FUNCTION OF THE MOTOR APPARATUS OF THE STOMACH IN EXPERIMENTAL LEAD INTOXICATION

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From numerous data in the literature it is known that lead poisoning is accompanied by disturbed activity of the digestive apparatus (constipation, diarrhea, attacks of lead colic, etc.). Fairly extensive studies have also been made of the changes in the secretory activity of the gastric glands in lead intoxication [13, 15-18]. A number of works have described the morphological changes in the walls of the gastrointestinal tract [5, 8, 10] and have studied the physiological mechanisms of colic in the isolated intestine [1, 6, 7, 10, 20]. Little attention has been given to studying the motor activity of the digestive tract in saturnism. This problem is nevertheless of great interest as the most distinct manifestation of lead intoxication (the lead colic syndrome) is associated with disturbed motor function of the gastrointestinal tract. Several clinical works [4, 9, 21] do not give a sufficiently full idea of the changes in the motor system of the stomach which develop in saturnism. We only know of one experiment in which an attempt was made to study the motor system of the stomach by the balloon method [19]. However, the results obtained in it are extremely ambiguous because of a number of errors in the methods used: gastric contractions were recorded without allowing for neutralization of gastric juice and the short duration (on the smoked band 2.5-3.5 hr); the volume of the balloon was too great (it was inflated with water to 50-80 ml). The trials were on 2 dogs with slight intoxication, in one of them the "background motor function" was continuous.

It was thus necessary to carry out the experimental observations of the motor activity of the stomach on well-developed patterns of lead intoxication. The test object was the periodic motor activity of the stomach observed constantly in a fasting state in man and many animals [3].

EXPERIMENTAL METHODS

The trials were on 7 dogs fitted with Basov fistulae. In 3 intoxication was subacute (62-77 days) and in 4 chronic (178-246 days). The animals were poisoned daily with a 2, 3, 4, or 5% solution of lead acetate at a rate of 1 ml per kg bodyweight, i.e., 20, 30, 40, or 50 mg/kg. The lead solution was given with 200-300 ml milk which amounted to 15-20 ml per kg liveweight. This amount corresponds with the amount of milk in a mixed ration for dogs [2]. Gastric movements were recorded on a kymograph band with air-water transmission by the method perfected by V. F. Mostun [14]. The volume of the recording balloon was 10-12 ml. "Fasting" periodic gastric motor activity (16-18 hr after feeding) of the experimental dogs was recorded before poisoning (10-15 trials to establish a base value) and during intoxication once or twice or more frequently per week. In all there were 203 trials.

Findings on the change in general condition and behavior of the dogs during poisoning and results of 67 blood analyses were used as criteria of intoxication and its degree.

RESULTS

The main clinical characteristic of lead intoxication in the experimental animals was its wavelike course, expressed in alternating periods of deterioration (loss of appetite, vomiting, passivity, slovenliness, loss of weight,

