SPINO-BULBO-SPINAL RESPONSE IN UNANESTHETIZED RATS

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The spino-bulbo-spinal response at the level of the 5th and 6th segments of the lumbar enlargement of unanesthetized, unstrychninized rats has a latent period of 11-21 msec, a duration of 3-12 msec, and a maximal amplitude of 17-224 μV.

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During recent years in the course of an investigation of mechanisms of reflexes between the limbs of decerebrate cats immobilized with flaxedil and maintained on artificial respiration after intravenous injection of strychnine in subtetanic doses, a late or delayed response has been obtained [8]. Subsequently a similar late component of the response was obtained also by means of strychninization and investigated in cats, and named the bulbo-spinal response [9]. To judge from the most competent monographs [4-7], and also from the two articles mentioned above, no such responses have been found in rats.

We have attempted to obtain bulbo-spinal responses in rats experimentally without the use of relaxants or strychnine.

EXPERIMENTAL METHOD

Experiments were carried out on 56 Wistar and noninbred rats. The dorsal and ventral roots of the lumbar enlargement were dissected under ether anesthesia. The dorsal roots were stimulated with square pulses of a descending current through Ag–AgCl electrodes 0.5-0.6 mm in diameter, 2 mm apart, the electrode nearer to the brain lying approximately 1 cm from the point where the root entered the spinal cord. The electrodes with the roots themselves were kept in a bath of mineral oil at 36°. During recording of the root potentials the rat remained awake, received no drugs, and was carefully fixed to a frame. The root potentials were fed through a type UBT-5 amplifier into the input of a 2KO-1 oscillograph. Time-lapse photographic recording of single evoked responses was carried out several tens of times at intervals of 5 sec.

EXPERIMENTAL RESULTS

Multicomponent evoked potentials in response to single stimuli in 5 rats are shown in Fig. 1. The variability of the spino-bulbo-spinal response (identical in shape to that of cats) is clearly visible, being dependent both on the conditions of recording and the intercentral relationships. Transection of the spinal cord in the region of the upper thoracic segments in 21 rats and local cooling of the medulla and spinal cord in 13 rats demonstrated in 36 experiments the bulbar origin of the late component of the root response in the lumbar region of the spinal cord (Fig. 2). In four rats a spino-bulbo-spinal component was obtained which was isolated from the remaining components of the evoked response (Fig. 3). This phenomenon was obtained in response to stimulation of the 5th dorsal root of the lumbar enlargement of the spinal cord of near-threshold strength for a monosynaptic reflex. From the facts described above, it can be postulated that the spino-bulbo-spinal reflex pathway is more sensitive to stimulation than the propriospinal pathway.

The principal statistics describing the spino-bulbo-spinal response in 18 rats are given in Table 1. The distribution of frequencies of the latent period, duration, and maximal amplitude of the spino-bulbo-spinal response in individual animals obeys the Gaussian law of normal distribution. Special calculation showed that during normal recording of the evoked potentials, no statistically significant changes took place in these three parameters of the spino-bulbo-spinal response to indicate exhaustion or fatigue of this particular reflex arc.

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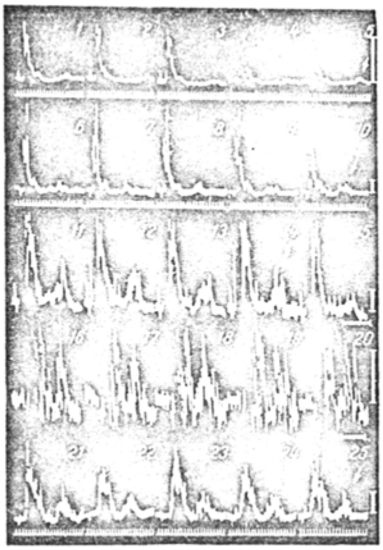

