



International Foundation for Functional Gastrointestinal Disorders

IFFGD
P.O. Box 170864
Milwaukee, WI 53217-8076

Phone: 414-964-1799
Toll Free: 888-964-2001
Fax: 414-964-7176
Internet: www.iffgd.org

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Report from IFFGD Research Award Winner

Understanding Intestinal Gas

By: Fernando Azpiroz, M.D, Ph.D.
Chief Section GI Research, University Hospital Vall d'Hebron
Autonomous University of Barcelona
Barcelona, Spain

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By: Fernando Azpiroz, M.D, Ph.D., Chief Section GI Research, University Hospital Vall d'Hebron, Autonomous University of Barcelona, Barcelona, Spain.

Dr. Azpiroz is the recipient of the IFFGD 2005 Research Award to Senior Investigator, Clinical Science. Dr. Azpiroz's clinical practice develops in a large referral unit, and specifically focuses on functional gut disorders. His research program investigates the origin of gastrointestinal symptoms including aspects of the control mechanisms of gut motility, visceral sensitivity, and more recently, intestinal gas dynamics (the movement of gas through the gut).

At a Glance

- It is normal to have gas in the digestive system.
- Gas can cause discomfort for some persons.
- Some persons have too much gas. Some have problems passing gas.
- In still others, their GI tracts are more sensitive to the presence of gas.
- Finding out why gas is causing discomfort helps find ways to reduce discomfort.

Everybody has gas in his or her digestive tract (the esophagus, stomach, small intestine/bowel, and large intestine/bowel). The amount of gas varies and there is a wide range of normal (7–14 Tbsp. or 100–200 ml). What this gas is made up of and how it is distributed through the intestines are determined by how it is produced, how it moves through various areas of the bowel, and how it is eliminated.

There are several ways by which gas enters the body or is produced by it, and several ways that the body can dispose of it. The actual amount of gas in the digestive system at any given time results from the balance of these processes.

Gas enters the digestive tract through:

- Swallowing of air. People swallow air to varying extents. We get rid of some of the swallowed air by belching. The rest is passed into the intestines.
- Back-passage of gas from the blood stream into the intestines.
- The production of gas through chemical reactions within the intestines.
- As a by-product of the fermentation of food by intestinal bacteria.

Gas leaves the digestive tract through:

- Belching.
- Absorption into the blood.
- Being consumed by intestinal bacteria.
- Passing out through the anus (flatus).

The amount of gas that is absorbed into the blood depends on the amount of gas present, the amount of time that gas comes into contact with the absorptive cells lining the intestine, and the physical properties of each part of the intestinal gas.

Intestinal bacteria and gas

Bacteria play an important role in the make up of intestinal gas. The colon, or large intestine, contains a great amount of

bacteria. Some bacteria produce gas while others consume it. Food particles that the digestive system is not capable of absorbing are broken down into smaller simpler ones by gas-producing bacteria. This process is called fermentation. Hydrogen and carbon dioxide are gases released in the process.

Other types of colonic bacteria consume large amounts of gas, particularly hydrogen. They in turn release small amounts of methane or sulphur-containing gases, which are responsible for the bad odor associated with intestinal gas. Part of the gas that is absorbed into the blood is released through the lungs and can be detected by breath tests. This provides doctors with a means of evaluating different functions of the digestive system. The remaining gas is passed out through the anus.

Movement of gas through the gut

Researchers, in studies of healthy subjects and patients with gas symptoms, have learned several things about how gas travels through the gut (transit). In these studies gas is continuously infused directly into the intestines. At the same time the investigators measure the amount of gas passed through the anus, changes in patients' girth (waist size), and how the patients feel.

Healthy subjects evacuate all the infused gas without discomfort. Most of the healthy population can tolerate without difficulty an infusion of gas at a rate of up to 1.8 quarts/liters per hour. Gas passes more quickly through the intestines when individuals stand up than when they lay down.

