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EFFECT OF LUMBAR SYMPATHECTOMY ON MUSCLE CIRCULATION IN DOGS AND PATIENTS

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ABSTRACT

The effect of lumbar sympathectomy on the muscle circulation was investigated in 16 dogs with experimentally proposed ischemic limb and 23 limbs of 21 patients with peripheral vascular diseases of the legs. Muscle blood flow was measured in the anterior tibial muscle by using Xe-133 clearance technique. In the experimental situation, lumbar sympathectomy had no demonstrable effect on the rate of development of collateral circulation. In clinical study, both maximal blood flow during exercise and post-exercise hyperemia did not significantly alterate before and after sympathectomy.

INTRODUCTION

Lumbar sympathectomy has been extensively employed in the treatment of peripheral vascular diseases for about 50 years. However, a wide difference of opinion exists as to its effects on the muscle circulation. Effects evaluated by clinical follow up of patients with intermittent claudication has varied from excellent to very poor. More recently, therefore, several workers have investigated this aspect by measuring the muscle blood flow in the calf before and after sympathectomy with the use of venous occlusion plethysmography[1,2] or local isotope clearance method[3,4]. Xe-133 clearance method which was introduced by Lassen and his associates[5] has been widely used in either diagnosis or evaluation of treatments in obstructive arterial diseases of the legs. In this study Xe-133 clearance method was employed to measure the muscle blood flow in the anterior tibial muscle of the dogs and the effect of lumbar sympathectomy on the development of collateral circulation in the ischemic hindlimb was determined. Moreover, this article included to report the changes of Xe-133 clearance curve in the anterior tibial muscle before and after lumbar sympathectomy in patients with peripheral vascular diseases of the legs.

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MATERIALS AND METHODS

Sixteen mongrel dogs of either sex weighing from 10 to 15 kg were divided into 2 groups, 8 denervated and 8 control dogs. Ischemia of the left hindlimb was induced by incisions of bilateral illac, its branches and left deep femoral arteries and incision of 3 cm length of left superficial femoral artery in all dogs. In 8 dogs (denervated group) bilateral ganglionectomies were performed from the renal vein to below the pelvic brim one to two weeks after production of ischemia. Maximal blood flow in the anterior tibial muscle was measured after the exercise during arrested circulation under general anesthesia. The muscle was injected with 0.05 ml of Xe-133 saline solution (30 – 50 microcuries of Xe-133) and the disappearance rate of the tracer was measured with thallium activated NaI (Tl) crystal coupled to a ratemeter. The circulation in the left hindlimb was occluded perfectly for 2 min by the tourniquet around the thigh, while exercise was performed 40 plantar-dorsal flexions of the ankle passively by our hands. The ischemia was then released and the disappearance rate of Xe-133 was recorded under the resulting hyperemic conditions.

From these curves maximal blood flow (MBF) was calculated. Muscle blood flow can be calculated using the formula of Lassen[5]. This formula states Flow = $161 \times D$ ml/100 g/min where D is the decrease in one minute of a tangent drawn to the logarithmic plot of the clearance curve.

Measurements of blood flow were carried out before production of ischemia of hindlimb and just before the denervation. Measurements were performed again on 2 days and 1 to 2 weeks after denervation. Furthermore, in four dogs blood flow was measured at the time immediately after the production of ischemia. Two dogs including one denervated and one control dog were always experienced on the same days.

In clinical study 23 limbs in 21 patients with peripheral vascular diseases of the leg were subjected to lumbar sympathectomy (L2 – L3, 4). Xe-133 clearance curve was obtained from the anterior tibial muscle at one to seven days preoperatively and at seven to 36 days postoperatively by using a previously described method – Xe-133 non-ischemic work method[6]. In this method subjects were examined in the supine position. 0.05 to 0.25 ml of Xe-133 solution was injected into the anterior tibial muscle. To produce the hyperemia of the limb the patients were instructed to exercise their feet. The work intensity was 20 contractions per min of maximal dorsal flexion of the ankle for 2 min without ischemia of the thigh.

From the curves, we can know the maximal blood flow during the exercise (MBF_E) and the degree of post-exercise hyperemia – the duration of hyperemia after the exercise (T-time) and the hyperemia that remains one minute after the cessation of the exercise (R-index).

RESULTS

In experimental study average MBF before production of ischemia was 42.3 ± 12.5 ml/100 g/min. Immediately after the production of ischemia it decreased into about 10% (4.4 ± 2.1 ml/100 g/min) in four dogs. One week after, at the time of sympathectomy, it increased about three fold, indicating the development of collateral vessels.

After denervation there were no statistically differences in development of collateral circulation between denervated and control dogs by analysis of variance (ANOVA)[7] (Table 1).

