LOCAL CONTROL OF CORONARY FLOW

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INTRODUCTION

The heart needs coronary flow for its oxygen supply. Myocardial oxygen usage can vary over a wide range. In the potassium arrested heart O$_2$ consumption is as low as 21 ul O$_2$/s/100 g (14) whereas in dogs during severe exercise it may increase to 1 ml O$_2$/s/100 g (27, 13). Coronary flow adapts to the level of oxygen usage required. This adaptation is not strictly proportional because oxygen extraction from the coronary blood is not constant. It is generally suggested that oxygen extraction by the myocardium is maximal and therefore the only way for the heart to receive more O$_2$ would be to increase flow. This is (in general) not true as we will see below. It seems more likely that over a significant range of O$_2$ consumption the coronary venous oxygen pressure is related to the control signal responsible for coronary flow regulation (11, 10).

The mechanism responsible for local coronary control is as yet unrevealed. There is even doubt whether the mechanism is based on a single mediator or on complex interaction between many. The list of possible factors involved is long and contains: oxygen, adenosine, carbondioxide, potassium, prostaglandins, endothelial relaxant factor, myogenic response, etc. For extensive reviews on the estimated effect for the different factors the reader is referred to Feigl (13) and Belloni (3). The hypotheses which we will consider more closely are the first two in the list. This is not a random choice but it concerns the mechanisms that are considered as the major candidates for control.

The flow to the myocardial micro-circulation is not steady but pulsatile because of the effect of systole. The effect of contraction depends on the level of vasoconstriction (34).

If a stenosis is present in a major coronary artery the perfusion pressure on the coronary bed is decreased. For moderate stenoses, the local control mechanism will be able to compensate for this pressure drop by the induction of vasodilation.

EXPERIMENTAL CHARACTERIZATION OF LOCAL CORONARY FLOW CONTROL

In a recent study of our group (37) the local control of coronary flow could be characterized by a simple formula:

$$\text{CBF} = a \cdot \text{Pp} + b \cdot \text{MVO}_2 + c$$

where Pp equals coronary arterial pressure, MVO$_2$ = oxygen consumption and a, b and c are constants representing the sensitivity of coronary flow for coronary arterial pressure and oxygen consumption respectively. Obviously it is impossible to test a relation as eq. 1 without being able to manipulate arterial pressure and oxygen consumption independently.
In the literature often only one of both independent variables has been altered without control of the other one (e.g. 12, 26). In our study we have manipulated coronary arterial pressure in two ways, which is cannulation and partial occlusion of the main coronary artery. Both techniques were employed in anesthetized open chest dogs and goats. Arterial-venous oxygen content difference was monitored continuously by the method of Shepherd and Burger (32). Low levels of oxygen consumption were obtained by the administration of examethonium bromide and high levels by the administration of epinephrine. Within each animal eq. 1 was fitted to the experimentally found data of CBF, Pp and MVO₂. Both CBF and MVO₂ were normalized to 100 g of tissue.

In a cannulated left main preparation it is not difficult to vary oxygen consumption at constant perfusion pressure. However, varying