NEUROMUSCULAR SYSTEM IN CHILDREN

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The state of neuromuscular transmission in infants and young children differs significantly from its state in adults. The amplitude of the muscle potentials in infants during the first year of life is about one-third of their amplitude in adults. In most young children transformation of muscle responses was detected in response to stimulation at 25-50 Hz, which was not observed in adults. In addition, in young children features reflecting both posttetanic exhaustion and activation of synaptic transmission are found.

The character of the formation and transformation of the neuromuscular system in postnatal ontogenesis is an urgent problem in age physiology which has so far received little study [1, 4].

Most investigations have been conducted on animals. The character of the human neuromuscular system at an early age and the transformation of its function during postnatal ontogenesis have received less investigation.

Because of the importance of this problem to the general issue of human age physiology, certain aspects of the activity of the neuromuscular system have been studied in children of different ages and in adults.

EXPERIMENTAL METHOD

Electromyograms were recorded in 80 patients with congenital heart defects and with no pathological changes affecting their neuromuscular system. The ulnar nerve was stimulated by supramaximal square pulses (1 msec, 50 V) from a "Multistim" stimulator. The frequency of stimulation remained within the range not causing transformation of the amplitude or rhythm of the muscular responses, viz. 1-50 Hz [2, 7, 8]. Potentials of the hand muscles were recorded on a three-channel electromyograph (Disa Electronic). The ages of the subjects were as follows: 25 were under one year, 20 between 1 and 2 years, 15 between 2 and 3 years, and 20 over 16 years of age.

EXPERIMENTAL RESULTS AND DISCUSSION

The amplitude of the single muscle potential of children below 3 years of age was much lower than in adults. The smallest amplitude of muscle responses was found in children during the first two years of life (M±m 5.7±0.3 and 6.3±0.5 mV, respectively), while in children in the third year of life the amplitude was 53% higher than in the infants, but had not yet reached the values (14.3±1.1 mV) observed in adults.

The character of the response to infrequent stimulation was the same in all children; just as in adults, stimulation at 1-2 Hz was reproduced by the muscle without any sign of transformation.

In all adults, during stimulation at high frequency (25-50 Hz) the potentials generated by the muscles were equal. This picture was found in only 12 (20%) of the 60 children. In the other children, transformation of the amplitude of the muscle responses was recorded. In 21 children the amplitude of the potentials fell

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progressively during the first second of stimulation on the average by 47.9±3.5% while in 27 children it increased by 60.6±6.1% ($P < 0.001$). In some children the degree of increase in the potentials during tetanus of the muscle was so great that it was two or more times greater than the amplitude of the first response. In all cases the rhythm of stimulation and the rhythm of the muscular responses coincided exactly.

The state of conductivity after tetanus within the range of frequency of stimulation used (not exceeding 50 Hz) was unchanged in the adult. A similar picture was observed in 33 children, in whom the amplitude of the first posttetanic potential was the same as that before tetanus. In 17 subjects the amplitude of the responses after tetanus was 30.6±4.6% higher ($P < 0.001$), and in 10 children 24.3±4.3% lower ($P < 0.001$) than before tetanus.

Hence, in infants and young children three types of neuromuscular transmission during and after tetanus can be distinguished. In the first type synaptic conductivity is unchanged, as in adults, in the second there is significant activation of transmission, while in the third it is depressed. These three types do not coincide completely with the three types of response to tetanic stimulation. However, among children with the characteristically adult response to tetanus (preservation of stable values of potentials), those with an unchanged state of conductivity after tetanus also are predominant (10 of 12 cases; $P < 0.05$). The highest proportion of cases of posttetanic depression was observed in children with a lowered amplitude of potentials in response to frequent stimulation (7 of 21 cases), and the highest incidence of posttetanic facilitation in those with an increased amplitude (11 of 27). No connection could be found between the age of the children and the character of the response to frequent stimulation or the state of conductivity after it.

These results indicate considerable differences in the state of neuromuscular transmission in children and adults. The low amplitude of the muscle potentials recorded in children is in agreement with the results of experimental investigation indicating a low frequency and amplitude of the miniature potentials and motor end-plate potentials in animals in the early stages of postnatal ontogenesis [5, 16, 19]. The reason for the low value of the muscle potentials recorded in children may be the smaller quantities of mediator liberated and the low amplitude of the end-plate potentials, which are unable to generate spikes corresponding to the adult size.

The transformation of amplitude of the potentials and the activation and depression of transmission after tetanic stimulation observed in children, but not found in adults, also indicates special features of the neuromuscular system in the period after birth. In the adult state these phenomena can be found in patients with diseases of the neuromuscular system [9, 11, 17, 21, 22], or after the action of drugs disturbing mediator metabolism and synaptic transmission (hemicholinium, neuromuscular blocking agents) [3, 6, 10, 11, 13, 14, 18, 20], i.e., where a pathological state of the presynaptic region is present or is created artificially [12, 15]. By analogy with this, the phenomena of a decrease or increase in amplitude of the potentials in response to fast stimulation, and facilitation or exhaustion of conductivity after such stimulation, and also the low values of integral muscle potentials, suggest that in children during the first years of life the presynaptic phase of nervous transmission, i.e., the synthesis or secretion of acetylcholine, differs significantly from that in adults.

LITERATURE CITED

1. I. A. Arshavskii, Outlines of Age Physiology [in Russian], Moscow (1967).
2. N. E. Vvedenskii, Relationship between Stimulation and Excitation in Tetanus [in Russian], St. Petersburg (1886).
3. V. A. Kovanev and Ya. M. Khmelevskii, Vestn. Akad. Med. Nauk SSSR, No. 8, 3 (1962).
4. M.R. Mogendovich, Visceromotor and Postural Reflexes [in Russian], Perm' (1965), p. 5.
5. T. N. Oniani, Comparative Physiology of the Neuromuscular System [in Russian], Tbilisi (1964).
6. A. I. Shapovalov, Cellular Mechanisms of Synaptic Transmission [in Russian], Moscow (1966).
7. J. Basmajian, in: Normal Electromyography. Symposium on the Physiology of Muscle, Baltimore (1964), p. 479.
8. F. Buchthal, An Introduction to Electromyography, Copenhagen (1957).
9. H. C. Churchill-Davidson and A. T. Richardson, J. Physiol. (London), 122, 252 (1953).
10. H. C. Churchill-Davidson and T. H. Christie, Brit. J. Anaesth., 31, 290 (1959).
11. H. C. Churchill-Davidson, in: Recent Advances in Anesthesia and Analgesia, Boston (1963), p. 79.
12. O. Dahlback, D. Elmquist, T. Johns, et al., J. Physiol. (London), 156, 336 (1961).
13. J. del Castillo and B. Katz, J. Physiol. (London), 125, 546 (1954).

14. J. E. Desmedt, Nature, 179, 156 (1958).
15. J. E. Desmedt, in: Myasthenia, Springfield (1961), p. 150.
16. J. Diamond and R. Miledi, J. Physiol. (London), 162, 393 (1962).
17. L. M. Eaton and E. H. Lambert, J. Am. Med. Assoc., 163, 1117 (1957).
18. A. M. Harvey, J. L. Lilienthal, and S. A. Talbot, Bull. Johns Hopk. Hosp., 69, 547 (1941).
19. J. C. Eccles, The Physiology of Synapses, Berlin (1964).
20. A. W. Liley, J. Physiol. (London), 132, 650 (1956).
21. R. P. Wise, Anaesthesia, 17, 488 (1962).
22. W. D. Wylie and H. C. Churchill-Davidson, Practice of Anaesthesia, London (1966).