

Pathways of Enzymes into the Blood in Acute Damage of the Pancreas.*

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It has been known for a long time that in acute diseases of the pancreas and in injury of the pancreas, the amylase concentration in the blood increases acutely. To our knowledge, the pathway by which pancreatic enzymes get into the blood stream has not been analyzed. In order to do this, experiments were performed on dogs under pentobarbital sodium anesthesia. A peripheral vein was prepared for withdrawal of blood and in a number of animals the thoracic duct was cannulated in the neck and the lymph collected. The pancreas was exposed and the main pancreatic duct prepared. In 9 experiments, dog's gallbladder bile in amounts varying from 0.1 to 4 cc was then injected into the duct after which the duct was ligated; several samples of portal blood were withdrawn in some of these experiments. In one experiment the pancreatic duct was ligated only; no bile was injected. In this and in one other experiment in which the pancreatic duct was not ligated and in which the pancreas was not touched at all, secretin was given intravenously in order to stimulate the external secretion of the pancreas.† Venous blood and thoracic duct lymph were collected at regular intervals before and after the above procedures. In these samples amylase was determined using the method of Wohlgemuth¹‡ and lipase, using the method of Crandall and Cherry.² Trypsin determinations were performed in some instances but were of no value.

Results. Because our results were quite uniform, only a few representative experiments are given in Table I. It is apparent that in the fasting anesthetized dog, the concentrations of amylase in peripheral and portal blood and in thoracic duct lymph are almost equal. A rise in amylase concentration of the blood may appear as early as 5-10

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¹ Wohlgemuth, J., *Bioch. Z.*, 1908, **9**, 1.

† Secretin Astra was used for which we are much obliged to Prof. Hammarsten, Dr. Agren and Astra Company, Sweden.

‡ Amylase concentration is expressed by the degree of dilution of 1 cc of serum at which 1 cc of the diluted serum will digest 1 cc of a 0.1% starch solution at 38°C within 30 minutes.

² Crandall, L. A., Jr., and Cherry, I. S., *Am. J. Physiol.*, 1932, **100**, 266.

TABLE I.
Amylase and Lipase in Blood and Lymph.

Exp. No.	Procedure	Time after procedure, min.	Peripheral blood		Portal blood		Lymph (thoracic duct)	
			Amylase	Lipase	Amylase	Lipase	Amylase	Lipase
1.	4.0 cc bile inj.	0	64				64	
		5	64			128	64	
		15	128			128	128	
		60	128			128	512	
		120	128			128	512	
2.	0.4 " " "	0	32				32	0.16
		5	128					
		10	128				512	0.82
		30	128				512	
		60	256				2048	1.87
3.	2.0 " " " " Occlusion of portal vein for 10 minutes	0	64	0.20			32	0.06
		10	64	0.18	256	0.93	64	
		30	512				1024	
		60	512	1.18			2048	1.65
4.	Ligature of main pan- creatic duct Secretin i.v. 200 cat units	0	32				32	
		10	64				32	
		30	64				64	
		10	64				1024	
		30	64				1024	
		60	256				1024	
5.	Secretin only i.v. 100 cat units	0	64				64	
		10	64				128	
		30	64				128	
		45	128				256	

minutes after the injection of canine gallbladder bile (0.1 to 4 cc) into the main pancreatic duct. A further rise in amylase as well as in lipase concentration takes place later in peripheral and portal blood and lymph, the rise in peripheral and portal blood being about equal. Concentration of amylase in thoracic duct lymph is likewise increased. One-half to one hour after injection of bile it reaches usually higher values than in the blood. In Exp. 3 the portal vein was occluded above the inflow of the splenic vein for 10 minutes following the injection of bile into the pancreatic duct. In this experiment the amylase concentration in peripheral blood and lymph did not rise to any extent during the period of occlusion of the portal vein, while blood drawn from the latter showed considerable values for amylase and lipase. Amylase concentration in peripheral blood as well as in thoracic duct lymph rose considerably after release of the occlusion. In Exp. 4 and 5 intravenous injection of secretin was followed by an increase of amylase in lymph and blood whether the pancreatic duct was ligated or not. The concentration of amylase rose sooner and to higher

levels in the lymph than in the peripheral blood. Determinations of lipase were not done in all experiments, but whenever performed their relative changes in concentration followed closely those of blood amylase.

It is evident from our results that pancreatic enzymes reach the peripheral blood through the thoracic duct as well as through the portal vein. We believe that the main pathway is through the portal vein for the following reasons: The entire lymph from the thoracic duct is prevented from entering the peripheral blood in Exp. 1-2, and yet an increase of blood amylase occurs a few minutes following damage of the pancreas. This increase was observed also in one experiment in which the right main lymphatic duct as well as the thoracic duct were cannulated in the neck. Furthermore, the total amount of amylase reaching the circulation by way of the lymph is relatively small, because while the concentration of amylase in the lymph may be high, the factor of dilution in the blood stream has to be considered. This means that the greater part of the enzymes found in the blood in acute pancreatic disturbances passes through the portal vein and thus through the liver before reaching the general circulation. Further investigation shall deal with the question of whether the passage of enzymes through the liver may be the cause for such changes of the liver as are found frequently in acute pancreatic disease.

Summary. The concentrations of amylase and lipase in peripheral venous blood, portal blood, and thoracic duct lymph are equal in fasting anesthetized dogs. An increase of amylase in the blood often appears 5 to 10 minutes after damaging the pancreas. The increase of blood amylase and lipase following injury of the pancreas or retention of its secretion is due mainly to the inflow of pancreatic enzymes into the general circulation by way of the portal vein and to a smaller extent to inflow of enzymes by the lymph of the thoracic duct.

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