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Original Article

Association Between Halitosis Diagnosed by a Questionnaire and Halimeter and Symptoms of Gastroesophageal Reflux Disease

Hyo-Jung Lee,[1] Hee Man Kim,[2] Nayoung Kim,[3,4]* Jane C Oh,[5] Hyun Jin Jo,[3] Jung-Tae Lee,[1] Hee-Yung Chang,[6] Na-Hee Chang,[7,8] Soyeon Ahn[9] and Jeong-Yun Lee[10]

[1]Departments of Periodontology, Section of Dentistry and [3]Internal Medicine, Seoul National University Bundang Hospital, Seoungnam, Gyeonggi-do, Korea; [2]Department of Internal Medicine, Yonsei University Wonju College of Medicine, Wonju, Gangwon-do, Korea; [4]Department of Internal Medicine and Liver Research Institute, Seoul National University College of Medicine, Seoul, Korea; [5]Yonsei Plus Clinic, Seongnam, Gyeonggi-do, Korea; [6]Department of Periodontology, School of Dentistry, Wonkwang University, Iksan, Jeollabuk-do, Korea; [7]Department of Public Health, Graduate School of Chungang University, Seoul, Korea; [8]Biomedical Research Institute, Seoul National University Bundang Hospital, Gyeonggi-do, Korea; [9]Medical Research Collaborating Center, Seoul National University Bundang Hospital, Gyeonggi-do, Korea; and [10]Department of Oral Medicine and Oral Diagnosis, School of Dentistry, Seoul National University, Seoul, Korea

Background/Aims

The relationship between halitosis and gastroesophageal reflux disease (GERD) remains controversial. The aim of this study was to investigate an association between subjective and objective halitosis and GERD.

Methods

The subjects were enrolled from participants who visited a health promotion center at Seoul National University Bundang Hospital. For diagnosis of halitosis, a questionnaire was requested, and volatile sulfur compounds (VSCs) were measured by Halimeter. Self-conscious halitosis was defined as halitosis perceived by himself or herself. Informed halitosis was defined as halitosis perceived by others. Objective halitosis was defined when mean VSCs values were > 100 parts per billion. GERD was defined based on a questionnaire and endoscopy, including erosive esophagitis and non-erosive reflux disease (NERD).

Results

A total of 54 subjects (male:female = 33:21) with mean age of 46.0 ± 11.4 years were analyzed. The mean VSCs values were not significantly different between presence and absence of self-conscious halitosis (P = 0.322), but significantly different between presence and absence of informed halitosis (P = 0.021). Informed halitosis was associated with objective halitosis (P = 0.039). GERD, erosive esophagitis and NERD did not correlate with objective halitosis (P = 0.556, 0.206 and 0.902, respectively). In multivariable analysis, the relationship between objective halitosis and GERD symptoms including chest pain, heart burn, acid regurgitation, epigastric pain, hoarseness, globus sensation and coughing was not significant. Besides, GERD was not associated with self-conscious halitosis, informed halitosis and objective halitosis, respectively.

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*Correspondence: Nayoung Kim, MD, PhD
Department of Internal Medicine, Seoul National University Bundang Hospital, 173-82, Gumi-ro, Bundang-gu, Seongnam, Gyeonggi-do 463-707, Korea
Tel: +82-31-787-7008, Fax: +82-31-787-4051, E-mail: nayoungkim49@empas.com
Hyo-Jung Lee and Hee Man Kim equally contributed to this work.

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ORCID: Nayoung Kim, http://orcid.org/0000-0002-9397-0406;

Conclusions
GERD might not be associated with self-conscious, informed halitosis and objective halitosis indicated by Halimeter results. Informed halitosis could be correlated with objective halitosis determined by the Halimeter.
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Key Words
Halitosis; Gastroesophageal reflux; Questionnaires

Introduction

Halitosis is a general term used to define an unpleasant odor from the breath. Halitosis itself is not a serious illness but it frequently causes a very troublesome situation in interpersonal social relationship.[1,2] It has become an important market for the pharmacological and cosmetic industries.[3] The prevalence of halitosis varies according to study populations because the perception of halitosis differs among culturally diverse population.[3] In Japan, population-based studies have reported that the prevalence of halitosis is 6-23%.[4,5] In other countries, even more than 50% of the study population has been estimated to have halitosis.[6]

