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EFFECTS OF THE INGESTION OF COLD AND HOT WATER ON THE COURSE OF THERMAL CHANGES IN THE STOMACH AND INTESTINE

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EFFECTS OF THE INGESTION OF COLD AND HOT WATER ON THE COURSE OF THERMAL CHANGES IN THE STOMACH AND INTESTINE

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There are comparatively few temperature measurement data of the /108* internal organs, but the course of temperature changes in the internal organs as a result of the ingestion of food of various temperatures has been studied still less.

In 1882, Rozdayevskiy measured the temperature in the stomach through a fistula. According to the data of this author, the temperature in an empty stomach is 36.6°. Shaverin inserted a thermometer into the stomach cavity through a fistula and applied a heater or ice to the abdomen. In this case, the author did not observe particular changes in stomach temperature. According to his data, thermal stimuli do not affect acidity, but they affect stomach secretions. Veselkin inserted a thermocouple through a fistula, to measure the temperature of the stomach According to the data of the author, the temperature of the esophagus proved to be equal or close to the temperature of the rectum.

Recently, Vereshchagin studied the course of temperature changes in various organs, as a result of local exposure to heat, by means of a thermocouple. The author concluded that the temperature becomes highest in active organs (glands, muscles) and that in remote (from the point heated) organs, the temperature rises, due to the influx of heated blood.

We have been interested primarily in the question of how the temperature in the stomach changes, due to the temperature of ingest-

* Numbers in the margin indicate pagination in the foreign text.

ed food, and how the ingestion of food of a given temperature is reflected in the opening of the pylorus, as well as in how the temperature changes in the duodenum in this case.

We used a thermocouple with a mirror galvanometer to study this question. Except for the sensitive part of the junctions, the thermocouple leads were enclosed in a thin 4 millimeter rubber tube, which could be inserted easily into the stomach or into the duodenum. The principles of the corresponding equipment have been described by Vereshchagin and Veselkin and, therefore, it is superfluous to present a detailed description of the equipment here. The thermocouple was tested repeatedly beforehand, by means of fine chemical thermometers, to establish the limits of its sensitivity. Our experience, however, was convincing that a previously established scale could not be used constantly. In view of the high sensitivity of the thermocouple, unnoticeable causes sometimes can have an effect. In order to avoid unforeseen errors for which it is difficult to account, in our studies, we established and tested the temperature scale in each case before and after the test.

The temperature of the esophagus, stomach, duodenum and large intestine of people was measured on an empty stomach. Based on our studies, we could determine that the temperature in the esophagus is somewhat higher than in the oral cavity, and the stomach temperature is somewhat higher than that of the esophagus. Here, the temperature in the esophagus becomes constant upon introduction of the thermocouple to a depth of approximately 18 cm (from the teeth); after this, it remains unchanged to a depth of approximately 45 cm. As soon as the sensitive tip of the thermocouple passed through the esophagus (45 cm), an insignificant increase in temperature was found at once. We obtained similar data during removal of the thermocouple from the stomach. At each point in the esophagus and in the /109 stomach, the change was made over a more or less extended time (in 5-15 minutes), to guarantee measurement accuracy. The entire procedure presented no difficulties to the test subject, since it was carried out on people already accustomed to introduction of a thin probe. As an illustration, I present three examples of esophageal temperature changes.

TABLE 1. TEMPERATURE CHANGES DURING INTRODUCTION OF THERMOCOUPLE TO VARIOUS DEPTHS AND DURING THERMOCOUPLE REMOVAL

Depth in cm	10	15	18	20	30	40	45	50
Temperature	37.6°	38.0°	38.1°	38.1°	38.1°	38.1°	38.2°	38.2°
Removal from depth (Depth in cm)	50	40	30	20	18	15	10	
Temperature	37.8°	38.0°	38.0°	38.0°	38.0°	37.8°	38.4°	

As is evident from the figures presented, the temperature difference between the stomach and the esophagus is small. However, for the visceral organs not subjected to the effects of external factors, these small temperature differences are important to the understanding of the physiology and, perhaps, the pathology of the organs named. In the stomach, as a rule, the temperature is 0.05-0.2° higher than in the esophagus and 0.05-0.5° higher in the esophagus than in the oral cavity. On the other hand, in some cases, upon penetration of the thermocouple into the stomach (45-48 cm), the temperature decreases. It seems to us that this results exclusively in those cases, when there is distension and prolapse of the stomach, with a decrease in its tone, because of which the sensitive part of the thermocouple can temporarily not be in contact with the stomach wall.

