EFFECT OF VENTRAL NERVE CORD TRANSECTION ON METABOLIC PARAMETERS IN THE NERVOUS SYSTEM OF THE COCKROACH, *PERIPLANETA AMERICANA* L.

K. SUBHASHINI, K. YELLAMMA, P. MURALI MOHAN AND K. SASIRA BABU

Department of Zoology,
Sri Venkateswara University, Tirupati – 517 502

(Received on December 7, 1981)

Summary : *Periplaneta americana* were subjected to unilateral transection of the ventral nerve cord, and the levels of soluble and total proteins and total carbohydrates were determined 30 days postoperatively. Total proteins showed a decrease while soluble proteins and total carbohydrates showed an elevation. These changes were correlated with the degeneration of giant fibers in the ventral nerve cord.

Key words : *Periplaneta americana* ventral nerve cord transection giant fibres degeneration proteins carbohydrates

INTRODUCTION

The most striking feature of the ventral nerve cord of the cockroach is its giant fibre system, first demonstrated by Pumphrey and Rawdon-smith (11). Earlier work (12, 10, 16, 3) had suggested that the giant fibres arise from cell bodies located in the sixth abdominal ganglion. There are about eight giant fibres of 20-60 μ diameter in the ventral nerve cord of cockroach (1). Transection near the sixth ganglion caused degeneration of the giant axons in the nerve cord of cockroach (5, 14). The information available on the effect of degeneration due to nerve transection on the biochemical components is meagre in invertebrates, especially in insects. Since axon degeneration in a nerve could affect the overall biochemical make-up of the tissue, it would be interesting to investigate the possible changes in such important biological nutrient molecules as proteins and carbohydrates. With this point in view, an attempt is made in the present study to study the changes in the levels of these two parameters in the ventral nerve cord of the cockroach, *Periplaneta americana,* with reference to nerve transection.

MATERIALS AND METHODS

Male cockroaches were collected locally and maintained in meshed wooden cage Active cockroaches were immobilized by cooling, and the connectives were cut betwee sixth and fifth abdominal ganglia Only one connective was cut in the abdominal cor leaving the contralateral connective intact as the control. To prevent infection about to 2 *mg* of penicillin was applied, and the animals were returned to cages and fed wi bread and water. Thirty days post-operatively the animals were dissected for experiment Segments of operated and unoperated connectives were pooled separately and the level of proteins and carbohydrates were estimated in suitably prepared homogenates. Tota and soluble proteins were estimated by the method of Lowry *et al.* (9). For soluble protein the supernatant of homogenate prepared in 0.25 M sucrose solution was directly used fo developing the colour. For total proteins, homogenate prepared in 10% TCA solution wa used. Total carbohydrates were estimated in TCA homogenates by the method of Carro *et al.* (2). The post-operative time of 30 days was chosen for the present study in view o the completeness of histiological damage to the tissue in terms of collapse of giant fibre in the cord, as demonstrated in our studies and also by others (3).

RESULTS AND DISCUSSION

The data presented in Table I reveal considerable variations in the levels of tota proteins, soluble proteins and total carbohydrates in the transected connective of the ventral nerve cord, compared to the contralateral control.

TABLE I : Effects of unilateral transection of ventral nerve cord between the 6th and 5th abdominal ganglia (30 days post-operative) on the levels of total proteins (*mg/g* wet wt of tissue), soluble proteins (*mg/g* wet wt of tissue) and toal carbohydrates (*mg/g* wet wt of tissue) in the nervous system of *P. americana*. Each value is the mean ± standard deviation of 6 separate observations. For each observation tissue from 4 to 6 animals was pooled.

Parameter studied	*Contralateral cord*	*Transected cord*	*Per cent deviation*	*'t' test*
Total proteins	70.63 ± 4.53	53.41 ± 4.51	— 24	$P<0.001$
Soluble proteins	24.75 ± 1.55	27.64 ± 3.66	+ 12	$P<0.05$
Total carbohydrates	9.88 ± 0.37	13.29 ± 0.53	+ 35	$P<0.001$

The total protein level showed 24% decrease and the soluble proteins demonstrated slight yet statistically significant increase of about 12% upon transection. As shown from anatomical and histological findings (14), sectioning of the connectives between 6th and 5th abdominal ganglia causes degeneration of ascending axons, which have their cell bodies in the sixth ganglion. Loss of trophic supply from cell bodies and degeneration of giant fibres in the nerve cord have been found to bring about significant changes in protein and carbohydrate metabolism in the present study.

