differentiated into peptic and oxyntic types. The tunica propria, the support in between the gastric glands, and the connective tissue of submucosa have similar histology.

The muscularis is of unstriated type and made up of a circular layer of muscles. A distinct, outer longitudinal muscle layer is not seen. An outermost serosa with connective tissue fibres and blood capillaries wrap the entire wall.

Various views on the function of gizzard are : partly compensation for poor dentition (Pillay[12], Mahadevan[10]), trituration of food (Thomson[15]), and secretory as well as masticatory organ (Schmitz and Baker[13]). Our findings that the gizzard serves as a secretory and crushing region in edentulous *Gonialosa manminna* lend support to the inference drawn by Schmitz and Baker[13] in *Dorosoma cepedianum*.

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1. Al-Hussaini, A. H., *J. Morph.*, 1946, **78**, 121.
2. —, *Publ. Marine Biol. Sta. Ghardaqa*, 1947, No. 5, 4.
3. Castro, N. M., Sasso, W. S. and Katchburian, E., *Acta anat.*, 1961, **45**, 155.
4. Chandy, M. and George, M. G., *Proc. Nat. Inst. Sci. India*, 1960, **B26**, 126.
5. Ghazzawi, F. M., *Notes and Mem. Fish. Res. Dir. Cairo*, No. 6, 1.
6. Ishida, J., *Annot. Zool. Japon.*, 1935, **15**, 182.
7. Kapoor, B. G., *Ann. Mus. Civ. St. Nat. Genova*, 1958, **70**, 8.
8. —, Smit, H. and Verighina, I. A., *Advances in Marine Biology*, eds. F. S. Russell and M, Yonge, Academic Press, London, New York, San Francisco, 1975, **13**, 109.
9. López, R. B. and DeCarlo, J. M., *Actas Trab. Primer Congr. Sudam. Zool., La Plata*, 1959, **5**, 339.
10. Mahadevan, S., *J. Madras Univ.*, 1954, **B24**, 143.
11. Nagar, S. K., Khan, W. M. and Ahmad, S., *Ann. Mus. Civ. St. Nat. Genova*, 1961, **72**, 47.
12. Pillay, T. V. R., *Proc. Nat. Inst. Sci. India*, 1953, **19**, 777.
13. Schmitz, E. H. and Baker, C. D., *Trans. Amer. Microsc. Soc.*, 1969, **88**, 525.
14. Swarup, K., *Proc. Nat. Acad. Sci. India*, 1959, **B29**, 109.
15. Thomson, J. M., *Aust. J. Mar. Freshw. Res.*, 1954, **5**, 469.
16. Wier, H. C. and Churchill, E. P., *Proc. S. Dak. Acad. Sci.*, 1945, **25**, 34.
17. * Zambriborsch, F. S., *Sbornik Biologicheskogo fakulteta Odesskogo Universiteta*, 1953, **6**, 107 (In Russian) (Cited from Kapoor *et al.*, 1975).

* Paper not consulted in original.

# EFFECTS OF POST-NATAL UNDERNUTRITION AND SUBSEQUENT REHABILITATION ON ALDOLASE ACTIVITY IN RAT BRAIN

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ABSTRACT

Effects of post-natal undernutrition and subsequent rehabilitation on aldolase activity in rat brain were investigated. Rat pups were undernourished during the first 21 days of post-natal life by increasing the litter size. A 14% deficit in the enzyme activity was observed at 21 days as a consequence of undernutrition which appeared to be a permanent deficit and could not be reversed by rehabilitation into adult life. The results are discussed with reference to energy metabolism in brain tissue as a function of undernutrition during development.

## INTRODUCTION

UNDERNUTRITION during 'vulnerable periods' of brain development[5] in mammals has been shown to affect enzymes of carbohydrate[1,16–18], protein[13], lipid[14] and neurotransmitter metabolism[1,6,10,12,15]. Adlard and Dobbing[1] have reported lowered activity of the glycolytic enzyme aldolase and oxidative enzyme succinic dehydrogenase in brain as a consequence of undernutrition. This deficit in succinic dehydrogenase and lowered oxygen consumption which implies an *impairment in oxidative metabolism* has been shown to persist even in the adult life[11]. But a similar study for the enzyme aldolase has not been reported to see whether undernutrition during 'critical periods' of brain development results in a lowered metabolic activity in adult brain even after feeding *ad libitum* into adult life, hence the present study.

