Effect of degree and duration of protein energy malnutrition on peripheral nerves in children

SHANTI GHOSH, KUMKUM VAID, MAN MOHAN,
AND M. C. MAHESHWARI

From the Departments of Pediatrics and Neurology, Safdarjang Hospital, New Delhi, India

SUMMARY Nerve conduction studies were conducted in 67 children to assess the effect of malnutrition on the peripheral nervous system. Significant reduction in nerve conduction velocities was demonstrated in severe protein energy malnutrition and ongoing long-term malnutrition.

Malnutrition is widely prevalent in all developing countries and children are the worst sufferers. Approximately half the population of the world has survived a period of serious nutritional deprivation during childhood (Winick, 1969), and this is especially true for the developing countries. Although the severity of this undernutrition has not changed much, the age at which it strikes is changing. Because of urbanisation and industrialisation, the practice of breast feeding has declined, and malnutrition is occurring at an earlier age. This factor is of prime importance because this is the period of rapid growth and development (Stoch and Smythe, 1976).

Various studies on animals as well as on human beings have shown that malnutrition as an isolated entity will produce physical, chemical, and functional changes in the brain (Dobbing and Widdowson, 1965; Cravioto *et al.*, 1966; Chase *et al.*, 1971). These authors also point out that there is a definite period of susceptibility of the brain to malnutrition during which damage might be produced. This critical period appears to extend from prenatal to early postnatal life. Active synthesis of myelin also occurs during this period (Davison and Dobbing, 1966; Chase *et al.*, 1967), and this process may be affected in children suffering from protein energy malnutrition. Measurement of nerve conduction velocity is a recognised method for the evaluation of the status of peripheral nerves. Delayed motor nerve conduction velocities in children with protein energy malnutrition have been described by several in-

vestigators (Sachdev *et al.*, 1971; Kumar *et al.*, 1977). These investigators did not take into account the effects of age of onset and of duration and degree of malnutrition on the motor nerve conduction velocities. The present study was undertaken to assess the effects of duration and degree of malnutrition on peripheral nerves in children at different ages.

Patients and methods

Children with protein energy malnutrition, aged from 6 months to 4 years attending the under 5 clinic or admitted to the indoor services of the paediatrics department of Safdarjang Hospital, New Delhi, were included in the study.

Assessment of nutritional status was done according to the recommendations of the Nutrition Subcommittee of the Indian Academy of Pediatrics (Shah, 1972). Children who weighed up to 80% of the Harvard 50th percentile were taken as normal, those between 71-80% as having mild malnutrition (first degree), between 61-70% as having moderate malnutrition (second degree), between 51-60% as having severe malnutrition (third degree), and those less than 50% having severe malnutrition (fourth degree).

One hundred and twenty-seven children were included in the study. Twenty-eight children were suffering from mild to moderate malnutrition (grades 1 and 2), and 39 were suffering from severe malnutrition (grades 3 and 4). Sixty normal children without any nutritional problem attending the under 5 clinic served as control subjects.

A complete general physical examination, including nutritional anthropometry and a detailed

Address for reprint requests: Dr Man Mohan, S-III/305, R K Puram, New Delhi 110022, India.

Accepted 3 March 1979

neurological examination, was done in all patients and control subjects. Nerve conduction velocity was measured using surface electrodes on the median, ulnar, and peroneal nerves according to a standard technique described by Cohen and Brumlik (1976). Significance testing (Student's *t* test) is based on two standard deviations from the mean.

Results

The age and sex distribution of the children studied is shown in Table 1. As the nerve conduction velocity varies with age, the children were divided into five age groups (Table 1). The nerve conduction velocities in the ulnar, median, and peroneal nerves in the different nutritional groups mentioned earlier are given in Table 2.

Nerve conduction velocities were found to be markedly decreased in protein energy malnutrition

grades 3 and 4 as compared to the control children ($P < 0.001$). No significant difference was found between protein energy malnutrition grades 1 and 2 and control subjects. When, however, the children were classified according to Seoane and Latham's (1971) height-based classification to assess the effect of duration of malnutrition the mean nerve conduction velocities were found to be markedly decreased in children with ongoing long-term malnutrition as compared to control subjects ($P < 0.001$) while no significant difference was found between control subjects and current acute short duration malnutrition (Table 3).

Table 4 contains details of nerve conduction velocities when the onset of malnutrition was before and after 12 months of age. As is evident from the table, nerve conduction velocities were lower in children when the age of onset of malnutrition was less than 12 months as compared

Table 1 Age and sex distribution of children studied

Age (months)	Number of children (control)		Number of children suffering from PEM grades 1 and 2		Number of children suffering from PEM grades 3 and 4	
	Male	Female	Male	Female	Male	Female
6-12 (group 1)	10	5	6	3	4	4
13-18 (group 2)	10	5	4	2	6	7
19-24 (group 3)	8	4	4	2	1	5
25-36 (group 4)	8	4	4	3	4	2
37-48 (group 5)	4	2	-	-	6	-

PEM=protein energy malnutrition.

