Lymphology 14 (1981) 118–121

Constituents of Lymph from the Non-secreting Stomach of the Dog

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Summary

Gastric lymph collected from the non-secreting stomach of anesthetized dogs contained glucose, Na^+, K^+ and creatine phosphokinase in concentrations that were similar to those in arterial and gastric venous plasma. Gastric lymph contained greater concentrations of pyruvate and lactate than in either arterial or gastric venous blood. Gastric lymph contained a high concentration of total protein similar to that in simultaneously collected hepatic lymph. Gastric lymph was collected before and after the pylorus was ligated and the stomach distended with air. These procedures were used in another study in which total protein in gastric lymph was reported to be much lower than found in the present study. The lymph to plasma ratio for protein was decreased from 0.85 ± .04 to 0.69 ± .04. Pyloric ligation alone caused no change in lymph protein concentration.

Introduction

Lymphatics in the stomach, as in other organs, drain the interstitial fluid compartment. Thus, the constituents of gastric lymph should be a resultant of capillary filtration and mucosal cell activity. Lymph studies should yield valuable information concerning the stomach in various states of normal activity, as well as during various gastropathies.

There are few data concerning the flow and the composition of gastric lymph. *Aune* (1) published data on changes in gastric lymph flow caused by acetylcholine, histolog, secretin and scopolamine in a single dog. Later, *Bruggeman* (2) reported data on protein constituents in lymph collected by micropuncture from the stomach. She found a lymph to plasma ratio for total protein to be .51 in animals with the duodenum ligated at the pylorus and the stomach distended with air.

The specific aims of this study were to determine:

1. the concentration of several constituents of lymph from the nonsecreting stomach,
2. the concentration of total protein in gastric and hepatic lymph in the same animals,
3. and, if stomach distention and/or pyloric ligation would alter gastric lymph protein concentration.

Methods

Mongrel dogs (7–28 kg) of either sex were fasted for at least 24 hours with water ad libitum. The animals were anesthetized with sodium pentobarbital (30 mg/kg). The femoral artery was catheterized for measurement of pressure and collection of blood samples; the femoral vein for infusion of 0.9 % NaCl at 0.1 ml/kg/min. The stomach was exposed through a midline incision and the left gastroepiploic vein was catheterized via a small sidebranch for collecting blood samples and measuring venous pressure. The spleen was retracted posteriorally and wrapped in a saline soaked towel and covered with plastic film. Several of the lymphatic vessels of the body of the greater curvature of the stomach were ligated and allowed to swell. One or more lymphatic vessels were catheterized with polyethylene tubing. The abdominal incision was sealed with plastic film. The animals were heparinized with 500 U/kg followed by maintenance doses of 250 U/kg each hour. Lymph was collected under oil in calibrated centrifuge tubes in ice. Arterial and venous blood samples were drawn at the beginning, several times during the lymph collection and at the end of each expe-

0024–7766/81 1500–0118 $ 02.00

riment. After the animals were euthanized, the stomach was opened to verify the absence of food.

In another set of experiments, the above protocol was followed. In addition, catheters were placed in a lymphatic vessel from the liver and into the portal vein via the splenic vein allowing continuous outflow from this vessel. Thus, it was possible to collect both gastric and hepatic lymph in the same animal. After the lymph and blood collections had been made, the duodenum was ligated at the pylorus and another gastric lymph sample was collected. Lymph flow and venous pressures were monitored.

Na^+ and K^+ were determined by flame photometry, protein by both biuret and refractometer and pyruvate with a micro-modification with a Sigma Kit. Glucose, lactate and creatine phosphokinase (CPK) were determined with Cal Biochem. Kits. The mean values for each substance in arterial and venous blood and lymph were compared using the analysis of variance and the *Newman-Keuls* multiple range test (3).

In another group of dogs, gastric lymph concentration of protein was determined before and after ligating the duodenum at the pylorus and inflating the stomach with air.

Results

The mean concentration values of several constituents of gastric lymph (GL) were compared to those of arterial (AP) and venous (VP) blood and are shown in Table 1).

It may be seen that lymph collected from the non-secreting stomach contained glucose, Na^+, K^+, total protein and creatine phosphokinase (CPK) in concentrations that are similar to those of arterial and gastric venous plasma. Gastric lymph contained greater concentrations of pyruvate and lactate than found in either arterial or venous blood. Lymph flow from a single catheter varied from 15 to 50 μl/hr.

