THE RELATIONSHIP BETWEEN THE MOTOR CHRONAXIE OF ANTAGONISTIC MUSCLE GROUPS AND THE SUBORDINATIVE INFLUENCES OF THE HIGHER NERVE CENTERS IN THE PERIOD OF GROWTH OF A MALIGNANT TUMOR

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According to Bourguignon's law, the ratio between the chronaxie of the flexors and extensors is usually equal to two, or is very close to that value. This ratio between the chronaxie values may be called the subordinative index. As we have previously shown [1], in rabbits with a growing Brown-Pearce tumor, its absolute value is not only increased, but also distorted. Our observations are in agreement with the findings of several workers [1-10].

The problem of the link in the nervous system which exerts a definite effect on the quantitative aspect of these functional changes has not been solved. L. V. Latmanizova and her co-workers [3-7] sought to solve this problem by recording the action potentials of the cerebral cortex and the subcortical structures and comparing the results obtained with those of recordings of the functional state of the peripheral nervous system as studied by the methods of chronaximetry and accommodation tests. No convincing results were obtained, however [5].

In order to solve this problem we chose the method of successive exclusion, by means of appropriate measures, of the various links of the reflex arc, at the same time making observations on the chronaxie values.

EXPERIMENTAL METHOD

We divided 45 male chinchilla rabbits (weighing 2500-3000 g) into 4 groups: 10 rabbits in each of the 1st, 2nd and 3rd groups and 15 rabbits in the 4th group. The initial values of the chronaxie in each group were determined twice – before operation, and after it but before implantation of a tumor, which was performed in the right testicle of the rabbit as soon as the acute sequelae of the operation had cleared up. Further tests of the chronaxie were made during the time of growth of the tumor as follows: on the 1st, 5th, 10th, 15th and 20th days from the moment of transplantation. The chronaxie was determined by stimulation of the motor points of antagonistic muscle groups in the hind limbs, innervated by the sciatic and femoral nerves.

The individual links of the reflex arc were excluded surgically. The rabbits of the 1st group were subjected to denervation of the right testicle (the nerve fibers in the region of the spermatic cord were divided); completeness of denervation of the testicle was judged by absence of response to stimulation by the electric current. In the animals of the 2nd group, the sympathetic supply was interrupted in the thoracolumbar division, to the left of the spine (the sympathetic chain was divided in the thoracolumbar division on the left and the adventitia was removed from the wall of the aorta for a distance of 0.5 and 1cm in its abdominal portion). In the rabbits of the 3rd group the cerebral cortex was extirpated. The radical nature of the surgical procedures was verified at the end of the experiment by pathologoanatomical and histological examination. In the rabbits of the 4th group, unilateral division of the spinal cord was carried out at the level of the 10th thoracic vertebra (on the right side).

TABLE 1

Results of Chronaximetry and Values of the Subordinative Index in a Group of Rabbits after Denervation of the Right Testicle and Implantation of Brown-Pearce Carcinoma Cells

Rabbit no.	Initial background values					Values on the 30th day after operation					Values on the 15th day after implantation of the tumor				
	sciatic nerve		femoral nerve		ratio between chronaxie values (subordinative index)	sciatic nerve		femoral nerve		ratio between chronaxie values (subordinative index)	sciatic nerve		femoral nerve		ratio between chronaxie values (subordinative index)
	rheobase	chronaxie	rheobase	chronaxie		rheobase	chronaxie	rheobase	chronaxie		rheobase	chronaxie	rheobase	chronaxie	
490	5,50	0,26	11,75	0,13	+2,0	7,50	0,18	8,50	0,31	—1,7	6,62	0,36	11,75	0,15	+2,4
454	7,50	0,31	9,0	0,15	+2,1	3,50	0,21	10,50	0,16	+1,3	11,50	0,52	16,75	0,03	+17,3
542	4,75	0,41	8,25	0,21	+1,9	4,50	0,36	12,0	0,18	+2,0	6,75	1,09	35,50	0,21	+5,2
636	9,75	0,23	11,25	0,11	+2,1	4,25	0,41	8,25	0,16	+2,5	3,25	4,0	22,50	0,40	+10,0
547	6,25	0,22	12,0	0,12	+1,8	5,0	0,49	9,25	0,21	+2,3	8,80	0,26	17,87	0,26	+1,0
699	7,75	0,24	10,0	0,12	+2,0	7,50	0,21	16,25	0,10	+2,1	6,75	0,37	16,12	0,11	+3,3
495	5,50	0,26	11,75	0,13	+2,0	5,50	0,21	10,0	0,10	+2,1	4,37	1,24	20,28	0,19	6,5
111	7,25	0,26	14,0	0,13	+2,0	8,25	0,34	11,25	0,17	+2,0	10,37	0,82	17,50	0,29	+2,8
30	7,0	0,30	12,75	0,15	+2,0	6,25	0,42	10,0	0,21	+2,0	9,12	0,23	6,75	1,29	—5,6
695	4,75	0,22	14,25	0,11	+2,0	5,75	0,21	7,50	0,16	+1,3	Rabbit died				

