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EMOTIONS AND GASTRIC FUNCTION[1]

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REVIEWING the life histories of the patients with ulcers, Mittelmann and Wolff found that the patients had been subject to prolonged emotional turmoil, involving mainly conflict, anxiety, guilt, hostility and resentment.

During periods of experimentally induced anxiety, hostility and resentment, they found a rise in acidity and increased contractions in the stomachs of all the patients suffering from ulcer and in many of the normal subjects. Moreover, they were able to reverse this process and cause a decrease in acidity and motility by inducing in their patients feelings of contentment and well-being.

In all the patients with peptic lesions it was possible to demonstrate a chronological parallelism between the onset, recrudescence and course of gastroduodenal symptoms, and the occurrence of untoward emotional reactions. The situations that prompted these reactions were not necessarily dramatic or in the nature of crises, but, because of the existing emotional frame within which they occurred, they had important effects on the patients.

To demonstrate that the above-described emotional states were relevant to the gastroduodenal dysfunction and peptic ulcers in the particular patients studied, situations were experimentally created which induced destructive emotional reactions and precipitated symptoms when the patient was free of symptoms. Moreover, if such effects, symptoms and tissue defects already existed, all increased in intensity during such experimental procedures. On the other hand, in situations which engendered feelings of emotional security and assurance, gastric function was restored toward normal and symptoms eliminated, in those with symptoms and abnormal function.

The facts of this study emphasize the occurrence in the same individual of the aforementioned destructive emotions coupled with increased motility and secretion

[1] Delivered at the New York Academy of Medicine Graduate Fortnight, October 11, 1943.

and mucosal circulatory changes in the stomach and duodenum, followed by evidence of gastritis and duodenitis and ultimately actual ulceration. This sequence suggests that the increased secretion, increased motility and disturbed circulation, mucosal erosions and ulcerations are phases of the same process differing only in the amount of tissue destruction in the stomach and duodenum.

To further validate these views, an intensive investigation was made by Dr. Stewart Wolf and the speaker[2] of a man who afforded them an exceptional opportunity to visualize the inside of his stomach.

METHOD

The man, aged 56 at the time of the study, completely occluded his esophagus at the age of 9 by drinking scalding hot clam chowder. Since then, he has fed himself through a gastric fistula 3.5 cm in diameter, surgically produced shortly after the accident. It is his custom to put food into his mouth and, after tasting and chewing it, to expectorate it into an ordinary kitchen funnel inserted into his stoma. Through the stoma has protruded on his abdominal wall a collar of gastric mucosa essentially similar to that within the cavity of the stomach. The patient is in excellent health, has rare digestive complaints and is employed as a "diener" in the laboratory. He is a small, wiry man of Irish-American stock, unschooled, married and the father of one child. He is shy, sensitive, proud, stubborn and slightly suspicious. He is fun-loving but very conscientious.

Estimates of vascular changes were made.

The stomach was emptied every fifteen minutes and the juice obtained was titrated for free hydrochloric acid and total acid.

In many of the experiments, records of the stomach contractions were made.

Careful note was made of the patient's mood and the content of his thoughts and preoccupations. These data were collected during the experiments as well as at separate daily interviews. An attempt was made to classify the emotional and other reaction patterns as contentment, joy, gratitude, feelings of helplessness, dejection, doubt, fear, frustration, guilt, sadness, anxiety, tension, hostility and resentment. None of these existed alone, but usually it was possible to recognize one or two as dominant. The emotional reactions were then correlated with the various measurements of gastric function.

The emotionally charged situations were not experimentally induced. Spontaneously occurring life situations, problems and conflicts were utilized. Some of these involved events arising from time to time in the laboratory. Others occurred in the setting of the subject's home life. His reaction to each of these experiences was evaluated in the light of his individual personality pattern. Thirty-four observations on stomach function accompanying several different affective states were made. From these, illustrative examples will be presented.

[2] Human Gastric Function. Stewart Wolf and Harold G. Wolff. Oxford University Press, New York, 1943.

OBSERVATIONS

During the periods when the subject was relaxed and apparently contented, the color of the mucosa remained relatively constant. Contractions were usually of low amplitude and rhythmic, making a pattern of three small waves a minute.

Spontaneous Periodic Phases of Accelerated Gastric Function.—Every two to three hours, there occurred in the stomach a transitory phase of hyperemia, hypersecretion of acid and vigorous contractions. These followed a rather constant pattern and lasted only twenty to thirty minutes. After the phase of accelerated gastric function had subsided, the stomach assumed its former "basal" condition.