The causes of halitosis are mainly related to intraoral factors including microorganisms on the dorsal surface of tongue.[7-11] Volatile sulfur compounds (VSCs) including hydrogen sulfide, methyl mercaptan and dimethyl sulfide are known as the main components of halitosis, and they are usually produced by degradation of amino acids by gram negative anaerobic oral bacteria.[4,9,12] Non-oral factors of halitosis include pharyngotonsillar problems, problems of the gastrointestinal and respiratory system, liver cirrhosis, chronic renal failure, diabetes mellitus, even malignant disease, as well as imaginary halitosis such as pseudo-halitosis or halitophobia.[5,13,14]

Halitosis has been considered to be associated with the gastrointestinal system. As many as 41% of German dentists have believed that halitosis is caused mostly by stomach problems.[5] Recently, gastroesophageal reflux disease (GERD) has been reported to be one of the causes of halitosis.[15-19] Moreover a study has reported that GERD-related symptoms were associated with halitosis, regardless of the oral conditions.[17] In contrast, some studies have reported that halitosis is not associated with erosive GERD.[20,21] The relationship between halitosis and GERD therefore remains controversial.

The diagnostic method of halitosis has not been standardized, and there is no consensus of diagnostic criteria for halitosis. So far, the diagnosis of halitosis has been mainly dependent on subjective self-reported questionnaires developed by various researchers.[17-19] A Halimeter (RH-17K; Interscan Co., Chatsworth, CA, USA) has been introduced for diagnosis of halitosis by detecting VSCs, and is considered as an objective test for halitosis. The aim of this study was to investigate an association between GERD and halitosis diagnosed by self-reported questionnaires and VSCs measurements by the Halimeter.

Materials and Methods

Subjects

The study subjects were collected from the participants who had visited the Health Promotion Center at Seoul National University Bundang Hospital, Seongnam, Republic of Korea. This examination program included anthropometric measurement, a blood test, X-ray and esophagogastroduodenoscopy. Prior to the commencement of this study, all subjects were given an explanation of the study and signed informed consent forms. The subjects were requested to complete 3 types of questionnaires: (1) lifestyle habits and comorbidities, (2) halitosis questionnaire and (3) symptoms of gastroesophageal reflux. The participants who did not receive some part of health examination or did not complete a questionnaire were excluded. The participants whose values of VSCs by the Halimeter were $>$ 500 parts per billion (ppb) or $<$ 10 ppb were excluded. This study protocol was approved by the Institutional Review Board of Seoul National University Bundang Hospital (No. B-1102/122-301).

Halitosis Assessment

Halitosis questionnaire

The halitosis questionnaire was developed to assess subjective halitosis. The questionnaire includes questions about halitosis-related themes: presence of self-perceived halitosis, presence of hal-

itosis perceived by others, frequency, onset and duration of halitosis, oral conditions, and oral hygiene. The questions of the questionnaire are as follows: (1) Can you detect your bad breath? (a. yes, b. no) (2) How did you know that you have bad breath? (a. I know myself, b. I guess from other's comment. c. I think only I can detect my bad breath) (3) Have you ever been shocked by other people's reaction to your bad breath? (a. yes, b. no) (4) Do you have sinus infection? (a. yes, b. no) (5) Do you have rhinitis? (a. yes, b. no).

Volatile sulfur compounds measurement using Halimeter

The concentration of VSCs was measured by Halimeter (RH-17K; Interscan Co., Chatsworth, CA, USA).[22-25] The measurement of VSCs was performed in the morning (from 8 AM to11 AM). All subjects refrained from any oral activity such as food intake for at least 2 hours prior to the measurement. The subjects were instructed to close their mouths for 3 minutes, breathing only through the nose before every measurement, followed by a straw connected to the Halimeter being placed at 4 cm into their mouth. The measurement was done automatically and the mean value of consecutive 3-time measures was used for analysis.[8]

