Final steps in defining the relationship of S 13 virus to other avian tumor viruses will include the establishment of serologic responses.

Summary. Ether and chloroform destroyed all detectable infectivity of S 13 virus as determined by wing web inoculation of chicks.

Appreciation is expressed to Mrs. Ruth E. Matter and Mrs. Marie Dolinger for excellent technical assistance. For dependable care of the chickens, we acknowledge the assistance of Mr. Horace Heald. We also wish to thank Mr. Homer Bicksler and Mr. Al Kish of the Pennsylvania Farm Bureau for their co-operation.

1. Stubbs, E. L., Furth, J., *J. Exp. Med.*, 1935, v61, 593.

2. Furth, J., PROC. SOC. EXP. BIOL. AND MED., 1929, v27, 155.

3. Gottschalk, R. G., *Cancer Res.*, 1943, v3, 649.

4. Stubbs, E. L., *J. Am. Vet. Med. Assoc.*, 1938, v42, 73.

5. Cooper, P. D., *Nature*, 1961, v190, 302.

6. Andrewes, C. H., Burnet, F. M., Enders, F. F., Gard, S., Hirst, G. K., Kaplan, M. M., Zhdanov, V. M., *Virology*, 1961, v15, 52.

7. Andrewes, C. H., Horstmann, D. V. M., *J. Gen. Microbiol.*, 1949, v3, 290.

8. Feldman, H. A., Wang, S. S., PROC. SOC. EXP. BIOL. AND MED., 1961, v106, 736.

9. Drayton, H. A., *Brit. J. Cancer*, 1961, v15, 348.

10. Friesen, B., Rubin, H., *Virology*, 1961, v15, 387.

Received April 18, 1962. P.S.E.B.M., 1962, v110.

Stimulation of Thoracic Duct Lymph Flow by Epinephrine and Norepinephrine.* (27659)

D. B. DOEMLING† AND F. R. STEGGERDA
Department of Physiology, University of Illinois, Urbana

Epinephrine has been observed to cause an increase in rate of lymph flow from the thoracic duct of dogs under pentobarbital anesthesia(1). We have previously reported that pentobarbital depresses the rate of lymph flow approximately 25%, and that although under this anesthesia the absolute amount of stimulation of lymph flow by epinephrine was diminished, the percent increase was of the same order of magnitude as in the unanesthetized preparation(2). This paper reports on the relative potencies of intravenous epinephrine and norepinephrine in stimulating thoracic duct lymph flow in conscious dogs.

Materials and methods. Dogs were prepared with chronic thoracic duct-venous shunts(2,3). The thoracic duct was cannulated in the neck with polyethylene tubing (I.D. 0.86 × O.D. 1.52 mm). This cannula was exteriorized and connected to another cannula which had been inserted into the precaval vein by way of a branch of the right external jugular vein. A stockinet bandage was placed around the neck to protect the external loop of tubing. No anticoagulants were administered. Duration of lymph flow in such shunt preparations has averaged 13 days. For the lymph collection periods, the dogs were loosely restrained and trained to lie on their left sides. To collect lymph the loop of tubing was separated and the lymph was drained into a graduated cylinder. The jugular segment of the opened shunt was available for infusing solutions. For the experimental periods the dogs were in the basal state—postcibal for at least 16 hours and rested in position on a padded table for one hour. A total of 12 paired experiments were performed on 4 dogs (13-18 kg) in order to compare the effects of epinephrine (L-Epinephrine Bitartrate—Winthrop) and norepinephrine (L-Arterinal Bitartrate—Winthrop) on rate of lymph flow. After a steady rate of flow had been established, 7.5 μg/kg of the pressor amine in 10 ml of isotonic saline were injected intravenously over a 10-minute period. During a given experimental period both epine-

* In part from a thesis submitted in partial fulfillment of requirements for Ph.D. degree, 1958.

† Present address: Dept. of Physiology, Jefferson Medical College, Philadelphia.

TABLE I. Comparison of Effects of Epinephrine and Norepinephrine on Thoracic Duct Lymph Flow (12 Paired Tests; 7.5 μg/kg).

		Lymph flow			
		Control, ml/15 min.	Exp., ml/15 min.	Increase, %	P, control *vs* exp.
Epinephrine	Mean	11.0	30.4	183	.00
	S.E.	1.1	2.9	15	
Norepinephrine	Mean	10.7	20.8	87	.01
	S.E.	1.2	3.3	13	
P, epinephrine *vs* norepinephrine		.86	.04	.00	

phrine and norepinephrine were given; however the order was varied. Lymph was collected for consecutive 5-minute periods.

Results. In Table I are listed the mean volumes of lymph which flowed from the thoracic duct cannula during the 15 minutes preceding and the 15 minutes following the start of the 10-minute infusion period. Since our experiments and those of others have failed to demonstrate a correlation between body weight and rate of thoracic duct lymph flow in dogs, the volumes expressed here are simply on a per dog basis. Both pressor amines brought about a significant increase in lymph flow and the increase following epinephrine was significantly greater than that following norepinephrine.

The period of maximum response for norepinephrine was the last 5 minutes of the 10-minute infusion period, whereas for epinephrine the maximum was the 5 minutes following infusion (Fig. 1). The maximum responses were significantly different ($P = 0.00$) from each other. The stimulation of lymph flow lasted approximately 30 minutes.

