

Halitosis

A COMMON ORAL PROBLEM

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Halitosis, also known as oral malodor, or bad breath, is a common condition affecting approximately 50 percent of the adult population, mostly during the morning hours. In many instances, morning halitosis is a temporary affliction describing the production of objectionable odors by oral bacteria that have accumulated during sleep. In some individuals, however, bad breath is persistent; and in these individuals, it is considered pathological. Halitosis is a condition in which the first complaint comes not from the patient, but from persons around the patient. In most instances a patient is not aware of his/her condition. A notable exception are patients with perceived halitosis, halitophobia.

Malodor may arise from either the oral cavity, nasal passages and upper respiratory system, or from the upper segments of the

■ ABSTRACT ■

Halitosis is caused primarily by bacterial putrefaction and the generation of volatile sulfur compounds. Ninety percent of patients suffering from halitosis have oral causes, such as poor oral hygiene, periodontal disease, tongue coat, food impaction, unclean dentures, faulty restorations, oral carcinomas, and throat infections. The remain-

ing 10 percent of halitosis sufferers have systemic causes that include renal or hepatic failure, carcinomas, diabetes or trimethylaminuria. Modern analytical and microbiological techniques permit diagnosis of bad breath. Management of halitosis involves maintaining proper oral hygiene, and periodontal treatment, including tongue brushing.

digestive tract. Ninety percent of all malodorous conditions can be traced to oral causes and, thus, it is the obligation of the dentist to diagnose and treat these patients.¹ The remaining 10 percent of halitosis cases can be traced to respiratory, digestive or other non-oral causes.

A Long-standing Problem

Bad breath has plagued the human race for thousands of years and was reflected in the literature of Greek and Roman times including the writings of Hippocrates (460-377 BC), the "father of medicine."² According to ancient Jewish liturgical teaching,

ered that his wife had bad breath after allowed to divorce. "Filling the marriage. Even Shakespeare's breath in *A Midsummer Night's Dream*, where a troupe of actors nor garlic, for we get breath."

On many occasions, malodorous breath is stigmatized by society. In 1992, the market for mouthfresheners was valued at \$50 million dollars. In many years, the dentistry was slow to recognize the importance of halitosis. Clearly, the medical impact of bad breath has increased more impor-

and their degradation products.⁶ At any given time, a person's breath may contain up to 400 different volatile compounds (VC). The quality and proportion of these compounds in the exhaled air make up the oral "bouquet" of a patient. This paper will review the common causes, pathogenesis, diagnosis and treatment of oral malodor.

Etiology

Similar to caries and periodontal disease, the generation of oral malodor depends on the interaction of three factors: *host, pathogens and substrate*.

1. The Host

Malodor of oral causes. There is a direct correlation between poor oral hygiene and the intensity of bad breath. Perhaps the best known cause of halitosis is periodontitis. However, contrary to general belief, patients with periodontitis account for approximately only one-third of the halitosis population. A larger number of subjects develop bad breath as the result

of heavy plaque deposits on the dorsal third of the tongue. To understand the reasons for these particular locations, we need to review conditions that favor bacterial attachment and plaque deposition in general.

Oral bacteria thrive in a favorable environment, including the right temperature, humidity, pH, substrate, nutrients, and the presence or absence of oxygen. Because the oral cavity is an excellent environment for bacteria, retentive surfaces, such as periodontal pockets, interproximal dental surfaces and the tongue, are ideal for plaque accumulation. The tongue in particular is adept at harboring bacteria. It is the largest, continuous, retentive surface in the oral cavity. The filiform papillae, thread-like epithelial structures, cover the entire dorsal surface of the tongue and act like "Velcro" to help in the mechanical actions of the tongue, in mixing and moving food.

