Responses of vessel walls to chronically applied electrical stimuli*)

Lokale Reaktionen der Gefäßwand auf chronisch applizierte elektrische Reize

E. Betz and W. Schlote

With 7 figures

(Received October 25, 1978)

Summary

8 mm long sections of common carotid arteries of conscious, freely moving rabbits were electrically stimulated with DC-impulses by chronically implanted gold-electrodes daily for 1/2 h or two times 1/2 h per day for 4–6 weeks. The electrodes were arranged in such a way that the wall was stimulated transmurally. In the initial phase the tension of the vessel wall increased. After 1/2 h of stimulation the artery wall relaxed at the stimulated section. Repetition of stimuli led to smooth muscle cell proliferation within the stimulated region. The smooth muscle cells formed a cushion protruding into the lumen of the artery mainly at the anodic site of the stimulation-arrangement. The proliferating cells were smaller than those of the underlying tunica media. They were identified as smooth muscle cells by electron-microscopy, contained relatively more lysosomes and endoplasmic reticulum than the original media-cells and produced collagen-fibrils and elastic fibrils as an extracellular matrix material. Below very thick cushions of smooth muscle cells necrosis developed.

Animals which were additionally fed with 2% cholesterol in normal food developed typical atheromatous plaques at the site of the anodic stimuli.

Short lasting local electrical stimulations of thin pial arteries or arterioles with DC-impulses of low or moderate intensity usually cause circumscribed constrictions of the stimulated vessel sections (3, 20, 2). This can be seen by direct observations of the vessels. It has been reported that frequent repetitions of the same type of stimuli (10–15 Hz, 1–3 mA, 1 ms/imp), however, led to a gradual diminution of the contractile response and that after a series of stimulation periods the arteries finally dilate and no longer respond with constriction. In larger arteries (e. g. in the common carotid artery) the constriction can not be seen by direct observation with this type of stimulation. However, the tension of stimulated artery sections increases. Thus, it can be concluded that, in principle, the walls of great arteries respond in a similar manner as small arteries.

*) Supported by a grant of the Cilag-Foundation
The effects of repeated long term stimulations with chronically implanted electrodes have not yet been observed. In the following study such experiments have been conducted in order to follow the responses of various parts of the stimulated vessel wall in the course of several weeks. It resulted an intense proliferation of the smooth muscle cells in the stimulated vessel region. If the stimulation was combined with atherogenic food, typical atheromatous plaques developed at the site of the stimulated area within a few weeks. This effect was the reason for an extensive study which will be reported here.

Methods

The experiments were conducted on 78 rabbits (male and female, not selected). Age of the rabbits: 3-2 years. In the anaesthetized animal (Nembutal 25 mg/kg body weight) a 8 mm long cuff made of teflon was fixed around each common carotid artery in such a loose way that there was sufficient space for distension during pulsations of the vessel and so that no disturbances of blood flow during movements of the animal appeared. The wall of the teflon cylinder was 0.1 mm thick and contained two 8 mm long thin, flat gold stripes (0.05 by 0.1 mm) which were fixed in such a way into the teflon cylinder that after placing the teflon sheath around the vessel the electrodes were in opposition to each other. This arrangement permitted transmural stimulation of the vessel walls. The teflon cuffs had several thin holes so that the sheath looked like a rough sieve in order to keep the disturbance of the perivascular fluid exchange as low as possible. The electrodes were connected to a socket with a microplug by teflon-covered leads. The socket, made of Araldit, was fixed in the skull by two screws and the connections from the socket to the electrodes were led below the skin, so that infections were excluded. Anode and cathode were color-coded so that the anodic or cathodic site of stimulation could be identified. Figure 1 shows an electrode. The socket could be connected to the

Fig. 1. Schematic diagram of the stimulation arrangement for the electrical stimulation of the carotid artery. The cuff is made of teflon, the electrode material is gold, the leads are plastic coated copper leads.