The Correlation Between Breath Acetone and Blood Betahydroxybutyrate in Individuals with Type 1 Diabetes

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Abstract

Ketone testing is an important element of the self-management of illness in type 1 diabetes. The aim of the present study was to see if a breath test for acetone could be used to predict quantitatively the levels of the ketone betahydroxybutyrate in the blood of those with type 1 diabetes, and thus be used as an alternative to capillary testing for ketones. Simultaneous capillary ketones and breath acetone were measured in 72 individuals with type 1 diabetes attending a diabetes clinic and on 9 individuals admitted to hospital with diabetic ketoacidosis. Capillary blood measurements ranged from 0.1 mmol l−1 (the lower limit of the ketone monitor) to over 7 mmol l−1 , with breath acetone varying between 0.25 and 474 parts per million by volume. The two variables were found to be correlated and allowed modelling to be carried out which separated breath acetone levels into three categories corresponding to normal, elevated and 'at risk' levels of blood ketones. The results on this limited set of participants suggest that a breath acetone test could be a simple, non-invasive substitute for capillary ketone measurement in type 1 diabetes.

It has long been known that elevated levels of breath acetone can occur in individuals with untreated type 1 diabetes, and there has been much effort devoted to studies attempting to show the usefulness of acetone breath testing in the management or diagnosis of the disease. Acetone is formed by the decarboxylation of a ketoacid, acetoacetic acid, which is virtually 100% dissociated in the blood to form the acetoacetate anion (AcAc). Acetone is highly soluble in blood plasma, and appears in breath following gas exchange in the alveoli. Normal levels of acetone in the breath are between 0.3 and 1 parts per million by volume (ppm) and correspond to plasma levels of approximately 0.03 mmol l−1 , with AcAc of the order of 0.02–0.1 mmol l−1. However when insulin levels are low, the concentration of acetone increases as a result of the mechanism controlling the formation of its precursor, AcAc. Insulin mediates the concentrations of non-esterified fatty acids (NEFA) in the blood by providing a route for their esterification, and increased concentrations of NEFA caused by low insulin levels result in the rates of both transport into the hepatic mitochondria and conversion therein to AcAc being increased. AcAc can be reduced to betahydroxybutyric acid, which again is virtually fully dissociated, forming the betahydroxybutyrate anion, βHB. AcAc and βHB can increase in concentration when insulin is deficient or ineffective, with βHB predominating. Acetone, AcAc and βHB are collectively referred to as 'ketone bodies' in the blood: acetone is present as the neutral molecule, whilst the other two species are anions and thus their production from the two ketoacids also yields hydrogen ions. Excess ketoacids formed when insulin is insufficient can therefore give rise to a significant lowering of the blood pH if the normal buffering action of bicarbonate is overwhelmed, ultimately resulting in diabetic ketoacidosis, DKA.

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