TEMPERATURE CHANGES IN THE HUMAN GASTROINTESTINAL TRACT AND ITS RHYTHMIC ACTIVITY WHEN EMPTY

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A study of the temperature of the human digestive tract is of considerable physiological and clinical interest. Nevertheless, very little information is available even on the upper sections, which are easily accessible for temperature measurement. Not nearly enough investigations have been made of temperature changes in the esophagus, stomach, duodenum, and upper parts of the jejunum.

In studying the temperature of the human gastrointestinal tract over a period of many years [6], and finding the effect on it of various physiotherapeutic measures [8], we have several times observed regular temperature variations in certain sections, and it was found that they were associated with periodical changes in the activity of the digestive organs when the subject was in a fasting condition.

V.N. Boldyrev [1], as early as 1914, described a temperature increase in the rectum of the dog as occurring at the end of a period of vigorous gastric movements. We have published simultaneous recordings, in man [9], of the temperature inside the stomach and the periodic gastric movements.

The movements were usually accompanied by a temperature rise.

Changes in stomach temperature in fasting man were found by Benjamin, Wagner and Zeit [11]. These authors limited their observations to recording sensations of hunger, without making any record of gastric movements, and concluded that the temperature of the stomach fell during "hunger" contractions.

Periodic activity of the empty digestive organs is usually accompanied by vigorous contractions of the musculature of the stomach, as well as by contraction of the intestine, while there is also a secretion of bile, pancreatic juice, and succus entericus etc. It seemed, therefore, worthwhile to study the associated temperature changes, not only in the stomach, but in other sections of the gut, especially the duodenum.

In the present work, we report results obtained with simultaneous temperature recordings in several portions of the human digestive tract, from the esophagus down to and including the jejunum.

METHOD

Temperature measurements were made by means of thermocouples fixed to a fine duodenal probe. The currents in the circuit of each thermocouple were measured by separate mirror galvanometers, whose indications were continously recorded on photographic paper. The temperature in the armpit was also measured in the same way.

The temperature measurements were made with an absolute accuracy of 0.05°, and with a relative accuracy of 0.02-0.03°.

The position of the probe with the thermocouples in different parts of the digestive tract was controlled by means of a mobile x-ray apparatus during the time of the temperature recording. The investigations were carried out with the subject in a horizontal position,in a specially equipped room isolated from noise and other distractions. A detailed description of the method of temperature recording in the gut has been given elsewhere [7].

The periodic gastric movements were recorded by the usual manometric method with air transmission. In this case, a small light was attached to a Marey's drum, so that the gastric movements could be recorded photographically at the same time as the temperature.

In estimating the type of gastric motility, we used V.N. Ivanov's classification [2], which divides people (when fasting) into groups showing regular periodic gastric movements, irregular period movements, continuous activity, and a continuous or a very prolonged period of rest.

In all, 32 investigations were made in 12 subjects which were either practically healthy, or else suffering from minor forms of gastritis with various disturbances, or else who showed some impairment of gastric secretion.

Temperature measurements were made in the esophagus and stomach, in the stomach and duodenum, or else in the stomach, duodenum, and upper end of the jejunum.

RESULTS

Fig. 1 shows a photographic record of the temperature in the armpit and in various parts of the stomach and duodenum, as well as records of gastric motility in a healthy male of 29.

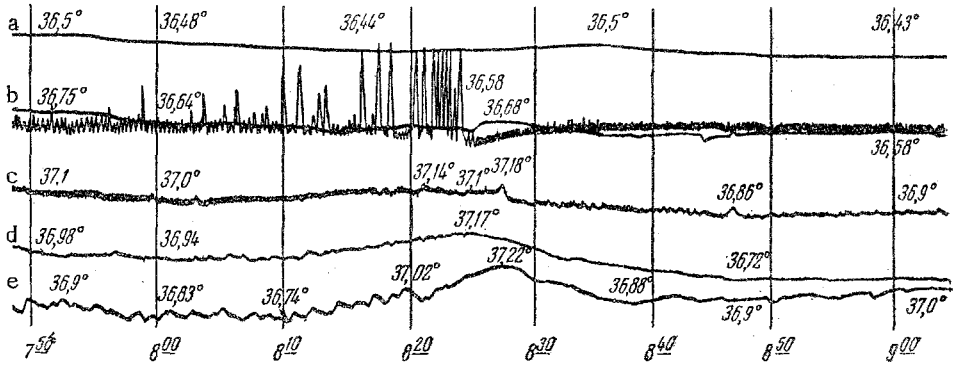

Fig. 1. Temperature changes of body and of various sections of the digestive tract, and gastric motility in a healthy male of 29. Curves: a) temperature of armpit; b) temperature of the cardia; c) gastric motility; d) temperature of antrum; e) temperature at superior duodenal flexure; f) temperature of descending portion of duode - num.

