Does Effective Diastolic Coronary Venous Retroperfusion Depend on Arterial-Like Blood Pressure in the Coronary Sinus?

PIETER D. VERDOUW, PhD
KEVIN BEATT, MD
LUUK BERK, MD
PATRICK W. SERRUYS, MD, PhD

In a number of studies, synchronized diastolic retroperfusion instituted 20 minutes after coronary artery occlusion has been shown to enhance recovery of regional contractile function.1-3 We hypothesized that, if retroperfusion was started before the onset of ischemia, it might prevent or at least delay the loss of regional function.

We therefore conducted a series of experiments in which we looked at the effects of retroperfusion on Yorkshire pigs (18 to 45 kg), anesthetized and instrumented as described previously.4 The retroperfusion system (model EC-1, USCI division of C.R. Bard) was set to pump 35 to 40 ml·min⁻¹ of arterial blood retrogradely into the coronary sinus starting just before a 20-minute occlusion of the left anterior descending coronary artery. Within 2 minutes of occlusion, we observed in the control and retroperfusion groups similar decreases in cardiac output (−0.3 ± 0.2 and 0.3 ± 0.1 liter·min⁻¹, respectively), mean arterial blood pressure (−12 ± 3 and −12 ± 3 mm Hg) and maximum rate of rise in left ventricular pressure (−370 ± 90 and −450 ± 60 mm Hg·s⁻¹), and an increase in left ventricular end-diastolic blood pressure (4 ± 1 and 3 ± 1 mm Hg). These changes persisted during the remainder of the occlusion period. During reperfusion, the recovery of the hemodynamic parameters in both groups was similar in time and magnitude. In the untreated animals coronary artery occlusion resulted in a loss of systolic wall thickening (from 30 ± 3 to 6 ± 3%) within 2 minutes. No recovery was seen during the 2 first hours of reperfusion. Retroperfusion neither modified the loss of regional function during occlusion (from 32 ± 3 to 5 ± 3%) nor enhanced its recovery during reperfusion.

In pigs, the residual flow after coronary artery ligation is <5% of the preocclusion value and a reduction of flow to approximately 30% of baseline will result in a complete loss of function. This implies that retroperfusion must increase the flow to the ischemic area by at least this amount before any improvement in function can be expected. In the canine model it has been shown that 50% of the delivered retroperfusion flow is able to reach the ischemic myocardium. If this applies to the pig, an improvement in function should have been observed. It is unclear why no improvement in function was seen, as theoretically a sufficient volume of blood (30 to 40 ml·min⁻¹) was delivered by the retroperfusion system into the coronary sinus of these pigs, which normally have left anterior descending coronary artery flow values of 30 to 40 ml·min⁻¹.

Recovery of regional myocardial function in pigs during the first 2 hours after a 20-minute coronary artery occlusion is minimal.5 In the same model enhanced recovery is possible by pretreating the animals with the stable prostacyclin analog Illoprost.6 After the initial series we performed 3 additional experiments in which the retroperfusion flow rate was increased until some effect on regional contractile function was observed. Some regional wall thickening returned with rates of 60 ml·min⁻¹ but this was with selective catheter postioning high in the anterior cardiac vein. Higher flow rates and coronary sinus pressures were necessary to achieve sustained improvement (Figure 1). Temporary cessation of retroperfusion resulted in loss of wall thickening (which returned once retroper-

---

From the Laboratory for Experimental Cardiology, Thoraxcenter, Erasmus University Rotterdam, Rotterdam, the Netherlands. Dr. Beatt is the recipient of a research fellowship from the British and Netherlands Heart Foundations. Manuscript received August 10, 1987; revised manuscript received February 8, 1988, and accepted February 14.
fusion was restarted). Continuous pumping at these higher flow rates caused a progressive increase in coronary sinus pressure that varied from 80 to 120 mm Hg and led to a loss of systolic wall thickening of the jeopardized myocardium.

We believe that at these higher flow rates the systolic time interval available for venous drainage is not sufficient to cope with the increased volume of blood delivered. The limited amount of data available suggests that effective retroperfusion depends on the retroperfusion pressure, which in turn is dependent on the capacitance and compliance of the individual coronary venous system. It is at present unknown whether there is a retroperfusion pressure that may be safely used for prolonged periods without risk of developing myocardial edema. In the absence of this data, extreme care must be exercised when using this system in the clinical setting, especially because the experimental data do not always support such use.