Definition

Subjective halitosis was defined as 2 types of halitosis: self-conscious halitosis and informed halitosis. Subsequently, self-conscious halitosis was defined as halitosis perceived by himself or herself. Informed halitosis was defined as halitosis when he or she was told by others that he or she had a malodor from his or her mouth. Objective halitosis was defined as $>$ 100 ppb of VSCs concentration measured by the Halimeter.[9,11,26] GERD included non-erosive reflux disease (NERD) and erosive esophagitis with or without gastroesophageal reflux symptoms surveyed by a questionnaire. Erosive esophagitis was defined based on the endoscopic findings according to the Los Angeles classification. NERD was diagnosed when a subject responded that reflux symptoms were present at a frequency of at least once per week in the absence of erosive esophagitis.[27] The questions of the GERD questionnaire are as follows[27,28]: (1) Have you experienced heartburn (a. soreness in the substernal area, b. a burning sensation or discomfort in the substernal area, c. sensation of salt pepper in the epigastric area or d. a burning sensation induced by water swallowing) within the past year? (2) Have you experienced acid regurgitation (a. sour water brash in the mouth or throat, b. a sense of food regurgitation) within the past year? (3) Have you experienced chest pain within the past year? (4) Have you experienced hoarseness within the past year? (5) Have you experienced a globus sensation in the throat (a. foreign body sensation in the throat, b. sticky food sensation in the epigastric area) within the past year? (6) Have you experienced a frequent cough within the past year? (7) Have you experienced epigastric soreness within the past year? The subjects who responded positively to any one of these 7 symptoms were asked to choose the most bothersome symptom. In addition, the frequency (a. 1-2 times per year, b. 1-2 times per month, c. 1-2 times per week, d. 3-4 times per week, e. daily) and severity (a. mild; b. moderate, bothersome to everyday life; c. severely disturbing work or sleeping) of the most bothersome symptom was determined. In addition, subjects were asked whether they had taken histamine type 2 (H2) receptor blocker or proton pump inhibitor (PPI) to relieve these symptoms.

Statistical Methods

The statistical analysis was performed using SPSS software (SPSS version 18.0, Chicago, IL, USA). Student's t test was used to compare means. The Chi-square test and Fisher's exact test were used to investigate relationships among factors. Multivariable analysis was performed using a logistic regression model. A value of less than $P < 0.05$ was considered to indicate a statistically significant difference.

Results

Between July 2011 and August 2012, a total of 93 subjects who had visited the Health Promotion Center were enrolled. Of them, 34 subjects were excluded because they did not receive upper GI endoscopy, and 5 patients were excluded because they had extreme values of VSCs ($>$ 500 ppb or $<$ 10 ppb). A total of 54 subjects including 33 (61.1%) male and 21 (38.9%) female were analyzed in this study, and the mean age was 46.0 $\pm$ 11.4 years (Table 1). The mean values of VSCs did not differ according to the status of obesity, alcohol intake, smoking, rhinitis and sinusitis (P = 0.068, 0.923, 0.209, 0.625 and 0.623, respectively). The subjects with diabetes mellitus had higher levels of VSCs than those without diabetes mellitus (329.4 $\pm$ 205.3 ppb vs. 132.2 $\pm$ 88.5 ppb, P = 0.034). The number of subject with self-conscious halitosis was 30 (55.5%) and the number of subject with informed halitosis was 12 (22.2%). The mean VSCs value was not significantly different between presence and absence of self-conscious halitosis (P = 0.322). The presence of informed halitosis showed higher values of VSCs than the absence of informed hal-

Table 1. Baseline Characteristics of All Subjects (N = 54)

