of tetany and convulsions." Carnegie Dickson states that in the case related by him the feeling of gastric discomfort and the tendency to vomiting were considerably allayed by the following method, which Professor Greenfield has for several years adopted with very marked benefit in many cases of gastric dilatation: After washing out the stomach with a solution of phosphate of soda, and previously, if necessary, with weak Condry's fluid or boric acid solution, a certain quantity, say ten ounces, of boiled milk containing sodium phosphate in the proportion of a drachm to the half-pint is left in the stomach diluted with hot water. Intravenous infusion of saline fluid may be adopted or copious hot water enemata may be given. The final and the appropriate treatment in all cases of gastric tetany should, however, be surgical. From what has been said as to the pathology of the condition it is clear that in almost all cases there is a grave mechanical obstacle to the onward passage of the food. It is this obstacle which causes the dilatation and the hypertrophy of the stomach. To relieve this obstruction and to do away with the stagnation of the stomach contents, surgical measures are necessary. In simple cases gastro-enterostomy will be the method of choice. In malignant cases a partial gastrectomy or gastro-enterostomy as circumstances dictate. In hour-glass stomach, gastro-gastrostomy combined with gastro-enterostomy performed in the distal pouch will, as a rule, be the suitable operation. Death occurring as the result of gastric tetany may occur in the first seizure or after a long series of attacks. Marten's case terminated fatally in the first attack, four hours after its onset. Trevelyan's patient, who had carcinoma of the duodenum, was first attacked with tetany on the morning of July 8, 1898, and died at 2 p.m. the same day. In other cases, as in Kussmaul's and in Carnegie Dickson's, there may be intervals of perfect health between severe attacks.

The records given by many writers show that gastric tetany is an extremely serious and often fatal disease. Thus in 11 cases accepted by Frankl-Hochwart as genuine, 10 died; Bouveret and Devic record 18 deaths in 23 cases; Albu, 31 deaths in 40 cases; Riegel, 16 deaths in 27. But almost without exception, such cases are of old standing. The chronic gastric ulcer, the stenosis which it causes, the dilated and hypertrophied stomach, have all been sources of troubles for months or for many years. It is only in the late stages of such cases that severe gastric tetany is seen. And such late stages are preventable. By treating all such cases surgically, and there is no other rational treatment, gastric tetany of the lethal type will soon be a forgotten disease. Even the slightest manifestations which I have mentioned, prickling, tingling or numbness of the hands, occasional and transient cramps in the muscles of the extremities, — even these are only seen in cases of long standing. The earlier adoption of surgical measures in these disabling conditions of the stomach,

conditions in which there is grave mechanical impediment to the free working of the organ, will banish altogether that class of patient which furnishes us with the last desperate forms of gastric tetany.

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A STUDY OF PATHOLOGICAL FERMENTATION IN THE STOMACH.¹

BY HENRY F. HEWES, M.D., BOSTON,

*Physician to Out-Patients at the Massachusetts General Hospital;
 Instructor in Chemistry at the Medical School of
 Harvard University.*

PATHOLOGICAL fermentation in the body produced through the agency of bacteria and other lower organisms introduced from without is today established as one of the most fundamental and fruitful sources of the various diseased conditions to which the flesh is heir.

The process has various manifestations and occurs in various localities in the body. It is a chief causal factor of the conditions and symptoms found in the so-called infectious diseases. It occurs in abscess formation and so-called septic infection generally. It is a prominent feature in the disturbances of the alimentary tract.

Whenever and however it occurs, its manifestation and action may be both local, causing disturbance of the part where the process is located, and general, causing systemic disturbance from the absorption of the pathological products due to its existence. We thus have to look to it as an element or associate in a great variety of diseased conditions and the study of the process, both generally and specially, is most essential and practical for the understanding of medicine.

I have been for some time investigating these processes of pathological fermentation in one principal locality of their occurrences in the body, the alimentary tract. And I wish to report to you to-night the results of a study of this subject in a very interesting case of gastro-enteric disease which I saw at this hospital. The case was one of gastrectasis due to obstruction from an ulcer of the pylorus and upper duodenum, and one of its chief manifestations in its symptoms and clinical findings was an excessive pathological fermentation in the stomach.

The history of the case was as follows:

James Dwyer, aged forty-six. Foundryman.

