Functional Reinnervation of Carotid Artery by Implanted Preganglionic Trunk in the Cat

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ABSTRACT—The preganglionic trunk of the superior cervical ganglion was implanted chronically into the carotid artery. A helical strip of the carotid artery with nerve was prepared, and electrical stimulation of the nerve caused a definite contraction. Part of the contraction was attenuated by phentolamine, and the remaining part of the contraction was nearly abolished by tubocurarine but not by hexamethonium and atropine. The present results clearly demonstrate that the carotid artery is reinnervated by preganglionic cholinergic fibers.

The surgically denervated superior cervical ganglion is reinnervated by original preganglionic fibers after chronic homologous cross-anastomosis and also by vagal afferent fibers after chronic heterologous cross-anastomosis in the cat (1–5). We report herein on the functional reinnervation of the carotid artery by implanted preganglionic trunk of the superior cervical ganglion in the cat.

Three cats of both sexes, weighing 3 to 5 kg, were anesthetized with ketamine (15 mg/kg, i.m.). Under anesthesia, the preganglionic trunk of the left side was cut at 10 mm below the superior cervical ganglion, and the cut end of the cranial side was ligated. The caudal preganglionic trunk (about 3 cm long) was carefully separated from the adjacent tissues. In order to implant the trunk easily (to avoid the movement of the common carotid artery by the pulse rate), an arterial clip was put at common carotid artery about 20 mm caudad to thyroid arterial branch. The caudal cut end of the preganglionic trunk was implanted under the adventitia of the common carotid artery about 10 mm caudad to the thyroid arterial branch and was then sutured. To minimize scar formation, the operating procedures were completed in about 15 min. The animals were kept for 115 to 130 days. Then the animals were examined for functional reinnervation of the preganglionic fibers to the carotid artery.

The cats were anesthetized with ketamine (15 mg/kg, i.m.) and bled to death from the abdominal artery. The common carotid artery with implanted preganglionic trunk at the left side was isolated and carefully separated from adjacent tissues. The common carotid artery with implanted nerve was cut into a helical strip (about 3 mm wide and about 3 cm long) with nerve (about 4 cm long). The implanted part was at the middle of the preparation. The common carotid artery of the right side (non-operated) was isolated and used as the control. The preparations were set in an organ bath containing Krebs-Henseleit solution (pH 7.4), which was bubbled with a mixture of 95% O₂ and 5% CO₂. The ends of the strips
were connected to a force-displacement transducer and the isometric changes were recorded on an ink-writing oscillograph. The applied tension was 1.5 g. Before starting the experiments, the strips were allowed to equilibrate for 60 min. The implanted nerve was stimulated by bipolar platinum electrodes, which were placed at 5 mm above the surface of the medium in the organ bath. Electrical stimulation of the nerve was 1 msec in duration, 10 Hz in frequency, maximal V in intensity for 20 sec. In non-operated common carotid artery, electrical transmural stimulation was given; and the conditions were 0.3

![Transmural stimulation](image1)

![Implanted-nerve stimulation](image2)

**Fig. 1.** Functional reinnervation of the carotid artery by chronically implanted superior cervical preganglionic trunk in cats. Effects of phentolamine, atropine, hexamethonium and d-tubocurarine on the contractile response of the carotid artery produced by transmural stimulation (non-operated right carotid artery) (left column) or implanted nerve stimulation (operated left carotid artery) (right column). In the right column, the implanted nerve was stimulated with rectangular pulses (1 msec in duration, 10 Hz in frequency, maximal V in intensity for 10 sec). In the left column, the preparation was stimulated transmurally, and the conditions were 0.3 msec in duration, 10 Hz in frequency, maximal V in intensity for 10 sec.
msec in duration, 10 Hz in frequency, maximal V in intensity for 10 sec.

In operated left carotid artery, the electrical stimulation of the implanted nerve caused a definite contraction (0.23 ± 0.1 g, n = 3) of the carotid artery in all three operated cats. In the three tested carotid arteries, the presence of phentolamine (10^-6 M) and d-tubocurarine (10^-6 M) reduced the contraction to 50 ± 11% and 33 ± 8% (n = 3) of the control response, respectively (Fig. 1, right column). Atropine (10^-6 M) and hexamethonium (10^-6 M) did not affect the contraction (Fig. 1, right column). In non-operated right carotid artery, the electrical transmural stimulation caused a contraction (0.32 ± 0.03 g, n = 4). The contraction was abolished by the presence of phentolamine (10^-6 M) and was not attenuated by the presence of atropine (10^-6 M), hexamethonium (10^-6 M) or d-tubocurarine (10^-6 M) (Fig. 1, left column). As shown in Fig. 2 (lower trace), the contraction produced by the stimulation of implanted nerve was partially attenuated by phentolamine and was abolished by the subsequent addition of d-tubocurarine (10^-6 M). In non-operated carotid artery, phentolamine (10^-6 M) nearly abolished the contraction produced by transmural stimulation, and the subsequent addition of d-tubocurarine (10^-6 M) did not affect it (Fig. 2, upper trace.)

The present experiments clearly provide pharmacological evidence that in addition to adrenergic fibers, preganglionic cholinergic fibers are able to reinnervate the carotid artery after chronic implantation of the preganglionic trunk in cats, suggesting that the transmissions are mediated by both α-adrenoceptors and nicotinic cholinoreceptors. Adrenergic neurons localize at mainly the superior cervical ganglion, but some of them are located at the preganglionic trunk. It is assumed that the phentolamine-sensitive response is due to reinnervation of adrenergic fibers which are distributed in the preganglionic trunk. Nicotinic cholinoreceptors in vascular smooth muscle cells may result from the induction by implanted preganglionic nerve activities.

![Fig. 2. Functional reinnervation of the carotid artery by chronically implanted superior cervical preganglionic trunk in cats. Effects of phentolamine and tubocurarine on the contractile response of carotid artery produced by transmural stimulation (non-operated right carotid artery) (upper trace) or by implanted nerve stimulation (operated left carotid artery) (lower trace). In non-operated right carotid artery (upper trace), the preparation was stimulated transmurally; and the conditions were 0.3 msec in duration, 10 Hz in frequency, maximal V in intensity for 10 sec. The implanted nerve (lower trace) was stimulated with rectangular pulses (1 msec in duration, 10 Hz in frequency, maximal V in intensity for 10 sec).](image-url)
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