TABLE I

*Body weight, brain weight and aldolase activity in rat brain as a function of undernutrition during the 21st days and subsequent rehabilitation into adult life*

| Age in days | Body weight (g) | | Brain weight (mg) | | Aldolase activity (μM alkali-labile phosphate produced/hour/g tissue) | |
|---|---|---|---|---|---|---|
| | Control | Exptl. | Control | Exptl. | Control | Exptal. |
| 1 | 6·2±0·2 | 6·3±0·3 | 227±13 | 216±9 | 211±12 | 222±17 |
| 21 | 39·4±1·0 | 15·6±0·8* (60%) | 1332±20 | 955±14* (28%) | 880±13 | 752±15* (14%) |
| 180 | 171·0±6·5 | 113·0±3·2* (34%) | 1658±21 | 1445±18* (12%) | 871±14 | 745±8* (14%) |

(Values represented as mean±SD of 5 observations).
*$p < 0.001$. Values in parenthesis indicate % deficits as compared to controls.

## MATERIALS AND METHODS

Undernutrition in rat pups was induced by increasing the litter size. Pups were matched for weight at birth and litter size of 16–18 pups constituted the experimental group[13] while well-nourished litters of 6 pups were maintained as controls. The animals were maintained at 28 ± 2° under 12 hr light and 12 hr dark conditions. Mothers were given food and water *ad libitum* and the young ones were taken care of by the mothers.

A set of 5 animals from each group were used for the determination of aldolase activity at 1 day and 21 days and others were weaned and rehabilitated with food and water *ad libitum* into adult life upto 180 days and then used for the determination of aldolase activity. The enzyme activity was determined according to Taylor[19].

## RESULTS AND DISCUSSION

Results on the effect of post-natal undernutrition during the first 3 weeks of post-natal life and subsequent rehabilitation on body weight, brain weight and aldolase activity are presented in Table I and the percentage decreases are shown in parenthesis. The data were statistically analysed and significant differences between the mean of the control *vs.* experimental calculated using *t*-test as *p*-values are shown.

At birth the average weight of pups was almost the same in control and experiental animals and this permitted comparisons between the two groups during later stages. It is clear from Table I that undernutrition during the first 21 days of post-natal life results in a deficit in body weight, brain weight and aldolase activity. As a consequnce of undernutrition, a 60% decrease in body weight and a 28% decrease in brain weight (the decreases are highly significant with $p < 0.001$) at 21 days are observed. These results compare well with those of Adlard and Dobbing[1] and Rajalakshmi *et al.*[13]. Activity of the enzyme aldolase also shows a significant ($p < 0.001$) 14% deficit at 21 days which again agrees with the results of Adlard and Dobbing[1]. Such a deficit would imply either a delay in maturation[1] or permanent deficit[1] of the enzyme.

Coming to rehabilitation, we see an incomplete recovery of 26% in body weight and 16% in brain weight with refeeding over 180 days following deprivation during 'critical periods' consistent with the reports of other investigators[2,3,4,6,8,20]. But the 14% deficit in aldolase activity appears to be a permanent one as no recovery is noticed at 180 days.

Decrease in the observed aldolase activity suggests a deficit in glycolytic metablism[7]. This in combination with the decreased oxygen consumption of the tissue[11] leads to a lowered total metabolic activity in malnourished rats[7]. Also, this deficit in total metabolic activity appears to be a permanent one, since both oxygen consumption by the brain tissue[11] as well as aldolase activity (present study) are lowered both during the course of development and in the adult rats which are suckled in large litters.

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1. Adlard, B. P. F. and Dobbing, J., *Brain Res.*, *1971a*, **28**, 97.
2. Chase, H. P., Dorsey, J. and McKhann, G. M., *Paediatrics*, 1967, **40**, 551.
3. Culley, W. J. and Lineberger, R. O., *J. Nutr.*, 1968, **96**, 375.

