ADRENERGIC INNERVATION OF THE CAPILLARIES

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The sympathetic innervation of microvessels in the mesentery of the small intestine and the fibrous capsule of the kidney was studied by Falck's method in 20 dogs in which experimental cardiogenic shock was induced by six daily infusions of noradrenalin. Under these experimental conditions the sympathetic innervation of the capillaries and postcapillaries could be detected in these vacular regions.

KEY WORDS: capillaries; sympathetic innervation.

The adrenergic innervation of the capillaries is a problem with a long history, but nevertheless it still remains a subject for debate. Most investigators who have used classical histological methods have agreed that microvessels, with no smooth-muscle cells in their structure, have no sympathetic innervation [3-5, 8, 11]. At the same time, other investigations indicating the existence of such innervation have been published [13, 14]. In recent years both views have been confirmed by electron-microscopic investigations which showed adrenergic and cholinergic terminals to be present close to the capillaries or in direct contact with them [1, 6]. However, the nature of the efferent nerve endings cannot yet be determined by electron microscopy because of the nonspecificity of the method used.

Attempts to use Falck's specific histochemical method to demonstrate adrenergic terminals in the capillaries of various vascular regions have not provided an answer to the problem. G. R. Leont'eva, on the basis of a laborious and meticulous investigation of the adrenergic innervation of the capillaries in representatives of all classes of vertebrates, concluded that it is absent in capillaries and veins which have no smooth-muscle cells [5]. Similar results were obtained by investigation of skeletal muscle and the heart [2], the mesentary of the small intestine [12], and other organs. Khaisman et al. [7], in avascular regions of the mesentery of the cat small intestine, observed adrenergic terminals branching from the sympathetic plexuses of arterioles, which by repeated dichotomous divisions, changed into preterminal and terminal segments.

Falck's method, used to study the presence of an adrenergic innervation of microvessels without smooth-muscle cells, has thus so far yielded negative results.

The object of the present investigation was to study the adrenergic innervation of microvessels in the mesentery of the small intestine and capsule of the kidney in experimental cardiogenic shock.

EXPERIMENTAL METHOD

Experiments were carried out on 20 dogs divided into three groups. Cardiogenic shock was produced by the method developed in the writer's laboratory [9]: by occlusion of the coronary artery in a waking animal after preliminary injury to the heart by repeated intravenous injections of microdoses (2.3 μg/kg·min) of noradrenalin (six dogs, experimental group 1). Another six dogs were killed at the end of a course of infusions (experimental group 2). Eight intact dogs served as the control (group 3). The animals were killed under thiopental anesthesia. Preparations of the mesentery of the small intestine and capsule of the kidney were treated by Falck's method [10].

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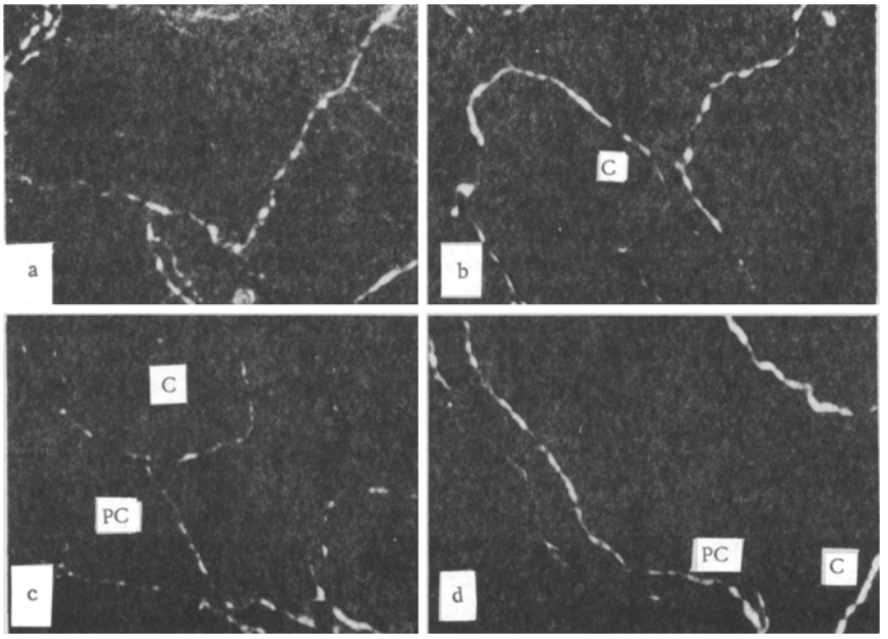

Fig. 1. Photomicrographs of adrenergic terminals of nonmuscular microvessels: a) mesentery of small intestine of intact dog; b) capillaries (C) of mesentery of small intestine in cardiogenic shock; c) capillaries (C) of fibrous capsule of kidney after course of noradrenalin infusions; d) capillaries (C) and postcapillaries (PC) in cardiogenic shock. Falck's method, 400×.

EXPERIMENTAL RESULTS

In the animals of all three groups, besides fluorescence of the adrenergic terminals of the arterioles and venules which has frequently been described, sympathetic terminals also were found along the course of the nonmuscular microvessels — capillaries and postcapillary venules — in close contact with their vascular wall. These terminals were clearly defined in the animals of experimental groups 1 and 2 — animals receiving infusions of noradrenalin and with simulation of cardiogenic shock. Adrenergic terminals, as we know, have high ability to adsorb noradrenalin from the blood flow. Infusions of noradrenalin and cardiogenic shock are accompanied by disturbance of the rheologic properties of the blood — by the formation of aggregates of erythrocytes and by stasis — these facts are well known. In the present experiments two factors contributing to the detection of sympathetic terminals in the microvessels were felicitously combined: The injected noradrenalin was adsorbed into them, increasing the intensity of fluorescence and the number of fibers detectable, and the intravascular aggregates and stasis of erythrocytes made the microvessels clearly outlined (Fig. 1b, c, d). To avoid mistakes in the identification of the blood vessels and to make sure that they contained no smooth muscle cells in their structure, the preparations were counterstained with acridine orange solution (1:10,000) and the relevant microvessel was reexamined under the microscope. During this manipulation the sympathetic terminals disappeared and the structure of the vascular wall became visible. Some difficulties arose in the attempt to prove the presence of specific terminals along the course of the capillaries and postcapillaries in intact dogs, in which the microvessels were invisible (Fig. 1a) and single sympathetic terminals could be taken for terminals of avascular regions described by Khaisman et al. [7]. However, the method of staining with acridine orange described above demonstrated that, besides the existence of free terminals, others also were present in close proximity to the microvessels, but they were present in much smaller numbers than in the animals of the group indicated above.

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