EFFECT OF SYMPATHETIC NERVE STIMULATION ON REACTIVE HYPEREMIA OF THE MYOCARDIUM

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UDC 616.127-005.3-02:
616.839]-092.9

KEY WORDS: coronary blood flow; peak of reactive hyperemia; stimulation of the stellate ganglion; arterial pressure; coronary dilator reserve.

Occlusion of the coronary artery for 15-20 sec is accompanied by reactive hyperemia (RH) of the myocardium, the peak of which is not increased after arrest of the blood flow for longer periods. More detailed studies of myocardial RH have shown that its peak depends on the perfusion pressure [4]. Adenosine and certain other agents increase the coronary blood flow to a degree which exceeded the peak of RH [2, 9]. Contradictory results have been obtained for sympathetic influences on the peak of RH: after desympathization of the heart the peak either decreased [7] or increased [8]. Comparison of the above data questions the view that the RH peak affords an absolute criterion for estimating the coronary dilator reserve.

The aim of this investigation was to study the effect of sympathetic nerve stimulation on the peak of myocardial RH in acute experiments on dogs.

EXPERIMENTAL METHOD

Experiments were carried out on 25 mongrel dogs with a mean body weight of 12 kg, under hexobarbital anesthesia (75 mg/kg), with morphine premedication (0.5 ml of a 1% solution/kg body weight). Thoracotomy was performed and the animal artificially ventilated with the RO-3 apparatus. Catheters were introduced into the left ventricle and aorta and pressure was measured with HP 1280C transducers (USA). Fluctuations of arterial pressure (BP) were damped by means of a barostat, connected to the aorta through the subclavian artery. The transducer of an SP 2201 flowmeter, 2 or 3 mm in diameter, was fixed on the circumflex or descending branch of the left coronary artery. The coronary artery was compressed by a soft clamp immediately below the transducer. The left stellate ganglion (SG) was dissected and a bipolar stimulating electrode applied. The parameters of stimulation were: 5 V, 8-10 Hz, 2 msec (ÉSL-2 stimulator). All parameters were

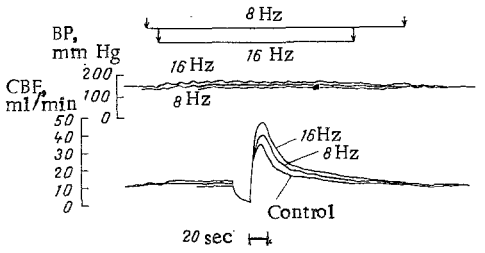

Fig. 1. RH of myocardium in control and during stimulation of SG (not only the increase in the peak of RH, but also the rise of BP in response to sympathetic stimulation can be seen).

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0007-4888/85/9905-0544 $09.50

TABLE 1. Effect of Stimulation of SG on Cardiodynamics and Peak of Myocardial RH (n = 30)

Parameter	Before occlusion of vessel		Peak of RH	
	Control	Stimulation of SG	Control	Stimulation of SG
SBF, ml/min	51,3±5	59,8±5 $P<0,001$	164,4±14	179,2±14 $P<0,01$
BP, mm Hg	90±2	90±2	91±2	90±2
LVP, mm Hg	93±2 $P<0,05$	99±3	97±2 $P<0,01$	102±3
HR, beats/min	166±7	167±6 N/s	162±7	175±7 $P<0,05$
CVR, relative units	2,23±0,2 $P<0,001$	1,8±0,13	0,65±0,05 $P<0,05$	0,59±0,04

Legend. Here and in Table 2: CBF) coronary blood flow, LVP) pressure in left ventricle, CVR) coronary vascular resistance, N/s) not significant.

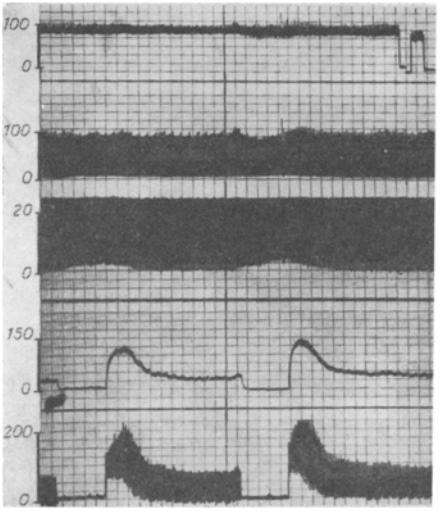

Fig. 2. Comparison of RH in control (left) and during stimulation of left SG (right). From top to bottom: BP (in mm Hg), LVP (in mm Hg), EDLVP) end-diastolic LVP (in mm Hg), CBF_{av}) averaged value of coronary blood flow (in ml/min), CBF_{mom}) momentary value of coronary blood flow (in ml/min). Tape winding speed 1 mm/sec.

