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PHENOL SOLUTIONS DIFFERENTIALLY BLOCK CONDUCTION IN CUTANEOUS NERVE FIBERS OF THE CAT

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The action of phenol in Tyrode solution on nerve conduction has been investigated in vivo in the desheathed sural nerve of cats. A section of 8 mm of the nerve was exposed to phenol solution. At low phenol concentrations (0.05–0.125%) a reversible block of A- and C-fibers occurred. At higher concentrations (0.6–1%) a selective and persistent C-fiber block could be achieved. The size of the residual A-volley was between 50% and 81% when all C-fibers were blocked.

Phenol has been used clinically to block peripheral nerves and spinal roots for relief of pain in man [4,7]. Animal experiments performed to examine the effects of phenol on conduction in myelinated and non-myelinated fibers yielded contrasting results. A selective and reversible block of C-fibers was reported in dorsal rootlets of cats [3]. On the other hand, an irreversible selective C-fiber block was found at higher phenol concentrations [5]. A subsequent physiological and histological study [6] failed to confirm these results in peripheral nerves of cats; reversible and irreversible conduction block of nerves was reported, which, however, was not selective for a particular fiber group at any of the phenol concentrations used. These contrasting findings might have resulted from the presence of the epineurium which constitutes a major barrier for diffusion to the space around nerve fibers. Therefore, we applied phenol to the desheathed nerve, i.e. a region of nerve where all surrounding connective tissue including the epineurium had been removed.

Experiments were performed in 6 adult cats weighing between 2.0 and 3.4 kg.

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They were anesthetized with sodium pentobarbital (Nembutal), [illegible]al dose 40 mg/kg i.p., and repeated supplemental doses of 3 mg/kg i.v. if required. The sural nerve was exposed in a pool formed by the skin flaps and filled with paraffin oil. Three sections of the nerve were cleaned by dissection for electrical stimulation, recording of compound action potentials and superfusion in a perspex chamber (see ref. 1 for details). The part of the nerve placed into the perfusion chamber was desheathed, i.e. the epineurium was carefully removed under the dissection microscope with watchmaker forceps. The length of the desheathed nerve exposed in the perfusion chamber was 8 mm. The volume of the chamber was 48 μl. The lid over the chamber as well as the nerve entrances were sealed with silicone grease. Irrigation of the nerve was performed by a roller pump arranged so that a slight negative pressure existed in the chamber. Flow rate of irrigation was about 1 ml/min. Usually, isotonic Tyrode solution was used. This solution could be replaced by phenol solutions of different concentrations. Phenol solutions of all concentrations used are given in per cent by weight and were made up in Tyrode solution. Compound action potentials of A- and C-fibers were elicited by electrical stimulation supramaximal for either kind of fibers. The potentials were photographed from the screen of an oscilloscope.

A total of 7 sural nerves was studied. Reversible and irreversible conduction blocks were observed, at low and high concentrations of phenol, respectively. A typical experiment is shown in Fig. 1. Increasing phenol concentrations led first to a reversible block of A- and C-fibers, A-fibers being more affected than C-fibers. At higher phenol concentrations (0,75%) a selective and irreversible C-fiber block was achieved. Results of reversible blocks are given in Table I. In all 4 cases where the effect of low concentrations of phenol was studied, selective block of conduction in A-fibers was observed in the concentration range of 0.05–0.125%. Conduction persisted in part of the C-fibers, as judged by the amplitude of the residual C-volley, which had a mean value of 28% (range 16–50%). At higher phenol concentrations A- and C-fibers were both reversibly blocked by phenol concentrations of 0.25–0.75%. At phenol concentrations around 1% a selective irreversible block of conduction in C-fibers was achieved within 0.7–2 min in 4 of 6 nerves studied (Table II). Conduction persisted in a variable proportion in A-fibers; the mean amplitude of the residual A-volley was 68% in these 4 nerves (range 50–81%). In 2 cases both A- and C-fibers were blocked irreversibly. Recovery of C-fibers never occurred in all 6 nerves treated with these phenol solutions at higher concentration during the follow-up time, which was between 30 and 110 min.

The reversible A-fiber block produced by low phenol concentrations has not yet been described in the literature. As no further investigations of the membrane physiological basis of this effect have been undertaken, the cause of this phenomenon remains unclear. In contrast to our findings, application of 0.5% phenol to dorsal roots yielded a reversible C-fiber block [3,5]. This contrast to our results of a reversible A-fiber block may be due to the fact that C-fibers are split

