Analyzing patient breath to detect stomach infection and type-2 diabetes via cavity enhanced laser spectrometry

Los Gatos Research (LGR)

Non-invasive analysis of patient breath using LGR carbon dioxide isotope analyzers

Measurement made easy

Introduction

Recent research at the S.N. Bose National Centre for Basic Sciences in India has shown that non-invasive analysis of patient breath shows great promise for detecting disease. The researchers analyzed exhaled breath via Off-Axis Integrated Cavity Output Spectroscopy (Off-Axis ICOS). They measured a stable isotope of carbon (¹³C) in the breath to quickly and accurately diagnose stomach ulcers caused by Helicobacter pylori (H. pylori) infection. The researchers also showed that a similar technique could also diagnose type-2 diabetes.

The study included 32 people suffering from different types of gastrointestinal disorders determined by endoscopy and biopsy tests to be H. pylori infection. Blood tests confirmed the status of type-2 diabetes. After an overnight fast, researchers collected a baseline exhaled breath sample from each. The subjects then drank either 75 mg ¹³C-labelled urea or ¹³C-enriched glucose dissolved in 200 ml of water. Researchers then collected post-dose breath samples in 15 minute intervals for up to 90 minutes for H. pylori detection and in 30 minute intervals for up to 300 minutes for type 2 diabetes.

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LGR carbon dioxide isotope analyzers

The analyzer used in the study was a carbon dioxide isotope analyzer from Los Gatos Research, a member of the ABB Group. A tunable diode laser operating at a wavelength near 2.05 μm was coupled into a 59 cm long optical cavity in an off-axis fashion. The cavity consisted of two highly reflective mirrors (R>99.99 %) at each end that extended the effective optical path length to over three kilometers. The laser is tuned over a 20 GHz span for rapid scanning to measure optical absorption induced by $^{12}\text{CO}_2$ and $^{13}\text{CO}_2$, and determine the isotope ratio, expressed as $\delta^{13}\text{C}\%o$. A feedback-controlled resistive heater and a diaphragm pump maintained temperature and pressure in the cavity at 45 °C and 38 mmHg respectively. For accurate and precise measurement, the system was calibrated with three standard gases of known concentration and isotope ratio. Researchers took 25 ml breath samples from the patients in an air-tight syringe and then injected the sample into the cavity.

In the cases of positive H. pylori infection, researchers observed that the Delta-Over-Baseline (DOB) values of $\delta^{13}\text{C}\%o$ reached a maximum in 30 minutes and then slowly decreased (see Figure 1). They observed no significant differences of DOB $\delta^{13}\text{C}\%o$ values in breath samples from the negative H. pylori patients.

Figure 1  Breath analysis results for H. pylori
Figure 2 displays the $^{13}$C-glucose derived DOB of $^{13}$CO$_2$ in 30 minute intervals of control, pre-diabetes, type-2 diabetes patients. The values were significantly lower for diabetes compared to pre-diabetes and control subjects from one to 4.5 hours. It was significantly higher for controls than pre-diabetes from 0.5 hours to 3.5 hours. Diabetic subjects produced the least amount of $^{13}$CO$_2$ in their exhaled breath compared to pre-diabetes and control subjects.

It can provide information in the very early stages of the disease without the need for conventional invasive blood- and biopsy-based tissue sampling. These new techniques eliminate prolonged testing times, high cost and patient inconvenience. As a result they can possibly become practical for routine clinical use, including large-scale screening tests in real-time.

These results suggest that breath analysis with laser-based cavity enhanced spectrometry may assist in accurate and fast noninvasive detection of H. pylori infection and type-2 diabetes. Advantages of this new diagnostic technique are many. Breath analysis by Off-Axis ICOS is painless as well as devoid of risk for the patient even if frequently repeated.