recorded on the HP 7758D polygraph (USA). The results of a preliminary series of 6 experiments confirmed data [4] showing that the peak of RH depends on BP (one such experiment is illustrated in Fig. 1). It was thus necessary to conduct the experiment with BP stabilization, by stopping stimulation of the sympathetic nerves before and after development of peak RH. The groups of experiments were carried out. In group 1, occlusion of the coronary artery for 20 sec was preceded by stimulation of SG for 45-60 sec. In group 2, stimulation of SG (15 sec) was stopped 5 sec before resumption of the blood flow in the artery after the same duration of occlusion (20 sec). In both groups the peak of RH was estimated. Values of RH in response to occlusion of the coronary artery for 20 sec without stimulation of SG served as the control.

EXPERIMENTAL RESULTS

In the experiments of group 1 stimulation of SG led to an increase of pressure in the left ventricle (LVP) but the heart rate (HR) was not increased. BP was kept constant because of the damping action of the barostat. The peak of RH was significantly higher than in the control. Calculation of the resistance of the coronary vessels (the quotient obtained by dividing BP by the mean blood flow) showed a significant fall in this parameter during stimulation of SG compared with the control (Table 1). Differences in the values of the peak of RH are clearly visible in Fig. 2.

TABLE 2. Effect of Stimulation of SG during Occlusion of Coronary Artery on Cardiodynamics and Peak of RH (n = 22)

Parameter	Before occlusion of vessel		During occlusion		Peak of RH	
	control	before stimulation	control	before stimulation	control	before stimulation
SBF, ml/ min	51,4±5,3	51,7±5,4	0	0	148,9±18	166,1±17,5
	H/				$P<0,01$	
BP, mm Hg	96±3	94±3	88±2	102±3	94±3	95±3
	H/		$P<0,01$		H/	
LVP, mm Hg	95±2	96±1	94±5	105±3	96±2	93±4
	H/		$P<0,01$		H/	
HR, beats/ min	176±6	177±8	187±10	201±9	175±8	185±10
	H/		$P<0,05$		$P<0,01$	
CVS, relative units	2,2±0,19	2,23±0,21	—	—	0,83±0,08	0,71±0,06
	H/				$P<0,05$	

In the experiments of group 2, to study the after-effect of sympathetic nerve stimulation on the peak of RH, SG was stimulated during the first 15 sec of the 20-sec period of occlusion. Under these conditions there was a wider scatter of values characterizing changes in cardiac activity during sympathetic stimulation compared with that found in group 1, evidently because of the relatively short duration of stimulation. However, both the force and the frequency of the cardiac contractions were increased. The peak of RH was increased by a greater degree when sympathetic nerves were stimulated only during occlusion of the vessel, compared with the control group. The same can also be said of the resistance of the coronary vessels. All the results of this group of experiments are given in Table 2.

Attention is drawn to a small rise of BP during stimulation of SG against the background of coronary arterial occlusion. This rise was not completely compensated by the barostat, evidently because of the fairly high rate of rise of pressure.

Both groups of experiments conducted with stabilization of BP showed that the peak of RH (and the calculated coronary vascular resistance at the height of the peak) was significantly higher ($P < 0.05$) during sympathetic excitation or its after effect than in the absence of sympathetic excitation.

This phenomenon was evidently due to an increase in myocardial oxygen consumption in response to an increase in the force and frequency of cardiac contractions. The intensity of metabolism of the myocardium and the throughput of the coronary vessels are known to be closely related. Whether adenosine plays a decisive role in elevation of the peak of RH (its formation has been demonstrated in myocardial ischemia and sympathetic excitation [3, 5]) is difficult to say. However, coronary vasodilatation in the course of RH and after injection of large doses of adenosine [2, 8] is not comparable. In the latter case, so-called functional shunting may take place, and this can increase the blood flow considerably.

Myocardial RH is a complex phenomenon, and is determined by more than one component. Great importance has recently been attached to metabolic factors in this response. For instance, coronary arterial occlusion for 100 msec, which did not give rise to a reactive increase of blood flow when the heart rate was relatively slow, induced RH when it was faster [8]. RH has been shown to increase with an increase in the load on skeletal muscles and the isolated dog's heart, perfused with blood from a donor [1].

Without denying the importance of passive and active (myogenic) responses in RH, the following preliminary conclusion can be drawn. Not only the real throughput of the vascular system of the heart, but also the dilator reserve of the coronary system are adjusted to the current level of myocardial metabolism. The peak of RH will therefore differ for different metabolic states. This may be a reflection of one aspect of the specificity of the myocardial blood supply and the character of regulation of the coronary blood flow.

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