the hypothermia. Tail temperature – normally 1–2°C above ambient temperature – rose by 1.5 ± 1.2°C after noradrenaline (0.2 μg) and 2.9 ± 1.0°C after noradrenaline (10 μg), indicating marked vasodilatation and increased heat loss. Carbamylcholine hydrochloride (0.1 to 1.0 μg base in 1 μl of pyrogen-free 0.9% w/v NaCl solution) although more potent than noradrenaline produced essentially similar effects on temperature with respect to latency (0.7 ± 0.4 to 1 ± 0.5 min), fall (1.4 ± 0.3 to 2.4 ± 0.4°C) and duration (33.8 ± 8.5 to 80.5 ± 26.7 min).

The relation of the above changes in core temperature to effects on some behavioural, metabolic and cardiovascular activities will be discussed.

This work, which was supported by a grant from the Medical Research Council, forms part of S. Poole's Ph.D. Thesis, University of London.

References

AVERY, D.D. (1971). Intrahypothalamic adrenergic and cholinergic injection effects on temperature and ingestive behaviour in the rat. *Neuropharmacology*, **10**, 753–763.

BECKMAN, A.L. (1970). Effect of intrahypothalamic norepinephrine on thermoregulatory responses in the rat. *Amer. J. Physiol.*, **218**, 1596–1604.

KIRKPATRICK, W.E., LOMAX, P. & JENDEN, D.J. (1967). The effect of muscarinic agents on the thermoregulatory centers in the rat. *Proc. West. Pharmac. Soc.*, **10**, 51–55.

POOLE, S. & STEPHENSON, J.D. (1977a). Core temperature: some shortcomings of rectal temperature measurements. *Physiol. & Behav.*, In press.

POOLE, S. & STEPHENSON, J.D. (1977b). Body temperature regulation and thermoneutrality in rats. *Quart. J. Exp. Physiol.*, **62**, 143–149.

Noradrenaline concentration in hypothalamic and brain stem nuclei of renovascular hypertensive rats

MARGARET A. PETTY & J.L. REID

Department of Clinical Pharmacology, Royal Postgraduate Medical School, London W12, U.K.

Catecholamine-containing neurones in brain stem and hypothalamus, are involved in blood pressure regulation. Changes in catecholamine concentration or the activity of synthetic enzymes have been described recently in localised areas of brain stem in spontaneously hypertensive rats (Versteeg, Palkovits, van der Gugten, Wijnen, Smeets & de Jong, 1976) and deoxycorticosterone-saline hypertension (Saavedra, Grobecker & Axelrod, 1976). In the present study noradrenaline levels were examined during the development of renovascular hypertension in the rat, which was produced by applying a silver clip to one renal artery with contralateral nephrectomy (One kidney Goldblatt model). Results were compared to those obtained from sham operated litter mates sacrificed at the same time. Nuclei were isolated and removed by the micro-dissection technique of Palkovits (1973) and noradrenaline concentration estimated by the radioenzymatic method of Henry, Starman, Johnson & Williams (1973).

The mean arterial pressure (MAP) of the clipped animals 72 h after operation was 146.77 ± 2.6, compared with 119 ± 2.18 ($P < 0.01$) in the sham operated group. In all regions investigated, both in brain stem and hypothalamus, there was a reduction in noradrenaline concentration in the hypertensive animals, compared with the sham operated controls. The reduction was significant in the nucleus of the solitary tract ($P < 0.05$) and the lateral reticular nucleus ($P < 0.01$) of the brain stem, whose levels were reduced to 49.6 ± 12.7%, and 52.49 ± 6.59% respectively. In the hypothalamus, the fall in noradrenaline was significant in the anterior hypothalamic, the paraventricular and the posterior hypothalamic nuclei ($P < 0.05$). The noradrenaline concentration was reduced to 62.73 ± 10.07%, 58.11 ± 7.89% and 57.67 ± 5.49% respectively in these areas.

Seven days after operation, the MAP of the renal artery clipped rats was 162.25 ± 4.43, compared with 111.94 ± 4.54 in shams ($P < 0.01$). At this time the noradrenaline levels of all the regions investigated were not different from sham operated animals. Four weeks after operation, the MAP was 161.28 ± 6.49 in hypertensives, compared with 124.4 ± 1.78 in shams ($P < 0.01$). There was a significant change in noredrenaline concentration ($P < 0.05$) in only two regions: the parahypoglossal nucleus of the brain stem, where it was reduced to 61.93 ± 5.1% of shams, and in punches removed from the cerebellar cortex, where levels were raised to 167.08 ± 19.47%.

At present it is not clear if the early changes in monoamine concentration reported have any direct causal relationship to the rise in arterial pressure, or merely reflect secondary attempts of arterial baroreflex mechanisms to compensate for the hypertension. In addition, more dynamic measures of

noradrenaline turnover will be necessary to determine whether the fall in tissue noradrenaline reflects increased or decreased activity of these central neurones.