The tongue has additional anatomical features that increase its retentiveness, the circumvallate and foliate taste papillae, and crevices associated with mucous glands and lingual tonsils. Moreover, conditions such as lingua plicata (scrotal or fissured tongue), median rhomboid glossitis, geographic tongue and black hairy tongue, further enhance lingual retentiveness and serve as a trap for bacteria, food, epithelial debris and oral fluids. In turn, retention of oral debris favors the growth of anaerobic bacteria and the generation of oral malodor. Although tongue coating and periodontal conditions make up the major source of bad breath, there

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ing the last 30 years, primarily on the pioneering work of Tonzetich,^{4,5} has produced a body of literature as on the etiology, treatment of oral malodor. It is now known that malodor is caused primarily by the breakdown of food by refraction and the release of mostly, but not exclusively, volatile sulfur compounds (VSC). VSC are the most common components of bad breath and are represented by hydrogen sulfide, methyl mercaptan, to a lesser extent, dimethyl sulfide and dimethyl disulfide. In addition, volatile organic compounds such as propionic, valeric, as well as isovaleric, skatole, are also sources of malodor breath. Volatile fatty acid products, such as acetic acid, are a rich source of malodor. Sulfur compounds, including hydrogen sulfide, diallyl sulfides

are other contributing factors; these include food impaction, faulty restorations, throat infections, oral carcinomas and even unclean dentures.^{1,7-9} All of the above conditions provide a retentive environment, favor harboring bacteria and oral debris, and lead to the development of oral malodor. The mechanism of odor formation in various retentive sites in the oral cavity appears the same.

If normal oral features favor malodor formation, then why is halitosis not more widespread? Halitosis does not always develop because of individual variations in oral flora, hygiene, retentiveness of oral surfaces, frequency of eating, salivary flow rates, or, in most patients, the absence of exacerbating factors such as xerostomia and retronasal drip. There are two additional factors with malodor. First, oral malodor is perceived only so long as it reaches a detection threshold. Undetected oral malodor is not objectionable. Second, halitosis is a dynamic condition. Oral factors that enhance or relieve malodor constantly change throughout the day. Salivation, mastication and swallowing all tend to decrease bad breath formation. Thus, reduced salivation and masticatory inactivity favor malodor production.

How does mastication and swallowing reduce oral malodor? In healthy individuals the anterior two-thirds of the tongue is in constant friction with the hard palate, cleaning the tongue and preventing deposition of plaque. The dorsal one-third of the tongue, in turn, is in contact with

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the soft palate, which lacks rugae and the cleansing effect. Hence, the dorsal third of the tongue is the area most prone to plaque deposition. The accumulation of soft deposits are further compounded in some patients by the presence of the gag reflex, which prevents proper tongue hygiene. For removal of soft deposits from the tongue, mouthwashes are considered appropriate. However, during gargling, the dorsal third of the tongue is positioned to push the soft palate to prevent fluid reflux into the nasal cavity. Thus, the dorsal third of the tongue is inaccessible to the action of the mouthwash. The efficiency of a mouthwash can be enhanced, if, during gargling, the subject pronounces the sound "ahhhh" to separate the tongue from the soft palate, which still blocks the retronasal area.

There is a major exacerbating factor, xerostomia, which alone does not cause malodor, but in the presence of a host, bacteria and substrate, aggravate the degree to which bad breath is

perceived. Xerostomia, or lack of saliva, has been shown to increase the levels of perceived volatile sulfur compounds. A variety of factors cause xerostomia. These include medications,¹⁰ radiation therapy to the head and neck, Sjögren's Syndrome and mouth breathing, to name the most prevalent ones.¹¹⁻¹³ Reduced salivation is also quite common especially in the elderly.

Saliva has a variety of protective functions, including antibacterial, antiviral, antifungal, buffering and mechanical cleansing of the oral cavity. Saliva is also a solvent for malodorous volatile compounds. As long as these compounds are in solution their perception is reduced. However, if salivary levels drop (for example, every time a person swallows or takes a breath through the mouth), then the relative concentration of volatile compounds in saliva increase and could become detectable. Most people swallow and take a breath before speaking. Thus, it is easy to understand why bad breath becomes more detectable during speech.

