DISTURBANCES IN AND RESTORATION OF FUNCTIONS OF VISCERA AFTER CLINICAL DEATH

PRELIMINARY COMMUNICATION. DISTURBANCE AND RESTORATION OF GASTRIC FUNCTION AFTER CLINICAL DEATH OF 2 AND 7 MINUTES DURATION

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Most of the studies made of the changes taking place in the organism of higher animals dying of acute hemorrhage, and subsequently resuscitated, have been related to biochemical and electrophysiological changes in cerebral and myocardial activity, and to basal metabolism [1, 2, 6, 7], as well as to certain aspects of higher nervous activity [3, 4, 5]. Up till now, no work has been done on the study of the changes which take place, as a result of fatally terminating blood loss, in the functioning of a number of the internal systems of the body, and in the first place in the alimentary tract and the kidneys.

We had at our disposal a dog called Malchik, 5-6 years old, a cross between an Alsatian sheepdog and a farmyard dog. This animal had been in the laboratory for a number of years, and was accustomed to staying immobile in a harness for long hours. It had been subjected to gastrotomy and esophagotomy in 1952, and had adapted well to feeding through a stomach tube inserted through an opening at the lower end of the ligated esophagus. The dog had been fed twice daily for 4 years, i. e., to the end of May 1956, during which time its weight had remained steady at about 17-18 kg. The following were examined: 1) the secretory function of the stomach, in response to 3-minute sham feeding with raw meat; 2) total acidity of the gastric juice; 3) the digestive power of the gastric juice, assessed according to Mett; 4) nature of the fasting (periodic) activity of the stomach, registered by V. N. Boldyrev's method.

EXPERIMENTAL METHODS

The experiments were started after thorough washing out of the stomach with warm water, for which purpose we used not less than 3 liters of water, after which we recorded the amount of juice secreted over a period of from 30 to 60 minutes; the dog was then sham-fed for 3 minutes. The latent period of gastric secretion was recorded, and the amount of juice secreted per 15 minute period was measured over 1-2 hours.

Peak secretion was usually observed during the first hour of the experiment. For this reason we frequently restricted our observations to one hour after sham feeding. The gastric juice collected during this hour was filtered, and its total acidity was determined by titration with N/10 NaOH, using 1% alcoholic phenolphthalein as indicator. Digestive power was assessed from the number of millimeters of protein column digested after 12 hours of incubation at 37.5°. Periodic stomach contractions were registered through air transmission on an electrokymograph, with the drum rotating at a rate of 50 cm in 15 minutes.

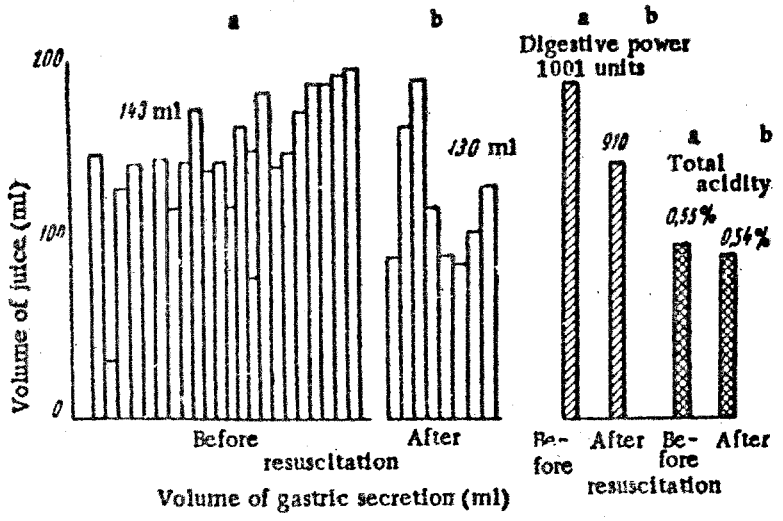

Fig. 1. Amount of gastric secretion (1st experiment).

EXPERIMENTAL RESULTS

The dog was twice bled to death. During the preceding 3 months we performed 22 experiments involving sham feeding with subsequent determination of volume, total acidity, and digestive power of gastric juice secreted during the next hour (Fig. 1, a). The dog was first bled to death on May 31, 1956 (Protocol No. 1979). Its weight was then 17.5 kg. Before the experiment we gave the dog a 2% solution of Pantopon, at a dosage level of 2 ml per 5 kg body weight. The femoral vessels were exposed under local procaine anesthesia. The volume of blood withdrawn amounted to 960 ml.