Fig. 1

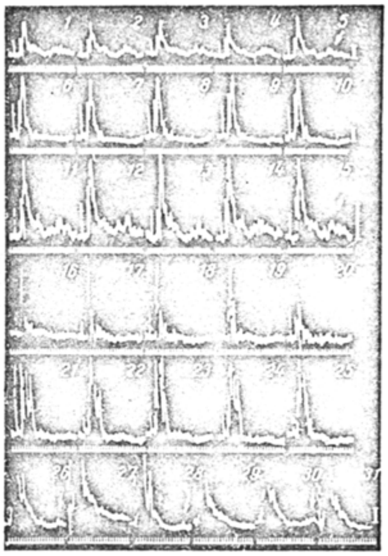

Fig. 2

Fig. 1. Spino-bulbo-spinal response in unanesthetized rats. Frames 1-5 (rat no. 127: stimulation of right dorsal root of 5th lumbar segment (DDL_5; 1 V, 6 μsec), recording from right ventral root of 5th lumbar segment (DVL_5), calibration 1000 μV, 1000 cps; frames 6-10 (rat no. 128): stimulation of left dorsal root with current of 2 V (frames 7-9, duration of impulse 6 μsec; frame 6, duration of impulse 48 μsec; frame 10, 300 μsec), recording from SVL_5, calibration 100 μV, 500 cps; frames 11-15 (rat no. 33): stimulation of DDL_5 (1 V, 30 μsec), recording from DVL_5, calibration 100 μV, 10 msec; frames 16-20 (rat no. 26): stimulation of SDL_5 (1 V, 6 μsec), recording from SVL_5, calibration 100 μV, 10 msec; frames 21-25 (rat no. 124): stimulation of SDL_6 (1 V, 30 msec), recording from SVL_6, calibration 100 μV, 1000 cps. Arrows denote spino-bulbo-spinal response.

Fig. 2. Effect of transection or cooling of spinal cord on spino-bulbo-spinal response. Frames 1-5 (rat no. 126): before surgical transection of spinal cord in region of middle thoracic segments, stimulation of SDL_5 (1 V, 6 μsec), recording from SVL_5, calibration 100 μV, 1000 cps; frames 6-10 (after transection), calibration 100 μV, 1000 cps; frames 11-20 (the same experiment as in frames 1-10, but with much greater amplification of potentials); frames 21-25 (evoked potentials after transection but with much stronger stimulation (1 V, 300 μsec), calibration on frames 11-25 the same, namely 100 μV, 1000 cps. Rat no. 116. Experiment with repeated cooling and heating of medulla by means of a mineral oil bath: frame 26 before cooling, frame 27 at 4°, frame 28 at 38°, frame 39 at 6°, frame 30 at 38°, frame 31 at 12°. Stimulation of SDL_5 (7 V, 6 μsec), recording of SVL_5, calibration 100 μV, 1000 cps.

According to data in the literature [8,9] this component of the evoked potential was recorded ipsilaterally and contralaterally in the cat, and it varied to a greater degree than the segmental monosynaptic and polysynaptic components. After division of the spinal cord at the level of the first cervical segment it disappeared. The great variability and long latent period of this component demonstrated, in the opinion of these workers, that the pathways of this reflex are longer and more complex than those of mono- and polysynaptic reflexes. The experimental data confirmed the hypothesis that besides a propriospinal system of movement coordination, there is also a spino-bulbo-spinal system, through which the bulbar reticular formation participates in the integrative activity of the spinal cord.

