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THE RENAL LYMPHATICS: AN IMPORTANT FLUID TRANSPORT SYSTEM

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Goodwin and co-worker first suggested a more active role of the renal lymphatics following an encyclopaedic review of the literature.[1,2] This accessory circulation in the kidney functions as a safety valve coming into play when ureteral obstruction or renal venous outflow encroachment develops.

Approximately 10 years ago our group[3] suggested an additional role of the renal lymphatics - transport of sodium destined for urinary excretion during periods of elevated renal venous pressure. This concept was subsequently broadened by the work of LeBrie and Mayerson[4].

During the past three years our efforts have included directional studies encompassing three broad areas,[5,6,7] determination of enzymes and hormonal concentrations in renal lymph fluid, determination of antibiotic concentrations within the renal interstitium (renal lymph), and finally, the measurement of respiratory gases within renal lymph fluid.

METHODS AND PROCEDURES

General: Adult mongrel dogs were employed in the study. During the past three years over 75 animals have had renal capsular or renal hilar lymphatic vessels cannulated for a variety of studies. In the majority of instances corresponding blood and urine samples were obtained to allow comparisons to be made with renal lymph.

Enzymes and Hormones:

Renal lymph was collected in a tube under ice for reninangiotensin assays. Corresponding renal vein samples were obtained for comparisons.

Renal lymph and plasma were prepared for assay using the technique of Helmer[8]. Bioassay of angiotensin in lymph was accomplished in the bilaterally nephrectomized, pentolinium blocked, male rat.

Antimicrobial Distribution in Renal Lymph, Blood and Urine:

Renal lymph was obtained in animals after lymphatic cannulation. The antibacterial agents were infused individually. Penicillin G, and Cephaloridine were injected intravenously over a 15 minute to four hour interval. Nitrofurantoin and nalidixic acid were administered by gastric tube. Therapeutic doses were arbitrarily selected.

Analysis of the biological samples followed standard procedures now available. In some instances bioassay of the samples was also performed.

Respiratory Gases in Lymph:

Renal lymph was collected anaerobically under mineral oil. The anesthetized animal had an endotracheal tube in place. Compressed air was used in all instances.

An Astrup meter was used for determination of oxygen tension (PO_2), carbon dioxide tension (CO_2) and pH.

RESULTS

Renin-Angiotensin Studies:

Figure 1 illustrates the levels obtained in corresponding samples of renal capsular lymph and renal vein plasma. Prepared samples of each (0.2 ml) were injected intravenously into the rat preparation. Renal lymph levels correspond to the 20 nanogram standard of commercial Angiotensin II. Renal vein plasma approaches the 10 nanogram standard.

In Figure 2 the results are summarized by a bar graph. The mean

pressor responses in renal lymph and renal vein plasma are 25 mm of Hg and 15 mm of Hg, respectively.

Antimicrobial Distribution in Renal Lymph, Blood and Urine:

The peak distribution of Penicillin G (Figure 3) is depicted in five animals. Blood concentration ranged from 90 to 150 micrograms. Renal lymph levels during corresponding periods were lower. Urinary concentrations were elevated. The dosage selected was 20,000 mcg per Kg.

Cephaloridine, 46 mg per Kg, was injected into six animals. A typical dose-response graph is illustrated in Figure 4. Renal hilar lymph concentrations exceeded the corresponding blood levels for one to three hours following administration. Lymph concentrations ranged from 25 mcg to 4 mcg per milliliter. Urine concentrations are listed.

Nalidixic acid was infused in a dose of 50 mg per Kg. Three hours after infusion the samples were analyzed. Plasma levels exceeded renal lymph concentrations (Figure 5) in each of four instances. Nitrofurantoin was infused by gastric tube into seven animals. At three hours renal lymph levels exceeded blood levels. Bioassay of renal lymph containing nitrfurantoin infused by gastric tube revealed suppressive activity against E coli.

Respiratory Gases in Lymph:

Renal lymph was collected anaerobically from seven animals. Oxygen tension was 150 mm. of Hg (mean) while the renal arterial level was 99 mm. of Hg (mean). During this corresponding period renal venous exygen tension was 64 mm. of Hg (mean). (Figure 6)

DISCUSSION

Since lymph fluid drains the interstitium it seemed logical to assume that renal lymph is derived in the main from renal interstitial fluid. Kaplan et al.[9] have suggested that renal lymph is derived from capillary transudate and renal tubular reabsorbate. Our renal lymph oxygen tension values would suggest that capillary transudate accounts for a minor fraction.

It would appear that antibiotics which concentrate in the renal lymph would be more appropriate in treating acute pyelonephritis since the latter entity is usually multifocal in origin and interstitial in location. Once the organism has been found sensitive to a number of antibacterials, the final choice should be based on the renal interstitial distribution of these same antibacterials.

