

STUDY OF PANCREATIC AND BILIARY SECRETION IN HORSES BY MEANS OF A CHRONIC FISTULA

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The Pavlov fistula method has been used successfully by numerous physiologists to study the physiology of digestion in various species of animals. It has made possible not only the discovery of distinctive features of the activity of the digestive glands in different animal species but also the proper organization of a rational diet.

Investigations on horses using the fistula method have revealed distinctive features of the secretion of saliva and bile in horses on different diets in a natural form or after technological processing or enrichment with various additives. The effect of the feeding program and of its content on the functional activity of these glands has been studied.

However, a wide gap in the investigation of the physiology of digestion in horses until recently has been the lack of data on the physiology of the pancreas. Whereas the physiology of this gland has been studied in other species of animal by means of the fistula method, in the horse on account of the difficult operative access there have been no reports of the successful formation of a fistula of the pancreatic duct. The only known papers in the literature are those of Colin [3] and of N. A. Popov and A. A. Kudriavtsev [1], who performed acute experiments on horses. However, in these papers the results given are only of the composition of the pancreatic juice of the horse.

The department of physiology of the Moscow Veterinary Academy, under the direction of N. F. Popov, has for many years been working on the problem of creating a permanent pancreatic fistula in the horse. In 1955 for the first time we performed the operation of formation of a fistula of the pancreas and the bile duct in a horse (see figure).

EXPERIMENTAL METHOD

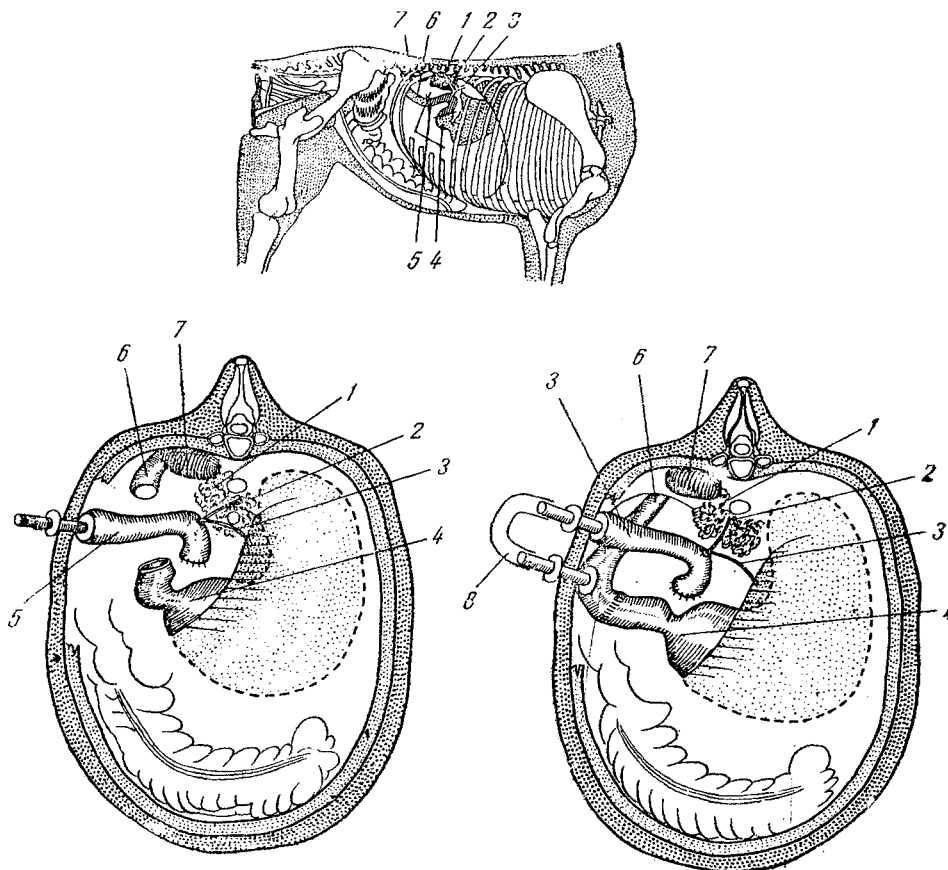
In operations on the pancreas in horses the main difficulty is in the complicated access, on account of the anatomical peculiarities of the disposition of the stomach, duodenum, pancreas and bile duct.