Up to a year ago the patient was perfectly well. At this time his wife was ill with a fatal

¹ Presented at the Massachusetts Hospital Clinical Meeting April 10, 1903.

illness and he was up all night with her, besides working all day, for three months. Towards the end of this vigil he began to note distress in his stomach and eructations of gas, the trouble occurring most frequently at ten or eleven o'clock at night, five hours or so after his evening meal. As time went on this trouble increased. Finally he came to have regular spells of severe pain in the epigastrium associated with eructation, regurgitation, waterbrash and finally vomiting, occurring each night. Vomited once or twice in the night, often a quart or more at a time. Vomitus was very acid. There was never blood. The vomiting gave relief of pain until the next night. During the day had some eructation and occasional regurgitation of very acid stuff, but no special distress. There was loss of twelve pounds' weight in six months.

The patient came to me in the morning, having eaten nothing since 6 p.m. on the previous day. He had vomited once in the night.

At this time 1800 cc. of contents were expressed from the stomach. With inflation the lower border of the stomach was four inches below the umbilicus, upper limit normal. There was a suggestion of thickening of the stomach or intestinal wall in the region of the pylorus. The stomach held 2500 cc. of water without difficulty. The blood and urine were practically normal and there were no other evidences of disease about the case.

The record of the physical and chemical examination of the contents was as follows:

Quantity 1800 cc.

Upon standing, contents separated into three layers and bubbles of gas could be seen rising from lower portion.

Odor, sour -- the odor of acetic acid and butyric acid in gastric contents.

Reaction acid (litmus).

Free acid present (congo red).

Free HCl absent (Gunzburg reagent).

Combined HCl present (Ewald Sjoqvist test).

Lactic acid present (Fe_2Cl_6 test in ether extract of residue from distillation).

Butyric acid present (ethyl ester in distillate).

Acetic acid present (Ethyl ester in distillate test).

Total acidity = 0.43%.

Total free organic acids = 0.14%.

Total combined acids = 0.28%.

Pepsin present.

Rennin present.

The contents gave the reaction for alcohol (iodoform test; bichromate test).

The gas evolved by the contents was found to be principally carbon dioxide. The quantity of gas evolution was measured by placing contents in one of these gas tubes at 37°C . It was found that 100 cc. of contents formed 30-40 cc. of gas in twenty-four hours.

Specimens of contents removed on several occasions after the patient had, first; complete lavage of the stomach, then regular feeding for a day upon selected food which contained traces only of organic acids or their salts, then a twelve-

hour fast showed a similar character to that of which the analysis is given.

The patient was placed upon a suitable method of diet with lavage every second day. From the institution of the treatment vomiting and distress ceased. After a short period the patient was able to keep at his work and feel perfectly well by keeping upon this system of diet and using the stomach tube once a week at the most. Finally the use of the tube was entirely done away with. In six months the patient had gained twenty-five pounds and was as well as ever.

Eight months from the time of the first visit the patient was taken suddenly in the afternoon with dizziness followed by extreme weakness. An hour later there was a copious movement of the bowels, which was black and tarry in appearance (patient's statement). For three days following there were one or two similar movements. Patient was extremely restless and very weak. On the fourth day vomited some blood. The next day he came to my office with the above history.

At this time was very pale and walked unsteadily.

Pulse 110, temperature 99°F .

Blood showed hemoglobin 25%.

Red count, 1,400,000 per cmm.

White count, 15,000 per cmm.

Stained specimens showed marked anemia, with a few blasts present. A diagnosis of ulcer of the duodenum was made and the patient sent to the hospital. At ten o'clock that night he had a large hemorrhage indicated by copious discharge from the bowels of a tarry nature, containing blood, and by a drop in the hemoglobin to 10% and in the number of red corpuscles to 800,000. On the next day the patient, then unconscious, was operated upon by Dr. Harrington. A large bleeding ulcer of the duodenum with evidence of present or previous ulcer growth extending from the pylorus an inch and a half along the duodenal wall was found. Patient died six hours later. The autopsy confirmed the previous findings.²

The element of this case which has been the subject of this special investigation is the pathological fermentation which was associated with it.

The evidences of this fermentation, found both in the symptoms and in the results of the physical and chemical examination, were first, the excessive formation of gas demonstrated by the experimental observations described and evidenced by the symptoms of swelling of the stomach and excessive eructation.

Second, the presence in the gastric contents of certain chemical substances not found in the normal stomach, or quantities of these substances greatly in excess of those which are found in normal conditions. The most prominent and important of these substances were alcohol and these organic acids — lactic acid, butyric acid and acetic acid. The presence of these compounds

² See Mass. Gen. Hospital autopsy reports, 1902.

was evidenced by the results of the chemical analysis.

Third, the presence in the sediment of excessive numbers of bacteria, including *sarcinae*, and of the yeast fungus.