Both actions, breathing and swallowing, lead to reduced amounts of saliva and a relatively high concentration of volatile compounds in halitosis patients. This reduction in salivary flow is even more critical in xerostomic patients, where the release of VSC is further enhanced. Instead of a normal salivary film wetting the entire oral surface, xerostomic patients form a very thin salivary film that can easily dry out. Volatile compounds are easily released from a dry salivary film

and become detectable during speech. Because we speak exclusively during exhalation, every time the tongue thrusts against the hard palate and lingual side of the front teeth, it acts as a puffer emitting small whiffs of oral air enriched in objectionable volatile compounds. This is especially obvious during expression of words containing consonants such as c, d, h and t, which require the interaction of the tongue and the palate.

Malodor of non-oral causes. As mentioned earlier, 90 percent of malodor cases have oral causes. The remaining 10 percent of halitosis cases have systemic causes and include conditions such as anaerobic infections or tumors of the upper respiratory tract,¹⁴⁻¹⁷ cirrhosis,^{18,19} diabetes mellitus,²⁰ uremia and kidney failure,²¹ or trimethylaminuria.^{22,23} The severe nature of these conditions outweighs the relatively mild consequences of malodor. Therefore, patients with the above conditions rarely complain of halitosis. The one possible exception are patients with trimethylaminuria (TMAU), also known as Fish-Odor Syndrome. This condition may affect as much as one percent of the U.S. population,²³ but the lack of familiarity by the medical community makes it underdiagnosed or undiagnosed. Only several dozen cases have been documented in the literature during the last quarter of a century.²⁴

It manifests as a subtle general body odor, often associated with a complaint of foul taste and smell.²² Trimethylamine is a degradation product of choline with

resemblance to fishy odor, hence the name Fish-Odor Syndrome. The absence or deficiency, due to an inborn error, of a metabolic enzyme in choline metabolism, most likely a flavin containing monooxygenase (FMO), leads to accumulation of trimethylamine in the blood, urine, sweat, saliva and exhaled air. TMAU can be diagnosed by specialized clinics using the choline challenge, followed by gas chromatography of exhaled air. There is no cure for TMAU. Prevention of malodor can be achieved by avoidance of choline-rich food products, such as legumes, broccoli, beans, eggs, fish and organ meats like kidney and liver. However, this form of treatment is tenuous and varies from patient to patient.

II. The Pathogen

The second component necessary for oral malodor is the presence of the pathogen. There is no precise etiologic agent among the more than 300 oral bacteria that cause halitosis.²⁵ More than 80 species isolated from the subgingival plaque were surveyed and found to be able to generate *in vitro* VSC, odorous fatty acids or both.^{26,27} Kleinberg and Codipilly²⁸ had surveyed 12 gram-negative and 13 gram-positive pathogens to identify which pathogens use amino acids as their substrate to generate objectionable odor. The results of these studies confirmed earlier findings: There are several pathogens, not one, that cause halitosis and these are gram-negative anaerobes, such as *Fusobacterium nucleatum*, *Veillonella alcalescens*, *Porphyromonas gingivalis*, *Prevotella*

tella intermedia, *Prevotella loeschii*, *Treponema denticola* and *Klebsiella pneumoniae*.^{25,29,30} This list, however, is probably not inclusive.

The nature of the pathogens that cause halitosis is likely to be determined by their type of substrates. According to Loesch and De Boever,²⁵ it is unlikely that all 300 pathogens in the oral cavity use the same substrates; this would not be an efficient strategy for bacterial survival. It is likely that certain strains of bacteria generate volatile sulfur compounds only from specific substrates at a specific time.

III. The Substrate

The third important component of malodor formation is the required substrate for the bacteria. In the majority of cases, exogenous proteins (food) and their degradation products or endogenous substrates (proteins from oral fluids or tissue) represent the substrate. Once large proteins are degraded into single amino acids, bacteria will incorporate them into their metabolic pathways. Sulfur-containing amino acids are a prime target; these include methionine, cysteine and cystine, the latter representing two cysteines coupled through a disulfide bridge. The end result of bacterial metabolism is the generation of volatile sulfur compounds, the most recognized components of bad breath. In addition, arginine, ornithine, tyrosine and several hydrophobic amino acids, such as alanine, valine, leucine, isoleucine and glycine, may serve as substrates for the formation of unpleasant volatile compounds *in vitro*.