TABLE 1. Changes of MBF (ml/100 g/min) in 8 Denervated and 8 Control Dogs

	Denervated Group	Control Group
Normal (Before Production of Ischemia)	41.0 ± 10.0 (100%)	43.6 ± 15.2 (100%)
At the Time of Denervation (1–2 Weeks after Production of Ischemia)	11.5 ± 4.9 (28.0%)	12.5 ± 7.7 (28.7%)
2 Days after Denervation	11.9 ± 4.4 (29.0%)	12.8 ± 8.2 (29.6%)
1–2 Weeks after Denervation	20.2 ± 7.9 (49.3%)	22.3 ± 13.8 (51.1%)

In clinical study (Table 2) no significant alterations in both maximal blood flow during exercise and post-exercise hyperemia occured in muscle circulation before and after denervation in case 1 to 20. In case 21 to 23, however, increase of maximal blood flow during exercise and improvement of post-exercise hyperemia were shown. Although this finding meaned the benefit results of denervation, their contralateral legs – clearance curves from both legs were always gained at the same time – also had shorter and smaller post-exercise hyperemia after denervation. This indicated that flexions of the ankle joints in Xe-133 clearance test was weaker than those before operation. Reexamination revealed approximately similar curves as preoperative ones.

These results suggested that lumbar sympathectomy did not influence on both muscle blood flow during exercise and post-exercise hyperemia.

DISCUSSION

Although it is better to measure the muscle blood flow during exercise for evaluation of degrees of muscle circulatory insufficiency, we employed Xe-133

TABLE 2. Xe-133 Clearance Curve in the Anterior Tibial Muscle Before and After Sympathectomy in 23 Limbs with Peripheral Vascular Diseases

						Xe-133 Clearance Curve						
						Before Denervation			After Denervation			
Case	Sex	Age	Diagnosis	Symptoms	Site of Occlusion	MBFE ml/100g /min	T-time min	R-index %	MBFE ml/100g /min	T-time min	R-index %	Post-Operative Days
1	M	42	TAO	Ulcer	Below Knee	41.9	2.5	27.9	30.6	2.0	23.2	28
2	M	36	TAO	Coldness	Below Knee	40.3	2.75	15.2	41.9	1.5	8.1	11
3	M	29	TAO	Claudication in the Calf	Fem-Pop. A.	5.6	6.0	79.5	3.2	7.5	80.3	36
4	M	44	TAO	Coldness	Below Knee	41.9	2.5	19.3	41.9	2.0	20.8	30
5	M	46	TAO	Ulcer	Below Knee	20.9	2.75	41.7	20.9	2.5	42.2	7
6	M	26	TAO	Ulcer	Below Knee	20.9	1.5	14.4	20.9	1.5	9.4	14
7	M	26	TAO	Ulcer	Below Knee	20.9	1.5	6.7	22.5	1.5	8.6	14
8	M	47	TAO	Coldness	Below Knee	16.9	0.5	0	12.1	1.0	0	15
9	M	64	ASO	Coldness	Below Knee	24.2	1.5	21.2	29.0	2.0	21.2	30
10	M	37	TAO	Cyanosis	Below Knee	17.7	1.5	6.0	15.3	1.5	6.0	10
11	M	29	TAO	Ulcer	Below Knee	22.5	1.5	4.0	22.5	1.5	3.2	14
12	M	41	TAO	Coldness	Below Knee	17.7	1.0	0	17.7	1.25	5.0	8
13	M	35	TAO	Claudication in the Calf	Pop. A.	1.6	4.5	77.6	2.4	5.0	78.6	10
14	M	35	TAO	Coldness	Below Knee	6.4	4.0	67.4	6.4	3.75	65.1	10
15	M	39	TAO	Ulcer	Below Knee	17.7	3.0	42.0	17.7	3.5	56.3	12
16	M	66	ASO	Claudication in the Calf	Ilio-Fem. A.	3.2	5.5	74.5	4.8	6.0	75.8	16
17	F	33	Raynaud's d.	Ulcer	Digital A.	41.9	1.5	6.1	40.3	1.75	8.6	10
18	M	44	TAO	Ulcer	Below Knee	24.2	3.25	31.8	24.2	3.25	31.7	7
19	M	45	TAO	Ulcer	Below Knee	26.5	1.5	10.3	27.0	1.5	11.4	10
20	M	33	TAO	Ulcer	Below Knee	30.2	1.75	11.6	31.0	1.75	13.4	10
21	M	31	TAO	Claudication in the Calf	Fem-Pop A.	2.4	7.75	90.1	5.6	6.5	73.0	20
22	M	46	TAO	Claudication in the Calf	Fem-Pop A.	0	6.5	78.2	7.2	3.5	48.6	26
23	M	40	TAO	Ulcer	Below Knee	27.4	3.5	34.2	40.3	1.5	20.4	17