The contents removed from the normal stomach give practically no gas formation in experimental tests such as those used to test this matter in the case in hand.

They show no test for alcohol upon removal from the stomach and give no test for lactic, butyric or acetic acid unless the food contain these substances or the salts of the acids, in which case the quantity present is never in excess of the food content.

The sediment contains very few bacteria or yeast fungi and almost never *sarcinae*. Here is a tube of normal contents arranged to show gas formation, which has been kept at 37° C. for forty-eight hours. As you see, there is practically no evidence of gas formation as compared with the tube from the contents of our case, where a half tube full of gas has formed in twenty-four hours.

Having established the fact of fermentation and the definite products in this case, I proceeded to make a further investigation to determine, if possible, by experimental methods the genesis and controlling conditions of this pathological fermentation.

The first step in the investigation consisted of a biological study of the fresh contents to determine what active forms of organized ferments which might serve as causes of fermentation were present.

Gelatin plate cultures were taken from several specimens of the fresh contents removed at various times from the stomach after a twelve hours' fast.

In the first attempt numerous colonies of various appearances were obtained. A careful examination of all these colonies showed that they represented four (4) distinct types of bacteria, and four only.

These four types were:

(1) A coccus growing in small white colonies on the gelatin.

(2) A short bacillus growing in small white colonies and showing in instances in the growth in gelatin evidence of gas formation.

(3) A long bacillus growing in large creamy white colonies and liquefying the gelatin.

(4) An organism growing in white colonies and answering to the morphological characteristics of the *sarcinae ventriculi*. The *sarcinae* were obtained only once. This was in the culture made from the first specimen of contents obtained.

Several plate cultures taken from this same contents showed in all instances one or more of these four respective organisms and in no instance any other form of organism.

Here is a plate culture preserved by formalin representing a first dilution of an original gelatin culture from the contents, containing three of the above forms of bacteria,—the coccus, the

short bacillus and the long bacillus. You can see the evidences of gas formation about some colonies, those of the short bacillus.

I have here also agar culture of each of the four types of bacteria found, isolated on the agar in pure culture: (1) the coccus; (2) the short bacillus; (3) the long bacillus; (4) the *sarcinae*. Here is also a pure culture of the short bacillus in gelatin, showing the abundant gas formation about the colonies.

From these culture experiments, then, we have obtained evidence of the existence of at least four forms of organized ferment in our contents.

That the number of forms of organism obtained on gelatin growths was limited to four in all cases was a surprise, for it has been proven that the mouth in normal conditions contains a large number of organisms which are swallowed with the food, many if not all of which grow on gelatin. Also the food itself contains many bacteria, and many forms of bacteria introduced from these sources and in this manner have been isolated from the normal stomach.³

Miller has isolated seventeen forms of bacteria from the mouth. Abelous⁴ has isolated sixteen forms of bacteria from the stomach in a set of observations. A few of these were found present in the stomach of a man killed at the height of digestion. None were pathogenic. All sixteen forms produced some fermentation of food *in vitro*. Most of them caused no appreciable effect of this kind in normal gastric contents. At first their action was very slow, taking several days to be appreciable and not to be compared with the energetic action of our pathological ferments in this case.

It is to be presumed that the failure of many of such forms as are found in the normal stomach contents to grow in this case and the reduction of the active bacterial products to four forms, was due to the inhibiting effect of the products of the fermentation upon bacterial growth. Also there were doubtless organisms present here which did not grow on gelatin. Thus the yeast fungus seen in such growth in the sediment does not grow on this medium. From its appearance in the sediment, however, it gave every evidence of being or having recently been in active growth in the contents.⁵

The capacity of yeast to cause fermentation of sugar is long established since the original observations of Cagniard-Latour.⁶ The capacity of yeast to perform this fermentation in the human stomach is proven. Kuhn isolated and grew yeast from the stomach and produced by its action alcohol and gas in carbohydrate solutions *in vitro*.

Having determined the presence of these possible causes of our fermentation, the next step in the investigation was to associate them definitely in the chain of cause and effect with this fermentation by experimental demonstrations. To accomplish this fact, mixtures of food substances

³ Straus: *Ztschr. f. klin. Med.*, xxvii, 1895.

⁴ Abelous: *Soc. de Biologie*, Feb. 9, 1889.

⁵ *Ztschr. f. klin. Med.*, Nos. 49 and 50, 1892.