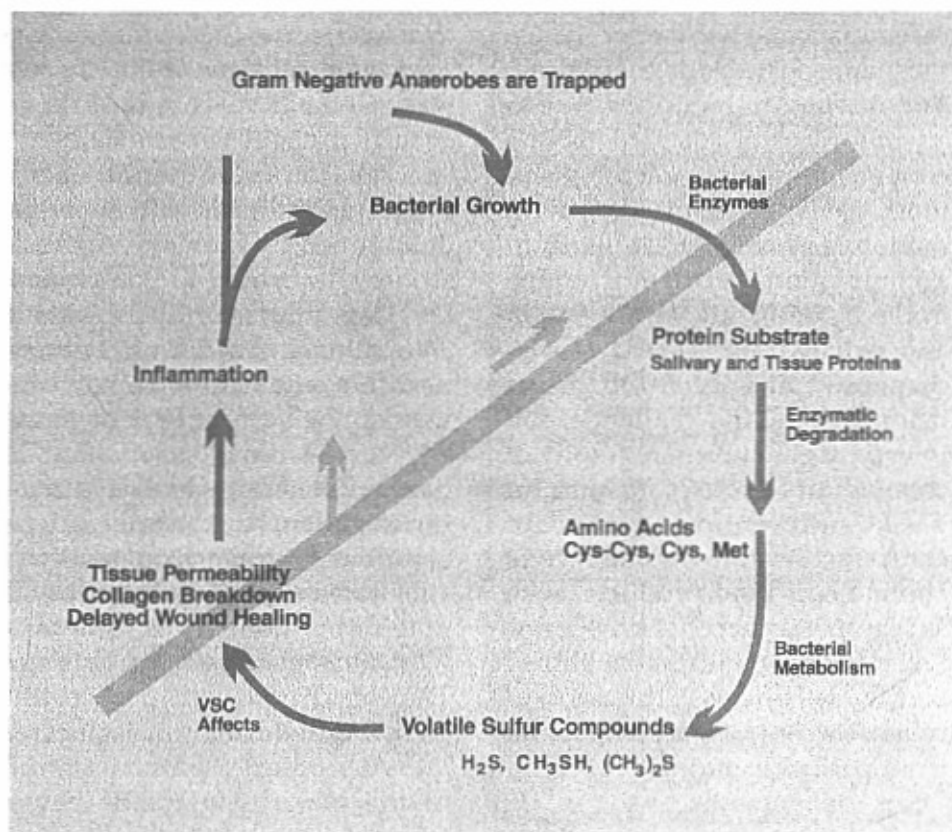


Figure 1. *The malodor cycle.*

Figure 1 depicts a possible self-perpetuating cycle of oral malodor. Bacteria, in particular gram-negative anaerobes, are entrapped by oral retentive surfaces, along with food and cellular debris. In the oral environment there are favorable conditions for bacterial growth. This growth requires anaerobic conditions and nutrients, which are provided by oral fluids, tissue and food. As bacteria act on the protein substrates, intact proteins are degraded into single amino acids. Of primary importance for oral malodor formation are amino acids containing sulfur, such as methionine, cysteine and cystine. These amino acids are metabolized by bacteria to release volatile sulfur com-

pounds. VSC and other unpleasant compounds have a variety of biological effects on the host tissue, including increased permeability of mucosa,³¹ increased degradation of collagen, altered gingival fibroblast activity and periodontal ligament cells,³² and delay in wound healing.³³ All of these effects in turn enhance inflammation, the degradation of proteins and malodor formation. This sets up a vicious cycle that we termed the "malodor cycle."