The death agony was of short duration, lasting for 2 minutes 46 seconds. Clinical death lasted for 2 minutes. Cardiac activity returned 30 seconds after commencement of intra-arterial transfusion of blood and of artificial respiration. The first spontaneous inspiration appeared $1^1/_2$ minutes after commencement of resuscitation. Spinal reflexes reappeared 3 minutes 45 seconds after resuscitation began, corneal reflexes in the left eye after 6 minutes 15 seconds, and in the right eye after 7 minutes, while tendon reflexes reappeared after 7 minutes

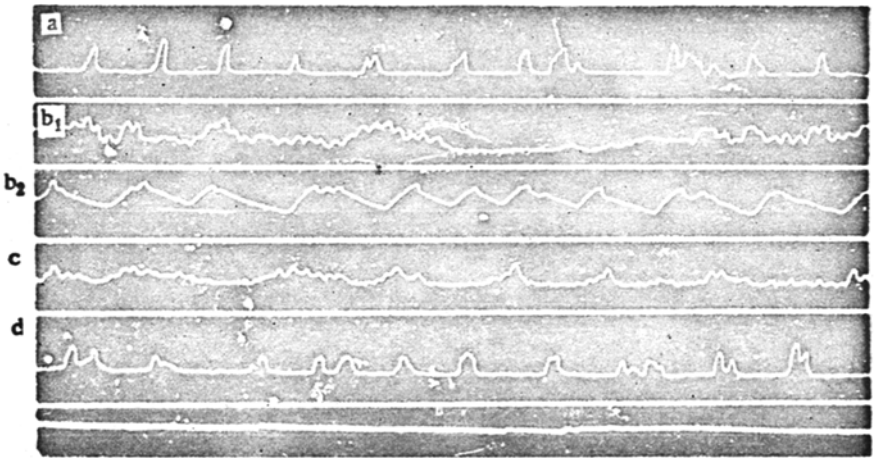

Fig. 2. Characteristics of "hunger" contractions.
a) experiment of April 24, 1956 (control); b_1) experiment of June 3, 1956 (3 days after resuscitation); b_2) continuation of the experiment of June 3, 1956; c) experiment of December 11, 1956 (4th day after second resuscitation); d) experiment of February 14, 1957 (2 months after second resuscitation); below: time signal (1 sec.).

The animal reacted to light and sound after 11 hours. It began to walk on the following day, with a very uncoordinated gait. It was taken for experiment 44 hours after resuscitation.

Studies of the gastric secretion and of other aspects of gastric function were executed systematically over a month. Over this period (see Fig. 1 b) we observed a certain lowering of the volume, total acidity, and digestive power of the gastric juice.

Periodic gastric activity was examined 9 times in control experiments, and 7 times after resuscitation. Judging from the duration (summary) of the periods of activity before and after bleeding, no great change in the nature of this activity had taken place. Before the experiment, the mean duration of activity periods was 28 minutes, and of the pauses 43 minutes. After resuscitation the average length of the activity periods was increased to 33 minutes, while the length of the pauses remained unchanged. There were, however, considerable changes in the form of the contractions, which were well-marked and of considerable amplitude in the control experiments (Fig. 2, a), whereas for a long time after resuscitation they had a chaotic character, and consisted of slow, feeble waves of low amplitude (see Fig. 2, b_1 and b_2). Only after a lapse of 3 months was the normal periodic activity of the fasting stomach restored.

After a 2-month interval (July-September) the observations were resumed at the beginning of September, and were concluded on the 7th December, when the dog was again bled to death. As appears from Fig. 3, a, the volume of gastric secretion varied within relatively narrow limits over this period; total acidity and digestive power fell slightly, but remained at about the same levels (0.49% HCl and 757 enzyme units) over the 3-month period of observation. The periodic activity of the stomach gradually reverted to the normal state. On December 7, 1956 the dog was again bled to death, the intention this time being to prolong the duration of clinical death to 5 minutes.

The experiment was conducted similarly to the first one; (Protocol No. 2112; the vessels were exposed under local anesthesia, and general anesthesia was not applied). The agonal period lasted for 2 minutes 30 seconds. The volume of blood withdrawn amounted to 1150 ml. Regular breathing ceased 3 minutes 30 seconds after bleeding was begun, and was followed by a terminal pause, lasting for 22 seconds. This was succeeded by an agonal period lasting for 3 minutes, during which time corneal reflexes disappeared. All reflexes had disappeared 5 minutes after bleeding was begun. Resuscitative measures were instituted precisely 5 minutes after clinical death had been established. Cardiac activity recommenced 7 minutes 25 seconds later. The delay in re-establishment of cardiac activity was due to the appearance of ventricular fibrillation at the beginning of the resuscitation period; this was abolished by means of single condenser discharges. The heart resumed normal activity 50 seconds later. Thus the total duration of the state of clinical death was 7 minutes 30 seconds.