References

HENRY, D.P., STARMAN, B.J., JOHNSON, D.C. & WILLIAMS, B.H. (1973). A sensitive radioenzymatic assay for norepinephrine in tissues and plasma. *Life Sci.*, **16**, 375–384.

PALKOVITS, M. (1973). Isolated removal of hypothalamic or other brain nuclei of the rat. *Brain Res.*, **59**, 449–450.

SAAVEDRA, J.M., GROBECKER, H. & AXELROD, J. (1976). Adrenaline-forming enzyme in brain stem: Elevation in genetic and experimental hypertension. *Science*, **191**, 483–484.

VERSTEEG, D.H.G., PALKOVITS, M., van der GUGTEN, J., WIJEN, H.L.J.M., SMEETS, G.W.M. & de JONG, W. (1976). Catecholamine content of individual brain regions of spontaneously hypertensive rats. *Brain Res.*, **112**, 429–434.

The action of amino acids on evoked responses in the frog optic tectum

J.A. MILSON & J.F. MITCHELL

Department of Pharmacology, University of Bristol, Bristol BS8 1TD

The frog has a relatively simple and accessible visual system which has been subject to detailed physiological studies (Scalia, Knapp, Halpern & Riss, 1968; Gaze, 1958). The morphology of the nerve fibres within the optic tectum and their response to light falling on the retina are also documented (Potter, 1969; Maturana, Lettvin, McCulloch & Pitts, 1960), but despite this information, little is known of the synaptic transmitters involved in the anuran optic tectum. We are therefore investigating the pharmacology of the tectal response in frogs to optic nerve stimulation in the hope that this may provide information relevant to the less accessible visual pathways of mammals.

Decerebrate *Rana temporaria*, paralyzed with (+)-tubocurarine (0.2 mg i.p.) and cooled to 10°C were used. The optic nerve was electrically stimulated (0.8 ms square waves, 0.3 Hz) and the field potentials evoked in the contralateral tectum were recorded with surface electrodes and displayed on an oscilloscope and analogue pen recorder before and after averaging. The field potential complex consists of two negative waves (amplitudes 0.2–1.4 mV) with modal latencies of 12 and 30 milliseconds. The effects of possible neurotransmitter and related compounds perfused across the tectal surface on the amplitudes of these negative waves were investigated as a basis for subsequent experiments in which unitary responses will be studied.

Classified by their effect on the tectal field potentials, amino acids were found to fall into three groups:

1. no effect up to a concentration of 5 mM;
2. depression of the first wave and potentiation of the second wave;
3. depression of the entire field potential complex.

No amino acid was found which potentiated the first wave. α-amino n-butyrate and α-amino isobutyrate had no effect. Glycine (400 μM), taurine (400 μM) and β-alanine, the latter at high concentration (2 mM), clearly fell into the second category. The responses to glycine and taurine (400 μM) but not GABA (1 mM) were abolished by 0.1 μM strychnine. GABA caused depression of both waves of the field potential and the response was antagonised by 0.3 μM picrotoxin. Glutamate (200 μM), aspartate (200 μM) and L-homocysteate (10 μM) caused a profound, long lasting depression of the evoked tectal response with slow recovery, consistent with a non-specific excitatory action of these compounds (van Harreveld, 1959).

The relative potencies of the amino acids used may reflect the effectiveness of drug penetration or of individual uptake systems but the differential action of glycine and taurine on the two waves of the field potential response must reflect fundamental differences in the mechanism of production of the two evoked waves. As GABA equally depresses both waves, these experiments suggest that GABA may have a widespread inhibitory role in the tectum whereas glycine and taurine have selective roles at only a limited number of synapses.

References

GAZE, R.M. (1958). The representation of the retina on the optic lobe of the frog. *Q. Jl. exp. Physiol.*, **43**, 209–214.

VAN HARREVELD, A. (1959). Compounds in brain extracts causing spreading depression of cerebral cortical activity and contraction of crustacean muscle. *J. Neurochem.*, **3**, 300–315.

MATURANA, H.R., LETTVIN, J.Y., McCULLOCH, W.S. & PITTS, W.H. (1960). Anatomy and physiology of vision in the frog (*Rana pipiens*). *J. gen. Physiol.*, **43**, Suppl. 2, 129–171.

POTTER, H.D. (1969). Structural characteristics of cell and fiber populations in the optic tectum of the frog (*Rana catesbeiana*). *J. comp. Neurol.*, **136**, 203–232.

SCALIA, F., KNAPP, H., HALPERN, M. & RISS, W. (1968). New observations on the retinal projection in the frog. *Brain Behav. Evol.*, **1**, 324–353.