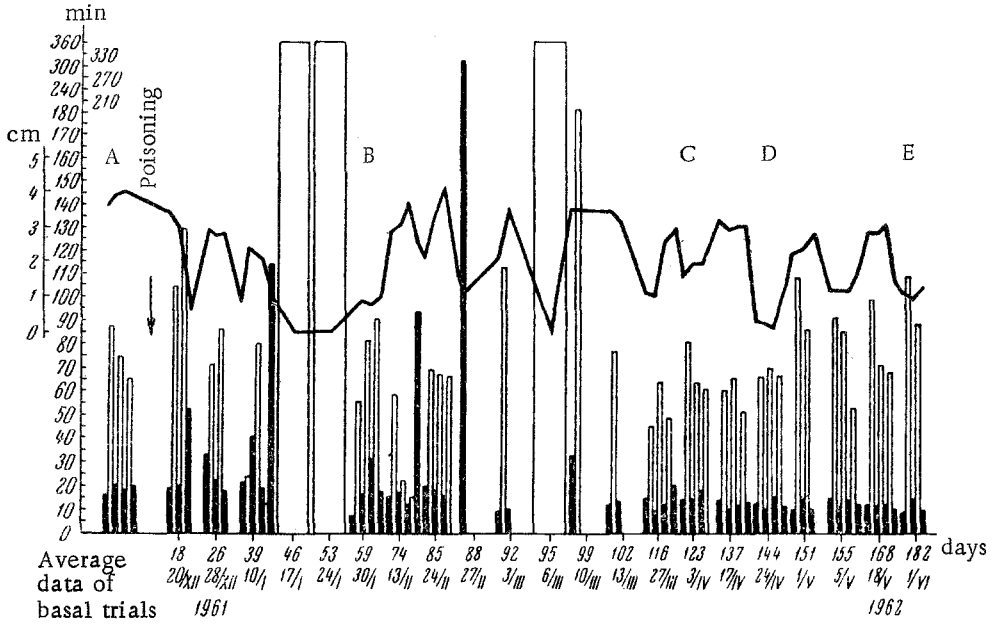

Fig. 1. Changes in periodic gastric activity in the dog Valet during chronic lead intoxication. Black columns) periods of gastric activity (in min); white) periods of rest (in min); broken curve above the columns) variations in amplitude of gastric contractions (in cm).

paresis of the rear, later of the fore extremities) and improvement of the general condition of the dogs repeated several times. Duration of the state of clinical compensation was determined by the individual characteristics of the animals (from 18 to 55 days). In most dogs with subacute intoxication (from the 25th to the 45th day) and in all dogs with chronic poisoning (from 3 to 6.5 months) characteristic clonic-tonic spasms were observed. Death of the animals always occurred during depression of their general condition with unabating spasms. Apparent normalization of the animals' general condition after the termination of poisoning occurred after 3 months (2 dogs).

The changes in the motor function of the stomach in chronic intoxication began with its intensification; in acute and subacute poisoning it was not always possible to detect the stage of stimulation, more frequently the motor function of the stomach was depressed only a few days after the animals were given lead acetate. After a short period of recovery the motor function of the stomach in the dogs with subacute intoxication was again depressed. This was shown by the absence of gastric contractions or shortening of the periods of activity and disturbance in the periodicity of its contractions, by the sharp fall in amplitude and decrease in the rhythm of gastric contractions. This state lasted 2 to 3 weeks after which the dogs usually died.

In animals with chronic lead intoxication the initial stimulation of gastric motor function became normal after only a few days and only after 19-40 days from the start of poisoning changed over to depression of its activity. During the whole period of poisoning 3-4 depression waves were observed, alternating with apparently normal gastric functional activity. The periods of depression of gastric activity with the development of intoxication were prolonged (from 8 to 72 days), the periods of remission were shortened (to 56-7 days). The periodic motor activity of the stomach in apparently normal conditions took on some special features characterized by increase and reduction in frequency of the cycles of the periodic motor function (period of activity and period of rest) with a reduced amplitude of contractions (Fig. 1 from March 13 through June 1, 1962; Fig. 2).

It is interesting that marked depression of gastric activity was in all cases preceded by days with constant gastric contractions of low amplitude with a neutral gastric juice reaction. Disturbances of the motor function of the stomach were most clearly defined at the end of the observation period, i.e., when intoxication was distinct. The gastric contractions in this case were either absent during the day of the trial, or were very weak and grouped in an amplitude range of 0.2-0.3 cm, or finally small fibrillary irregular twitchings were noted. In this period also there was a more abrupt decrease in frequency of the rhythm of gastric contractions, which was sometimes expressed in 1-2 considerable intervals during the period of activity.

