PATHOLOGICAL PHYSIOLOGY AND GENERAL PATHOLOGY

AFFERENT IMPULSES FROM AN INFLAMED AREA

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Despite the widespread notion that an inflamed area is a source of prolonged irritation to the receptors, until recently practically no direct investigation has been made of impulses from such a region. Work has been done [1, 8, 9, 10, 13, 16, 18, 19] to investigate "pain" impulses from damaged tissue, but these investigations have been confined to establishing along what fibers the pain impulses spread, and no special observations were made on changes related to the course of the inflammation.

The object of the present investigation has been to determine along what fibers the impulses from the inflamed area travel at various stages.

EXPERIMENTAL METHOD

We used the method in which two impulses are caused to meet, as proposed quite recently by Douglas and Ritchie [2, 4]. The method is as follows. It is known that according to what receptors are involved in connection with one or other stimulus applied at the periphery the excitation will spread along different afferent fibers. If the impulses from the periphery encounter a complex potential sent out antidromically, then impulses along the same fiber will extinguish each other. Thus from the changes in the amplitude of the separate components of a complex potential we may find along which afferent fibers a particular signal is passing.

In order to induce inflammation in the skin of the hind limb in the region innervated by the saphenous nerve (dorsum of foot) we injected 0.2-0.5 ml of sterile turpentine. The saphenous nerve was dissected out in the upper part of the thigh for a distance of 2-3 cm, and was carefully separated from the surrounding tissue. The nerve was divided proximally in the region of the groin. The peripheral cut end was placed on platinum bipolar stimulating electrodes. The electrodes and the nerve were placed deep in the cutaneous incision which was filled with vaseline oil at 30-35°. The nerve was stimulated by single square-wave impulses from an SIF-3 stimulator. The strength and duration of the stimulus elicited maximal excitation in the given group of fibers. The recording electrodes were connected to a branch of the saphenous nerve in the lower part of the leg. Electrical potentials were recorded by a DIZA electromyograph and by a Cl-4 oscillograph. Each record consisted of 5 superimposed traces made at intervals of 1 second.

The experiments were carried out on 30 cats anaesthetized with 250 mg/kg urethane and 50 mg/kg chloralose.

EXPERIMENTAL RESULTS AND DISCUSSION

In the cat the saphenous nerve contains the following groups of fibers: $A_{\alpha\beta}$, A_{δ}, and C; therefore a single electrical stimulus applied to this nerve produces three characteristic oscillations: $A_{\alpha\beta}$, A_{δ}, and C. In the last wave sometimes two components C_1 and C_2 can be distinguished [1, 4, 7].

An injection of turpentine causes a brief change in this complex potential; there is a reduction in all the components, but after a few minutes the complex potential elicited by stimulation of the saphenous nerve is restored. In certain experiments, 30-40 min after the injection of turpentine the A_{δ} and C waves are once more reduced.

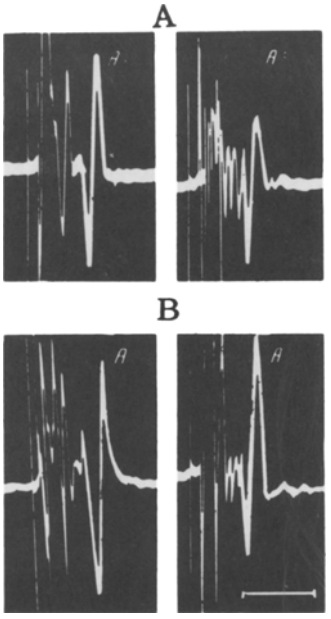

Fig. 1. Complex action potential in saphenous nerve of a cat 24 h after damage to the limb. A) On the right—damaged limb. The A_δ oscillation is greatly reduced; B) after division of the nerve below the recording electrodes. On the left—in the undamaged limb. The A_δ oscillations increase after elimination of the afferent impulses from the inflamed area. The distance between the stimulating and recording electrodes was 88 mm. Each record represents 5 superimposed traces at intervals of 1 second.