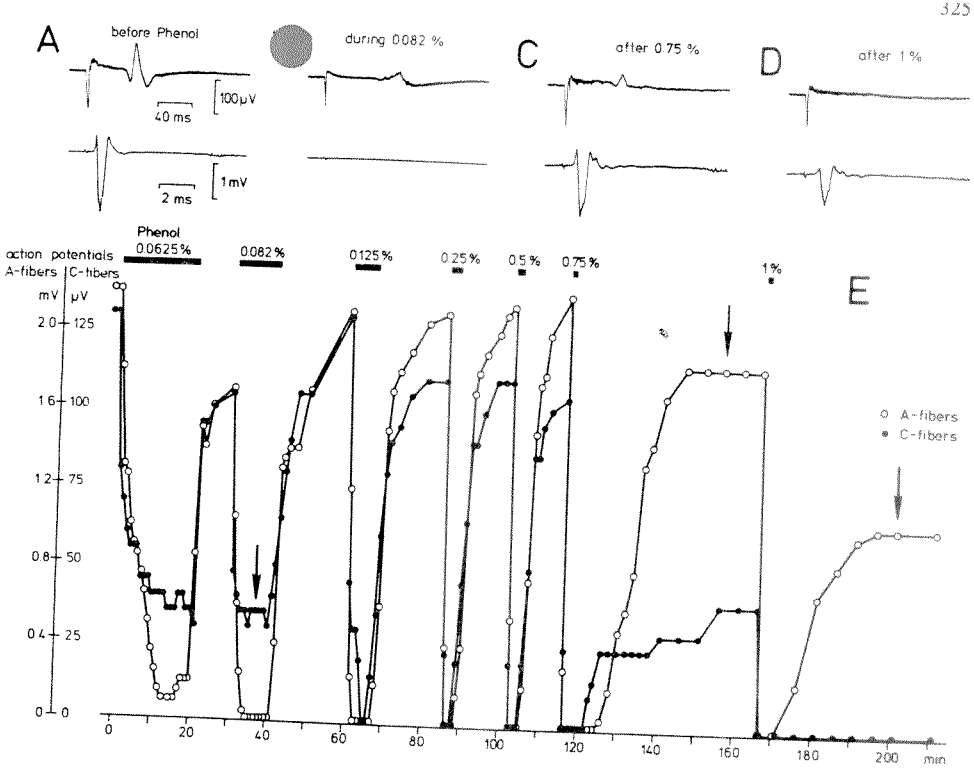

Fig. 1. Effect of irrigation with phenol solutions on A- and C-fibers of the sural nerve. A: compound action potentials of C-fibers (upper sweep) and A-fibers (lower sweep) before perfusion. B: records during irrigation of the nerve with 0.082% phenol solution. C: after irrigation with 0.75% phenol solution. D: after irrigation with 1% phenol solution. E: time course of amplitudes of the A-volley (○, left ordinate scale) and of the C-volley (●, right scale). The periods of perfusion are indicated. Arrows label the times of records shown in B, C, and D.

TABLE I

REVERSIBLE A-FIBER BLOCKS

The phenol concentrations that caused a reversible block of A-fibers. The selectivity coefficient indicates the amplitude of the compound action potential (relative to the control) of C-fibers that remained when all A-fibers were blocked.

Nerve no.	Phenol concentration	Duration of application	Selectivity coefficient
I	0.125%	20.5 min	28%
II	0.082%	9 min	52%
III	0.082%	11 min	30%
IV	0.10 %	15 min	25%

TABLE II

IRREVERSIBLE C-FIBER BLOCKS

The phenol concentrations that caused an irreversible block of C-fibers. The selectivity coefficient indicates the amplitude of the compound action potential of A-fibers that remained when all C-fibers were blocked.

Nerve no.	Phenol concentration	Duration of application	Selectivity coefficient
I	1%	1.5 min	50%
II	1%	0.7 min	0%
III	1%	1.0 min	62%
V	1%	1.0 min	81%
VI	1%	1.5 min	0%
VII	0.6%	2.0 min	81%

into fine branches proximal to the dorsal ganglion [2] and therefore may be more susceptible to phenol than in the peripheral nerve.

The irreversible C-fiber block at higher phenol concentrations has been previously observed in experiments on dorsal rootlets in vitro [5], using 7,5% phenol in Myodil, an oily substance. The time course for the reduction of amplitudes of A- and C-fibers in that study is of the same order of magnitude as in our results. This can be explained by similar experimental conditions, as dorsal rootlets are not enveloped by an epineural sheath, whereas in our experiment this sheath was removed before the application of the phenol solutions. The fact that in our experiments a differential irreversible C-fiber block could be brought about only in 4 of 6 nerves studied may be due to the fact that for 1% phenol solutions the time of application seems to be very critical. As pretreatment of the nerves with lower phenol concentrations was different in our experiments, no precise figure for the time of phenol application can be given. On average an application of 1% phenol solution for more than 1 min caused an irreversible block of both A- and C-fibers. Therefore, the extended treatment of the saphenous nerve with 1% phenol concentration for several minutes by Schaumburg et al. [6] may have contributed to the lack of a differential block. Another important factor in this result may be the presence of the epineural sheath of the nerve. The resulting slower diffusion rate of phenol into the nerve may have caused damage to all fibers in the periphery when the center of the nerve was still not yet reached.

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