High-Molecular-Weight Polyethylene Oxide Improves Blood Flow through Stenosed Carotid Artery

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Intravenous injection of 0.1 mg/kg high-molecular-weight polyethylene oxide (molecular weight 5.8×10^6) to narcotized cats with experimental stenosis of the right carotid artery considerably improved blood flow and reduce blood pressure in stenosed vessel. This normalizes cerebral blood supply via both carotid arteries despite a decrease in systemic blood pressure.

Key Words: *high-molecular-weight polyethylene oxide; arterial pressure; cerebral circulation; carotid stenosis*

High-molecular-weight polyethylene oxides (PEO) lower hydrodynamic resistance by reducing flow turbulence. The effect of these polymers is most pronounced in the areas of increased turbulence, in particular, in stenosed vessels. Previous studies demonstrated the ability of these polymers to lower hydrodynamic resistance and smoothen blood flow in experimental stenosis [6,7]. On the other hand, long-chain polyacrylamide had no effect on aortal and carotid blood flow in dogs with experimental carotid stenosis [5].

The aim of the present study was to evaluate the effect of high-molecular-weight PEO (molecular weight 5.8×10^6) on systemic and cerebral hemodynamics in animals with experimental carotid stenosis.

MATERIALS AND METHODS

Experiments were carried out on 10 cats of both sexes narcotized with Nembutal (40 mg/kg, initial narcosis) and Urethane (1 g/kg, basis narcosis). Catheters for monitoring blood pressure (BP) were implanted into the right and left lingual and right femoral arteries and for infusion of the test polymer into the left femoral artery under infiltration anesthesia. Blood pressure was recorded using a Salyut polygraph connected with KSP-4 recordes. Blood flow was measured using an MFV 1100 and 2100 flowmeters (Nihon Kohden) by applying cuff electromagnetic transducers on both carotid arteries after ligating their branches below the internal maxillary artery. After 30-min stabilization of hemodynamic parameters, the right carotid artery proximally the flowmeter transducer was radially occluded, so that the blood flow decreased 2-fold, and 10-15 min later 0.005% PEO (1 mg/kg) or an equivalent volume of physiological saline (control) were infused for 20 min. Blood pressure in the carotid and femoral arteries was recorded for 1 h after infusion. The difference between systemic BP measured in the femoral artery and blood pressure in the left (ΔBP_l) and right (ΔBP_r) lingual arteries was calculated. The data were processed statistically using STATISTICA 4.3 software.

RESULTS

Occlusion of the right carotid artery in control and experimental series decreased BP and blood flow

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proximally to the ligature by 15-17% and 46-52%, respectively, in comparison with the initial levels (Tables 1, Fig. 1 and 2). In both series, blood flow in the left carotid artery compensatory increased by 19-27% but then decreased to 55-66% of the initial level by the end of experiment. However, after ligation of the right carotid artery blood flow in the control series slightly decreased, while BP decrease in occluded vessel declined from 22 to 12 mm Hg within 80 min. Due to activation of some compensatory mechanisms, the contribution of the right carotid artery to the total carotid blood flow increased from 28 to 35% by the end of experiment. Thus, in the control series experimental occlusion considerably restricted blood flow in the right carotid artery; under these conditions blood flow cannot be restored by compensatory mechanisms.

Infusion of PEO increased BP in the right carotid artery distal to the ligature; after the end of infusion the difference between ΔBP_r and ΔBP_r disappeared (Table 1, Fig. 1). PEO considerably (by 62-70%) enhanced blood flow in the occluded vessel in comparison with control series (Fig. 2). This marked increase in the blood flow through a vessel with a stable narrowed diameter, despite a 26% decrease in systemic BP, may result from the ability of the polymer used to form the flow by decreasing both flow turbulence [2] and hydrodynamic resistance in the occluded vessel. The estimated concentration of PEO at the end of infusion was 2×10^{-6} g/ml, which is sufficient to produce a clear-cut hydrodynamic effect [1,4]. In previous studies [7], infusion of PEO with a molecular weight of 4×10^{6} at a rate of 0.16 mg/kg/min increased blood flow in both occluded and intact contralateral iliac arteries, but in occluded vessel this effect occurred more rapidly and at a lower concentration of the polymer. As blood concentration of the polymer increased, the blood flow in intact artery progressively increased, while in occluded vessel the effect of polymer became less pronounced.

Our experiments revealed other dynamics. Infusion of PEO restored the proportion between right and left carotid blood flow: the increase in the right carotid blood flow was accompanied by reciprocal decrease in the left carotid artery, followed by their equalization. This is probably determined by some peculiarities of cerebral circulation, in particular, the existence of circle of Willis: a decrease in ΔBP in occluded area restores BP in the distal portion of the right carotid artery, which promotes equalization of BP in the circle of Willis and restricts compensatory enhancement of blood flow in other major arteries, in particular, in the left carotid artery.