Depression of Gastric Function in Association with Fear and Sadness. Fear: The patient suddenly experienced intense fear one morning in the midst of a phase of accelerated gastric function. An irate doctor entered the room muttering imprecations about an important protocol which had been lost. The patient had mislaid it and feared he had lost the record and his job. He lay motionless on the table and his face became pale. Prompt and decided pallor occurred also in his gastric mucosa, and associated with it there occurred a fall in the rate of acid production. A minute later, the doctor found his paper and left the room. Forthwith the face and gastric mucosa of the patient regained their former color.

Sadness: Sadness, dejection and feelings of self-reproach were accompanied in this subject by taciturnity, lack of "energy," slowness of movement of the body generally and by pallor of the gastric mucosa, decreased acidity and motor activity. Even the stomach's normal response to the ingestion of food was inhibited under these circumstances.

One morning, the patient was depressed and uncommunicative over having lost, through his own negligence, an option on a house which he had long been eager to acquire. He was limp and dejected and filled with feelings of self-depreciation and refused to relate the nature of his trouble until several hours later. Beef broth was administered directly into his stoma and it was noted that the hyperemia and acceleration of acid production and motility, which regularly followed ingestion of beef broth, were partially inhibited.

Acceleration of Gastric Function in Association with Emotional Conflicts Involving Anxiety, Hostility and Resentment. During a period of "basal function" of

the stomach one-half hour after a spontaneous phase of accelerated function, a member of the staff entered the room to pay off and discharge the subject from a job he was doing for the doctor after hours in order to earn some extra money. The doctor had complained earlier that he was slow, ineffective and charged too much. The subject, who takes great pride in his conscientious attitude toward his duties, resented heartily these charges. When the physician told him he need not report for work any more, he accepted the rebuff politely, but quickly his stomach became red and engorged and soon the folds were thick and turgid. Acid production accelerated sharply and vigorous contractions began. This happened in spite of the fact that another spontaneous phase of accelerated gastric function was not to be expected for at least an hour and a half.

These changes were noted frequently in association with feelings of strong hostility and resentment on the part of the patient, and also with anxiety. It is noteworthy that these incidents occurred far more commonly than did those described earlier, in which there was an associated inhibition of secretion, motor activity and vascularity.

The degree and duration of the changes in gastric function were also roughly proportional to the intensity and duration of the emotional reaction.

An illustration of prolonged acceleration of gastric function is as follows: The patient was usually in a state of comparative financial insecurity, and because of this he was compelled to accept gifts from a certain benefactor. The latter meddled in the subject's personal affairs and when denied a hand in managing them, threatened to withdraw support. During two weeks of such meddling, the patient became intensely anxious about his future welfare and resentful of the activities of his benefactor. He was eager to throw off his dependence. At the end of the two weeks, the opportunity for release came in the form of a raise in pay for his job at the hospital. This good fortune he received with the deepest feelings of relief.

Gastritis, Pain and Mucosal Erosions. In the presence of hypermotility and hypersecretion, the gastric mucous membrane not only became red but engorged and turgid as well.

During periods when his stomach was in this state, occurring as they did in association with emotional conflicts involving anxiety, hostility and resentment, the patient often complained of heartburn and abdominal pain. Indeed, it was possible to demonstrate experimentally that the tissues of the stomach wall were more sensitive to pain in their hyperemic state than normally. Vigorous contractions of a magnitude insufficient to cause pain in its normal state were painful when the stomach was intensely engorged.

Furthermore, the susceptibility of the mucosa to injury resulting in hemorrhage was found to be greatly enhanced in this condition of engorgement and hyperemia. Even relatively trifling traumas such as striking the membrane with a glass rod or stroking it with dry gauze resulted in small erosions and bleeding points. Frequently during periods of such hyperemia, vigorous contractions produced bleeding points around the periphery of the exposed collar of mucosa without the necessity of instrumentation.

Healing in the Stomach: The Protective Properties of Mucus. Ordinarily these small erosions and bleeding points which occurred from time to time were quickly covered with mucus and healed uneventfully in twenty-four hours or less. The failure of any of these lesions to persist as a chronic ulceration will be shown to be due largely to the effective protection afforded by the mucus.

When irritating substances such as mustard, strong acid or alkali were placed on the lining of the stomach without care being taken to remove the mucus coating, only a slight to medium erythema resulted. When the accumulation of protective mucus was continually aspirated away, however, and mustard was applied directly to the cells of the mucosa, acute inflammation and edema resulted. Bleeding points and small erosions appeared throughout the area involved. Pinching and faradic stimuli applied to the mucosa in this condition caused pain, although pain did not occur when these stimuli were applied to the mucosa in its normal state.