TABLE 1. Statistics Relating to Spino-Bulbo-Spinal Response*

Lumbar segment	Rat no.	Latent period	Duration	Maximal amplitude	Response present, percent
5th	26	13,6±0,18 (33) 8±0,9	6,8±0,29 (33) 25±3,0	90±2,4 (33) 16±1,9	100 (33)
	33	17,2±0,12 (108) 7±0,5	7,4±0,13 (108) 18±1,2	114±3,4 (108) 31±2,1	99 (109)
	105	12,0±0,13 (101) 11±0,8	10,8±0,20 (101) 18±1,3	224±4,7 (101) 21±1,5	100 (101)
	116	17,7±0,22 (37) 8±0,9	— —	— —	100 (37)
	120	13,1±0,11 (105) 9±0,6	— —	— —	98 (107)
	125	14,7±0,34 (33) 13±1,7	3,5±0,34 (33) 56±7,0	17±0,7 (33) 24±3,0	85 (39)
	126	13,2±0,09 (163) 9±0,5	6,9±0,12 (163) 22±1,2	42±1,1 (163) 34±1,9	100 (163)
	127	17,8±0,28 (39) 10±1,1	11,5±0,29 (39) 16±1,8	64±2,2 (39) 21±2,4	100 (82)
	128	21,0±0,31 (24) 7±1,0	10,7±0,36 (24) 16±2,4	72±4,1 (24) 28±4,0	100 (24)
	136	17,6±0,22 (68) 10±0,9	— —	— —	90 (76)
	138	13,5±0,19 (102) 14±1,0	5,1±0,18 (102) 36±2,5	34±1,3 (102) 38±2,6	97 (105)
	140	15,0±0,10 (119) 7±0,5	— —	— —	97 (123)
	144	12,4±0,08 (119) 7±0,5	2,8±0,08 (119) 31±2,0	76±4,6 (119) 67±4,3	96 (125)
6th	28	13,2±0,17 (62) 10±0,9	3,6±0,16 (62) 35±3,2	84±4,8 (62) 45±4,1	98 (63)
	121	11,1±0,09 (155) 10±0,6	5,3±0,09 (155) 21±1,2	73±1,8 (155) 30±1,7	99 (156)
	122	14,1±0,12 (147) 10±0,6	6.3±0,10 (147) 19±1,1	100±2,2 (147) 38±2,3	100 (147)
	124	12,2±0,07 (142) 7±0,4	5,6±0,12 (142) 26±1,5	86±2,1 (142) 30±1,8	99 (144)
	143	11,9±0,16 (79) 12±0,9	5,2±0,22 (79) 37±3,0	69±2,5 (79) 32±2,5	97 (82)

*The latent period and duration of the spino-bulbo-spinal response were measured in msec and the maximal amplitude in μV. The first line gives the arithmetic mean and its error, the second line the coefficient of variation and its error (in percent); the number of tests is given in parentheses.

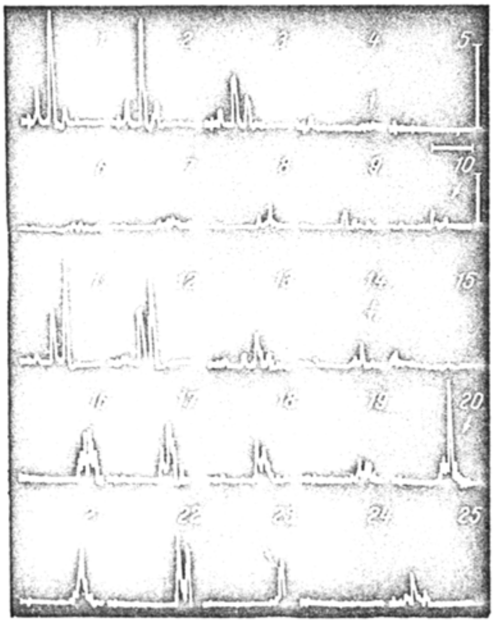

Fig. 3. Spino-bulbo-spinal response to near-threshold stimulation. Rat No. 57. Stimulation of SDL_5, recording from SVL_5. Frames 1-10 (stimulation 0.3 V, 6 μsec, calibration 1000 μV, 10 msec); frames 11-15) stimulation 0.25 V, 6 μsec. Frames 16-25) stimulation 0.2 V, 6 μsec. Calibration for frames 11-25 and 1-5 the same. The more uniform propriospinal response, as a rule of three components (frames 1-3, 11, 12, 25), the more variable late spino-bulbo-spinal response, not split up into components (frames 9, 16, 17, 20-23), and the simultaneous appearance of monosynaptic and spino-bulbo-spinal components (frames 4, 6-8, 10, 14, 18, 19) can be seen. Frames 5, 15, and 24 show that the stimuli were in fact near threshold.

Work in this field is interesting in many respects. First, it extends our knowledge of the pathways terminating on the spinal motoneurons [4-6], second, it confirms the hypothesis of the multistage structure of the reflex arc [1, 2], and third, by revealing the existence of reflex arcs, acting in parallel, with the same outlet through the ventral root of the spinal cord, it reveals possible pathways and mechanisms of compensation in case of injury to one or several reflex arcs [1-3].

Hence, a spino-bulbo-spinal response, differing from that obtained in the strychninized cat, can be obtained experimentally in unanesthetized rats.

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