Efferent Control of the Carotid Body Chemoreceptor

The carotid body chemoreceptors have been shown to be influenced by an efferent pathway arising from the cervical sympathetic nerve supply[1]. Recently, evidence has appeared which suggests that there may be a second efferent pathway to the receptor complex. It was demonstrated that there is spontaneous nerve activity passing centrifugally in the sinus nerve[2], the nerve which carries the afferent chemoreceptor fibres. In addition it has been shown that stimulation of the peripheral end of the sinus nerve depresses chemoreceptor activity[3]. Observations on the structure of the carotid body further suggest that the nerve endings on the Type I (glomus) cells of the carotid body are efferent and not afferent[4]. It may be deduced therefore that this efferent pathway, in addition to the sympathetic system, may control the receptor. We have examined the problem by recording chemoreceptor activity in a slip of the sinus nerve whilst the remainder of the nerve is intact. If sufficient of the efferent fibres remain functional during this procedure, and they have tonic effects, their section should lead to a change in receptor activity. We have also stimulated the peripheral end of the sinus nerve while recording chemoreceptor activity.

Method. Cats were used, either anaesthetized with sodium pentobarbitone (30 mg/kg, i.p.) or decerebrated under halothane anaesthesia. A slip of sinus nerve was laid on a stainless steel plate and dissected to obtain a few fibres showing chemoreceptor activity. The remainder of the nerve was intact. Nerve potentials were recorded by conventional means and their frequency measured by the time counted for a preset number of impulses to occur (usually at least 200). The arterial CO_2 tension and pH were kept constant; arterial oxygen tension was varied by changing the inspired oxygen tension in the artificially ventilated cat. Arterial pressure was maintained above 100 mm Hg. In this way data for plotting oxygen response curves for the chemoreceptors were obtained. Further details of our techniques will be found elsewhere[2].

Results. Experiments on 9 cats were performed. In 5 the oxygen response curve was displaced upwards after the sinus nerve was cut so that the rate of discharge at any given oxygen tension increased. This response was at once apparent. In 2 cats there was no change in rate and in 2 cats the results were equivocal, either unchanged or slightly increased. The most pronounced example of this shift at low oxygen tensions is shown in Figure 1. Before the sinus nerve was cut, the discharge rate of this fibre was 8.8 imp/sec at a $P_{a\,O_2}$ of 100 mm Hg and 16.5 imp/sec at a $P_{a\,O_2}$ of 70 mm Hg. After the remainder of the sinus nerve was cut, the discharge rate increased to 12–13.5 imp/sec at a $P_{a\,O_2}$ of 100 mm Hg and to over 25 imp/sec at a $P_{a\,O_2}$ of 70 mm Hg. In the other animals the effect was also most pronounced at low oxygen tensions but could amount to an increase of one impulse per second at high tensions.

We have also confirmed the finding of Neil and O'Regan[3] that stimulation of the sinus nerve will

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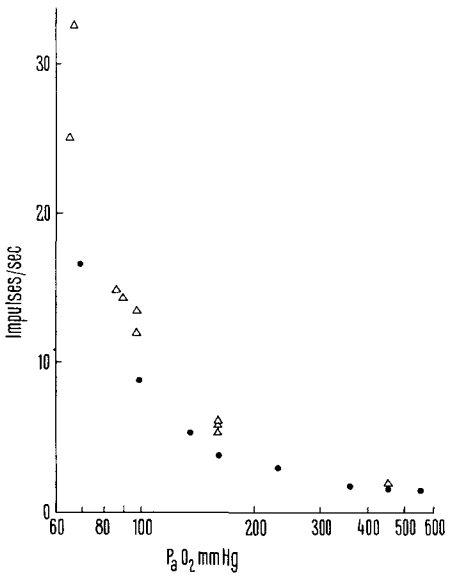

Fig. 1. Oxygen response curve of chemoreceptor afferents from the carotid body of the cat. Ordinate, nerve impulses per sec; abscissa, arterial oxygen tension in mm Hg. Arterial carbon dioxide tension 28–30 mm Hg; pH 7.33–7.37; arterial blood pressure, 110–130 mm Hg. The action potentials were recorded from a slip dissected from the sinus nerve. Closed circles show response when the remainder of the sinus nerve was intact and contiguous with the glossopharyngeal nerve. Open triangles show the response after the remainder of the sinus nerve was cut. The cervical sympathetic nerve supply to the carotid body was cut at the beginning of the experiment.

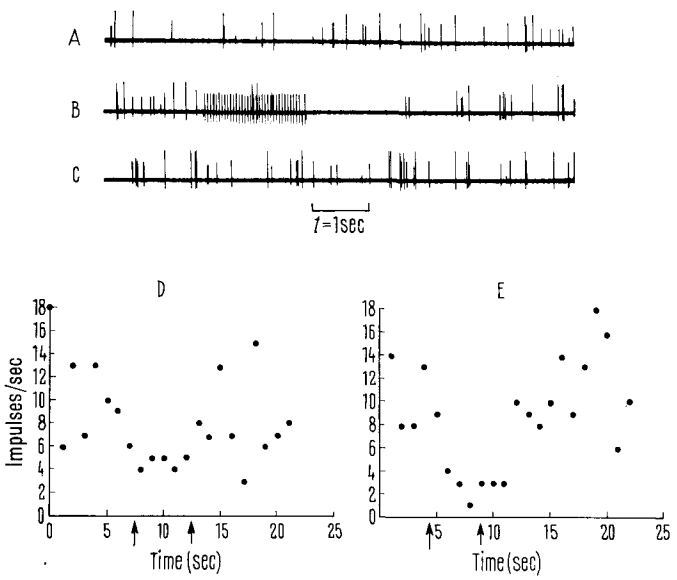

Fig. 2. Chemoreceptor activity recorded from a slip of the sinus nerve whilst the remainder of the nerve, and hence any efferent fibres, were stimulated electrically. (A–C) Overlapping strips of a continuous filmed record showing chemoreceptor activity. In (B) the stimulus artefact marks the period of stimulation at 20/sec and shows suppression of activity. (D) and (E) are graphs showing the number of chemoreceptor impulses per second plotted against time elapsed. In each graph between the arrows the sinus nerve was stimulated, in (D) at 10/sec and in (E) at 100 sec.