The mechanism by which individual amino acids can be converted into volatile sulfur or other objectionable compounds is complex and requires an understanding of amino acid and lipid

metabolism. For instance, proteins are degraded into amino acids by bacterial enzymes. Individual amino acids, such as methionine and cystine, both can be converted into cysteine. In turn, all three can release hydrogen sulfide or methyl mercaptan, propionic and acetic acid, and ammonia. Figure 2 demonstrates the possible metabolic pathways from proteins into volatile sulfur compounds.

Diagnosis of Halitosis

The fastest and still one of the most reliable ways of diagnosing bad breath is the smelling of exhaled air. This method, is crucially subjective and only qualitatively. Recent progress in halitosis research has made possible both quantitative and qualitative measurements of the various volatiles that contribute to bad breath.³⁴

First, a portable sulfur monitor was introduced during the last decade.³⁵ This instrument also known as a Halimeter (Interscan Corp., Chatsworth, CA), is a modified industrial sulfur monitor. It can measure in parts per billion the levels of H₂S and CH₃SH, but it is inadequate for detection of indole, skatol, volatile acids, amines or other objectionable volatile compounds that are part of the malodor "bouquet." The performance of the HalimeterSM should be considered semiquantitative. It can monitor treatment efficacy and progression and may provide useful information in conjunction with other diagnostic procedures.

A more reliable method uses microbiological evaluation of the VSC-generating potential

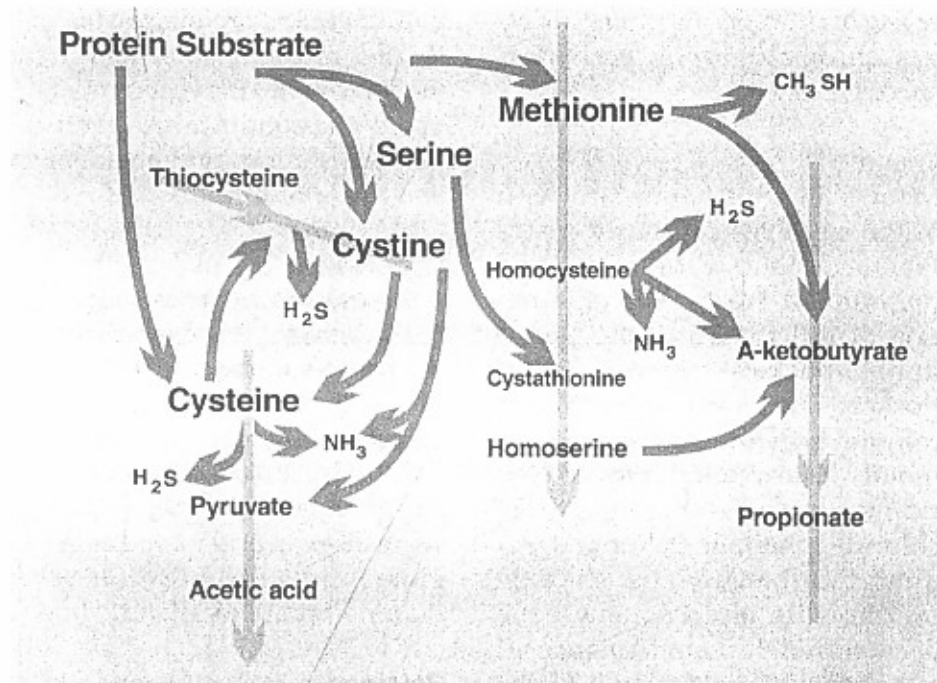


Figure 2. The possible scheme of bacterial metabolism of methionine, cysteine and cystine and generation of volatile sulfur compounds and acids as part of the malodor cycle. Compounds participating in oral malodor formation are highlighted in bold. Data are redrawn based on Kleinberg and Westbay.⁷

bacteria in salivary samples.³⁴ A special anaerobic bacterial media enriched in sulfur-containing amino acids and lead acetate (a color indicator) has been developed. Generation of VSC is visualized by the presence of a brown precipitate, lead sulfide. The amount and time it takes to develop the brown precipitate are indicative of the VSC-generating potential of that individual. A severe malodor patient may develop the precipitate in minutes compared to hours for milder cases, making this a valuable chairside diagnostic procedure and monitor of treatment efficacy.