To answer the question as to how the stomach reacts to the ingestion of food of different temperatures, we introduced the thermocouple into the stomach to a depth of 45-50 cm, and the temperature of the latter was determined. After this, the test subject was allowed to drink (on top of the thermocouple probe) 200-300 cm^3 of water at a specific temperature. The change of temperature in the stomach as

TABLE 2: TEMPERATURE CHANGES IN STOMACH AFTER INGESTION OF WATER OF VARIOUS TEMPERATURES

Test no.	Armpit temperature	Pretest stomach temperature	Water temperature	Amount of water drunk, cm³	Stomach temperature right after drinking	Time in minutes									
						0,25	0,5	1	2	3	4	5	6	7	8
					Temperature										
1	36,6°	37,8°	55,0°	300	45,0°	45,0°	45,0°	45,0°	43,0°	43,0°	42,8°	42,6°	42,4°	42,0°	41,6°
3	36,4°	37,8°	22,0°	300				33,0°		30,0°		29,0°	31,0°		
4	36,2°	37,5°	22,0°	300		30,0°	34,0°	34,0°	35,0°	36,0°	36,5°	36,5°	36,5°	36,6°	35,5°
7	35,5°	37,6°	52,0°	250	37,6°	37,6°	37,6°	37,6°	37,6°	44,2°	38,6°	38,5°		38,5°	38,2°
21	36,0°	36,8°	22,0°	250			26,8°	31,8°	34,8°	36,0°	36,5°	36,9°	37,0°		
13	36,1°	38,2°	48,0°	250				41,0°	40,8°	40,7°	40,5°	40,1°		39,5°	39,1°
10	35,0°	37,5°	22,5°	250				29,0°	30,6°	31,2°	34,0°	35,7°	36,1°	36,6°	
11	36,1°	37,5°	57,0°	250					38,5°	40,9°	40,5°	38,9°	38,5°	38,1°	
17	36,2°	37,4°	21,0°	300				34,1°	30,0°	34,5°	36,1°	37,5°			
15	36,5°	36,0°	65,0°	300	38,0°	38,0°	38,0°	38,0°	38,6°	39,1°	43,1°	49,0°	40,0°	38,9°	38,1°
16	36,3°	38,0°	11,0°	250	18,3°			29,1°	34,5°	37,2°	37,8°	38,0°	38,1°	38,1°	38,1°

TABLE 3

Armpit temperature	Stomach temperature	Duodenal temperature	Water temperature	Amount of water drunk, cm³	Time elapsed after drinking water, in minutes							
					1	2	3	4	5	6	7	8
					Temperature							
36,4°	37,9°	37,3°	56°	250	37,3°	37,3°	37,3°	37,3°	37,3°	37,3°	38,9°	38,9°
36,5°	37,9°	38,2°	50°	250	38,2°	38,2°	38,7°	39,5°		39,5°	39,5°	39,5°
36,6°	38,4°	38,0°	18°	250	38,0°	37,2°	34,0°	34,9°	34,2°	34,5°		36,4°
36,5°		37,5°	58°	250	37,5°	37,5°	38,0°	38,6°	38,8°	38,5°	37,8°	
36,8°	37,6°	37,4°	25°	250	37,45°	37,45°	36,0°		35,5°			35,5°

[Translator's note: commas in tabulated figures are equivalent to decimal points.]

