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Time-Course of Cigarette Smoke Contamination of Clinical Hydrogen Breath-Analysis Tests

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The time-course of the contamination of exogenous hydrogen from cigarette smoke on postprandial breath hydrogen concentration was evaluated in 10 subjects, six regular smokers and four occasional smokers. Breath hydrogen values were determined by gas chromatography 10 min, 5 min, and immediately prior to smoking a filter cigarette; during smoking from a sample of exhaled air containing smoke; and 5, 10, and 15 min after extinguishing the cigarette. A three- to 137-fold increase above basal hydrogen concentrations was produced by exhaled cigarette smoke, but most subjects had re-equilibrated to baseline values within 10 to 15 min after the cigarette. If subjects undergoing clinical hydrogen breath tests cannot refrain from smoking during the duration of the test, one should allow an interval of at least 15 min from the end of smoking to the collection of a breath sample.

Additional Keyphrases: *variation, source of · chromatography, gas*

The hydrogen breath-analysis test has been used in gastrointestinal diagnosis for over a decade (*1*), its primary application being in evaluation of lactose malabsorption (*2–4*). The technique is based on the principle that hydrogen is produced in the colon by normal fecal bacteria when ingested carbohydrate escapes complete absorption in the small intestine; a fixed fraction of this colonic hydrogen is absorbed into the bloodstream and excreted by the lungs (*5*).

Although the original test was based on continuous collection of expired air in a closed system (*6*), subsequent procedures for breath H_2 tests involved sampling the air at fixed periods after the oral carbohydrate load (*2, 3, 7*).

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Tadesse and Eastwood (*8*) reported a substantial increase in breath H_2 and CH_4 concentrations when cigarettes were smoked during the course of a breath test. Because the contaminant gases in cigarette smoke are of *exogenous* origin and poorly soluble in blood, they postulated that the interference caused by smoking would be transient. However, they studied only five subjects. In their report, they provide only mean data, no individual data or any expression of variance around the mean, and no indication of whether the subjects were fasting or in the postprandial state at the time of study.

We encountered a subject with unexpectedly high and erratic values for H_2, unexplained until she was discovered smoking surreptitiously during the course of a lactose absorption test. We then undertook to re-evaluate the issue of cigarette-smoke contamination of expired air in the context of a H_2 breath test.

Materials and Methods

Ten healthy subjects participated in the study. Six were regular smokers, who consumed at least 20 cigarettes per day; the remaining four were occasional smokers. They ranged in age from 20 to 39 years, and none had obvious clinical manifestations of chronic lung disease. One subject was studied in the fasting state; the remainder were studied at various intervals after meals.

Samples of mixed, expired air were collected by having subjects breathe through a low-resistance, one-way Hans Rudolph valve into a 5-L gas-bag. Breath H_2 concentration was measured in a gas chromatograph (Microlyzer Model 12; Quintron Instruments Co., Milwaukee, WI 53215), calibrated with a standard gas mixture containing 100 μL/L of H_2 in N_2 (Scotty Gas II; Supelco Inc. Bellefonte, PA 16823) (*9, 10*). Samples of air were collected 10 min, 5 min, and immediately before the test for [illegible] was lit. While smoking, subjects exhaled [illegible] cigarette smoke directly into the gas-bag [illegible] of the cigarette. The [illegible]

to completion, then samples of breath were collected 5, 10, and 15 min later. A total of seven breath samples were collected and analyzed for each subject.

Results

Table 1 shows the absolute concentrations of breath H_2 before, during, and after smoking. The average breath H_2 concentration from exhaled breath containing cigarette smoke was 123 (SD 44) μL/L. The three pre-cigarette H_2 concentrations were averaged for each individual, and the increase or decrease in breath H_2 concentration, in terms of percentage of the pre-smoking mean, was computed for the samples collected during and after smoking (Table 2). Mean H_2 concentrations during smoking were twice those reported by Tadesse and Eastwood (*8*), but the range was broad, probably reflecting the depth of inhaling. Although in eight of 10 subjects values for H_2 were the same or lower than one or more value recorded before smoking, the mean after-smoking values were slightly higher, and the variance was slightly greater.

Discussion

We confirm the previous observations (*8*) that cigarette smoke induces a massive increase in breath H_2 concentration due to exogenous contamination of alveolar gas with H_2 from the cigarette. The increase appears to be transient, and H_2 is rapidly washed out of the lungs of young, healthy volunteers. Within 10 or 15 min, most of our subjects seem to have re-equilibrated to their pre-smoking breath-H_2 concentrations, or the trend of the data was consistent with a postprandial response to dietary carbohydrate incompletely absorbed from their last meal. Our design simulated actual clinical breath tests by including subjects who had consumed carbohydrates shortly before the test.

Because gas exchange is impaired in individuals with emphysematous changes of their lungs secondary to chronic smoking, a greater persistence of residual cigarette smoke might be seen in patients with chronic lung disease. Poor gas exchange, however, might confound the reliability of any interval-sampling collection procedure for such patients, even in the absence of concurrent smoking.

The H_2 breath-test technique is a simple, non-invasive, inexpensive approach to the diagnosis of some gastrointestinal disorders (*1, 11*). Our study shows that the contamination of expired air with H_2 produced by tobacco smoking is a transient phenomenon. The H_2 is rapidly washed out of the lungs, and, if there is a sufficient interval before breath collection, smoking should not interfere with a valid recording of the breath H_2 response to an ingested carbohydrate. Tadesse and Eastwood (*8*) suggested that at least 10 min be allowed between the end of cigarette smoking and collection of a breath sample; our data are consistent with that recommendation.

We do not advocate smoking during the H_2 breath-analysis test, and feel that efforts to encourage subjects to refrain from this practice during the entire duration of a study should be made. However, in community-level surveys of lactose absorption, in which minute-to-minute control of each subject is difficult and in which initial cooperation is dependent upon the acceptability of the restrictions and inconveniences imposed, allowing an insistent subject to smoke—except within 10 to 15 min of collection—might facilitate his or her participation. Moreover, in the occasional patient in the clinic who is made unbearably uncomfortable by prolonged abstinence from smoking, the use of cigarettes away from the collection intervals should not interfere with the validity of the results. The effect of cigarette smoke contamination in tests on individuals with severe lung disease remains to be evaluated.

Table 1. Breath H_2 Concentrations before, during, and after Smoking a Cigarette

	H_2 concn, μL/L						
Subjects	10 min prior	5 min prior	Zero time	During smoke	5 min after	10 min after	15 min after
1	1	2	2	95	3	2	2
2	3	2	4	159	4	4	3
3	6	9	9	87	14	9	12
4	24	30	32	120	48	67	67
5	2	2	3	75	6	4	4
6	1	1	1	138	3	1	1
7	13	15	13	163	7	19	19
8	3	6	7	147	7	7	6
9	5	4	5	54	6	5	5
10	8	14	16	188	23	12	20
$\bar{X}$	7	8	9	123	12	13	14
(SD)	(7)	(9)	(9)	(44)	(14)	(20)	(20)

Table 2. Relative Change in Breath H_2 Concentration during and after Smoking a Cigarette, Compared with Concentration at Zero Time

	% change in H_2 concn			
Subjects	During smoke	5 min after	10 min after	15 min after
1	5588	80	20	20
2	5200	33	33	0
3	988	75	12	50
4	319	67	134	134
5	3119	158	72	72
6	13700	200	0	0
7	1092	−49	39	39
8	2658	31	31	13
9	1056	28	7	7
10	1383	82	−5	58

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