preparations should be carried in their original container, again in the hand luggage (18). Table 2 highlights other points that diabetic passengers should keep in mind during a flight (19).

### What should passengers on insulin therapy pay attention to?

- Patients using insulin twice a day:
- During their travel to the East, patients should have their normal morning injections, however, reduce their evening dose by 10%. It may be more suitable to use insulin in frequent and small doses (such as making a half-dose of fast-acting insulin that you receive before meals) on flights that last more than 24 hours.
  - During their travel to the West, as the patients may remain awake for a long time (6-7 hours) after a normal evening insulin dose and meal, they can take a small dose 6 hours after this dose and then have their meals.

Patients using a single dose of long-acting insulin daily:

- During their travel to the East, these patients should continue their treatment schedules and receive their meals regularly according to the time zone at the destination.
- Traveling to the West does not cause a serious problem, except for a mild hyperglycemia that may occur the next day of arrival. This situation can be corrected by increasing the insulin dose on the relevant day (20).

### Use of insulin pump and continuous glucose monitor systems in passengers

Flight-related hypoglycemia has been reported in diabetic individuals treated with an insulin pump (continuous subcutaneous insulin infusion) (21). This may be related to the compression of air inside the infusion set or the direct effect on the pump's insulin release system. It has been shown that the insulin pump releases more insulin than the rate set during decompression (22). Although the ambient pressure at sea level is 760 mm Hg (1 atmosphere), the cabin pressure decreases to 200–560 mm Hg when the planes rise to 40,000 feet (23). A decrease in the ambient pressure can lead to an undesired release of insulin from the pump. The air dissolves in water in direct proportion to the ambient pressure. When planes rise, the ambient pressure decreases, and air bubbles form in the solution.

The bubbles in the pump are replaced with insulin and lead to an increase in insulin release. This increase in insulin release may lead to the development of hypoglycemia 1–2 hours after departure. When the plane begins to land, the air pressure rises again, and the bubbles dissolve again in the solution and stop the release of insulin for a while. A decrease in insulin release can lead to hyperglycemia. If air bubbles are removed before landing, the pump releases normally (24, 25). These changes in insulin release during a flight can lead to different clinical effects depending on multiple factors such as insulin sensitivity, glycemic control, food intake, and pump settings. A study has shown that changes in the environmental pressure during commercial flights do not affect the mechanical function of an insulin pump. However, to avoid the problems described above, individuals who use insulin pumps should be informed about the issues to be considered during a

**Table 3. Rules to be considered during flight in people who use insulin pumps**

- The cartridge should contain only 1.5 mL of insulin.
- The pump must be disconnected before take-off.
- At the height of the flight, the cartridge must be removed from the pump, and all existing air bubbles removed before reconnecting.
- After landing, the pump must be disconnected, and the line should be filled with 2 U of insulin. Then, the pump should be reconnected.
- In case of flight emergencies, including cabin decompression, the pump should be disconnected.

flight (Table 3) (26). The increasing use of advanced continuous glucose monitor (CGM) systems reveals the importance of evaluating the sensor system as well as the pump function under different pressure conditions (27, 28). In CGM systems, like many glucometers, the glucose oxygenase method is used. However, the accuracy and performance of the CGM system are minimally affected by hypobaric weather conditions such as 0.5 and 0.75 atm (29). However, there are insufficient data in the literature to evaluate the accuracy and performance of insulin pumps and CGM systems during flight conditions in diabetic patients.

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