TABLE 2 continued

Time in minutes															
9	10	11	12	13	14	15	17	20	22	25	30	35	36	40	45
Temperature															
41,3°	41,0°					40,0°		39,0°		38,2°		37,8°			37,6°
		32,0°		33,0°		34,0°		35,0°		36,0°	37,0°	37,5°	37,8°		
35,4°	36,5°	37,0°	37,0°		37,1°			37,1°	37,3°	37,6°					
38,4°			38,3°		38,2°			33,0°	37,9°	37,7°		36,8°			
38,7°	38,5°	38,4°	38,4°	38,2°		38,0°	37,9°			37,9°	38,1°	38,1°	38,1°	38,2°	
36,6°			36,5°	36,6°			36,7°	37,3°	37,3°	37,4°	37,5°				
37,7°	37,5°														
38,0°	38,2°	38,2°	38,2°	38,2°	38,4°	38,4°	38,3°	38,2°	38,1°	38,1°	38,0°				
38,0°	38,0°	38,0°	37,8°	37,8°	37,8°	37,8°	37,8°	37,8°	37,6°	37,6°	37,8°	38,0°	38,0°	38,0°	

TABLE 3 continued

Time elapsed after drinking water, in minutes													
9	10	11	12	13	14	15	16	18	20	22	26	27	30
Temperature													
39,8°	39,8°	39,8°		39,7°	39,6°		38,0°	37,7°		37,4°	37,4°	37,3°	37,0°
39,6°	39,5°	39,2°	39,1°	38,7°		38,6°	38,2°		38,2°		38,0°	37,8°	37,8°
		37,0°	37,5°		38,0°								
37,7°	38,0°	37,7°	37,5°										
	35,8°	35,8°		36,8°		37,0°		37,4°					

a result of the water drunk was noted simultaneously. In some cases, only hot or cold water was given and, in others, water at one temperature and another in turn. The second portion of water was given when the temperature in the stomach returned to the initial value. Examples of such studies are presented in Table 2.

It is seen from Table 2 that the ingestion of hot water, as a rule, raises the stomach temperature. However, the stomach temperature never reaches the temperature of the water ingested, remaining 7-16° lower, immediately after ingestion of the water. With the sensitive part of the thermocouple left at a depth of 30 cm in the esophagus and with hot water (60°) given, we obtained a maximum temperature reduction in the esophagus of a total of 6°. It is difficult to think that, with its further passage below a depth of 30 cm, where the temperature was measured, to the stomach, the water could have lost 16-6=10°, by means of heat transfer. Therefore, it must be thought that the stomach, in response to the thermal stimulus, immediately begins to secrete, apparently, mainly mucus, by which such a rapid reduction of temperature in it is achieved. This is consistent with the data of I.P. Pavlov, Boldyreff and Mahlo, who saw the secretion of mucus upon stimulation of the stomach mucosa. /112
It is of interest to note that the stomach temperature of persons suffering from stomach diseases (ulcers, gastritis) does not become as high after drinking hot water as that of persons with a healthy stomach. Besides, the temperature reduction initially is faster in sick stomachs than in healthy ones. However, in healthy stomachs, the time interval from the start of drinking to recovery of the initial temperature usually is shorter than in sick stomachs. In general, after drinking hot water, the stomach temperature returns to the initial point in 7-40 minutes. Upon expiration of this interval of time, the stomach temperature even is somewhat reduced from the initial one (by 0.05-0.4°). This reduction lasts 12-20 minutes, after which the temperature usually returns to the initial point. The rate of the stomach temperature decrease after drinking hot water,

as we succeeded in noting, somehow depends on the practice of the test subject of ingesting food of a given temperature. In persons accustomed to the ingestion of high temperature food, in the stomach, the latter immediately produces the maximum increase and, then, decreases faster. However, final equalization of the temperature (return to the initial temperature) occurs slowly in this category of persons. With introduction into the stomach of low temperature (11-23°) water, immediately after drinking, we obtained a higher temperature in the stomach than the temperature of the water ingested. On the average, the temperature in the stomach in these tests did not drop below 18.3°, i.e., the stomach, owing to its secretion and heat conductivity, can immediately raise the temperature of the cold water (in any case, at places of its contact with the stomach wall) by 4.8-8°. In this case, we could note that, in persons accustomed to cold food and drink, the maximum cooling in the stomach occurs immediately or soon after drinking and, in test subjects accustomed to hot water, the lowest stomach temperature occurs after 2-5 minutes.

