Sympathetic preganglionic pupillodilator fibres in the light reflex[1]

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Summary. The modifications of the sympathetic pupillodilator activity in the light reflex have been demonstrated by recording the electrical discharge of single preganglionic fibres in the cervical sympathetic nerve.

Several studies[2–6] have been performed to investigate a possible modification of the activity of the sympathetic pupillodilator fibres in light reflex. The studies carried out by analyzing the pupillary size after unilateral section of the third cranial nerve or of the cervical sympathetic nerve, or after administration of autonomic blocking drugs, have not given definitive evidence of a sympathetic active role in the light reflex. Recently such a sympathetic role has been demonstrated by analyzing the electrical activity of the long ciliary nerve in the cat under light general anaesthesia[7].

The aim of the present research is to find, in the central stump of the cervical sympathetic nerve of the cat, preganglionic fibres involved in the light reflex, and to analyze their pattern of discharge in response to light and darkness. Furthermore, recordings from pupillodilator fibres in the cervical sympathetic nerve permit comparison of the direct with the consensual sympathetic reflex, which could not be valued when the sympathetic activity was isolated from the long ciliary nerve, as this preparation needed ipsilateral eye enucleation.

Methods. The animals were under general anaesthesia (Thiopentone sodium: 40 mg/kg i.p.) only during the preparatory surgery. The trachea was cannulated, polyethylene tubes were introduced into a femoral vein for drug administration and into a femoral artery to record blood pressure. Tracheal CO_2 was measured with an infrared absorption analyzer (Beckman LB1) during the whole experiment. The cervical sympathetic nerve was exposed, isolated and cut just below the superior cervical ganglion. Afterwards the animals were curarized (Tubocurarine 0.25 mg/kg i.v. or 1 mg/kg i.m.) and locally anaesthetized (Xilocaine solution). The sympathetic activity was recorded using the conventional few-fibre technique, splitting the central stump of the cervical sympathetic nerve. The fine bundles of fibres were placed on 2 platinum electrodes connected through an AC preamplifier (Grass P5) to a loudspeaker and an oscilloscope (Tektronix 565). The unitary discharge was observed while stimulating the eyes with different values of illumination (from 0 to 1500 lux).

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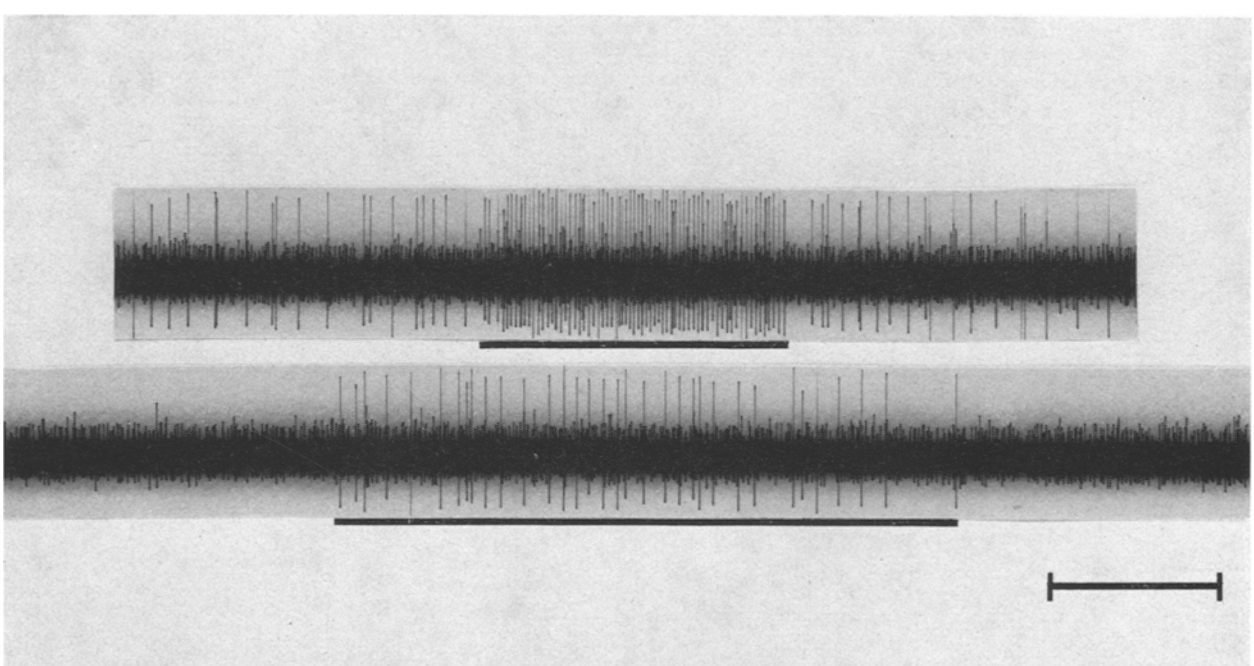

Unitary discharge of a light-responsive fibre during a period of tonic activity (upper trace) and of phasic activity (lower trace). Light intensity on the cat's eye: 1000 lux. Heavy line: darkness. Time signal: 10 sec.