In the horse the stomach is situated mainly in the left hypochondrium at the level of the 13th to 15th ribs and only its pyloric part reaches into the right hypochondrium where it is situated at the level of the upper third of the 11th to 13th ribs. The stomach is well fixed by ligaments to other organs. The immobility of the stomach creates great difficulties for the experimenter. The access to the pyloric portion of the stomach is particularly complicated and is possible only through the right half of the thorax.

The duodenum is equally immobile and deeply situated. Beginning at the pylorus it forms an S-shaped flexure on the visceral surface of the liver and is directed superiorly and posteriorly to the right kidney. The pancreatic ducts open into the duodenum at a distance of 12-15 cm from the pylorus in the S-shaped flexure. They are usually two in number: one — the main duct, opening jointly with the bile duct, the other — the accessory duct, opening into the duodenum at the same level. Thus, because the main pancreatic duct takes a course in the same connective tissue sheath as the bile duct and opens jointly with it into the duodenum, the formation of a fistula of the pancreatic duct in isolation from the bile duct has not appeared to be possible.

Pancreatic juice could be obtained only by resection of the part of the duodenum into which the pancreatic and hepatic ducts open. The approach to the site of opening of the ducts in the usual lateral position of the horse is inconvenient on account of the impossibility of bringing this part of the duodenum up into the wound. For this reason the horse was fixed in the dorsoventral position.

The operative approach to the abdominal cavity was made through the right hemithorax by resection of the 13th to 16th ribs. The main incision passed along the bed of the 16th rib from the angle to the costochondral junction and then forwards at an angle horizontally to the 12th rib. In order to prevent a pneumothorax the diaphragmatic layer of the pleura was sutured to the parietal layer along the whole length of the incision.



Scheme of the operation for formation of a permanent fistula of the pancreatic duct and bile duct in the horse. 1) Pancreas; 2) pancreatic duct; 3) bile duct and liver; 4) pyloric portion of the stomach; 5) resected portion of the duodenum; 6) duodenum; 7) right kidney; 8) external anastomosis between the fistulas.

In order to resect the part of the duodenum with the outlets of the pancreatic and bile ducts, the pyloric part of the stomach and the first part of the duodenum and part of the duodenum from the S-shaped flexure were brought into the wound and fixed. Next the part of the duodenum in the S-shaped flexure, i.e., from a point 6-7 cm beyond the pylorus to a point immediately beyond the flexure, was resected. The cranial end of the resected portion of the duodenum was sutured, and into the caudal end was inserted a metal cannula which emerged from the upper end of the wound. The patency of the intestine was restored by the formation of an anastomosis. A second metal cannula was inserted into the part of the intestine distal to the anastomosis and brought out of the lower end of the wound.

In order to prevent a copious loss of pancreatic juice and bile (this leads not only to disturbance of the normal digestive processes but also to the rapid death of experimental animals) both cannulas were joined by means of an external anastomosis using a rubber tube. Thus, the juice and bile secreted during the experiment is collected in a flask while that secreted at other times passes into the intestine and there is no disturbance of the normal process of digestion. Pancreatic juice mixed with bile began to be excreted immediately after the operation through the cannula inserted into the intestine.

EXPERIMENTAL RESULTS

Experiments were carried out on 2 foals on which these operations had been undertaken in order to study the secretory activity of the pancreas and the secretion of bile. The experiments showed that the secretion of pancreatic juice and bile in the horse is continuous; there was no cessation of secretion even after starvation for 42 hours. Secretion of juice takes place rhythmically with intervals of 1-2 and sometimes 4-5 minutes.