Gas transit is normally very effective, but if an amount of gas stays within the gut, the subjects may develop abdominal distension and symptoms. Different experimental models of gas retention have shown in healthy subjects that abdominal distension is related to the amount of gas within the gut. However, the perception or feeling of abdominal symptoms also depends on other factors. It turns out that gas is better tolerated when the gut is relaxed and if it's in the large bowel rather than in the small bowel.

The clinical significance of intestinal gas

Troubles that individuals have related to gas in the gut include conditions such as belching, excessive or foul-smelling air, and impaired anal evacuation.

Belching – Excessive belching is a common gas related complaint that doctors see. Patients who belch a lot accidentally swallow air that gathers in the stomach, and is then released by belching. Often, belching is triggered by an uncomfortable feeling of fullness in the upper abdomen that patients mistake as excessive gas in the stomach. During repeated but ineffective attempts at belching, air is actually drawn into the stomach with increasing discomfort, although some relief may be felt when belching finally does occur. In most of the cases a clear explanation can resolve the problem. The solution is to avoid intentional belching, thereby preventing additional air swallowing. If the upper abdominal discomfort persists, another problem may be present that a doctor will need to diagnose and treat.

Too much and/or foul-smelling gas – Some patients complain of bad smelling air, which may become socially disabling. Odor stems from the presence of small quantities of sulfide substances that are produced by specific bacteria in the colon. Other patients complain of too much passage of gas through the anus. The frequency of anal gas evacuation in healthy subjects varies depending on the diet, but is usually around twenty times per day. There are parts in the normal diet that are not completely absorbed in the small bowel and are fermented in the colon. These tend to increase gas production and include:

- Fermentable dietary fiber.
- Dietary starch.
- Complex carbohydrates, that appear to be the most important source of gas, in beans.
- Sugars such as sorbitol and fructose.

Furthermore some substances contained in beans block the intestinal enzyme that normally digests starch so that starch cannot be absorbed in the small bowel and passes into the colon, where it is fermented increasing gas production.

Some diseases, which are easily recognizable by a doctor, affect the normal absorption of nutrients within the small bowel. Patients with these usually treatable diseases may have excessive gas production and evacuation. Regardless of the cause, those with increased gas production and evacuation do not complain of abdominal symptoms unless they have associated irritable bowel syndrome (IBS), because healthy subjects handle most gas loads without difficulty or symptoms.

Difficult gas evacuation – While some patients have excess gas, others find gas difficult to get rid of. The process of gas evacuation requires effective muscle-nerve coordination, which not everybody has. Lack of coordination may also produce constipation with retention of stool. In some patients these problems can be resolved by biofeedback treatment. When normal coordination is restored there is also less retention of stool, which in turn leads to reduced fermentation time and reduced gas production.

Abdominal gas symptoms in IBS and related syndromes

Patients with functional GI disorders such as IBS frequently attribute their abdominal symptoms to gas. Bloating, for instance, where the abdomen feels distended and full, is one the most common and bothersome complaints in many patients with functional GI disorders. These patients usually feel gas as the cause of their symptoms, but there is little experimental evidence to support this feeling.

Do IBS patients produce more gas than others – A series of experiments conducted to address this issue showed that gas production was normal in IBS patients. While some test methods have produced inconsistent results it appears that gas production in IBS patients is not much greater than in healthy subjects and does not explain the abdominal symptoms.

Do IBS patients have a larger volume of gas in the intestines – Since gas production is normal, the next question is whether patients with gas-related symptoms actually have excess gas in their intestines. One study that used abdominal x-rays to estimate the amount of gas in the intestines found gas volume was relatively larger in IBS patients than in the control group. However, the extra volume in patients was not great enough to explain their symptoms. Furthermore, other studies using more sophisticated techniques failed to detect differences between IBS patients and healthy controls. Hence, IBS patients

neither produce excessive gas nor retain excess amounts of gas in their intestines.