TABLE 2

Results of Chronaxinetry and Values of the Subordinative Index in a Group of Rabbits after Sympathectomy and Implantation of Brown-Pearce Carcinoma Cells

Rabbit no.	Initial background values					Values on the 30th day after operation					Values on the 15th day after implantation of the tumor				
	sciatic nerve		femoral nerve		ratio between chronaxie values (subordinative index)	sciatic nerve		femoral nerve		ratio between chronaxie values (subordinative index)	sciatic nerve		femoral nerve		ratio between chronaxie values (subordinative index)
	rheobase	chronaxie	rheobase	chronaxie		rheobase	chronaxie	rheobase	chronaxie		rheobase	chronaxie	rheobase	chronaxie	
263	4,25	0,31	13,0	0,18	+1,7	12,25	0,29	18,75	0,15	+1,9	3,75	0,88	8,75	0,34	+2,6
290	7,75	0,31	9,0	0,15	+2,0	5,75	0,26	11,25	0,13	+2,0	5,0	0,26	12,50	0,08	+3,3
281	7,25	0,26	10,0	0,13	+2,0	5,75	0,41	20,0	0,19	+2,2	4,25	0,83	8,50	0.07	+11,9
283	5,50	0,26	11,75	0,13	+2,0	6,25	0,34	16,25	0,17	+2,0	3,25	0,47	19,50	0,07	+6,7
273	5,75	0,15	6,25	0,29	—1,9	10,0	0,21	12,0	0,10	+2,1	3,25	0,47	13,75	0,21	+2,2
75	9,25	0,21	16,25	0,11	+1,9	12,50	0,44	15,50	0,21	+2,1	7,50	0,78	13,25	0,08	+9,7
671	12,50	0,31	17,75	0,14	+2,2	9,0	0,21	14,75	0,31	—1,9	5,25	0,36	16,25	0,08	+4,5
685	6,75	0,25	12,50	0,11	+2,2	6,75	0,39	13,25	0,18	+2,2	5,0	0,67	14,25	0,28	+2,4
672	7,0	0,24	11,25	0,12	+2,0	8,25	0,47	17,50	0,22	+2,1	5,50	0,47	10,0	0,26	+1,8
673	6,50	0,19	10,75	0,10	+1,9	5,50	0,52	12,25	0,24	+2,3	3,75	0,41	13,0	0,13	+3,2

TABLE 3

Results of Chronaximetry and Values of the Subordinative Index in a Group of Rabbits after Extirpation of the Cerebral Cortex and Implantation of Brown-Pearce Carcinoma Cells

Rabbit no.	Initial background values					Values after operation					Values on the 15th day after implantation of the tumor				
	sciatic nerve		femoral nerve		ratio between chronaxie values (subordinative index)	sciatic nerve		femoral nerve		ratio between chronaxie values (subordinative index)	sciatic nerve		femoral nerve		ratio between chronaxie values (subordinative index)
	rheobase	chronaxie	rheobase	chronaxie		rheobase	chronaxie	rheobase	chronaxie		rheobase	chronaxie	rheobase	chronaxie	
264	12,50	0,31	17,85	0,14	+2,2	10,0	0,15	10,0	0,15	1,0	5,0	0,41	7,50	0,15	+2,7
285	9,10	0,26	18,0	0,13	+2,0	12,25	0,23	9,75	0,23	1,0	*Rabbit died*				
271	9,0	0,36	9,0	0,18	+2,0	5,50	0,52	5,50	0,39	+1,3	7,0	0,44	12,50	0,09	+4,9
257	10,25	0,22	15,0	0,11	+2,0	7,50	0,52	10,0	0,36	+1,5	5,0	0,47	10,0	0,47	+1,0
295	7,50	0,26	19,25	0,10	+2,6	9,50	0,15	9,50	0,15	1,0	4,75	0,36	8,75	0,09	—1,2
282	5,75	0,34	20,0	0,13	+2,6	12,0	0,52	10,75	0,15	+3,5	5,25	0,23	6,75	0,23	1,0
280	11,75	0,16	17,50	0,08	+2,0	6,0	0,23	6,25	0,23	1,0	4,50	0,47	10,50	0,07	+6,7
286	9,45	0,21	12,50	0,12	+1,8	8,75	0,31	8,75	0,31	1,0	3,75	0,41	8,75	0,13	+3,1
287	6,50	0,31	13,0	0,18	+1,8	3,75	0,36	15,75	0,10	+3,6	6,25	0,15	6,25	0,23	—1,5
200	7,50	0,24	10,0	0,13	+1,8	9,50	0,39	9,50	0,39	1,0	3,0	0,52	19,75	0,07	+7,4