	Halimeter (mean ± SD, ppb)	*P*-value	Halimeter		*P*-value
			> 100 ppb (n [%])	≤ 100 ppb (n [%])	
Number of subjects	54		31	23	
Age (mean ± SD, yr)	46.0 ± 11.4		44.71 ± 10.3	47.78 ± 12.7	0.127
Gender		0.684			0.246
Male	155.9 ± 115.8		21 (67.7)	12 (52.2)	
Female	141.8 ± 120.2		10 (32.3)	11 (47.8)	
Body mass index		0.675			0.462
≥ 25 kg/m^2[a]	160.1± 129.3		11 (35.5)	6 (26.1)	
< 25 kg/m^2	146.0 ± 111.9		20 (64.5)	17 (73.9)	
Alcohol consumption		0.923			0.836
Yes	137.0 ± 91.0		18 (58.1)	14 (60.9)	
No	170.0 ± 146.3		13 (41.9)	9 (39.1)	
Smoking		0.209			0.319
Yes[b]	181.8 ± 128.9		8 (25.8)	3 (13.0)	
No	142.4 ± 113.5		23 (74.2)	20 (87.0)	
Diabetes Mellitus		0.034			0.380
Yes	329.4 ± 205.3		4 (12.9)	1 (4.3)	
No	132.2 ± 88.5		27 (87.1)	22 (95.7)	
Rhinitis		0.625			0.462
Yes	169.5± 124.8		11 (35.5)	6 (26.1)	
No	141.7± 113.3		20 (64.5)	17 (73.9)	
Sinusitis		0.623			0.273
Yes	172.2 ± 98.1		7 (22.6)	2 (8.7)	
No	146.1 ± 120.5		24 (77.4)	21 (91.3)	
Self-conscious halitosis		0.322			0.667
Yes	166.7 ± 131.0		18 (58.1)	12 (52.2)	
No	130.1 ± 94.4		13 (41.9)	11 (47.8)	
Informed halitosis		0.021			0.039
Yes	215.6 ± 128.1		10 (32.3)	2 (8.7)	
No	131.8 ± 107.6		21 (67.7)	21 (91.3)	
GERD		0.126			0.556
Yes	81.5 ± 60.9		6 (19.4)	6 (26.1)	
No	156.6 ± 119.4		25 (80.6)	17 (73.9)	
Erosive esophagitis		0.787			0.206
Yes	139.3 ± 97.6		2 (6.5)	4 (17.4)	
No	149.6 ± 121.0		29 (93.5)	19 (82.6)	
NERD		0.963			0.902
Yes	152.1 ± 103.1		5 (16.1)	4 (17.4)	
No	150.1 ± 120.2		26 (83.9)	19 (82.6)	

[a]Obesity in Korean is defined as ≥ 25 kg/m^2 in body mass index, [b]Current and former.
GERD, gastroesophageal reflux disease; NERD, non-erosive reflux disease.

itosis (P = 0.021), and informed halitosis correlated with objective halitosis diagnosed by Halimeter (P = 0.039). GERD, erosive esophagitis and NERD were not significantly associated with objective halitosis (P = 0.556, 0.206 and 0.902, respectively).

GERD symptoms, including chest pain, heartburn, acid regurgitation, epigastric soreness, hoarseness, globus sensation and coughing, were not significantly associated with objective halitosis (Table 2). In multivariable analysis, each of GERD symptoms was not significantly associated with objective halitosis (Table 2).

In multivariable analysis, self-conscious halitosis was not sig-

Table 2. Association Between Symptoms of Gastroesophageal Reflux Disease and Halimeter

	Halimeter			Halimeter (> 100 ppb)		
	> 100 ppb (n = 31, n [%])	≤ 100 ppb (n = 23, n [5])	*P*-value	OR[a]	95% CI	*P*-value
Chest pain			0.217			0.369
Yes	3 (9.7)	5 (21.7)		0.48	0.01-2.39	
No	28 (90.3)	18 (78.3)				
Heartburn			0.717			0.120
Yes	6 (19.4)	3 (13.0)		3.19	0.74-13.75	
No	25 (80.6)	20 (87.0)				
Acid regurgitation			0.529			0.762
Yes	12 (38.7)	7 (30.4)		1.20	0.37-3.94	
No	19 (61.3)	16 (69.6)				
Epigastric soreness			0.981			0.776
Yes	8 (25.8)	6 (26.1)		0.83	0.23-3.03	
No	23 (74.2)	17 (73.9)				
Hoarseness			0.218			0.123
Yes	6 (19.4)	1 (4.3)		5.28	0.62-54.55	
No	25 (80.6)	22 (95.7)				
Globus sensation			0.443			0.410
Yes	3 (9.7)	4 (17.4)		0.51	0.10-2.54	
No	28 (90.3)	19 (82.6)				
Coughing			0.741			0.640
Yes	7 (22.6)	4 (17.4)		1.39	0.35-5.44	
No	24 (77.4)	19 (82.6)				

[a]Adjustment for age and gender.