TAO : Thromboangitis Obliterans
ASO : Arteriosclerosis Obliterans

TABLE 3. Repeat Measurements of MBF (ml/100 g/min) at One Hour Intervals

Case	1st	2nd	3rd
1	30.6	29.0	29.8
2	43.8	42.2	41.2
3	38.0	37.0	37.0
4	42.2	39.8	45.8

ischemic work method in our experimental study. The reason was that the work load performed by our hands was not always constant. The differences of work load influence the clearance curve easily in non-ischemic work method[6]. By Lindbjerg[8] the maximal blood flow did not differ significantly after 50% and 100% of maximal exercise during ischemia, indicating exact work load was not critical for evaluation of maximal flow in ischemic work method. In four dogs, a measurement of blood flow was repeated 3 times at one hour intervals (Table 3). A good correlation was obtained.

It is generally accepted that intermittent claudication is a characteristic symptom of the peripheral vascular diseases. Strandness[9] wrote in detail about the physiology of sympathetic denervation and intermittent claudication. The increased resistence to flow in the collateral circulation results in a pressure gradient across the area of obstruction. If the strength of contraction of the exercising muscle exceeds the blood pressure in its nutrient arteries, only a limited or ceased blood flow will be obtained during muscle contraction in these patients, resulting in ischemic muscle pain. The logic therapeutic approach is, therefore, based on two important goals; increase the volume flow through the collateral arteries and, more importantly, raise the artery pressure distal to the obstruction. If sympathectomy could effectively reduce collateral resistence and decrease pressure drop across these vessels, thus effectively raise perfusion pressure of the exercising muscle, claudication might be benefited.

Although some reports[10][11] were made that sympathectomy decreased collateral resistence or developed the circulation, there is little objective evidence to support this. Although Hishida[12] found from the experiments using dogs that sympathectomy promoted development of collaterals in arteriograms under reactive hyperemia, it was not known whether the enlargement of collateral vessels was primary effect of sympathectomy on those vessels or secondary effect due to decreased resistence to flow distal to them. Khobreh and Roy[13] reported that there was no essential change in muscular vascularization before and after sympathectomy in arteriograms with foot exercise.

Systolic ankle pressure was measured by Strandness and Bell[14] using the strain-gauge method both at rest and after exercise in 29 patients before and after sympathectomy. Those authors found no evidnece from their studies that sympathectomy significantly reduced collateral arterial resistence as no consistent rise in the ankle pressure was measured. Nielsen *et al.*[15] reported that systolic blood pressure in big toe measured by using a strain-gauge method decreased from 59 mmHg to 42 mmHg after lumbar sympathetic block by xylocaine in 16 patients with occlusive arterial disease. This finding indicated that the block reduced the peripheral resistence more predominantly than the collateral resistence. In our experimental study, sympathectomy was performed after some developments of collateral vessels and it did not effect on those vessels. Thus, our finding would support the contection that sympathectomy had no demonstrable effect on decreases of collateral resistence. Jacobson and Bush[16] reported the same conclusions that lumbar sympathectomy had no effect on exercise tolerance or on the rate of development of collateral circulation in dogs whose exercise tolerance was assayed by running ability on a treadmill.

It is true that high lumbar sympathectomy which means the ganglia are removed starting from the first lumbar ganglia, would effectively denervate the entire limb and system of bypassing collaterals of the thigh[17]. Kiss *et al.*[18] reported that high lumbar sympathectomy improved the muscle circulation for two months compared to the control leg in dogs by using Xe-133 clearance technique. In contrast to this, Tice *et al.*[2] reported that high lumbar sympathectomy did not influence on the muscle blood flow measured by plethysmography. By Show *et al.*[19] 131 extremities treated by lumbar sympathectomy, 85% of the operations included at least the first, second and third lumbar vertebrae, were compared with 106 control extremities in ten year follow-up studies. They reported that no evidence that lumbar sympathectomy caused growth of collateral circulation or muscle circulation was shown. Our present report in clinical study included two patients groups, including proximal occlusion group (popliteal, femoral and/or iliac arteries) and distal occlusion group (leg arteries). In even distal occlusion group both maximal blood flow during exercise and post-exercise hyperemia did not alterate before and after sympathectomy, indicating collateral vessels under the knee were not influenced by sympathectomy.

From these findings we concluded that sympathectomy did not induce demonstrable denervation of collateral arteries which were larger than arterioles and had no direct effect upon the exercised muscle.

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