TABLE 1. Systemic BP and the Differences between BP in the Femoral and the Left and Right Lingual Arteries during and after Infusion (*M±m*)

Parameters, mm Hg	Initial values	After occlusion	Infusion, min				After infusion, min					
			5	10	15	20	10	20	30	40	50	60
Control (physiological saline)												
BP	124±4	124±4	124±4	123±4	123±4	123±5	124±4	121±5	118±6	118±8	119±8	118±9
ΔBP_r	1.3±0.7	22.2±1.9	21.0±2.4	21.3±2.0	21.3±2.6	21.6±3.2	20.8±3.2	18.8±2.6	15.3±2.9	14.4±3.0	14.4±2.5	11.8±3.2
ΔBP_l	2.6±0.9	2.6±1.4*	2.4±1.5*	2.0±1.6*	2.4±1.9*	3.4±1.8*	3.2±2.0*	2.4±1.4*	2.0±1.3*	0.8±0.2*	2.6±1.2*	1.2±0.6*
Experiment (infusion of PEO)												
BP	122±3	123±3	121±3	114±3	101±1⁺	91±2⁺	92±2⁺	106±3⁺	111±3⁺	115±2	114±2	113±2
ΔBP_r	2.4±0.9	20.6±4.1	20.6±3.1	17.0±2.8	9.4±2.7	6.8±2.1	5.4±1.5	5.4±1.7	1.4±0.4	2.0±0.8	1.4±0.7	1.2±0.4
ΔBP_l	1.4±0.2	3.4±1.2*	3.4±1.2*	3.4±1.7*	3.4±1.6*	2.8±1.9	2.8±1.1	2.2±0.9	1.8±1.1	0.6±0.4	0.8±0.4	1.8±1.1

Note. $p<0.05$: *compared with ΔBP_r, ⁺compared with initial BP.

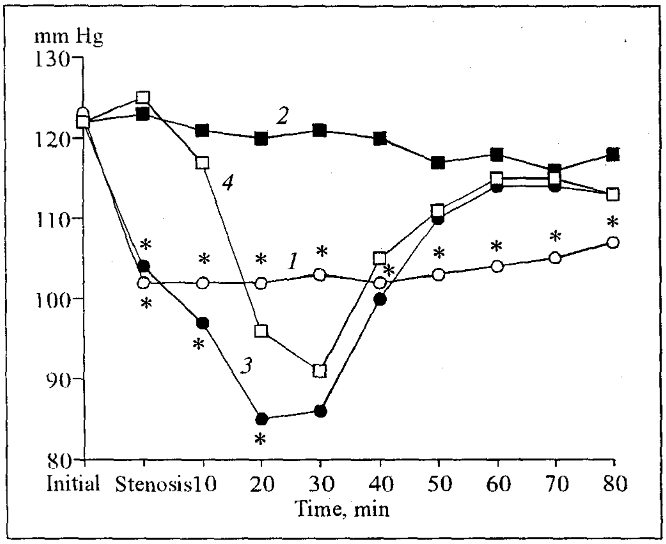

Fig. 1. Blood pressure in the right (*1*, *3*) and left (*2*, *4*) carotid arteries in the control (*1*, *2*) and experiment (*3*, *4*). Blood pressure in the carotid arteries was measured through the lingual arteries, i.e., distally to the ligature. Here and in Fig. 2, *$p<0.05$ between *1* and *2* and between *3* and *4*.

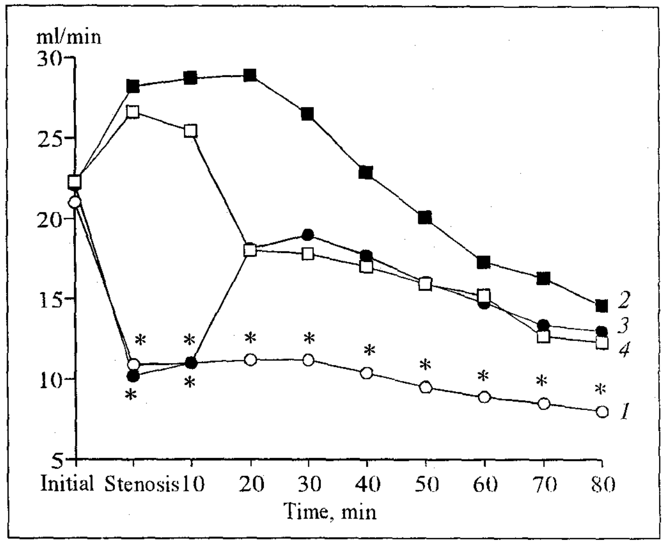

Fig. 2. Blood flow in the right (*1*, *3*) and left (*2*, *4*) carotid arteries in the control (*1*, *2*) and experiment (*3*, *4*).

Thus, intravenous injection of 0.1 mg/kg PEO (molecular weight 5.8×10^6) decreases BP drop and considerably improves blood flow in occluded artery against the background of reduced systemic BP.

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