Gastric lymph and hepatic lymph were collected simultaneously in nine additional animals. The gastric lymph to plasma ratio (L/P) for protein and the hepatic L/P for protein were .80 ± .04 and .83 ± .02 respectively. Portal vein pressure average 8 ± 1 mmHg and gastro-

Table 1 Composition of blood and gastric lymph

	Arterial	Venous	Lymph
Glucose mgm/% (n = 7)	106.6 ± 4.8*	98.2 ± 4.3	102 ± 10.8
Na^+ meq/l (n = 8)	148 ± 3.5	153 ± 5.7	148 ± 4.2
K^+ meq/l (n = 8)	3.6 ± .6	3.8 ± .6	3.5 ± .8
Protein (mg/ml) (n = 8)	68.1 ± 4.9	67.5 ± 4.3	60.2 ± 6.1
CPK (mu/ml) (n = 11)	31.7 ± 6.2	36.5 ± 8.2	26.3 ± 6.5
Pyruvate mgm% (n = 6)	.996 ± .135	.942 ± .111	1.881 ± .274+
Lactate mgm% (n = 6)	10.78 ± 1.05	10.97 ± .987	21.28 ± 3.38+

*Mean Value ± S.E.
+Significantly different from arterial and venous plasma $P < .05$

epiploic pressure averaged 12 ± 1 mmHg. Hepatic lymph flow from a single catheter averaged 0.58 ml/hr while gastric lymph flow was 35 μl/hr.

In seven of these animals, gastric L/P for protein was .83 ± .04 before and .81 ± .04 after ligating the pylorus. There was no significant change in either venous pressure or lymph flow. Gastric lymph was collected before and after the pylorus was ligated and the stomach distended with air in seven additional animals. The L/P for protein decreased significantly from .85 ± .04 to .69 ± .04 ($P < .05$) with no significant difference in maintained venous pressure or lymph flow.

Discussion

Gastric lymph collected from the non-secreting stomach contains glucose, Na^+, K^+ and CPK in concentrations that are similar to those of arterial and gastric venous plasma. Gastric lymph contained greater concentrations of pyruvate and lactate than found in either arterial or gastric venous blood. These relationships are similar to those found in cardiac lymph (4). If lactate was high and pyruvate was low, one would suspect organ ischemia. However, since both were high ischemia does not seem a logical explanation. Perhaps a better explanation can be offered when lactate and pyruvate are determined in lymph from the secreting stomach where lymph flow is much greater.

Our data showing that the L/P for protein in stomach lymph was .88 was an unexpected finding in view of the L/P of .51 reported by *Bruggeman* (2). In an attempt to explain our high L/P for protein in contrast to the lower value reported by *Bruggeman,* we tried to duplicate her technic of ligating the duodenum at the pylorus alone or together with air inflation of the stomach. It was concluded that the latter technic significantly lowered the L/P for proteins and was probably the major difference in the two studies.

What is a plausible reason for this decrease in L/P for protein without a change in lymph flow? In the small intestine, lumenal distention increases blood flow to the muscularis serosa and leaves mucosa – submucosa flow unchanged (5). If this same phenomenon occurs in the stomach, then the lower L/P during distention might represent a redistribution of capillary filtration and lymph formation to the less permeable capillaries of the muscularis layer.

It has been shown repeatedly that hepatic lymph contained high concentrations of protein; the L/P ranging from .67 to .89 in six species of animals (6). Lymph from the liver, thus, contained a higher concentration of protein than lymph from any other organ that had been examined. It was, thus, of interest to compare the concentration of protein in gastric and hepatic lymph in the same animals. As can be seen above, the L/P for protein in gastric lymph was similar to that in hepatic lymph. Lymph flow rate from the liver averaged over ten times that measured from the stomach. Thus, the high flow rate together with the high concentration of protein in hepatic lymph would be a reflection of the high permeability of the hepatic sinusoids allowing easy passage of protein from blood into interstitial fluid of this organ.

These studies offer no information on protein permeability of the gastric capillaries since neither capillary pressure nor lymph flow was changed experimentally. The high protein content of the interstitial fluid as reflected in lymph, might serve as a useful mechanism for gastric secretion. Since the colloid osmotic pressures across the gastric capillary would be similar, capillary pressure would have to be elevated minimally to allow fluid filtration for secretion. The high protein concentration in the lymph draining the non-secreting stomach would be expected to decrease substantially with secretory activity as is found in lymph from the mammary gland. The L/P for protein in the non-lactating sheep is .58 and shows decrease to .33 with lactation (6).

Acknowledgement

Preliminary observations from this study were presented in abstract at the Annual Meeting of the Federation of American Societies for Experimental Biology in Dallas, Texas, April, 1979.

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