Impact of High Altitudes on Glucose Control

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Airplane flight results in exposure to hypobaric conditions. At cruising altitude, usually 10,000 to 13,000 meters (~30,000 to 42,000 feet), the pressure in the cabin is 0.75 atm, which is 75% of the pressure measured at sea level. The difference in pressure between 1.0 and 0.75 atm is what passengers experience as temporary ear discomfort at take-off and landing

What does elevation have to do with diabetes then? It would be anticipated that people with diabetes travel as frequently as everybody else. It has been described in the literature[1] that some glucose meters are affected with changes in altitude. The glucometers studied underestimated glucose levels by approximately 1–2% for each 300 meters/1000 feet of elevation after correlation for changes in temperature and humidity. The lower the oxygen partial pressure, the lower the glucose value. Most glucometers use glucose-oxygenase methods, which are dependent on oxygen in the surrounding environment.[2] The partial pressure of oxygen in the airplane cabin is 16 kPa compared to 21 kPa at sea level, thus there is a risk that a glucometer can show a false hypo- or normoglycemia while in the air, when the true value in fact could be higher.

These effects of high altitudes do not apply only to flying conditions. There are many cities around the world situated at high altitudes: Colorado Springs, United States, 1840 meters (~6040 feet); Mexico City, Mexico, 2200 meters (~7220 feet), and La Paz, Bolivia, 3640 meters (~11,940 feet). It might be that people with diabetes living in these cities are taking much lower insulin doses than necessary because of false, low self-monitoring of blood glucose readings and therefore have a higher HbA1c level compared to a similar population living close to sea level. For instance a comparison between residents of Colorado Springs and Boston would be interesting to see.

Hypoglycemia has been reported, in connection to flying, in people with insulin-treated diabetes using continuous subcutaneous insulin infusion.[3] This may be due to trapped air within the ampule/infusion set or related to a direct effect on the pump's insulin delivery system, but this has not been completely investigated. With the increasing use of continuous glucose monitoring (CGM), especially in sensor-augmented pumps,[4] it is of importance that sensor systems as well as insulin pumps be evaluated in various pressure conditions.[5] The glucose oxygenase method is used by CGM systems and by most glucometers. However, the accuracy and performance of one CGM system was minimally affected when challenged under hypobaric conditions at 0.5 and 0.75 atm.[6] The Food and Drug Administration has advocated that all sensors being used for glucose sensing be evaluated under relevant pressure conditions.

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Abbreviations: (CGM) continuous glucose monitoring

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What then are the implications for our patients with diabetes?

It is commonly suggested to refrain from calibrating a CGM during flights. This should be done prior to take-off and/or after landing; however, this has not been investigated. Further studies are needed to assess accuracy and performance of both CGM systems as well as insulin pumps of patients with diabetes under in-flight conditions.

References:

1. Karon BS, Boyd JC, Klee GG. Glucose meter performance criteria for tight glycemic control estimated by simulation modeling. Clin Chem. 2010;56(7):1091–7.
2. Tang Z, Louie RF, Lee JH, Lee DM, Miller EE, Kost GJ. Oxygen effects on glucose meter measurements with glucose dehydrogenase- and oxidase-based test strips for point-of-care testing. Crit Care Med. 2001;29(5):1062–70.
3. King BR, Goss PW, Paterson MA, Crock PA, Anderson DG. Changes in altitude cause unintended insulin delivery from insulin pumps: mechanisms and implications. Diabetes Care. 2011;34(9):1932–3.
4. Hermanides J, Nørgaard K, Bruttomesso D, Mathieu C, Frid A, Dayan CM, Diem P, Fermon C, Wentholt IM, Hoekstra JB, Devries JH. Sensor-augmented pump therapy lowers HbA(1c) in suboptimally controlled Type 1 diabetes; a randomized controlled trial. Diabet Med. 2011;28(10):1158–67.
5. Price ME Jr, Hammett-Stabler C, Kemper GB, Davis MG, Piepmeier EH Jr. Evaluation of glucose monitoring devices in the hyperbaric chamber. Mil Med. 1995;160(3):143–6.
6. Jendle J, Adolfsson P, Örnhagen H, Shad R, Cooper K, Gautham R. Glucose sensor performance during pressure changes. Diabetologia. 2011;54(Suppl 1) S396.