4. Dobbing, J., *Proc. Roy. Soc. Lond.* (*Biol.*), 1964, **159**, 503.
5. —, *Applied Neurochemistry*, Oxford, Blackwell Scientific Publications, Ltd., 1968*b*.
6. — and Sands, J., *Biol. Neonate*, 1971, **19**, 363.
7. Dyson, S. E. and Jones, D. G., *Prog. in Neurobiol.*, Vol. 7, Pergamon Press, 1976.
8. Guthrie, H. A. and Brown, M. L., *J. Nutr.*, 1968, **94**, 419.
9. Himwich, W. A., Davis, J. M. and Agrawal, H. C., *Recent Advances in Biological Psychiatry*, Vol. 10, Plenum Press, New York, 1968.
10. Im, H. S., Barnes, R. H., Levitsky, D. A. and Pond, W. G., *Brain. Res.*, 1973, **63**, 461.
11. Myslivecek, J., Chaloupka, Z., Hassmannova, J., Rokyta, R., Semiginovsky, B., Sobotka, P., Springer, V., Vozeh, F. and Zahlava, J., *Ontogenesis of the Brain*, Charles University, Prague, 1968.
12. Ordy, J. M. and Samorojski, T., *Anat. Rec.*, 1970, **166**, 357.
13. Rajalakshmi, R., Parameswaran, Telang, S. D. and Ramakrishnan, C. V., *J. Neurochem.*, 1974, **23** (1), 129.
14. Reddy, P. V., *Ph.D. Thesis*, Indian Institute of Science, 1977.
15. Sereni, F., Principi, N., Perletti, L. and Sereni, L. P., *Biol. Neonate*, 1966, **10**, 254.
16. Swaiman, K. F., Daleiden, J. M. and Wolfe, R. N., *J. Neurochem.*, 1970, **17**, 1387.
17. — and Wolfe, R. N., *Proc. Soc. Expt. Biol. Med.*, 1970, **134**, 185.
18. —, *Brain Res.*, 1972, **43**, 296.
19. Taylor, J. F., *Methods in Enzymology*, Vol. 1, Academic Press, N.Y., 1955.
20. Winick, M. and Noble, A., *J. Nutr.*, 1966, **89**, 300.

## NATIONAL SYMPOSIUM ON MICROCHEMICAL TECHNIQUES

The Second National Symposium on Microchemical Techniques sponsored by the University Grants Commission, New Delhi and the University of Mysore, Mysore, was held at the Department of Post-graduate Studies and Research in Chemistry, University of Mysore, Mysore, from 16–18 May, 1980. Over 80 scientists and research workers from Universities and other National Institutions participated in the Symposium. Prof. M. Santappa, Vice-Chancellor, Sri Venkateswara University, Tirupati, inaugurated the Symposium.

Prof. H. Sanke Gowda, Director of the Symposium, in his welcome address explained the aim of the Symposium and pointed out the importance of microchemical techniques in several desciplines. The first plenary lecture was delivered by Prof. Arun K. Dey of Allahabad University who gave a fascinating account of his research during the past two and a half decades on organic dyes as reagents. Dr. K. Narayana Rao (BARC, Bombay) described the problems and advantages associated with the gas chromatograph-mass spectrometer combination for microchemical analysis. Research papers (18) were presented during the sessions. The topics covered by the papers included nondestructive neutron activation analysis, flow injection analysis, radiochemical neutron activation analysis, atomic absorption spectrophotometry and spectrophotometric determination of traces of metals and drugs.

On 17th May 1980, Prof. G. Aravamudan of Indian Institute of Technology, Madras, delivered the second plenary lecture on the principles, methodologies and limitations of microchemical techniques in the determination of traces of selenium. The discussions were centred on the importance of microchemical techniques in the determination of elements at micro and ultramicro levels. Prof. R. S. Subrahmanya of Indian Institute of Science, Bangalore, gave an interesting talk on "Reversibility of electrode proctes on the basis of d.c. and complex plane polarography".

On the final day, Prof. R. C. Kapoor of Jodhpur University delivered a plenary lecture highlighting polarography as a microchemical technique. Fifteen papers were presented dealing with different microchemical techniques such as the detection of micro quantities of blood in urine, fatty acids in blood, manganese in *Tephrosia purpurea*, determination of bacterial endotoxins, role of TLC in the separation of divalent metals, microchemical techniques in air pollution, etc. In the afternoon session, 10 papers were presented dealing with the analysis of amino acids, GLC and TLC for the micro estimation of pyrazines, degradation of sorbic acid in foods, etc.,

Prof. M. Santappa complimented the Director and his colleagues for the tremendous success of the Symposium and suggested that Post-graudate Courses in Analytical Chemistry should be offered by the Universities in our country. The need for coordination of micro analytical work in modern areas and the initiation of research projects in some of the emerging areas like (i) development of methods of trace analysis and (ii) refined microanalytical techniques was pointed out.

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