TABLE 4

Results of Chronaximetry and Values of the Subordinative Index in a Group of Rabbits after Unilateral Division of the Spinal Cord at the Level of the 10th Thoracic Vertebra and Implantation of Brown-Pearce Carcinoma Cells

Rabbit no.	Initial background values					Values on the 10th day after operation					Values on the 15th day after implantation of the tumor				
	sciatic nerve		femoral nerve		ratio between chronaxie values (subordinative index)	sciatic nerve		femoral nerve		ratio between chronaxie values (subordinative index)	sciatic nerve		femoral nerve		ratio between chronaxie values (subordinative index)
	rheobase	chronaxie	rheobase	chronaxie		rheobase	chronaxie	rheobase	chronaxie		rheobase	chronaxie	rheobase	chronaxie	
516	5,25	0,26	10,25	0,13	+2,0	7,50	0,26	9,50	0,31	—1,2	11,25	0,26	18,75	0,21	+1,2
517	4,75	0,28	7,75	0,12	+2,3	8,0	0,26	10,75	0,41	—1,6	5,75	0,26	15,0	0,26	1,0
518	6,50	0,22	14,25	0,11	+2,0	8,75	0,23	12,25	0,23	1,0	6,75	0,36	10,75	0,36	1,0
520	4,75	0,28	11,25	0,14	+2,0	10,0	0,52	10,25	0,39	+1,3	10,0	0,29	10,0	0,29	1,0
512	6,25	0,25	16,25	0,11	+2,2	11,25	0,18	10,0	0,18	1,0	2,75	0,47	5,0	0,47	1,0
622	3,50	0,28	11,25	0,12	+2,3	8,50	0,26	11,0	0,26	1,0	11,25	0,15	11,25	0,15	1,0
652	13,75	0,27	18,12	0,12	+2,2	9,50	0,13	11,75	0,13	1,0	6,0	0,23	14,50	0,15	+1,5
682	9,50	0,15	6,25	0,29	—1,9	7,25	0,25	10,75	0,34	—1,4	9,25	0,21	9,50	0,21	1,0

EXPERIMENTAL RESULTS

The observations showed that in the rabbits of the 1st group, in which the right testicle was denervated and a suspension of tumor cells was subsequently inoculated, the values of the chronaxie and of the subordinative index (Table 1) underwent the same quantitative changes as in the rabbits in which growth of a malignant tumor was taking place but which had been subjected to no form of operation on the nervous system. The same thing was observed in the animals of the 2nd group, after interruption of the sympathetic supply in the region of the thoracolumbar division and subsequent implantation of tumor cells in the right testicle (Table 2).

In the rabbits of the 3rd group, in which the cerebral cortex was extirpated, the chronaxie values were considerably altered (Table 3).

These changes took the form of partial equalization of the values of the chronaxies of the flexors and extensors in the postoperative period. In 2 of the 10 rabbits the subordinative index became equal to unity.

In the majority of animals, however, the values of the chronaxie and of the subordinative index were little different in the period after implantation of the tumor from the corresponding values in rabbits in which growth of a malignant tumor was taking place without extirpation of the cerebral cortex.

In the rabbits of the 4th group, in which the spinal cord was divided unilaterally at the level of the 10th thoracic vertebra, the changes in the chronaxie and subordinative index found in the rabbits of all the remaining groups in the period of growth of the malignant tumor were completely absent. The values of the chronaxie of the flexors and extensors of the hind limbs became almost identical, and remained constant during the experiment from the moment of operation (Table4).

The chronaxie changes which we observed in rabbits during growth of a malignant tumor, although they depended on the functional state of the peripheral links of the reflex arc and on the integrity and functional activity of the cerebral cortex, thus depended to no less degree on the influence of the divisions of the central nervous system lying between the cortex and the segment of the spinal cord at the level of the 10th thoracic vertebra.

SUMMARY

The purpose of this research was to ascertain which portion of the nervous system affects the relationship between the flexor and extensor chronaxie in the hind limb of rabbits after implantation of a Brown-Pearce carcinoma. Denervation of the testicle, thoracolumbar sympathectomy, hemisection of the spinal cord, and extirpation of the cerebral cortex were undertaken in groups of experimental animals. Changes in the chronaxie relationships were found in the last two groups but not in the first two.

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