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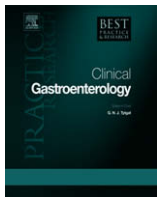

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Methods and functions: Breath tests

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Breath tests provide a valuable non-invasive diagnostic strategy to in vivo assess a variety of enzyme activities, organ functions or transport processes. Both the hydrogen breath tests and the ^{13}C-breath tests using the stable isotope ^{13}C as tracer are non-radioactive and safe, also in children and pregnancy.

Hydrogen breath tests are widely used in clinical practice to explore gastrointestinal disorders. They are applied for diagnosing carbohydrate malassimilation, small intestinal bacterial overgrowth and for measuring the orocecal transit time.

^{13}C-breath tests non-invasively monitor the metabolisation of a ^{13}C-labelled substrate. Depending on the choice of the substrate they enable the assessment of gastric bacterial *Helicobacter pylori* infection, gastric emptying, liver and pancreatic function as well as measurements of many other enzyme activities.

The knowledge of potential pitfalls and influencing factors are important for correct interpretation of breath test results before drawing clinical conclusions.

Hydrogen breath tests

Principle

The technique of hydrogen breath tests is based on the principle that there is no human hydrogen gas production, but hydrogen is produced by intestinal bacteria when ingested carbohydrates escape complete absorption in the small intestine. Usually, hydrogen producing bacteria only colonise the colon. A fixed fraction of this colonic hydrogen diffuses into the bloodstream and is exhaled by the lungs where it can be analysed in breath (Fig. 1).

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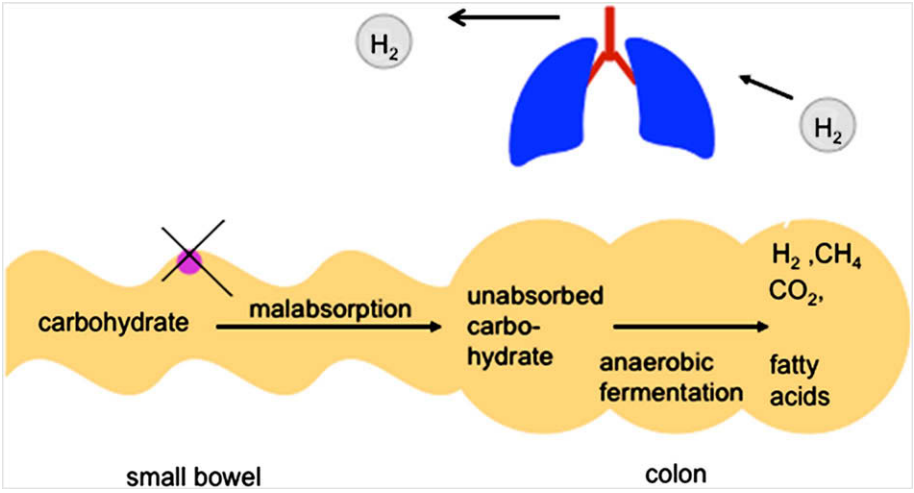

Fig. 1. Principle of hydrogen breath tests.

This principle can be applied to control the absorption of absorbable carbohydrates. **Malabsorption** of an orally ingested carbohydrate such as lactose or fructose is indicated by a significant increase in breath hydrogen as the non-absorbed carbohydrate undergoes bacterial metabolisation to hydrogen in the colon.

If a carbohydrate such as lactulose is physiologically not absorbed in the small intestine its bacterial degradation in the colon and subsequent increase in breath hydrogen can indicate when the substrate has reached the large bowel and therewith the **orocoecal transit time**.

In patients with **small bowel bacterial overgrowth** hydrogen producing bacteria also colonise the small intestine. Orally ingested absorbable carbohydrates such as glucose are bacterially fermented in the small intestine before they can be absorbed leading to an increase in breath hydrogen.

Analysis of hydrogen in breath

Hydrogen concentrations in endexspiratory breath samples are measured using gas chromatography or electrochemical cells. Portable, even pocket sized breath analysers enable a reliable direct measurement in practice or at bedside [1,2]. As hydrogen has a high diffusion capacity samples should be analysed if possible immediately and not be stored longer than 12 h. The hydrogen concentration is expressed as ppm (parts per million). The increase of the hydrogen concentration in breath samples taken at defined time points during the test period is related to the baseline value before ingestion of the test substrate. Normal hydrogen baseline values are reported to be 7 ± 5 ppm [3]. Baseline values $>$15–20 ppm do not allow a reliable test performance.

General factors affecting hydrogen breath tests

The interpretation of hydrogen breath tests can be difficult and therefore the knowledge of influencing factors is important.

The hydrogen breath test depends on the presence of hydrogen producing bacteria. However, the colonic flora of some patients does not produce hydrogen. So called 'non-H2-producers' are found in 3–25% and will result in false negative hydrogen breath test results. This can be explained by the predominance of methane producing bacteria in the colon which use hydrogen to reduce carbon dioxide to methane [4,5]. Some groups try to overcome this problem by initial testing for non-H2-producers using lactulose as this is physiologically not absorbed in the human body and will result