Fig. 2 shows an x-ray photograph of the position of the probe with the thermocouples. (The probe itself cannot be seen, on account of lack of contrast).

The first part of the recording was made during a period when there was little gastric movement. Ten minutes later, separate, stronger contractions of the stomach musculature can be seen, and these merge into a period of vigorous contractions, which terminate after 23 minutes, after which a period of rest again ensues.

At the start of the investigation, a relatively high temperature was recorded in both stomach and duodenum. After 10 munutes,it fell somewhat, but then, when the stomach movements began (and these were evidently associated with movements of the other portions of the tract),the temperature in the antrum and duodenum began to rise. The temperature of these parts reached an even higher value during the period of vigorous stomach movements. Here the temperature of the antrum rose by 0.14°, and that of the descending duodenum by 0.4°.

At the beginning of the record (Fig. 1, f) short-duration variations of temperature in the descending part of the duodenum can be seen, and these cease after the end of the period of vigorous gastric movements, and are replaced by a more marked temperature rise. During the subsequent period of rest, the temperature in the stomach and duodenum falls.

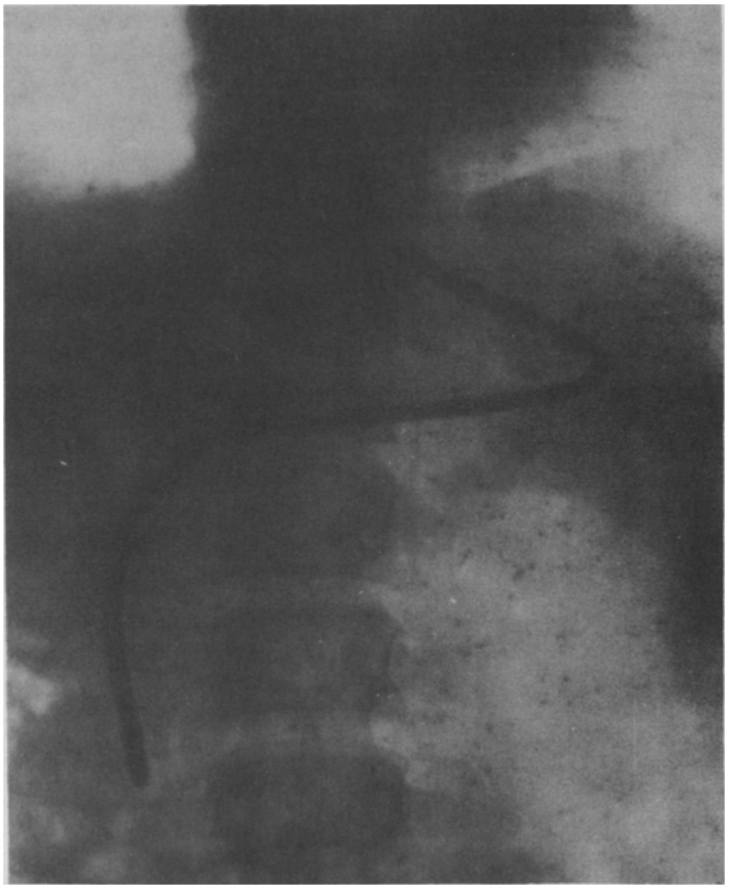

Fig. 2. X-ray photograph of probe with thermocouples. Patient supine.

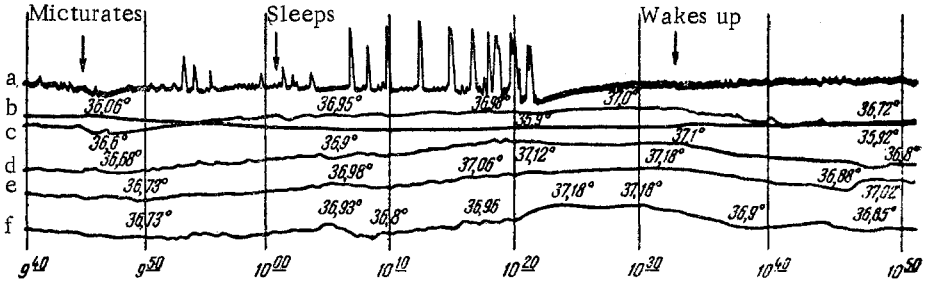

Fig. 3. Temperature changes of the body and of different parts of the digestive tract, and gastric motility in a healthy male of 18. Curves: a) gastric motility; b) temperature of armpit; c) temperature of fundus; d) of body; e) of antral portion of the stomach; f) temperature of the descending portion of the duodenum.