The taking of food sharply stimulates the secretion of pancreatic juice and bile. In order to discover the mechanism of secretion of pancreatic juice and bile at times unrelated to the taking of food, we carried out experiments in which injections of 0.1 and 0.3% solutions of hydrochloric acid and also horse gastric juice, obtained from an isolated gastric pouch, were given into the duodenum. It was observed in these experiments that the hydrochloric acid solutions and the gastric juice cause a considerable increase in the spontaneous secretion of pancreatic juice and bile within 15 minutes of their injection. The volume of secretion depends on the concentration of the acid solution injected; the higher the concentration of the acid the greater the volume of secretion caused.

The Secretion of Pancreatic Juice and Bile in the Horse on Hay, Oats and Bran (the foal Orlik)

Time and conditions of experiment	Volume of juice in ml	pH of juice	Digestion of starch in mm of a starch stick	Lipolytic power of the juice in units of 0.1N solution of alkali	Food
Experiment dated January 29, 1955					
Before feeding	320	8.10	0.75	26	1 kg of hay
After feeding:					
1st hour	477	7.84	1.0	24	
2nd »	501	7.47	0.5	22	
3rd »	523	7.33	1.0	36	
4th »	498	7.32	1.5	44	
Experiment dated January 31, 1955					
Before feeding	284	7.32	4.0	26	1 kg of oats
After feeding:					
1st hour	519	7.77	3.0	22	
2nd »	557	7.80	3.5	24	
3rd »	569	7.79	3.0	26	
4th »	546	7.78	3.0	30	
Experiment dated February 5, 1955					
Before feeding	292	7.52	1.2	20	1 kg of wheat bran
After feeding:					
1st hour	559	7.37	1.5	26	
2nd »	585	7.01	1.5	26	
3rd »	637	6.64	1.6	28	
4th »	576	7.35	2.0	30	

The experiments carried out confirm the findings obtained in other animals: gastric juice, and in particular its acid are the connecting links between the secretion of gastric and pancreatic juice. The experiments also demonstrate the effect which the activity of the glands of the stomach can exert on the secretion of pancreatic juice in the horse.

In a study of the secretion of pancreatic juice and bile in response to different forms of food, we established that the ingestion of different foods causes an unequal secretory reaction, both as regards the volume of juice secreted and its enzymic content (see table).

The highest secretion of juice is observed during feeding with wheat bran. Ingestion of bran causes within one hour a significant increase in the volume of juice which is more than twice the initial level. The maximum rise in secretion takes place in the 3rd hour and in the 4th hour the secretion falls slightly. The enzymic content of the juice rises about the 4th hour of secretion.

During feeding with oats an increase in the secretion of juice is also observed within an hour of taking food and its maximum rise is in the 3rd hour. However, during feeding with oats the volume of juice secreted is smaller than during feeding with bran. The enzymic activity of the juice in respect to its lipolytic enzyme is increased about the 4th hour and in respect to its amylolytic enzyme stays at almost the same level during the four-hour period.

The curve of secretion when hay is eaten is the same as with oats or bran. However, the volume of juice is significantly smaller than when the horse is fed on oats or bran. The enzymic activity of the juice is the same as when fed on oats, except that its starch-digesting power is slightly lower.

Salted oats causes an intensive reaction, especially within an hour of feeding. Feeding with cooked oats was not accompanied by any increase in the spontaneous secretion of pancreatic juice and bile.

The experiments described show that feeding with various types of fodder causes a different reaction on the part of the pancreas and the secretion of bile in the horse.

Consequently the creation of a permanent fistula of the pancreas and bile duct in the horse permits the study of the distinctive features of digestion in that animal as determined by the working of all the principal digestive glands — salivary, gastric and pancreatic. In this way physiological data may be obtained which may serve as a basis for the correct organization of the feeding of healthy and sick horses.

SUMMARY

A method of placing a fistula on the duct of the pancreas and bile duct of a horse was developed.

The effect of various food contents and regimen of feeding on the gastric and bile secretion was studied by means of this method.

LITERATURE CITED

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* In Russian.