A study of pre- and postganglionic fibres in the intestinal nerve (Remak's nerve) of the chicken

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Summary. The mean peak CV's of two electrophysiologically defined groups of fibres in the intestinal nerve of the chicken have been determined.

One group of fibres is constituted by the processes of enteric cholinergic neurones which project along the side branches of the intestinal nerve and synapse within the nerve trunk. These preganglionic fibres have a mean peak CV (at 40 °C) of 0.31 m·s⁻¹.

The other group is made up of fibres of postganglionic neurones which project orally along the nerve trunk. The results suggest that some postganglionic neurones project only as far as the next ganglion whilst others project beyond the next two ganglia for distances greater than 5 mm. The postganglionic fibres have a mean peak CV (at 40 °C) of 0.71 m·s⁻¹.

These figures demonstrate that both pre- and postganglionic fibres are unmyelinated. The temperature coefficient (Q₁₀) for the CV of unmyelinated fibres in the intestinal nerve was 1.57.

Introduction

The intestinal nerve (Remak's nerve) of the chicken, a ganglionated nerve trunk, gives off numerous side branches along its length which innervate the small and large intestines (Akester 1979). The organization of this nerve is still poorly understood. Experiments in which the nerve was ligated have indicated that more adrenergic fibres ascend than descend the rectal segment of the nerve trunk; a reverse of the situation found at the upper limits of the nerve (Bennet and Malmfors 1970; Akester and Akester 1975). Also electrophysiological evidence has recently been provided for descending adrenergic fibres which modify ganglionic transmission in the non-cholinergic, non-adrenergic excitatory pathway to the rectum (Ishizuka et al. 1982).

The side branches of the nerve trunk are thought to contain excitatory autonomic nerves since an increase in circular muscle tension and intraluminal pressure were seen when the nerve trunk was stimulated (Hodgkiss 1984a). In addition the side branches contain the fibres of enteric cholinergic neurones which synapse with postganglionic neurones in the main nerve trunk (Hodgkiss 1984b). The function of these enteric neurones and the postganglionic neurones with which they synapse is unknown. In the present study both pre- and postganglionic nerve fibres have been further characterized by measuring the CV's of both groups of fibres.

The relationship between the CV of unmyelinated fibres in the intestinal nerve and temperature was also examined since no figures are available for the temperature coefficient (Q₁₀) of CV in avian unmyelinated fibres.

Materials and methods

The chickens (Brown Leghorn) used in this study were hatched and reared at the Poultry Research Centre. Between 6 and 12 weeks after hatching they were killed by cervical dislocation. A 20 cm length of the small intestine and its associated mesentery in the region of Meckel's diverticulum was removed, taking care not to damage the delicate intestinal nerve or its side branches located in the mesentery adjacent to the gut.

A 2–3 cm length of intestinal nerve and the complete lengths of all corresponding side branches were dissected from the small intestine. Usually this length of nerve trunk was situated aboral to Meckel's diverticulum. The mesentery containing the nerve and its side branches was pinned to the base of an organ bath (volume 100 ml) which was lined with Sylgard resin (Dow Corning). The bath contained Krebs solution of the following composition (mM): NaCl 118; KCl 4.75; CaCl₂ 2.54;
NaH₂PO₄ 1.2; MgSO₄ 1.2; NaHCO₃ 25 and glucose 11. The Krebs solution which was gassed continuously with 5% CO₂ in O₂ was maintained within 0.5 °C of 37 °C and changed by overflow every 15 min with preheated, oxygenated solution.

In some experiments a low Ca, high Mg Krebs solution was employed, it contained no added Ca but 5 mM Mg. Nicotinic cholinergic transmission was blocked by adding hexamethonium bromide (Sigma) to bathing solution. The volume of the stock solution of hexamethonium added was never more than 0.5% of the bath volume.

The ends of the main nerve trunk and one or more side branches were cleared of fat and connective tissue and drawn into tightly-fitting suction electrodes. The electrodes on the side branches were connected via an isolation unit (Grass SIU5) to a physiological stimulator (Grass S48). The side branch was stimulated with rectangular pulses which were of fixed duration and frequency within any one experiment, although with different preparations the pulse duration was varied between 200 μs and 500 μs, and the frequency from 0.5–1.0 Hz. The stimulus intensity selected was about 10% greater than that giving a response of maximum amplitude and invariably this was between 10–35 V. The CAP recorded at the oral end of the main nerve trunk (oral CAP) was amplified at a bandwidth of 10–3000 Hz (DAM 5A, W.P. Instruments) and displayed on the screen of a storage oscilloscope. Five to seven, steady state (Hodgkiss 1985), consecutive responses were superimposed on the oscilloscope screen and photographed. The conduction delay was determined from the beginning of the stimulus artefact to the peak of the component of the CAP. Since the CV's were low no allowance was made for activation time at the cathode which in these experiments was the outer silver wire of the suction electrode.

The CV's of preganglionic fibres in the side branches were determined as shown schematically in Fig. 1. Initially the recording electrode was sited at position (a) on the main nerve and the stimulating electrode was sited at position (1) on the side branch. The CAP was recorded from the nerve trunk oral to the junction with the side branch (Hodgkiss 1984b) and is, therefore, referred to as the oral CAP to distinguish it from the CAP recorded from the side branch. The oral CAP recorded with this arrangement is shown schematically alongside 1a (Fig. 1B). The side branch was then stimulated at position (2) and another oral CAP was recorded shown schematically alongside 2a (Fig. 1B). This procedure was repeated with the stimulating electrode located at position (3) and then at position (4). The latency of the peak of the oral CAP at each position was plotted against the distance along the side branch between the stimulating electrode and the nerve trunk (Fig. 1C); the slope of the line through the data points gives the CV of the preganglionic fibres.

The stimulating electrode remained at position (4) on the side branch and the recording electrode was moved successively to positions (b), (c) and (d) on the nerve trunk. The latency of the peak of the oral CAP at positions (a), (b), (c) and (d) was plotted against the corresponding distance along the nerve trunk between the recording electrode and the side branch (Fig. 1D); the slope of the line gives the CV of the postganglionic fibres. In all instances when the data for conduction latency were plotted against distance a linear relationship was found. A similar technique was employed by Landmesser and Pilar (1972) to determine the CV's of nerve fibres in the chick oculomotor nerve.

In a few experiments both the recording and stimulating electrodes were placed on the same side branch to record the CAP and determine the CV's of the one or two groups of fibres in the side branch.