BED-Vol. 36, Advances in Bioengineering
ASME 1997

# A NEW APPROACH TO UNDERSTANDING STARLING'S LAW AT THE MICROSTRUCTURAL LEVEL

**Xiaping Hu[1], Fitzroy Curry[2] and Sheldon Weinbaum[1]**

[1]CUNY Graduate School and
Department of Mechanical Engineering
The City College of New York
New York, NY 10031

[2]Department of Human Physiology
School of Medicine
University of California
Davis CA 95616

## ABSTRACT

1996 marked the 100th anniversary of Starling's classic paper proposing that the capillary wall behaves like a semipermeable membrane in which there is net filtration on the arterial side and a net absorption on the venous side due to the colloidal osmotic pressure of plasma proteins.While the validity of the general premise was experimentally demonstrated by Landis in 1930, who showed that in human skin capillaries at heart level that the two competing flows nearly balance one another with the small excess resulting in a lymph flow, recent experiment summarized in [3] have shown that the simple Landis-Starling diagram shown in most textbooks is not true in nearly all other body locations. In nearly all tissues in which detailed measurements of the plasma and interstitial hydrostatic and oncotic pressures have been made along the length of the calillary there is little reabsorption on the venous side since the local interstitial oncotic pressure rises sharply as the flow rate is reduced. This has been beautifully demonstrated by Michel and Philips [3] in individually perfused frog mesentery capillaries, where it is shown that the interstitial colloidal osmotic pressure depends critically on the filtration rate and there is still a small positive net filtration on the venous side. This intriquing paradox has just been reviewed in Michel (1997).

In the proposed paper a new theory is presented to describe the detailed structure of the osmotic gradients and flows across the endothelial surface glycocalyx, the inter-endothelial cleft and the exit region downstream of the cleft exit. The heterogeneity of the flow across the surface of the glycocalyx caused by the local breaks in the junction strand and the non-uniformity of the protein concentration both behind the surface glycocalyx and across the junction strand is considered for the first time. The non-linear coupling of the local fluid flow to the local plasma protein concentration is examined and it is shown that the primary gradient in osmotic force is felt across the surface layer of matrix. The model shows rather remarkably that there there is a heretofore unrecognized large asymmetry in the fluid flow pattern on each side of the junction strand and that the water enters the cleft nearly uniformly along its length despite the widely separated discrete breaks that have been observed in the junction strand [1]. The model provides very good predictions of the experimental measurements in Michel and Philips [3].

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