

Is There An Effective Countercurrent System in the Superficial Renal Cortex?¹ (35718)

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Countercurrent flow has long been hypothesized to play a role in certain biological processes and the evidence in favor of a countercurrent system being involved in urinary concentration is remarkably good (1). More recently, Steinhausen and his colleagues have claimed the existence of a countercurrent system being present in the superficial renal cortex (2) and suggested the possibility that such a system plays a role in determining cortical nephron function. The countercurrent elements were peritubular capillaries and tubules wherein it was claimed that flows were in opposite directions. Evidence will be presented in this report indicating that although there can be counterflow between tubular fluid and blood in an adjacent capillary, the organization of vascular and tubular structures is such that it is inappropriate to call the structural relations a countercurrent system.

Methods. As a part of a study on hydrogen ion concentration gradients between blood and tubular fluid (3), micropuncture samples were collected from capillaries and adjacent tubular loops from kidneys of 300–350-g male rats. Preparative procedures were the same as those usually used in this laboratory (4). Capillaries were punctured with 9- μ pipettes and tubular loops with 11.5- to 13- μ pipettes. At the time of puncture, a small droplet of oil was first extruded, and the direction of flow in both capillaries and loops was determined. In many cases, a single puncture described the flow direction in two tubular loops since both were part of the same nephron and the first puncture was proximal

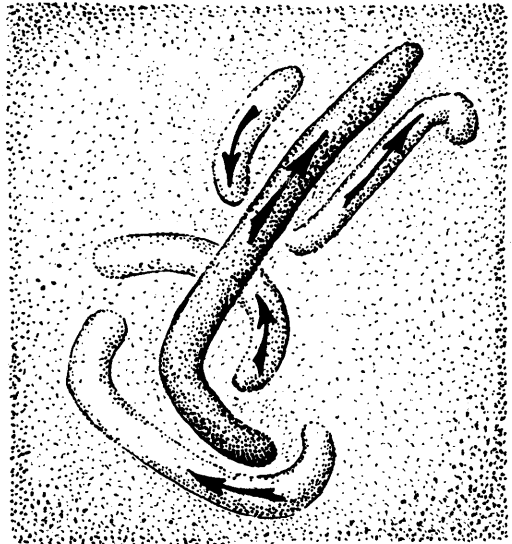


FIG. 1. Flow directions in a capillary and four adjacent loops. Arrows indicate direction of flow. The heavily stippled tube is the blood vessel and the lightly stippled conduits are tubules.

to the glomerulus. The line sketches of the structural and flow relationships were drawn.

Results and Discussion. Figure 1 shows a drawing of flow relationships in four superficial loops in proximity to a capillary. The arrows indicate direction of flow. The lower two loops were from one nephron, whereas the upper two loops parallel to the capillary were from a second nephron. In the lowest loop, it is apparent that part of the tubular flow is in the same direction as blood flow, while part of the flow is in the opposite direction (as it rounds the bend at the right). In the loop above, the flow is at right angles to blood flow. In the upper two loops, the flow is countercurrent in one loop while it is with the current in the other loop.

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TABLE I. Relation of Flow Directions Between Adjacent Tubules.

No. of animals	Flow directions	
	Opposite	Pairs in the same direction
9	15	6

The relationship shown in the upper loops appear to be characteristic of long superficial parallel segments of the same nephron. Table I summarizes the flow directions of pairs of loops in relation to blood flow. The great majority have flow in one loop in the direction of the blood and flow in the second segment is countercurrent to the blood. In only 6 of 21 pairs of loops were the flows in the same direction. Of these, four were countercurrent, and the other two had flow in the same direction as the blood.

The above data would indicate that only a part of tubular and capillary flow relationships are in a countercurrent system. It seems that rather than having a countercurrent system of the type suggested previously (3), flow directions of tubular fluid are quite likely to be in the same direction as blood flow. In fact, it would appear that the pre-

dominant countercurrent flows are between adjacent parallel convolutions of the same nephron.

In those instances where diffusion or other concentration-dependent processes are taking place along the nephron, flow direction will most certainly have quantitative effects. It may be possible that some of the scatter seen in micropuncture data are caused in this way.

Summary. Flow relations between adjacent tubular loops and an interdigitated capillary were examined by following the direction of movement of injected oil droplets. Little evidence for a true countercurrent flow between blood and tubular fluid could be obtained. Countercurrent flow between adjacent tubular loops was often seen.

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