The area of hormonal assays in renal lymph fluid is under further study in our laboratory. We have noted increased angiotenin levels in renal lymph during graded renal arterial ischemia. Concentrations of aldosterone in lymph fluid should be of considerable interest. Such studies are being conductd by our laboratory.[10]

SUMMARY

1. Renin-Angiotensin levels on an equal volume basis were found in higher concentrations in renal lymph.
2. Antibacterials and their distribution in the renal lymph, blood and urine are listed. Cephaloridine and nitrofurantoin concentrations in renal lymph exceeded the corresponding blood levels.
3. Oxygen tension in renal lymph exceeded the corresponding arterial levels. Implications of these levels are discussed.
4. Future studies underway in our laboratory are mentioned.

One of us (A. T. K. C.) wishes to acknowledge the encouragement of the late Yale J. Katz, M. D., Ph. D. Our work on the lymphatics began in his laboratory in 1957.

The warm support of Willard E. Goodwin, M. D., Professor of Surgery/Urology, University of California (Los Angeles) School of Medicine, has also been invaluable.

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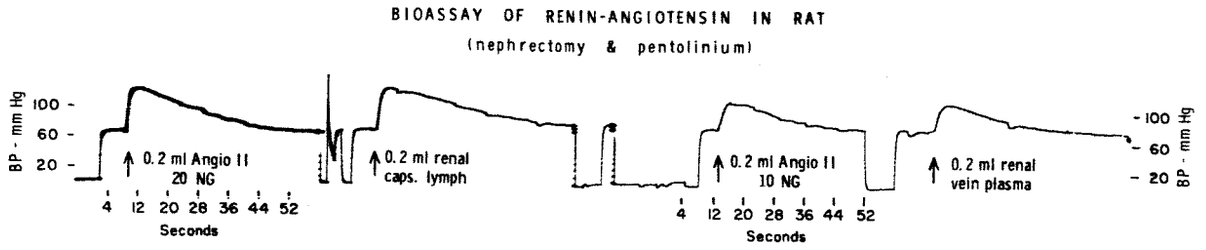
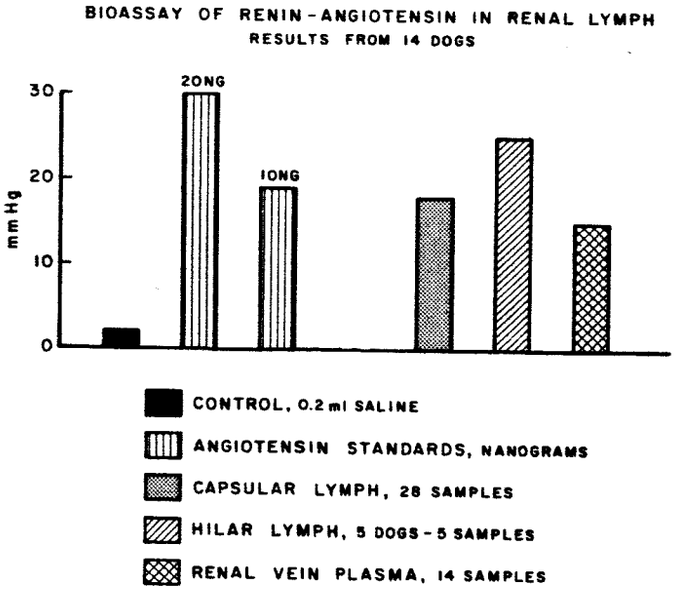


Figure 1



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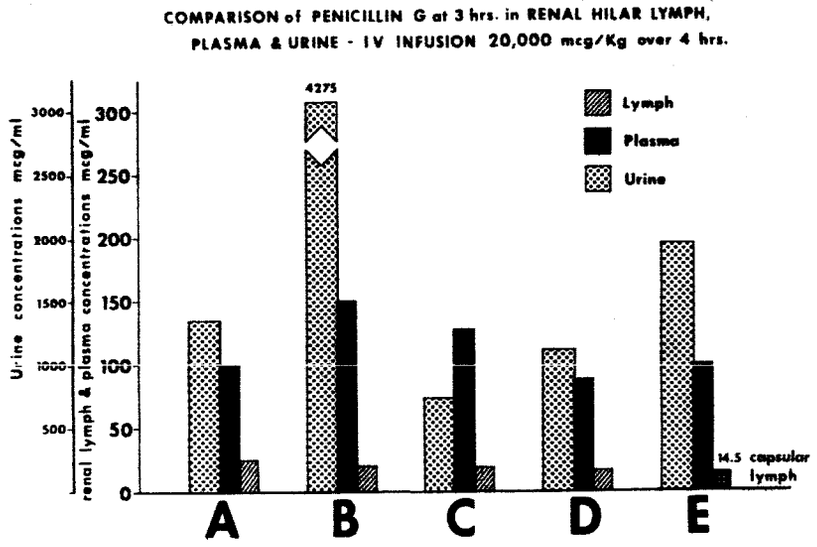