We performed the next series of tests, in order to determine the effect of high and low temperatures from the stomach to the duodenum. In order to be able to decide on the passage of the thermocouple into the duodenum and, also, at the same time, to be able to study the function of the duodenum and the organs adjacent to it, we fastened a rubber barrier tube to the base of the sensitive portion of the thermocouple and, above the point of attachment, in the barrier rubber, we cut several openings (apertures). The two rubber tubes connected in this manner (thermocouple and barrier tube, with one metallic tip) is easily inserted into the duodenum. The duodenal temperature usually is a little below that of the stomach, by 0.05-0.3° on the average. Besides, we note that, in duodenitis and cholecystitis, the duodenal temperature is somewhat higher than normal, for example, 38-38.2° instead of 37-37.9°. The temperature changes in the duodenum after the ingestion of hot or cold water are seen from Table 3.

It is evident from the table that, after drinking hot water, the duodenal temperature usually does not change for a certain period of time, and that this interval is variable for all test subjects. After the time interval indicated, the duodenal temperature gradually begins to rise. However, this rise never reaches such high figures as occurred in the stomach. The maximum duodenal temperature increase in our cases was 2.5°. The duodenal temperature increase is found /113 in the first 7 minutes from the time of ingestion of water into the stomach. The time interval of the elevated duodenal temperature is shorter than in the stomach. The maximum reaches 22 minutes. After this, the duodenal temperature begins to decrease gradually, and it reaches a temperature 0.05-0.4° below the initial temperature, so that, after 10-20 minutes, it again returns to normal. The latter phenomenon evidently is associated with the transfer of the contents to the next section of the intestines.

Ingested cold water appears in the duodenum after 2-3 minutes. The duodenal temperature reduction is somewhat more substantial (4°) than the increase after hot water. In our cases, the low temperature remained in the duodenum for 14-18 minutes. It turns out that cold water appears to pass through the pylorus faster than hot. The duodenum evidently reacts strongly to a cold stimulus, and the secretion (of the liver, pancreas and duodenum) entering it rapidly equalizes tho temperature of the cold contents entering from the stomach.

With the aid of the abovementioned barrier tube, we also successfully established that the penetration of hot water into the duodenum strongly inhibited the secretion of bile. In some cases after the ingestion of hot water, bile was not secreted at all for 30 minutes or more and, more than that, after the ingestion of cold water, the cessation of bile secretion lasted only 5-8 minutes. This is consistent with the tests of Sorokin, who was convinced that the application of a warm lump of mud at 40-42° to the region of the liver considerably decreases bile secretion. Glikson, from the laboratory of I.P. Razenkov, after applying radiant energy to the neck region of dogs (the remaining part was carefully covered), also could be persuaded that the pancreas secretion increases in this case.

Conclusions

1. The temperature in the esophagus is 0.1-0.4° higher than in the oral cavity.

2. The temperature in the duodenum is somewhat lower than in the stomach, by 0.05-0.4°. In cholecystitis and duodenitis, the duodenal temperature is 0.15-0.3° higher than in the stomach. In gastritis, the stomach temperature increases by 0.5-1.5°.

3. Hot water is retained longer in the stomach than cold. Both hot and cold water are passed into the duodenum, when the water temperature becomes more or less near the temperature of the surrounding organs.

4. In normal stomachs, the temperature equals or is 0.05-0.3° higher than that in the esophagus. In distended stomachs, the temperature frequently is 0.05-0.2° lower than in the esophagus.

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