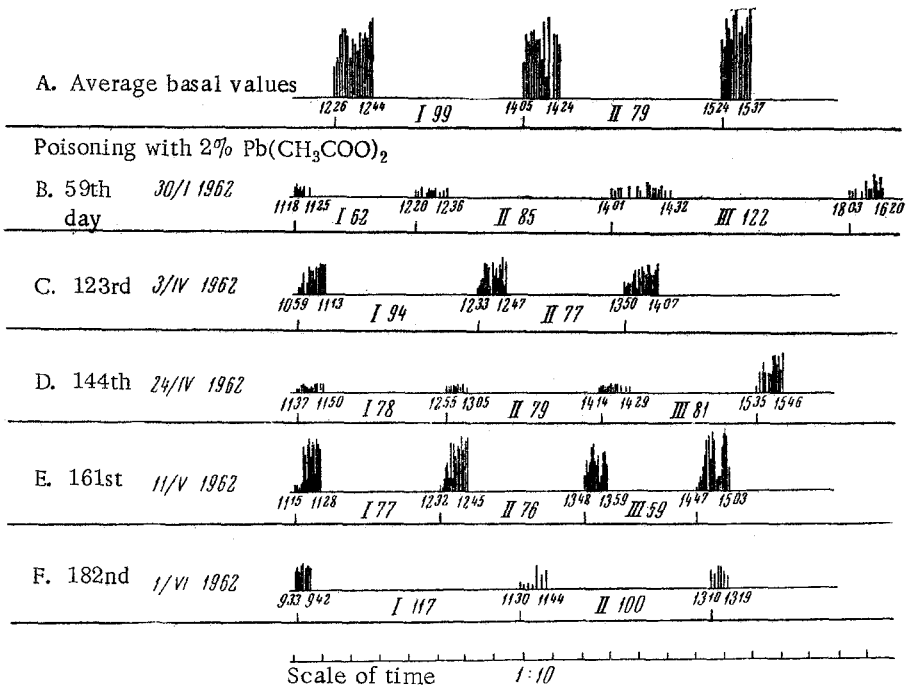

Fig. 2. Plan of gastric motor behavior in the dog Valet. Vertical lines correspond to gastric contractions. The number of vertical lines in the period of contractions on the plan corresponds exactly to the number of contractions on the kymogram. The large figures under the horizontal lines denote cycles – the period of activity and the subsequent period of rest (in min).

Calculation of the amount of lead obtained by the animals showed that the original depression of gastric motor activity developed in animals with subacute (after 10-15 days) and in those with chronic intoxication (after 19-40 days) with an average intake of 10.4 ± 0.68 g of the lead salt. The secondary wave of depression of gastric motor function corresponded to an intake of 40 ± 3.1 g $Pb(Ch_3COO_2)$. This wave of depression in dogs with subacute intoxication developed after 42-58 and in those with chronic intoxication after 85-166 days from the start of poisoning. The third wave of depression, usually accompanied by death, occurred with an intake of 61.2 ± 1.1 g of the lead salt.

During the poisoning of the animals, parallel to the periods of depression of the general condition of the animals and of the gastric motor activity, there was also a deterioration in blood values, a curve depicting the changes is represented by a 2-3-peak broken line. By the end of life the degree of anemia in the animals was considerable: the amount of hemoglobin had fallen to 2.3 g % or less, reticulocytosis reached 40-62%, and basophil-granular erythrocytes appeared (5-8 per 50 visual fields).

The special feature of experimental saturnism shown by the wavelike development of intoxication and disorder of the gastric motor function is of great interest, as a similar phenomenon is seen in clinical lead poisoning in man. In workers with a long record of work in lead factories, who have no apparent sign of intoxication, there also occur sudden, one would think, unfounded aggravations, most frequently in the form of lead colic spontaneously passing and repeated many times. The mechanism of this phenomenon is not clear. We have found no information in the literature on the possibility of a similar course of experimental lead intoxication. Nevertheless, the observed fact and its mechanisms are of interest in understanding the pathogenesis of saturnism in general.

SUMMARY

It was established in chronic experiments on dogs that the picture of experimental lead poisoning was to a considerable extent similar to that seen during clinical manifestations of saturnism in human beings. This similarity was manifested by the intermittent character of its course, i.e., repeated changes of aggravation (correspondingly "exacerbation") and amelioration (correspondingly "lead carrier state") periods. Registration of the motor

function of the stomach in these animals indicated that its disturbances in chronically intoxicated animals also had a course with alternating periods of aggravation and normalization. Obvious lead intoxication was also accompanied by a marked depression of the motor function of the stomach.

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