Figure 3

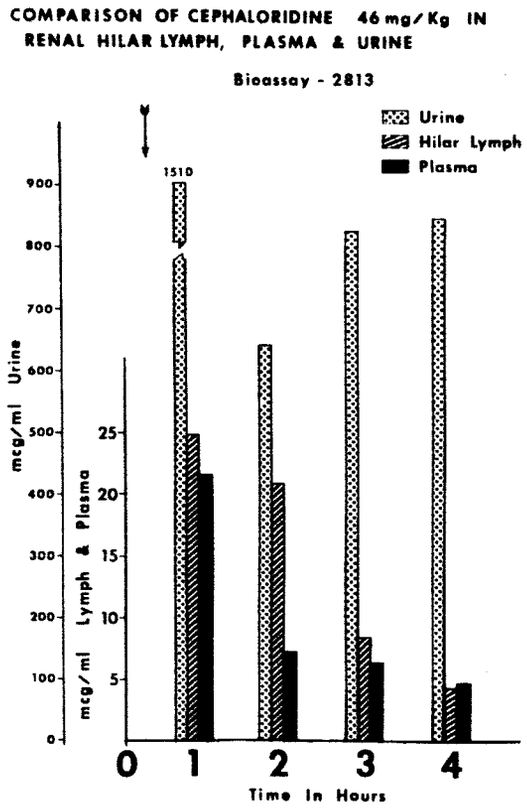
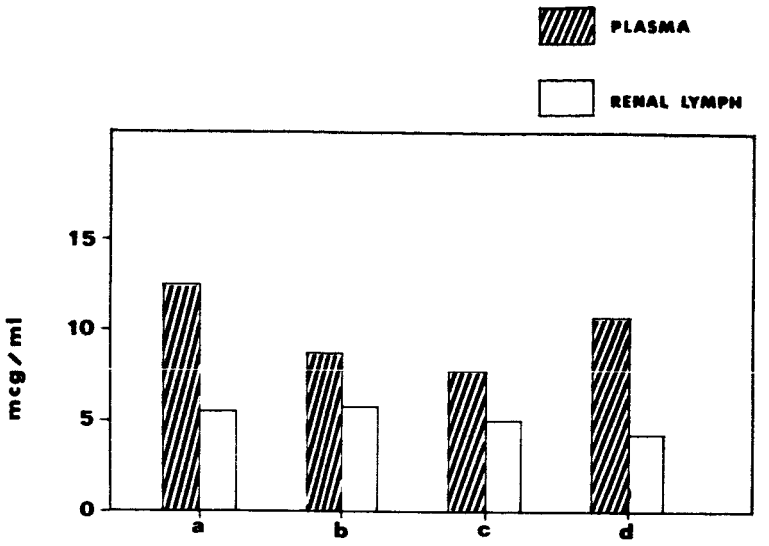


Figure 4



Concentrations of Nalidixic Acid in Dogs 3 hrs after 50 mg/Kg infused by Gastric Tube

Figure 5

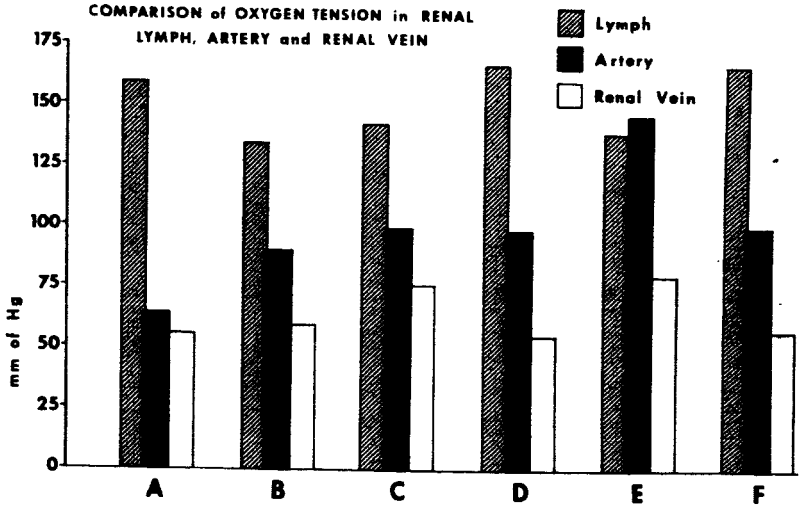


Figure 6