Table 2 Nerve conduction velocities in ulnar, median, and peroneal nerves in different grades of malnutrition (classification recommended by Indian Academy of Pediatrics)

Nerves	Groups	Control (m/s)		PEM grades 1 and 2 (m/s)		PEM grades 3 and 4 (m/s)	
		Mean	SD	Mean	SD	Mean	SD
Ulnar	1	44.74	2.83	42.44	8.69*	36.06	10.23‡
	2	53.34	8.51	53.38	4.18*	36.65	14.16‡
	3	63.76	6.45	58.83	2.04*	34.72	13.82‡
	4	68.31	3.99	65.64	3.50*	31.17	4.96‡
	5	80.10	5.68	—	—	34.43	5.05‡
Median	1	41.07	4.32	38.78	6.37*	32.18	8.39‡
	2	48.27	5.30	49.03	4.20*	34.72	15.02‡
	3	58.08	4.83	57.08	2.80*	27.92	9.74‡
	4	61.65	4.16	62.30	2.64*	28.37	4.78‡
	5	71.58	3.90	—	—	30.50	5.65‡
Peroneal	1	40.30	4.59	37.61	4.01*	27.72	7.94‡
	2	48.03	5.82	47.83	3.49*	33.62	11.87‡
	3	52.44	1.40	52.10	4.13*	30.28	12.84‡
	4	62.90	7.90	61.90	2.76*	28.00	7.16‡
	5	64.50	4.64	—	—	31.85	8.77‡

*Not significant $P > 0.05$.

†Highly significant $P < 0.01$.

‡Very highly significant $P < 0.001$.

Table 3 Nerve conduction velocities in ulnar, median, and peroneal nerves in malnutrition classified according to Seoane and Latham's (1971) classification

Nerves	Groups	Control (m/s)		Current acute short duration (m/s)		Current long-term (m/s)	
		Mean	SD	Mean	SD	Mean	SD
Ulnar	1	44.74	2.83	45.80	4.96*	30.36	7.14†
	2	53.34	8.51	53.35	4.55*	25.68	5.55†
	3	63.76	6.45	58.83	2.04*	26.57	5.42†
	4	68.31	3.99	65.64	3.50*	31.17	4.96†
	5	80.10	5.68	—	—	34.43	5.05†
Median	1	41.01	4.32	41.05	4.66*	27.99	4.18†
	2	48.27	5.30	50.52	5.29*	22.34	3.90†
	3	58.08	4.83	57.08	2.80*	25.50	9.98†
	4	61.65	4.16	62.30	2.64*	28.37	4.78†
	5	71.58	3.90	—	—	30.50	5.65†
Peroneal	1	40.30	4.59	38.55	2.91*	24.97	4.98†
	2	48.03	5.82	47.20	5.12*	24.57	6.18†
	3	52.44	1.40	50.43	3.18*	22.42	4.13†
	4	62.90	7.90	61.90	2.76*	28.00	7.16†
	5	64.50	4.64	—	—	31.85	8.77†

*Not significant $P > 0.05$.†Very highly significant $P < 0.001$.

Table 4 Relationship of age of onset of malnutrition to nerve conduction velocity

Age at onset	Ulnar (m/s)		Median (m/s)		Peroneal (m/s)	
	Mean	SD	Mean	SD	Mean	SD
Less than 12 months	34.59	10.64*	30.95	9.32*	29.63	8.43*
More than 12 months	51.66	12.54	48.42	12.70	47.20	11.67

*($P < 0.001$) Very highly significant.

to those with onset after 12 months of age, the differences being very highly significant ($P < 0.001$).

Discussion

With increasing awareness of the possibility that malnutrition during certain periods of life can have serious effects on the growth of the nervous system, various studies have been and are being carried out to identify these critical periods of development of the nervous system, as well as to ascertain the exact nature of defects and the extent to which these are reversible after nutritional rehabilitation.

Results from both animal and human studies have shown that intrauterine and postnatal malnutrition during the first 18 months of life interferes with the brain cell division after which the cell size is primarily affected. All changes which occur during this period are, therefore, likely to be irreversible whereas changes occurring after this period would be reversible after nutritional rehabilitation.