The onset of periodic periods of gastric motility are not associated with any corresponding changes in the temperature of the cardia. The temperature in the armpit rose by 0.06° immediately after the end of the period of vigorous movement.

The high temperature in the digestive tract at the onset of the experiment is evidently due to the subject's reaction to swallowing the probe with the thermocouples and the balloon for recording gastric motility. This phenomenon was very marked when the temperature recording began immediately after the probes had been swallowed.

Temperature changes at the upper end of the jejunum were similar to those in the descending portion of the duodenum with the difference only that both the short-lasting temperature variations during vigorous gastric movements and the cupola-like elevation at the end of this period were less well shown and occurred somewhat later than the corresponding temperature changes in the duodenum.

The temperature changes already described in the gastrointestinal tract were found in most of the experiments both during sleep and in the waking condition, and were accompanied by regular periodic gastric movements (Fig. 3). These changes were observed especially often in the descending portion of the duodenum (in 14 cases out of 17).

The greatest temperature variations associated with periods of gastric motility in the fasting subject occurred in the region of the body and of the antral portions of the stomach and in the descending part of the duodenum. In certain cases, the temperature in these regions changed by 0.4-0.45° in a period of 40-50 minutes.

No regular temperature changes in the esophagus associated with the periodic activity of the digestive organs could be found.

Sometimes, a small increase of temperature in the armpit was found to follow a period of vigorous gastric motility. In other cases, this increase did not occur. However, here the difficulty of making a continuous recording of the temperature in the armpit should be borne in mind.

We cannot entirely agree with the view of P.I. Itskov [4] that when digestion is taking place, the temperature in the stomach is constant. In cases where there is a true periodic activity of the digestive organs in the fasting subject, the temperature in the gastrointestinal tract does show more or less well-developed regular fluctuations.

The mechanism of these undulating temperature variations in the gut appears to be quite complex. The explanation of Benjamin, Wagner and Zeit that the temperature fluctuations in the fasting subject are due to an anemia of the stomach wall occurring during the "hunger" contractions of its muscles, cannot be accepted. First, we have found that during the period of vigorous stomach movements, there is a gradual increase in the temperature of the stomach, and secondly, that the explanation cannot be extended to include temperature changes in the duodenum and in the upper part of the jejunum.

Evidently, in addition to the periodically occurring changes in the metabolic processes in the human organism as a whole (A.D. Slonim [10]), and the changes in the metabolism and the circulation of the digestive organs, there is also an important phasic secretion of bile and of pancreatic and intestinal juices, as well as a movement from one section to another of the liquid intestinal contents which are at different temperature. In this connection, the periodic voiding of the duodenal contents into the stomach, as described by V.N. Ivanov [3], must play an important part. The small and sometimes rhythmic temperature variations are most immediately connected with changes in the conditions of contact between the thermocouples and the mucosa during the vigorous movements of stomach and intestine.

The regular periodic gastric motility is not always associated with the characteristic temperature changes in the stomach and intestine, and this may be due to disturbance of the sequence, or to certain components being missing from the set which comprise the activity of the digestive organs. N.P. Nekhoroshev has pointed out the possibility of such deviations [5].

A final solution of the problem of the mechanism of the temperature variations which we have discovered in the digestive tract of the fasting human subject requires special experiments to be carried out on animals.

Temperature changes in the stomach, duodenum, and upper part of the jejunum in fasting man, both in the waking state and during sleep, are largely due to periodic changes in the activity of the digestive organs.

The undulating temperature variations described above are so great that they must be considered in relation to temperature changes in the gastrointestinal tract. A knowledge of the undulating temperature variations is essential for a correct evaluation of any temperature changes occurring as a result of various actions on the human organism.

SUMMARY

The author conducted a prolonged parallel registration of the periodic motor gastric function on an empty stomach and of the temperature in the esophagus, stomach, duodenum and the initial portion of jejunum in man. Periodic changes of the temperature (especially in the body and the antral portion of the stomach and in the descending portion of duodenum) associated with periodic activity of digestive organs in fasting persons were revealed.

The above temperature variations are caused by a complex of phenomena, comprising the periodic activity of digestive organs. These phenomena should be considered when studying the correlations and dynamics of temperature in the human gastrointestinal tract, on an empty stomach.

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