suppress chemoreceptor activity in a slip dissected from the nerve (Figure 2). At high frequencies of stimulation, up to 10–100/sec for 1–5 sec, the suppression outlasted the period of stimulation by up to 2 sec. In Figure 2, B the stimulus artefact marks the period of stimulation; the discharge is not totally suppressed during stimulation but the prolonged depressant effect is shown here and also on the graph of Figure 2, E. In both of the graphs, showing the effect of different stimulus frequencies, the scatter of the frequency plot appears to be reduced during stimulation though this point has yet to be rigorously tested.

A shift of the oxygen response curve of chemoreceptor afferents such as we have found after interruption of the centrifugal pathway is to be predicted on the basis of NEIL and O'REGAN'S[3] result if there is effective tonic activity in these fibres. In addition a more marked effect may be expected at low oxygen tensions if the efferent pathway were more active under this condition. BISCOE and SAMPSON[2] have shown that activity in the centrifugal sinus nerve pathway increases as the arterial oxygen tension is lowered. If their centrifugal pathway is indeed efferent to the carotid body then these results are commensurate. The failure to demonstrate the shift in the oxygen response curve of chemoreceptors in some cases is to be expected in anaesthetized animals since the amount of the shift depends on the resting activity, which will vary with the level of anaesthesia.

The prolonged depression by stimulation suggests persistence of a chemical transmitter effect whilst if there is a reduction in scatter of the frequency signal this will alter the information transmitted.

Presumably if the interpretation given by BISCOE and STEHBENS and BISCOE, LALL and SAMPSON[4] of their results is correct, namely that nerve endings on Type I cells are efferent, then this efferent system will be acting through the Type I cell to set the receptor sensitivity and alter the oxygen response. How this could come about is open to speculation but the means may involve release of catecholeamines from the Type I cells[5] perhaps influencing the oxygen gradients through the tissue and thus across the receptor, whatever that may be[6].

Résumé. Potentiels d'action enrégistrés dans les fibres nerveuses des chémorécepteurs de la carotide du Chat. La fréquence des potentiels augmente en réponse à toutes les tensions d'oxygène quand le nerf sinusal est réséqué. La stimulation de l'extrémité périphérique provoque une diminution prolongée de l'activité chémoréceptrice.

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Small Intestinal Absorption of Simple Sugars and Water in the Cat

The cat would be unique among mammals if its absorption of D-glucose and D-xylose were identical as reported[1]. In other species D-glucose is rapidly absorbed by active processes whereas D-xylose is much more slowly absorbed by similar processes[2]. Paradoxically, D-galactose and 3-methyl-D-glucose which appear to share the same affinity for the active sugar transport mechanism as D-glucose, are absorbed at expected rapid rates in the cat[1,3]. These reports suggest that simple sugar transport in the cat intestine has unusual features, the definition of which might yield fundamental information about basic mechanisms. Unfortunately, there were methodological limitations in previous studies. The present study was designed to better define sugar absorption in the cat by using several sugars over a wide concentration range in both jejunum and ileum.

Materials and methods. Adult male cats of 4 kg average weight were deprived of food but not water for 16 h before experiments. After anesthesia with i.p. Dial with urethane (CIBA, Summit, N.J.), the intestine was exposed and two 20 cm segments (jejunum distal to the ligament of Treitz and ileum proximal to the ileocecal valve) were measured and cannulated at both ends. Solutions of D-glucose, D-galactose or D-xylose in Krebs' bicarbonate buffer[4] in concentrations of 1, 10, 20 or 40 mM/l were circulated through the segments at 5 ml/min from a 40 ml reservoir by a perfusion pump for 1 h. A non-absorbable indicator, polyethylene glycol (PEG), was added to each solution (2 g/l)[5]. Sugars were analyzed chemically[6,7] and PEG content spectrophotometrically[8]. Absorption in this model is the measured disappearance of a substance per hour from the intestinal lumen.

Calculations were as follows: (1) PEG ratio $=$ $\frac{\text{PEG initial, mg/ml}}{\text{PEG final, mg/ml}}$ (2) Water absorption, ml/h/g wet tissue weight = (1-PEG ratio)(40 ml)/wet weight in g. (3) Sugar (or sodium) absorption, mM/h/g wet tissue weight = [sugar, initial, mM/l] – [sugar, final, mM/l] (PEG ratio) 40 ml/wet weight in g. Standard t_0 – tests and analysis of variance were used for comparison of group means[9]. Means were considered significantly different when p was 0.05 or less.

Results. Absorption data for sugar and water are shown in the Table. The figures represent means and standard deviations for groups of 6 cats studied at each sugar concentration in both segments.

Statistical comparisons showed that the absorption of each sugar at all concentrations was greater in jejunum

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