The mean conduction velocity of ulnar, median, and peroneal nerves was found to in-

crease steadily with age in the control group, being highest at 4 years of age. Similar results were reported by Thomas and Lambert (1960), Johnson and Olsen (1960), Gamstorp (1963), Moosa and Dubowitz (1971), and Kumar *et al.* (1977). Values were highest in the ulnar nerve, followed by the median and peroneal nerves in that order, in agreement with Gamstorp (1963). Nerve conduction velocity was found to be significantly delayed in all three nerves in children suffering from severe protein energy malnutrition (grades 3 and 4) while there was no significant difference in the mild to moderate malnutrition groups (1 and 2).

Nerve conduction velocity increases steadily in all three nerves during normal development in infancy because the myelination of the nerves is taking place during this period. The peroneal nerve which has a longer course, takes a longer time to myelinise and has a lower conduction velocity than the other two nerves, even in normal children. It is now recognised that myelin is composed of concentric protein and phospholipid lamellae derived from the cell membrane of oligodendrocytes in the central nervous system and

from Schwann cells in the peripheral nervous system (Davison, 1972). Undernutrition and deficiencies in fatty acids resulting from protein energy malnutrition may lead to permanent molecular errors in brain membrane composition, and thus affect the biochemical maturity of the brain. Since proteins act as the backbone of lipid incorporation in the brain and nerve, a nutritional deficiency of protein, should have a longer lasting deleterious effect on brain or peripheral nerve than a transient deficiency in the essential fatty acids. In protein energy malnutrition myelination, therefore, gets affected and so the nerve conduction velocity does not increase.

Nerve conduction is affected mostly by the duration of the malnutrition (Table 3). Values were significantly lower in ongoing long-term malnutrition while the difference between the current acute short duration malnutrition and control children was negligible. There was no child in the past chronic malnutrition group in this study. The changes were more marked if the onset of malnutrition was below 12 months of age compared with malnutrition of later onset.

References

- Chase, H. P., Babiere, C. S., Welch, N. N., and O'Brien, D. (1971). Intrauterine under nutrition and brain development. *Pediatrics*, **47**, 491–499.
- Chase, H. P., Dorsey, J., and McKhann, G. M. (1967). Malnutrition and synthesis of myelin lipid. *Pediatrics*, **40**, 551–559.
- Cohen, H. L., and Brumlik, J. (1976). *A Manual of Electroneuromyography*. Harper and Row: Hagerstown, Maryland.
- Cravioto, J., De Licardie, E. R., and Birch, M. G. (1966). Nutrition, growth and neurointegrative development: an experimental and ecological study. *Pediatrics*, **38**, 319–324.
- Davison, A. N. (1972). Biosynthesis of the myelin sheath. In *Lipids, Malnutrition and the Developing Brain—A Ciba Foundation Symposium*, pp. 73–83. Elsevier, Excerpta Medica, North-Holland: Amsterdam.
- Davison, A. N., and Dobbing, J. (1966). Myelination as a vulnerable period in brain development. *British Medical Bulletin*, **22**, 40–44.
- Dobbing, J., and Widdowson, S. M. (1965). The effect of undernutrition and subsequent rehabilitation on myelination of rat brain as measured by its composition. *Brain*, **88**, 357–368.
- Gamstorp, J. (1963). Normal conduction velocity of ulnar, median and peroneal nerves in infancy, childhood and adolescence. *Acta Paediatrica*, Supplement 46, 68–73.
- Johnson, E. W., and Olsen, K. J. (1960). Clinical value of motor nerve conduction velocity determination. *Journal of the American Medical Association*, **172**, 2020–2035.
- Kumar, A., Ghai, O. P., and Singh, N. (1977). Delayed motor nerve conduction velocity with protein calory malnutrition. *Journal of Pediatrics*, **90**, 149–153.
- Moosa, A., and Dubowitz, V. (1971). Postnatal maturation of peripheral nerves in preterm and fullterm infants. *Journal of Pediatrics*, **79**, 915–922.
- Sachdev, K. K., Taori, G. M., and Pereira, S. M. (1971). Neuromuscular status in protein calories malnutrition. *Neurology (Minneapolis)*, **21**, 801–805.
- Seoane, N., and Latham, N. C. (1971). Nutritional anthropometry in the identification of malnutrition in childhood. *Journal of Tropical Pediatrics Environmental Child Health*, **17**, 98–104.
- Shah, P. M. (1972). Nutrition subcommittee of the Indian Academy of Pediatrics Report. *Indian Pediatrics*, **9**, 360.
- Stoch, M. B., and Smythe, P. M. (1976). Effects of severe undernutrition during infancy on subsequent physical growth and intellectual functioning. *Archives of Disease in Childhood*, **51**, 327–331.
- Thomas, J. E., and Lambert, E. H. (1960). Ulnar nerve conduction velocity and H reflex in infants and children. *Journal of Applied Physiology*, **15**, 1–9.
- Winick, M. (1969). Malnutrition and brain development. *Journal of Pediatrics*, **74**, 667–679.