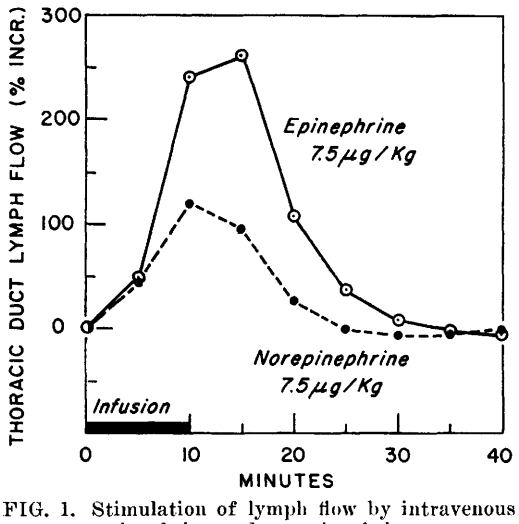

FIG. 1. Stimulation of lymph flow by intravenous epinephrine and norepinephrine.

Discussion. The thoracic duct is the final common pathway for lymph formed in both hind quarters and in the viscera of the peritoneal cavity. The design of this experiment does not permit conclusions as to the relative contributions to the increased lymph flow of the various organs drained but it is possible to speculate on the basis of other reported observations. Since little or no lymph is contributed by the hind legs when an animal is at rest, the marked increases in lymph flow following administration of either epinephrine or norepinephrine are probably due to changes occurring in the abdominal viscera. Some of the increase might be attributed to a stimulation of lymph propulsion since both pressor amines cause constriction of lymphatic vessels when given intravenously to rats(4). In addition both cause contraction of the spleen in the dog; epinephrine is 10 times more potent in this regard(5). However, the magnitude of the response and the fact that rate of flow did not subsequently fall appreciably below the control level argues against lymph propulsion as the only factor. There must also have been an actual increase in lymph formation particularly in the liver in the case of epinephrine. In conscious rats and rabbits epinephrine, but not norepinephrine, has been observed to cause reflexly an increase in liver blood flow even though the local action is constriction(6). An increase in blood flow coupled with venous constriction would be expected to result in an increase in lymph formation in the liver.

The greater potency of epinephrine in causing constriction of the spleen and in increas-

ing lymph formation in the liver appears to be major reasons for the greater stimulation of thoracic duct lymph flow by epinephrine as compared to norepinephrine.

Summary. The effect of 2 pressor amines on rate of thoracic duct lymph flow was studied in conscious dogs. Intravenous epinephrine and norepinephrine both produced a significant increase in lymph flow. The response was significantly greater for epinephrine.

1. Gesler, R. M., Matsuba, C. A., Dragstedt, C. A., *J. Pharm. Exp. Therap.*, 1956, v116, 356.

2. Doemling, D. B., Steggerda, F. R., *Physiologist*, 1957, v1, 21.

3. ———, *J. Appl. Physiol.*, 1960, v15, 745.

4. Baez, S., *Shock and Circulatory Homeostasis*, edited by Green, H. D. Trans. 4th Conf., New York, Josiah Macy, Jr. Foundation, 1955, p112.

5. Ahlquist, R. P., Taylor, J. P., Rawson, C. W., Sydow, J. L., *J. Pharm. Exp. Therap.*, 1954, v110, 352.

6. Grayson, J., Johnson, D. H., *J. Physiol.*, 1953, v120, 73.

Received May 7, 1962. P.S.E.B.M., 1962, v110.

Relationship between Adenosine Triphosphate and Cation Transport in the Human Red Cell.* (27660)

JOHN KONSEK AND CHARLES BISHOP (Introduced by Fred R. Griffith, Jr.)
Department of Medicine, University of Buffalo School of Medicine, and Buffalo General Hospital, Buffalo, N. Y.

Demonstration that the red cell membrane was permeable to Na^+ and K^+(1,2) led to the conclusion that gradients of these ions across the red cell membrane must be maintained by active processes. Since the mammalian red cell derives virtually all its energy from glycolysis and stores much of this energy as ATP it was not surprising that obligatory relationships between cation transport and ATP utilization of metabolic activity should have been shown by Danowski(3), Harris(4), Eckel(5) and Maizels(6,7). Schatzman(8) discovered that strophanthin abolished the red cell's ability to concentrate K^+ or eject Na^+ but the mechanism could have been production of "leaky" cells or interference with active transport mechanisms in the cell membrane. Whittam(9) correlated K^+ movement with ATP concentration and noted that digoxin or ouabain allowed K^+ leakage without affecting ATP levels, thus suggesting interference with ATP utilization for cation transport. Subsequently(10) he showed that glycolysis *per se* was not required for active K^+ uptake in stored cells but that shunt activity from added nucleosides could also supply the energy needed. Straub(11) "lysed" red cells and after "reconstituting" them showed that the inward movement of K^+ was linked to lactic acid production. In the presence of arsenate, lactate production continued but K^+ inflow ceased. Gardos(12) was able to force ATP into these "lysed" cells at pH 2.3 and when the cells were "reconstituted", K^+ accumulated indicating the need for ATP only. Logically an ATPase would couple ATP breakdown to cation transport and Skou(13) found in crab nerve an ATPase activated by the simultaneous presence of Na^+ and K^+. Post, *et al.*(14) demonstrated a similar ATPase in red cell ghosts. Since so many of the preceding studies were performed on enzymes, pieces of membrane, on non-intact red cells it seemed necessary to restudy some of the relationships in normally functioning human red cells in their natural environment. The development in this laboratory of methods for maintaining and assessing viability of incubated human red cells(15,16) has allowed the following studies on the precise relationships among Na^+ and K^+ movements, ATP

* Supported in part by grants from Nat. Inst. of Arthritis and Metab. Dis., N.I.H., Bethesda, Md., and Western New York Chapter, Arthritis and Rheumatism Foundation. The first author was a summer fellow of Nat. Science Foundation.