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Introduction

Capillaries are historically the final entry in the description of the organic components of the cardiovascular system. Correspondingly, a precise understanding of their function and behavior has been late in developing and surprisingly is not yet complete. Although we are rapidly advancing in our knowledge of the molecular basis of cellular processes, the structure, behavior and function of this most extensive and ubiquitous organ system, spanning about 1,000 km per kilogram of tissue, remain elusive.

Capillaries, first envisioned as the connection between the arteries and veins, became conceptually locked as entities functioning to convey oxygen, a process modulated by the blood stream factors of oxygenation, oxygen carrying capacity, and blood flow velocity. Although it was recognized from the very beginning, that there was a natural variability in the number and frequency of capillaries with red blood cell passage, no systematic attempts were made to determine the mechanism underlying the fluctuations in the number of capillaries with blood flow. Failure to identify an anatomical 'precapillary sphincter' and the notion that capillaries were relatively rigid structures endowed the capillary system with a static permanence, and the mechanism regulating blood throughput became assigned to the arterioles.

The laissez faire surrounding capillaries is exemplified by our concepts of 'capillary recruitment' in the analysis of muscle perfusion during exercise. In this context, it became well established that increased metabolic demand was satisfied by an increased number of conduits convecting blood through the tissue, but little attention was given to the state and conditions of these conduits when the demand was not present.

The recognition of the existence of reperfusion injury and 'no-reflow' phenomena caused capillaries to return to the limelight as entities with autonomous properties that in given circumstances could become transiently or permanently impaired. 'Functional capillary density' has now become a variable describing how the tissue will fare when it is subjected to stress. The increased use of this term and the recognition that its variability has diverse origins led us to organize a symposium to address mechanisms that affect tissue perfusion at the level of single capillaries.

The contributions to this Symposium highlight the fact that control of single capillary perfusion has many components. Mechanically it is determined by the interaction between the formed elements of blood and the geometrical features of the conduits. Biochemical events in the endothelium are a primary determinant of flow in pathophysiological conditions, and the interaction between hydraulic and osmotic pressure in modulating tissue volume and capillary dimensions affect the dimensions of the capillary structure as a whole. Furthermore, there is increasing evidence that there may be a form of single-capillary vasomotion originating from spontaneous activity in endothelial cells. This limited enumeration of flow effectors leads to speculation about the signals to which capillaries respond and whether oxygen and other metabolites may be determinants of flow modulation in single units. It remains an open question as to what is a 'closed' capillary and the events that occur in its environment in this condition.

As a historical note, this symposium 'Functional Capillary Density: Active and Passive Determinants' was held in Huntington Beach, Calif., USA, April 22, 1994. It is the last of a series of symposia held over the past decade in conjunction with the annual meeting of the Microcirculatory Society, and sponsored by the Tucson-San Diego-Baltimore Program Project on Regulation and Exchange in the Microcirculation supported by NIH grant HL17421. Unification of two laboratories in this Program Project brought by the move of P.C. Johnson to San Diego and evolution of the experimental research program now housed in a single institution in one city will undoubtedly lead to new opportunities for the continuation of this forum on research and study of the microcirculation.