Do patients have abnormal gas transit – No major abnormalities in the transit of solids and liquids through the gut have been detected in patients with functional GI disorders using conventional techniques. In contrast, the situation concerning the transit of gas is not as clear. The gas challenge test, in which gas is infused into the intestines of patients, has shown that patients complaining of gas symptoms have abnormal gas transit. They develop intestinal gas retention, abdominal distension, and/or abdominal symptoms in response to amounts of gas that are well tolerated by healthy subjects. Interestingly, symptoms induced by intestinal gas infusion in patients by-and-large replicate their usual complaints. Impaired gas clearance in these patients is related to abnormal gut reflexes that contribute to gas retention delayed gas transit.

Which area of the gut is affected – In a series of studies, gas labeled with a radioactive isotope was infused into the intestine and the radioactivity in different regions of the gut was scanned. This technique enables researchers to evaluate gas transit through different areas of the intestines. The study results indicated that in patients complaining of abdominal bloating the small bowel is responsible for impaired gas transit. This is in contrast to the common perception that gas is retained in the colon.

Other elaborate gas infusion studies showed that gas is retained in the first parts of the small bowel because it is not propelled into the more distant regions of the intestines. Gas that was infused into the first parts of the intestine remained there while gas that was infused into more distant areas was cleared from the gut in a normal manner. This may mean that gas pools in certain areas of the small intestines causing distension of those regions even though the total gas volume in the intestines is not increased. Interestingly, the small bowel in IBS patients has been shown to be overly responsive to stimulation (hypersensitive), so the presence of excess gas in these areas may contribute to the perception of discomfort and distension.

Does the abdomen really get distended – IBS patients frequently complain of abdominal distension, but it is difficult to determine whether this feeling reflects what is actually happening or a subjective sensation (in other words, it feels like it is distended when it is not). Distension usually develops during the day and resolves after an overnight rest. Several studies that looked at changes in abdominal girth using tape measures, CT scans, or more complex research techniques have shown that the subjective sensation of abdominal distension is associated with evidence that the abdomen is, indeed, distended when patients feel that it is.

Since the total volume of intestinal gas is not increased, what causes distension? The abdominal wall normally adapts to its content. It has been recently shown that when gas is infused into the colon, healthy subjects develop a reflex contraction of the abdominal muscles that can be measured by recording the electrical activity of the muscles (i.e., electromyography). The contraction of abdominal muscles enables them to adapt to the addition volume of gas. This reflex does not work correctly in patients complaining of bloating. Their abdominal muscles fail to contract, leading to exaggerated abdominal protrusion and bloating. Hence, these patients do have abdominal distension, but it may be related to abnormal control of abdominal muscles and protrusion of the abdominal wall, rather than to a true increase in volume of gas.

How do all these data fit together – Gas transit studies have consistently shown that IBS patients, especially those attributing their symptoms to intestinal gas, have impaired handling of intestinal contents. This is due to abnormal gut reflexes, which may result in pooling of gas in some areas and local distension of the abdomen. Additional evidence indicates that these patients also have overly sensitive intestines that increase perception of intestinal stimulation. However, this does not imply that gas is necessarily the offending element. Other intestinal components, such as impaired muscle reactions, could trigger the abnormal responses, and thus be responsible for abdominal symptoms that patients mistakenly attribute to gas.

Treatment options

Treatment depends on the cause of the symptoms. Treatment options can be classified into two main categories depending on 1) whether the patient has evidence of excessive amounts of gas in the gut, or 2) whether there is no evidence of excess gas and the patient actually has a functional bowel syndrome with unexplained abdominal symptoms.

Excessive gas – For patients with excessive belching it's usually enough to explain the condition and reassure the patient. However, if another abnormality is present, specific treatment is required. In cases where patients have difficulty passing gas through the anus, biofeedback training may resolve the problem. In patients with excessive and/or foul-smelling gas evacuation, therapy is directed towards reducing intestinal gas production. This entails dietary modifications, specifically trying to reduce the amount of undigested residues reaching the colon where intestinal bacteria convert them into gas.