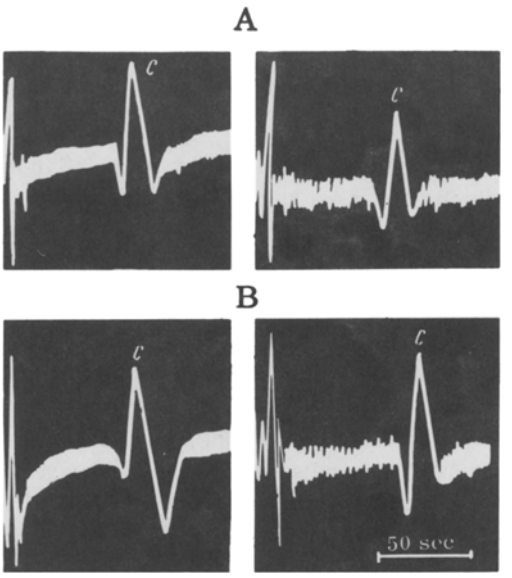

Fig. 2. C component of the complex action potential in the saphenous nerve 24 h after damage to the limb. A) on the left—in the undamaged limb, on the right—in the damaged limb; the C component is reduced; B) after division of the nerve below the recording electrodes. On the left—in the undamaged limb, on the right—in the damaged limb; the C component was increased after elimination of afferent impulses from the inflamed area. The distance between the stimulating and recording electrodes was 88 mm. Each record represents 5 superimposed traces at intervals of 1 second (time marker 50m seconds).

It is at this time that the inflammatory reaction develops. The inflammatory process is particularly well shown in animals 1-3 days after the injection. At this time there was a profuse edema into the foot, and then a marked increase in the sensitivity of this foot; the animal limped, and withdrew the foot at the lightest touch. To study impulses from the damaged zone at these times we made records of the complex action potential evoked by an antidromic stimulus applied to the saphenous nerve in both a healthy and a damaged foot. In control experiments (6 animals with untreated feet) it was shown that for the given group of fibers when an electrical stimulus was applied after very careful dissection of the nerve the components of the complex action potential were as a rule identical in both hind limbs. In the experimental groups however in most cases there was a marked difference in the action potentials on the two sides. After 1-3 days of development of the inflammation there was a marked reduction (by 3.7-79.2%) in the A_δ and C components in 12 of the 18 animals. The A_δ component was reduced on average by 46.8%, and the C component fell by 49.4% (Fig. 1, A; Fig. 2, A). It is important to note that there was practically never any slower component C_2 (according to Douglas the pain component) though in the healthy limb the component C_2 was recorded in many experiments. Changes in the components $A_{\alpha\beta}$ in the damaged limb were of various kinds. Only in 9 of the 18 experiments was there a marked reduction in these components by as much as 9.1-56.4%. In 4 animals the $A_{\alpha\beta}$ oscillation was increased in the undamaged limb by 6.6-20%. In 5 animals no comparison of these components could be made because they slowed a different configuration on the healthy and damaged sides.

The dependence of the changes in the components of the complex action potential on afferent impulses from the inflammatory zone was confirmed in subsequent experiments in which in order to exclude these afferent impulses we divided the nerve below the recording electrodes. We carried out 10 such experiments. The complex action potential was recorded 30-60 min after division of the nerve. It was found that in 7 of the 10 experiments the com-

ponents A_δ and C in the damaged limb recovered after division of the nerve, whereas in the healthy limb in 8 out of the 10 animals there was practically no change (Fig. 1, B and Fig. 2, B). Thus reduction in the components of the complex action potential during development of the inflammatory process is brought about by flow of impulses from the inflamed area.

As our investigations have shown the inflammatory zone is a source of prolonged impulsation. The impulses spread chiefly along A_δ and C fibers, and also along $A_{\alpha\beta}$ fibers, and these potentials may be recorded for 3 days after damage to the tissue.

At one time it was suggested that impulses from the pain receptors travel along the C fibers. It is now established that these fibers convey also impulses from other cutaneous receptors—the mechanoceptors, thermoreceptors, and chemoreceptors [1, 3, 11, 13, 14, 15]; therefore the discovery of activity in A_δ and C fibers in our experiments does not necessarily indicate that the inflammatory process stimulates activity only of pain receptors. Quite possibly it may stimulate also receptors which are concerned with mechanical, thermal, or chemical stimuli. This idea is all the more probable because inflammation evokes in tissues combined mechanical, physicochemical and biochemical changes. The results quoted here do however afford evidence that whatever receptors are stimulated by inflammation they are innervated chiefly by A_δ and C fibers which have a low rate of conduction. This finding is in line with the fact that these receptors show a low degree of adaptation, and may continue in a state of prolonged excitation for hours or even days.

SUMMARY

We have applied the method of colliding impulses suggested by Douglas and Ritchie, and have established that impulses from an inflammatory focus spread principally along the A_δ and C fibers. These impulses may be recorded even up to the third day after tissue injury.

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