Table 3. Multivariable Analysis Association Between Halitosis and Gastroesophageal Reflux Disease

	Self-conscious halitosis			Informed halitosis			Halimeter (> 100 ppb)		
	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value
GERD	3.00	0.56-16.14	0.201	0.55	0.09-3.54	0.530	0.69	0.17-2.78	0.598
Age (≥ 45 yr)	0.41	0.11-1.46	0.167	7.11	1.11-45.60	0.039	0.90	0.27-3.05	0.865
Gender (male)	0.24	0.05-1.24	0.042	0.88	0.13-6.16	0.898	2.29	0.48-10.90	0.297
Obesity	1.90	0.37-9.82	0.442	4.68	0.83-26.47	0.081	1.30	0.32-5.32	0.713
Smoking	6.52	1.07-39.63	0.042	2.00	0.28-14.33	0.489	1.76	0.32-9.85	0.519
Alcohol	0.43	0.10-1.95	0.274	0.44	0.07-2.76	0.383	0.38	0.09-1.70	0.208
Rhinitis	2.81	0.43-18.38	0.281	3.36	0.49-23.22	0.219	1.38	0.30-6.27	0.678
Sinusitis	0.54	0.06-4.99	0.586	1.55	0.17-13.99	0.697	2.89	0.37-22.49	0.310

GERD, gastroesophageal reflux disease.
Multivariable analysis using logistic regression model: age, gender, smoking, alcohol, rhinitis and sinusitis.

nificantly associated with GERD (odds ratio [OR], 3.00; 95% confidence interval [CI], 0.56-16.14) (Table 3). Smoking was strongly associated with self-conscious halitosis (6.52; 95% CI, 1.07-39.63). Informed halitosis was not significantly associated with GERD (OR, 0.55; 95% CI, 0.09-3.54). Old age was strongly associated with informed halitosis (OR, 7.11; 95% CI, 1.11-45.60). Objective halitosis was not significantly associated with GERD (OR, 0.69; 95% CI, 0.17-2.78).

Discussion

This study showed that GERD was not significantly asso-

Table 4. Review of Studies Investigating the Association Between Halitosis and Gastroesophageal Reflux Disease

References	Year	Subjects		Diagnostic methods		Association between halitosis and GERD	
		Total	Subgroups	Halitosis	GERD	Conclusion	
Moshkowitz et al[19]	2007	132	GERD (n = 72)	Self-reportedquestionnaire	1. Endoscopy 2. Questionnaire	Positive	Halitosis and GERD
Di Fede et al[18]	2008	300	GERD (n = 200) Control (n = 100)	Self-reported questionnaire	1. Endoscopy 2. 24-hour esophageal pH test	Positive	Halitosis and GERD
Yoo et al[29]	2008	72	*H. pylori* infection(n = 72) Erosive mucosal lesion (n = 48) Non-erosive mucosal lesion (n = 24)	1. Halimeter 2. VSC-generating enzyme measurement	Endoscopy	Positive	Halitosis and erosive mucosal lesion
Struch et al[17]	2008	3005	General population	Self-reported questionnaire	Questionnaire	Positive	Halitosis and GERD
Kim et al[16]	2010	169	GERD symptoms (n = 169) ERD (n = 80) NERD (n = 89)	Halimeter	Endoscopy		ERD has higher halitosis than NERD
Kinberg et al[34]	2010	94	Halitosis (n = 94) Esophageal pathology (n = 10)	Chart review	Endoscopy	N/A	
Tas et al[21]	2011	358	Dyspepsia(n = 358) Esophagitis (n = 37)	1. Self-reportedquestionnaire 2. Organoleptic test	Endoscopy	Negative	Halitosis vs. esophagitis
Kislig et al[20]	2013	66	GERD (n = 66) ERD (n = 31) NERD (n = 35)	1. Self-reported questionnaire 2. Organoleptic test 3. Halimeter	1. Endoscopy 2. Questionnaire	Negative	Halitosis vs. esophageal mucosal damage
Present study	2014	54	GERD (n = 12) NERD (n = 9) Erosive esophagitis (n = 6)	1. Self-reported questionnaire 2. Others 3. Halimeter	1. Endoscopy 2. Questionnaire	Negative	Halitosis vs. GERD, NERD and erosive esophagitis