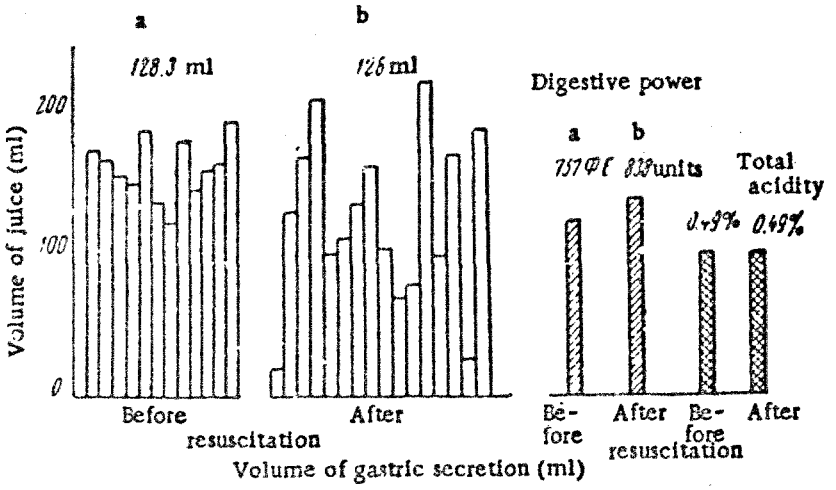

Fig. 3. Gastric secretion (2nd experiment).

The first spontaneous inspiration was observed 8 minutes 30 seconds after resuscitation was begun. In spite of repeated administration of adrenalin vascular tonus was not recovered until after intravenous injection of 0.1 ml of ephedrine solution at the 13th minute of resuscitation. Pupillary reflexes were present at the beginning of

the 15th minute, spinal reflexes 14 minutes 20 seconds after commencement of resuscitation, corneal reflexes after 15 minutes 35 seconds, tendon reflexes after 16 minutes 40 seconds, and palpebral reflexes after 17 minutes 5 seconds. After 2 hours the dog was deeply unconscious, and the extremities were in extension, and somewhat rigid. Milk containing 0.15 g of Barbamyl* was introduced through a stomach tube. The dog remained curled up on its side for 20 hours; it reacted to light and sound, and responded to the voice of the experimenter by raising its head and licking its lips.

After 42 hours it tried to jump out of its bed, and greedily approached food. It was taken for the usual sham feeding experiment after 3 days.

During the subsequent 2 months the secretory activity of the stomach showed wide fluctuations in the amount of juice produced, from 18 ml during the first hour of an experiment to 216 in another. The acidity also showed wide variations, from 0.39 to 0.56%, and the digestive power from 3 to 9 mm. The volume of gastric juice secreted during 1 hour (mean of 15 experiments) was 126 ml, which is only slightly less than was found during the preceding 2 months, viz., 128.3 ml.

Much the same applies to the mean values for total acidity and digestive power of the juice (see Fig. 3,b). Considerable changes were evident in the periodic activity of the stomach, chiefly due to an even greater prolongation of the periods of activity, whereas the length of the pauses between these periods remained much the same as after the first bleeding. The average increase in the length of the periods of activity was 10 minutes (44 instead of 34 minutes).

Our experiments thus show that both the secretory and the motor functions of the stomach are affected to a greater or smaller extent after different durations of clinical death due to exsanguination. It appears from our preliminary data that the most considerable and the most persistent changes are in the periodic activity of the stomach (so-called "hunger" contractions), which had not fully reverted to normal even after 2-3 months following exsanguination. The secretory function is affected to a smaller degree, although wide fluctuations in the hydrochloric acid content, digestive power, and volume of gastric juice secreted are seen.

Work is being continued on this dog, and on a number of other animals similarly treated.

Our further experiments will show the basic cause of the changes observed by us in our experiments.

SUMMARY

The author has studied the secretory and motor ("hunger" periodical motions) stomach activity in the gastro-oesophagotomized dog. Following the establishment of standards of the activity under investigation, the dog was twice bled to death in short experiments. The clinical death lasted 2 minutes in the first experiment and 7 minutes in the second. Then the changes of the stomach activity and the dynamics of the processes of recovery were studied. Exhaustion of the secretory function of the organism and chaotic motor function of the stomach were revealed. The process of recovery took from 2 to 4 months.

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* Russian trade name.

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