Finally, a more elaborate and reliable method for both qualitative and quantitative evaluation of malodor patients is gas chro-

matography (GC) equipped with a sensitive flame-photometric detector (FPD) and coupled with mass spectrometry (MS). This method identifies and quantitates individual components of the exhaled breath. Since the digestive and respiratory system share the oral cavity, analysis of the exhaled oral air may be misleading in identifying the source of the volatile compounds. Therefore, it is important to analyze separately exhaled air from the mouth, nasal cavity or lungs. Quantitation of volatile compounds found in each of the air samples could reveal the source of malodor and, thus, establish proper treatment.

One of the problems associated with halitosis is the inability of a patient to self diagnose. A

normally functioning olfactory system becomes desensitized to its own stimulants. Most patients are not aware of their own halitosis until someone mentions it to them. This inability to recognize the problem leads, in some patients, to constant fear of having bad breath, a condition known as imaginary halitosis, or halitophobia. The practitioner has to differentiate between real and imaginary halitosis using diagnostic procedures. Smelling a patient's breath may not be sufficient to convince a halitophobic patient. On the other hand, the absence of objectionable volatile compounds in the exhaled breath does not mean a patient cannot be treated. Certain psychiatric conditions, such as schizophrenia or affective disorders, are associated with complaints of malodor. These patients may need specialized treatment from a psychiatrist.

Differential Diagnosis

Oral malodor has a typical quality associated with it. So do diabetics (ketonic breath) or upper respiratory tumor patients. Studies of the exhaled lung air of patients suffering from bronchogenic carcinoma revealed significantly higher levels of *o*-toluidine, and in half the patients, aniline, when compared to controls.¹⁷ In another study the breath of lung cancer patients contained acetone, methylethylketone and *n*-propanol at significantly higher levels than in controls.¹⁶ Differentiation of patients based on an organoleptic assessment (sniffing) may be difficult for the inexperienced practitioner. These patients can be properly diagnosed only through analysis of the ex-



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Treatment

Management of halitosis of oral origin involves primarily maintaining proper oral hygiene and periodontal treatment: elimination of inflammation and periodontal pockets, regular dental flossing, and proper tooth and tongue brushing. A variety of mouthwashes containing cetylpyridinium chloride, benzethonium chloride, phenolic flavor oils, sodium bicarbonate, zinc chloride or zinc with alpha ionone have been tested for maintenance of a halitosis-free status. These mouthwashes were all effective in reducing by 24 percent to 59 percent the levels of hydrogen sulfide or methyl mercaptan when compared to a placebo mouthrinse.³⁷ The effect lasted for three hours. Other studies have shown the effectiveness of mouthwash containing molecular chlorine dioxide in treatment of halitosis. Of 923 treated patients, 918 had elimination of their breath malodor.³⁸

A two-phase oil-water mouthwash³⁹ appears to be 50 percent more effective in reducing halitosis than those available commercially. This solution takes into account that most bacteria have a hydrophobic coat; thus, the oil phase is effective in removing bacteria. Oral rinsing with existing commercial mouthwashes is also claimed to be effective, but no systematic study of these products and reduction of volatile oral compounds has been conducted. Commercial

mouthwashes are successful only if used in conjunction with treatment to disrupt the vicious malodor cycle that maintains bacterial growth, amino acid metabolism and malodor formation.

Conclusion

Although halitosis is clearly an annoyance for those who perceive it, and a handicap for the subject in question, one should be encouraged by the words of Dr. L.Z.G. Touyz of McGill University in Montreal, who, at a recent workshop on oral malodor in Belgium, said, "Bad breath is better than no breath at all." □

References

A copy of the references accompanying this article is available from the Managing Editor, *The New York State Dental Journal*.



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