NRCP Research Journal
Vol. 3, No. 2, July-September, 1993

DEVELOPMENT OF A PHOTOMETRIC DUAL-SLIT SYSTEM FOR THE MEASUREMENT OF RBC VELOCITIES IN SINGLE MICROVESSELS, USING COMMERCIALLY AVAILABLE COMPUTER COMPONENTS

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INTRODUCTION

Adequacy of tissue perfusion is the major function of the cardiovascular system. As such, an accurate method should be made available to evaluate the efficiency by which this function is performed, be it during normal physiologic reactions, or in pathologic states such as shock, cardiac failure, diabetes, hypertension and other conditions where perfusion is suspected to be compromised. Oftentimes, the functional state of the peripheral circulation is assessed by using conventional gross methods such as cardiac output, cardiac index, systemic blood pressure, or volume flow rates measured from large distributing arteries. However, it has become increasingly evident that changes in the distribution of blood within a particular regional circulation may occur, with little or no overt changes in these systemic parameters. It becomes imperative therefore to make measurements at sites where the actual exchanges between blood and tissue take place, namely in the microcirculation. Furthermore, variations in blood vessel reactivity and vascular impedence to flow are also best observed in the microcirculation, where the resistance vessels (small arteries, arterioles and post-capillary venules) are found.

Hemodynamic assessment of the microcirculation is usually performed by an intravital microscopic technique, which allows direct observation of the peripheral vasculature, and which uses the red blood cells themselves as tags for measurement of flow velocities.

This technique requires the use of high-precision, computer-assisted equipment, which may cost around a quarter of a million pesos, a kingly sum way beyond the moderate budgets usually allocated for locally funded research projects. In response to this, the project was undertaken to study the feasibility of constructing a computer-assisted RBC velocimeter, employing local manpower and technology, and improvising with commercially available computer components, thereby reducing equipment cost to around a twentieth of the cost of pre-fabricated models.

The project was a joint endeavour of the Department of Physiology and the National Institute of Physics, University of the Philippines System.

BASIC THEORETICAL PRINCIPLES

The dual-slit or two-window method of measuring RBC velocity was introduced by Wayland and Johnson in 1967 and has been employed by laboratories worldwide for the past twenty years. It consists of two photodiodes positioned along the axis of the vessel under observation. As blood flows past the first, or upstream diode, the stream of RBCs produces a signal pattern. As the RBCs traverse the second, or downstream, diode, a similar pattern is produced after a signal delay or time interval, T. Since the interdiodal distance is fixed, the velocity of RBC flow can be calculated from the formula

$v = d/T$, where d is the inter-diodal distance and T is the time interval between the appearance of the signal at the first and at the second diodes.

The time interval, T, is mathematically computed from the cross-correlation function defined as:

$$\varnothing(t) = \int_{t_o}^{t_o + T} f_u(t)\ f_d\ (t + T)\ dt$$