The protective powers of mucus have been shown to consist of three distinct mechanisms: First, it presented a continuous slippery surface to irritants. Second, by combining with and neutralizing the acid in immediate contact with it, it maintains the acidity of the stomach lining itself at a relatively low level. When a drop of Toepfer's solution was allowed to fall on the wall of the stomach, it failed to indicate an acid reaction despite the fact that a sample from a nearby pool of accumulated gastric juice contained 65 units of titratable free acid. An important aspect of this protective device is the fact that mechanical and chemical irritation of the gastric mucosa, as well as the presence of acid in high concentration in the stomach, accelerates the rate of production of mucus. Circumstances arose, however, when the amount of acid in the stomach exceeded the powers of this compensatory mechanism. Then the third protective property of mucus was invoked. The mucus precipitates and forms an insoluble, continuous, tough membranous coating over the cells of the gastric mucosa, thus insulating them from chemical attack.

Result of Continued Contact of Gastric Juice with a Mucosal Erosion. To demonstrate the effects of

contact of gastric juice with an eroded surface, the following experiment was conducted:

Two small bleeding points were produced in the gastric mucosa by traumatizing it with a smooth-edged forceps. These tiny eroded areas were kept in contact with gastric juice for one-half hour. The protective mucus which accumulated rapidly in this region was sucked away frequently and fresh gastric juice applied. A sharp acceleration of acid secretion and concomitant hyperemia of the whole gastric mucosa resulted from this procedure, and these effects persisted for one-half hour after the exposure of the erosions to the action of gastric juice had been stopped. After the undisturbed lesions had become covered by mucus, the color and acid values returned to normal.

This experiment supports the idea that the acceleration of acid secretion resulting from erosions being bathed in gastric juice is one mechanism involved in the maintenance of hyperacidity in patients suffering from peptic ulcer.

It can thus be shown that when an unprotected mucosal erosion is exposed to the digestive action of gastric juice, additional tissue damage occurs and chronic ulceration results.

COMMENT

The difference between a hypersecreting stomach and actual gastritis is, as has been shown, mainly one of degree. Prolongation of inordinate hypersecretion in the stomach with the inevitable accompanying hyperemia, then, carries with it the hazard of possible structural damage to the lining of the stomach or even more likely to that of the duodenal cap, since the latter is less well protected.

Once an erosion has been effected, contact of acid gastric juice with the denuded surface would perpetuate the vicious cycle as illustrated in the experiment described.

It has been shown that situational factors resulting in emotional conflict with anxiety, hostility and resentment may induce in the stomach profound and prolonged hyperemia, hypermotility and hypersecretion. Adequate neural mechanisms exist to explain these phenomena. The reason that the patient experimented with has not acquired peptic ulcer may be that the hyperemia and hypersecretion which were observed in the presence of conflict have been relatively transitory. He is not the sort of person who harbors grudges or maintains emotional stress for prolonged periods. Usually he expressed his feelings in words or in action, and his more serious conflicts were relatively short lived. Since the occurrence of gastric hyperfunction in certain emotional settings has been demonstrated, however, and since the destructive power of excessive gastric secretion has been established, one may infer that these emotionally charged situations are involved directly in the genesis of peptic ulcer in man. Hyperacidity, gastritis, minor mucosal erosions and finally peptic ulcer occurring during the course of sustained emotional tension should not be looked on as separate clinical entities. The evidence indicates that they are all phases of the same pathologic process.

PETROLEUM, PAST, PRESENT AND FUTURE. II

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The domestically available energy source most closely related to crude oil is natural gas. The production and consumption of natural gas by states, although by no means identical to the distribution shown for crude oil in Fig. 9, follows much the same general pattern in that transportation by pipe line makes for a marked flexibility in distribution. To most of us it does not mean much when we are told that the country's proved natural gas reserves amount to some 95 trillion cubic feet.[11,12] A little figuring will show, however, that on a weight basis this is equal to about 75 per cent. of the proved reserves of petroleum. At the present rate of consumption the proved gas supply should last about thirty years, or twice as long as the oil supply. Methods are known for converting these natural gas hydrocarbons into liquid petroleum fractions. The heavier constituents can be processed by such direct methods as cracking or dehydrogenation, followed by polymerization and alkylation. Methane, however, which is the major constituent of natural gas, can best be converted into gasoline by the Fischer-Tropsch process. In that case the methane must first be reacted with steam to give a mixture of carbon monoxide and hydrogen, which is then treated with a catalyst to produce liquid hydrocarbons. Technical information is available on this process, but as yet this country has no large-scale operating experience. The process has been used commercially in Germany for some time, and a small pilot-plant unit for carrying out the Fischer-Tropsch

[11] Energy Resources Committee, "Energy Resources and National Policy," Rept. to Nat. Resources Comm., January, 1939.

[12] E. H. Poe, *Oil Gas Jour.*, July 28, 106, 1943.