Results and discussion. From the sympathetic nerve of 18 cats, in local anaesthesia, we have isolated 12 units influenced by different light intensities. The discharge frequency of the tonically active fibres showed lower values (0.2–5 imp/sec) during illumination and higher values (0.5–18 imp/sec) in darkness. Other units were phasically active, only showing activity in darkness or at low values of light intensity. The same units exhibited spontaneous discharge changes, at times even shifting from tonic to phasic activity (figure): however, an inverse relationship between light intensity and discharge frequency was always present. A highly significant correlation, probably linear, was found in our experimental conditions, between the discharge frequency in the light and in the darkness, independently from the type of activity of the fibres ($r = 0.758$).

The pattern of discharge frequency of the fibres, shifting from light to darkness, consisted mostly in an initial peak of frequency, then the firing frequency settled down at lower values, but higher than those presented during the previous illumination. Occasionally the phasic units, after the initial peak, became progressively silent. When shifting from darkness to light the unitary discharge showed a sudden complete inhibition lasting 2–4 sec, followed by a gradual return of the firing frequency at a level that depended on the light intensity. These fibres could never be evidenced in preliminar experiments in which the animals underwent different levels of general anaesthesia whether Nembutal, Urethane-Chloralose or Chloralose were used. Very small doses of Nembutal (5 mg/kg) administered in unanaesthetized cats greatly decreased the resting discharge of the sympathetic light-responsive units and completely abolished the response to darkness.

An increase or decrease of the discharge rate always coincided with pupillary dilatation or constriction both in the normal and in the sympathectomized eye. Such preganglionic fibres are evidently concerned with pupillary dilatation, since no other ocular structures are reported to have such a functionally strict relationship with light intensity[8]. The presence of light-responsive sympathetic fibres indicates that the sympathetic nerve not only maintains a tone in the dilatator pupillae muscle but also modulates finely its discharge activity in order to adjust, together with the parasympathetic nerve, the pupil size in the reflex response to changes of illumination. In most of our trials, the per cent variation in frequency was higher when shifting from light to darkness than vice-versa and it was particularly evident in those phasic fibres which, after a few minutes of darkness, exhibited a progressive decrease till complete inhibition and no change of activity to the successive illumination occurred. These data suggest that the sympathetic system plays a bigger role in pupillary response to darkness than to light. Furthermore, the parasympathetic activity recorded from the short ciliary nerves in the cat showed that the discharge enhancement during the light reflex is bigger than the decrease in the reflex to darkness[9]. These results confirm the Duke-Elder hypothesis[10], according to which the reflex to light is primarily parasympathetic whereas the reflex to darkness is primarily sympathetic.

The study of the role of the sympathetic output in the direct and consensual light reflex showed that the variations of discharge frequency of light-responsive fibres were much larger when the same change of illumination was performed on the ipsilateral than on the contralateral eye. This fact gives electrophysiological demonstration that the sympathetic reflex to light is mainly ipsilateral in the cat, notwithstanding numerous crossings of both afferent[11,12] and efferent[12] pathways in the brain stem and upper cervical segments.

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The potential independent series resistance in rat ventricular fibres[1]

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Summary. Current clamp experiments performed in rat ventricular fibres revealed the presence of a resistance Rs (between 14.5 and 15.5 KΩ) in series with the membrane capacity. Rs behaved as a lumped resistance and its value remained constant throughout the action potential repolarization phase.

Introduction. Since the results of Hodgkin et al.[2] on the squid axon, the presence of a resistance (Rs) in series with the membrane capacity (Cm) was observed in various cardiac tissues[3–5]. There has been evidence that in voltage clamp experiments the presence of Rs causes deviations of the transmembrane voltage from the command pulse and shifts the voltage-current relationships[6,7]. In the squid axon, Rs is usually attributed to the Schwann cell layer, while in cardiac muscle it may represent the cleft resistance[8].

During a cardiac action potential, Na, Ca and K ions move through the cell membrane. If the cleft narrowness

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