There is no good evidence that altering the population of colonic bacteria can reduce gas production. Based on the scarce data available some dietary recommendations can be made. A diet aimed at reducing gas production to a minimum could include meat, fowl, fish and eggs; among carbohydrates, gluten-free bread, rice bread, and rice; some vegetables, such as lettuce and tomatoes; and some fruits, such as cherries and grapes. In contrast, avoid foods that increase gas production such as beans, Brussels sprouts, onions, celery, carrots, raisins, bananas, wheat germ, and fermentable fiber. After a one week gas-free diet, patients usually experience symptom relief. An orderly reintroduction (one item per week) of gas-producing food can help identify those foods in the diet that do or do not cause problems. In persons with documented lactose intolerance, a lactose free diet may be recommended. Notably, recent studies have shown that most of these patients can consume normal amounts of dairy products without abdominal symptoms.

Unexplained abdominal symptoms – Guidelines for treatment are more difficult for patients with IBS and related syndromes who attribute their abdominal symptoms to gas. Because the actual amount of intestinal gas is hard to measure, advice for these patients is rarely based on good objective evidence. Since many patients with gas-related symptoms have IBS, the same treatment options that apply for IBS would apply here. Recent experimental studies suggest that mild exercise, a traditional recommendation, improves intestinal gas clearance.

Gas-reducing drugs – Gas-reducing substances, like silicone-derivates or activated charcoal, have been widely used to treat gas related symptoms. However, experimental data are controversial and not overly convincing. Simethicone (e.g., Gas-X, Mylanta Gas, Phazyme) has an antifoaming effect, thereby preventing gas trapping. However, its effectiveness in the

treatment of gas symptoms is controversial. Activated charcoal (e.g., Charco Caps, Charcoal Plux) has adsorbent properties. However, in controlled studies, activated charcoal did not reduce the volume of intestinal gas production in laboratory experiments or in patients, nor did it reduce the formation of foul-smelling gas.

Stimulation of gut motility – Better clearance of intestinal gas could theoretically be achieved by drugs that stimulate intestinal movement or motility. However, existing drugs that stimulate gut motility have bothersome side-effects that limit their usefulness here. New drugs in development that stimulate gut contraction may prove useful in patients with gas symptoms.

Inhibition of gut contractions – Patients with gas-related abdominal symptoms have reduced tolerance for intestinal gas loads. Drugs that reduce intestinal spasm probably enhance the tolerance of intestinal gas by reducing gut motor activity. Smooth muscle relaxants are a group of drugs that reduce gut contraction, and include natural belladonna alkaloids and related products, such as hyoscyamine hyosciamine (Levsin, NuLev, Levbid, Anaspaz), dicyclomine (Bentyl, Spasmoban) and scopolamine (Transderm-Sco, Buscopan). These substances block the chemical substance that produces gut contraction, thereby inhibiting gut motility. Smooth muscle relaxants can make it easier to tolerate intestinal gas pooling, but on the other hand, may contribute to gas retention. These compounds may help to relieve abdominal pain. An analysis of smooth muscle relaxants in the treatment of IBS concluded that they are superior to placebo in the management of symptoms, specifically reducing abdominal pain and distension. Peppermint oil has an anti-spasm effect on the GI tract due to the action of its principal ingredient, menthol. Some studies have reported that peppermint oil reduces abdominal distension and gas emission, but a recent large analysis showed that its effectiveness is not clear-cut.

Reduction of gut sensitivity – Drugs that act on intestinal sensory nerves and reduce gut perception may also be effective. Low dose antidepressant drugs have proven useful in the treatment of abdominal pain and IBS symptoms. Hypnosis has been used successfully to treat patients with IBS and has been shown to improve bloating. There are no studies on the effect of hypnosis on gas volume and dynamics, but it has been reported that hypnosis adjusts colonic motility and normalizes disordered rectal sensitivity in patients with IBS.

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