Food-Induced Heartburn: Effect of Osmolality

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It is a common clinical observation that certain foods cause heartburn, some by an effect on the lower esophageal sphincter and others by a direct "irritant" effect on the esophagus. This study investigated the effect of solution osmolality in the production of esophageal pain. Subjects were divided into an "acid-positive" and "acid-negative" group using a conventional Bernstein test. Six (54%) and 9 (82%) of 11 acid-positive subjects developed pain with hypertonic saline and sucrose (630 mOsm/kg water). One of 15 acid-negative subjects developed pain ($p < 0.01$). This study suggests that foods with high osmolality are the cause of pain in the acid-sensitive esophagus.

Peptic esophagitis is an exceedingly common condition probably ranking next to duodenal ulcer as a cause of upper gastrointestinal symptoms. It is usually the result of reflux of acid gastric juice into the lower esophagus or due to the reflux of bile or pancreatic juice (1-8). Heartburn is the prime symptom of esophagitis. The sensation is presumably due to the histologic consequences of gastroesophageal reflux resulting in neural sensory receptors becoming more superficial in location (9, 10).

It is a common clinical observation that many foods cause heartburn. Some, like chocolate, may reduce the lower esophageal sphincter (LES) pressure; others like orange juice produce heartburn by direct effect on the esophagus (11). Until recently heartburn produced by citrus and spicy drinks was believed to be due to the acid pH of these agents. Price et al. found that when these juices were neutralized with alkali their "irritating" effect was not reduced (12). In order to find a common factor among foods causing heartburn we examined the relationship between solution osmolality and the production of pain in the acid-sensitive esophagus.

Methods

Subjects who had infrequent heartburn, no history of gastrointestinal disease, and a negative Bernstein test (13) were designated as the "acid-negative group". The "acid-positive group" consisted of subjects with regular heartburn and a positive Bernstein test. Approval for the study was obtained from the Committee on Research involving Human Subjects of The University of Western Ontario.

Fifteen acid-negative and 11 acid-positive subjects were studied. Following a conventional Bernstein test, three solutions of isotonic saline, hypertonic saline, and hypertonic sucrose were infused into the esophagus at a rate of 6 ml/min. The solutions were prepared and coded by the hospital pharmacy (Table 1).

The solutions were infused randomly, and the code was broken at the end of the study. Symptoms were recorded as positive (pain reproduced), negative (no pain), or positive unrelated (pain unlike regular heartburn pain). Statistical analyses for this study was performed using Student's *t*-test (14).

Results

There were 11 subjects in the acid-positive and 15 subjects in the acid-negative group. Six (54%) and 9 (82%) of the acid-positive subjects developed pain with hypertonic saline and sucrose. There was a statistically significant difference in the frequency of heartburn between the acid-positive and the acid-negative groups with hypertonic solutions ($p < 0.01$). Hypertonic sucrose was observed to cause pain more frequently than hypertonic saline in the acid-positive group, but this was not statistically signifi-

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Table 1. Test Solutions

	Concentration (g/L)	Osmolality ($mOsm/kg\ H_2O$)
Isotonic saline	8.5	290
Hypertonic saline	18.4	630
Hypertonic sucrose	215.5	630

Ph was corrected to 7 using 4 N sodium hydroxide.

cant ($p = 0.99$). One of 15 acid-negative subjects developed pain with both hypertonic sucrose and saline. This subject experienced heartburn infrequently.

Discussion

The sensation of heartburn is usually related to two factors: (a) the presence of acid or less often bile in the esophagus and (b) esophageal sensitivity. The increased sensitivity theoretically is dependent on mucosal damage resulting in permeability to hydrogen or other ions. Six (54%) and 9 (82%) of 11 acid-positive subjects developed pain with hypertonic saline and sucrose, respectively, whereas only 1 of 15 acid-negative subjects developed pain with both solutions.

This study has therefore demonstrated that hypertonic solutions of saline and sucrose with the same osmolality as a commercial orange juice (630 mOsm/kg water) will cause pain in some subjects with an acid-sensitive esophagus, but isosmolar solutions will have no effect. The implication of this finding is that symptoms caused by many so-called "irritants" may be related to the osmolality of the agents rather than an unidentified constituent. Most liquids consumed have an osmolality ranging from 50 (tap water) to 500 mOsm/kg water. Many foods have high osmolalities, eg., orange juice concentrates (650 mOsm/kg), apple juice (700 mOsm/kg), grape juice (1170 mOsm/kg), and sherbets (2000 mOsm/kg) (15, 16). "Spicy" foods are generally prepared with a large amount of salt to impart flavor; a pizza liquidized and filtered has an osmolality of approximately 1000 mOsm/kg of water.

We have shown that hyperosmolar solutions can cause esophageal pain. Our findings go part of the way to demonstrate a common factor among foods that cause this symptom, but they certainly do not explain the individual susceptibilities in patients. It is possible that hyperosmolar foods consumed regularly may induce the mucosal damage or perpetuate injury already present.

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