The reduction in the total proteins in the axons might be due to lack of protein supply from the cell body by means of axonal flow after nerve transection. Although the cell body of a neuron constitutes only a fraction of the total cell volume, it is the principal site of the protein synthesis upon which the entire cell is dependent (4). In many invertebrate nervous systems, the mitochondria are located in the axolemma (8). Kroon (6) and Lehninger (7) reported that mitochondria have the ability to synthesize proteins. Although the amount of proteins being formed in the axonal mitochondria may be very small compared to that synthesized in the cell body, it could be of decisive importance for proper physiological functioning. However, the mitochondria in the degenerated axons may not be expected to have the persistent ability to synthesize proteins following transection, thus resulting in the decrement of total proteins. But there is a conflicting report from Welsch *et al.* (15), who showed increased level of total protein in the transected nerve fibres of lobster walking leg. This increase was interpreted as due to stimulated nucleic acid synthesis in these fibres. Enhancement in the level of sucrose-soluble proteins may be due to an increase in the differential or selective synthesis of the proteins of soluble fraction, or it may be an adaptive compensatory attempt on the part of the organisms to balance the increased catabolic protein degradation in the degenerating cord.

The level of total carbohydrates showed a considerable elevation (about 35%) in the transected connective, compared to their level in the contralateral connective. Enhancement in the level of total carbohydrates may be due to decreased levels of Krebs cycle enzyme activities during the process of degeneration. The decreased Krebs cycle enzyme activities contribute to impairment of functional capacity of this cycle (13). It has been shown that succinate dehydrogenase and aldolase showed decreased levels of activity (14), thereby affecting carbohydrates in the transected cord due to accumulation.

These observations make it obvious that transection of the cord and consequent degeneration of giant fibres would significantly affect the metabolic machinery of the transected cord.

ACKNOWLEDGEMENTS

The authors are thankful to Prof. K.S. Swami for providing facilities. K.S. and K.Y. are grateful to C.S.I.R. for providing reasearch fellowships during the tenure of which this work was carried out.

REFERENCES

1. Babu, K.S. and K. Subhashini. Studies on giant fibre system in sixth abdominal ganglion of the cockroach, *Periplaneta americana L. Ind. J. Exp. Biol.*, **17** : 979-981, 1979.

2. Carroll, N.V, R.W. Longley and J.H. Roe. Glycogen determination in liver and muscle by use of anthrone reagent. *J. Biol. Chem.*, **220** : 583-593, 1956.

3. Dagan, D. and Y. Sarne. Evidence for the cholinergic nature of cockroach giant fibres : Use of specific degeneration. *J. Comp. Physiol.*, **126** : 157-160, 1978.

4. Farely, R.D. and N.S. Milburn. Structure and function in the giant fibre systems in the cockroach. *J. Insect Physiol.*, **15** : 437-476, 1969.

5. Hall, M.E., D.L. Wilson and G.C. Stone. Changes in synthesis of specific proteins following axotomy: Detection with two dimensional gel electrophoresis. *J. Neurobiol.*, **9** : 353-366, 1978.

6. Hess, A. Experimental anatomical studies of pathways in the severed central nerve cord of the cockroach. *J. Morph.*, **103** : 479-502, 1958.

7. Kroon, M. Protein synthesis in mitochondria III. On the effect of inhibitors of the incorporation of amino acids into protein by intact mitochondria and digitonin fraction. *Biochem. Biophys. Acta.*, **108** : 275-284, 1965.

8. Lehninger, A. Cell organells : The mitochondrion. In : *The Neurosciences.* The Rockfeller University Press, New York, 1967.

9. De Lorenzo, A.J.D., M Brzin and W.D. Dettbarn. Fine structure and organization of nerve fibres and giant axons in *Homatus americanus. J. Ultrastruct. Res.* **24** : 367-384, 1968.

10. Lowry, O.H., N.J. Rosebrough, A.L. Farr and R.J. Randal. Protein measurement with the folin phenol reagent. *J. Biol. Chem.*, **193** : 265-275, 1951.

11. Pipa, R.L., E.F. Cook and A.G. Richards. Studies on the hexapod nervous system. II. The histology of the thoracic ganglia of the adult cockroach, *Periplaneta americana L. J. Comp. Neurol.*, **113** : 401-433, 1959.

12. Pumphrey, R.J. and A.F. Rawdon-Smith. Synaptic tansmission of nervous impulses through the last abdominal ganglion of the cockroach, *Proc. R. Soc. Lond (B)*, **122** : 106-118, 1937.

13. Roeder, K.D. Organization of the ascending giant fibre system in the cockroach, *Periplaneta americana. J. Exp. Zool.*, **108** : 243-262, 1948.

14. Rosenberg, K.E. Krebs cycle dehydrogenase systems activity in the gastro-intestinal tract of rat after whole body ionizing irradiation. *Radiat. Res.*, **40** : 317-329, 1968.

15. Subhashini, K. Studies on morphology and physiology of giant fibre system in 6th abdominal ganglion of the cockroach, *Periplaneta americana. L.* Doctoral dissertation, S.V. University, Tirupati, India, 1981.

16. Welsch, F., W.D. Dettbarn and E.J. London. The effects of nerve transection in walking legs of lobster on acetylcholine, aceyl cholinesterase, choline acetyltransferase, adenosine triphosphatase and protein composition. *Comp. Biochem. Physiol.*, **47** : 943-957, 1974.

17. Wiggleswoth, V.B. The histology of the nervous system of an insect, *Rhodnius prolixus* (Hemiptera). **I.** The peripheral nervous systems. *Quart. J. Micro. Sci.*, **100** : 285-298, 1960.