⁶ *L'Institute*, 1835, iii, 150.

similar in character to those present in the contents of the case were made up, sterilized and inoculated with the various forms of organism isolated. This experimental work was done with the three forms of bacteria which were present on repeated culture experiments.⁷

The food mixtures used were solutions of glucose and peptone. The test solutions, having been sterilized and found by tests to be free from alcohol and organic acid, were inoculated and placed in gas test tube at 37° C. and tested at various periods up to forty-eight hours to detect the evidences of fermentation, gas formation, or alcohol or organic acids.

As a result of these experiments it was found that each of the three forms of organism isolated possessed the capacity to produce in the food mixture some decomposition products similar in nature to those abnormal products found in the fermenting contents from which the bacteria were isolated.

The action of the several forms of organisms showed considerable variety.

All three formed gas (CO₂) and alcohol at some stage of the fermentation and all formed some kind of organic acid.

The specific action of each organism may be seen from the accompanying table. As you can see from this, when the products of each organism are combined we have the whole collection of abnormal organic products which are found in our contents.

TABLE.

1. *Coccus* in 100 c.c. neutral carbohydrate-proteid solution for 24 hours produced — gas 50 cc.
Alcohol.
Lactic acid (a trace).
Acetic acid.
Total acidity = 44 cc. decinormal soda in 100 c.c.
Total free (organic) acid = 14 c.c. decinormal soda in 100 c.c.
2. *Short bacillus* in 100 c.c. solution for 24 hours produced — gas 40 cc.
Alcohol.
Butyric acid.
Acetic acid.
No lactic acid.
Total acidity = 30 cc. decinormal soda in 100 cc.
Total free acid = 10 cc. decinormal soda in 100 cc.
3. *Long bacillus* in 100 c.c. solution for 24 hours, produced — gas 20 cc.
Alcohol.
Lactic acid (much).
Acetic acid.
Total acidity = 40 cc. decinormal soda in 100 cc.
Total free acid = 16 cc. decinormal soda in 100 cc.

Control solutions of the food mixtures showed none of these abnormal products and no gas formation under the same conditions.

We have thus in our case determined a genesis of the pathological fermentation present by the experimental method. That is, we have, to use the traditional phraseology, isolated certain

⁷ Sarcine were obtained but once in culture. They were present in numbers in the sediment in the first specimen of contents only. The ferment action of this form of bacteria has been studied by Cohn (Contribution to the Study of the Sarcine Ventricule, *Compt. rend. de la Soc. de Biol.*, Dec., 16, 1899). He found that sarcine in pure solutions of peptone formed acetic and formic acids and some butyric acid. In carbohydrate solution they formed acetic, formic and lactic acids.

definite organisms repeatedly from a contents, grown these in pure culture, and produced by their inoculation to sterilized food mixtures an infection similar in character and producing similar fermentation products to that found in our original case.

Also we have determined the special ferment action of each of the three organisms present.

Of course, it does not follow from this work that the organisms isolated are the whole cause of the fermentation in our case. Also, in this work the complete fermentation process has not been investigated. We simply determined the fermentation by the presence of certain abnormal decomposition products and reproduced the fermentation which will form these products.

This work is sufficient, however, to serve as an experimental demonstration of pathological fermentation in the body and to give us a fundamental understanding of the process, as it was produced in our case, serviceable for clinical instruction, and it was to obtain a simple scheme of demonstration of this subject for use in medical instruction that this work was undertaken.

Further investigation of the subject — consisting of the identification and study of the properties of the bacterial ferments isolated in this case; their action in varying strengths of free hydrochloric acid; their growth and products in various food substances, as pure carbohydrate or proteid solution; and the influence of various so-called disinfecting drugs upon their activity — will be reported in a late article.

I wish to express my thanks to Prof. Harold C. Ernst for assistance in this work, a part of which was done in his laboratory.

INTERNAL MEDICINE, TO WHAT EXTENT REQUIRED OR ELECTIVE IN THE MEDICAL COURSE?¹

BY S. G. BONNEY, A.M., M.D., DENVER, COL.,

Dean and Professor of Medicine, Denver and Gross College of Medicine.

IN order to more clearly define the applicability of the elective system to internal medicine it is almost necessary to consider first its general relation to a medical course and to review briefly the trend of medical educative thought.

The sociologic and economic conditions of the country do not at present, as formerly, require a large number of physicians to supply from time to time the needs of the smaller communities. There is on the contrary an appeal for relief from the incubus of the insufficiently prepared practitioner, in order that more encouraging inducements may be offered to the type of the educated physician.

From a strictly business standpoint these inducements to spend years of preparatory study are now becoming not particularly attractive to those contemplating general medicine in view of the active competition incident to the overcrowding of the profession. Failure to remain

¹ Read before the American Academy of Medicine in Washington, May 12, 1903.