VSC, volatile sulfur compounds; GERD, gastroesophageal reflux disease; *H. pylori*, *Helicobacter pylori*; ERD, erosive gastroesophageal reflux disease, NERD, non-erosive gastroesophageal reflux disease.

ciated with self-conscious halitosis, informed halitosis and objective halitosis, respectively. In addition, individual symptoms of GERD were not associated objective halitosis. Only smoking and old age were significantly associated with self-conscious halitosis and informed halitosis, respectively.

The relationship between halitosis and GERD is controversial. Several studies have reported no significant association which is consistent with our findings (Table 4). The results of our study seem to match up with the previous studies which did not suggest scientific evidences for the causal relationship between halitosis and GERD,[20,21] and even inferring GERD as an extra-oral factor to play only a minor role as a potential cause for halitosis.[5,14]

However, other studies have proposed a significant relationship between halitosis and GERD (Table 4).[16-19,29] Di Fede et al[18] have reported that patients with endoscopically detectable erosion exhibited higher levels of self-reported halitosis in comparison to controls. Moreover, Moshkowitz et al[19] have reported that subjective halitosis may be considered as an extra-esophageal manifestation of GERD. Struch et al[17] have found a positive relationship between self-reported symptoms of GERD and self-reported halitosis in a German population. However, self-reported halitosis does not always correlate with objective findings of halitosis, such as VSC levels.[1,4,30] Two Korean studies investigated the relationship between halitosis by Halimeter results and GERD including erosive reflux disease and NERD.[16,29] In these studies, the ERD group had higher VSC values than the NERD group. However, these studies lacked a true control group, such as healthy subjects. The exact mechanism how acid reflux causes high VSCs in oral cavity in GERD patients remains unclear although GERD could be associated with halitosis.

Awareness of halitosis is not always consistent with the actual presence of halitosis. In our study, self-conscious halitosis was not associated with objective halitosis, but informed halitosis was associated with objective halitosis. This phenomenon is explained by the "bad breath paradox."[8,14,17] Individuals with objective halitosis can be unaware of the problem, whereas others are convinced that those individuals have halitosis even when no objective evidence are found.[17,31-33] In addition, some proportion of the latter ones may be considered to have pseudo-halitosis or halitophobia.[5,8,11]

Our study has several limitations. First, an objective examination about intra-oral conditions such as tongue coating and the presence of periodontal disease was not performed. Quirynen et al[14] have suggested that tongue coating (43%) is the most frequent associated halitosis factor, followed by a combination of tongue coating, periodontitis and gingivitis (18.2%) and periodontal disease (11.1%) as the sole underlying factor. However, one study by Kislig et al[20] have reported that GERD is not associated with objective tongue coating, and therefore intra-oral conditions may not be a critical factor to affect the association between halitosis and GERD. Second, the sample size was relatively small. Originally, 93 subjects were enrolled, but 39 subjects were excluded unexpectedly. We tested the differences of clinical features between 93 subjects and 54 subjects. The mean age, the mean VSCs values and the prevalence of GERD symptoms were not statistically different between them, but the portion of male subjects were significantly more in 54 subjects than in 93 subjects (61.1% vs. 44.1%, $P = 0.047$). In our results, male gender did not have any effect on halitosis, but the interpretation should be cautious due to the difference in gender between the initial enrolled subjects (n = 93) and analyzed subjects (n = 54). Third, the intake of medicines like H2 receptor blocker and PPI were not controlled. The effect of acid suppressants on halitosis remains unclear, but it might affect halitosis if reflux of gastric acid would be associated with halitosis. The effect of H2 receptor blocker and PPI on halitosis should be investigated.

In conclusion, this study shows that GERD is not associated with halitosis diagnosed by a self-reported questionnaire and by Halimeter. These suggest that acid reflux may not affect halitosis. In addition, Halimeter correlates more with informed halitosis than self-conscious halitosis, and therefore Halimeter is a reliable diagnostic method of halitosis.

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