EFFECT ON RENAL FUNCTION OF HEMISECTION OF THE SPINAL CORD OF DOGS

COMMUNICATION II. EFFECTS ON RENAL FUNCTION OF REPEATED HEMISECTION OF THE SPINAL CORD IN THE CERVICAL REGION

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We showed in our previous paper [1] that hemisection of the spinal cord at the C-1 and C-5 levels causes disturbances of renal function. The severity of these disturbances varies according to the level of the spinal lesion.

The present research was undertaken with the object of elucidating the nervous mechanisms which enters into the process of compensation of the disturbances of renal function due to a single hemitransection of the cervical spinal cord, and also of obtaining confirmatory evidence of the dependence of the severity of the disturbances on the level at which hemisection of the cord was performed.

EXPERIMENTAL METHODS

A second hemisection was performed on 4 dogs, which had previously suffered the same operation, on the same side. Where the earlier lesion had been inflicted at the level of the 5th cervical segment, the second one was at the level of the 1st segment, and vice versa. Only 2 dogs were studied after the second operation, since one (Belka) died on the operating table, and experiments on another dog, Ryzhyi, had to be abandoned owing to development of multiple papillomatous growths around the ureteric orifices of the bladder. The second hemisection was performed at the level of the 1st cervical segment in Kashtanka, and of the 5th segment in Zolushka.

The activities of the right and left kidneys were compared in the same way as described in Part I [1], with the difference that the creatinine content of the urine was not determined.

EXPERIMENTAL RESULTS

The changes in renal function observed after repeated hemisection of the right side of the spinal cord closely resembled those seen after the first operation, and their nature and severity depended on the level of the operation. The output of the right kidney of Zolushka was much less than of the left one, on the second day after repeated hemisection at the level of the 5th cervical segment, while the concentrations of urea and chloride were higher. From the 5th day on, we observed a steep fall in the concentration and amount of chloride cleared through the right kidney; output remained low, and urea concentration high. On the 2nd day after the operation neither the left nor the right kidney reacted to water loading by increased diuresis, although the duration of the experiment was 3 hours. On the 5th day after hemisection both kidneys gave only a small diuretic response to water loading, although 600 ml of water were introduced into the stomach, instead of the usual 400 ml. Only by the 8th day did both kidneys respond adequately to functional loading.

Beginning with the 2nd day after hemisection, Kashtanka showed a certain rise in diuresis on the operated side (average increase over the whole period of observation of 10-12%, but 1.5-1.8 times greater for individual 30-minute portions of urine), with correspondingly lower concentration of urea and chloride in the urine of this kidney, as compared with that of the contralateral one.

The time required for restoration of function was shorter after the second hemisection than after the first one. The disturbance of renal function following the second hemisection, above or below the level of the first one, lasted for less than two weeks, i.e., restoration of function was achieved nearly 5 times faster than after the first operation. Full restoration of the disturbed somatic functions following the second operation took place within 25-30 days, i.e., 1.3-1.4 times faster than after the first operation. Protein was absent from the urine of both kidneys after the second hemisection.

DISCUSSION OF RESULTS

We have shown that hemisection of the spinal cord causes considerable disturbances of renal activity, which is an indication of the existence of nervous regulation of kidney function.

Hemisection of the spinal cord at the level of the 5th cervical segment caused more severe disturbances than at the level of the 1st segment. Evidently the disturbances of function of the spinal sympathetic centers resulting from surgical trauma are greater when the wound is inflicted at a lower than at a higher level.

Our findings indicate that disturbances in renal function following hemisection of the spinal cord may be conpensated, similarly to disturbances in somatic functions. Restoration of somatic functions is, however, achieved in half the time that is required for restoration of normal renal function. This difference is probably related to the specific functional characteristics of the spinal somatic and vegetative reflex reactions, and in particular to the high inertia of the latter, and to their relatively smaller dependence on the higher levels of the central nervous system, which have been shown by E. A. Asratian [2] and his associates to play an important part in the restoration of disturbed functions of an injured organism.

What is the mechanism of restoration of disturbed renal function after hemitransection of the spinal cord?

It is generally believed that the process of restoration of functions of the higher animals following infliction of lesions of the spinal cord is not a result of regeneration of divided intracentral pathways. The relative rates of restoration of disturbed functions, and the results of macro- and microscopic examination of spinal cord specimens from Belka and Ryzhyi confirm this belief. It may therefore be assumed that participation of the higher levels of the central nervous system in the process of restoration of disturbed renal functions (if it does actually occur) is achieved through the uninjured conducting pathways of the contralateral side of the spinal cord, in the same way as for restoration of disturbed somatic functions.

Restoration of normal functioning of the kidneys, similarly to restoration of somatic functions, proceeds gradually, and shows none of the signs of automatic reconstruction. The gradual nature of the process of restoration of renal function may indirectly indicate that a training mechanism is concerned, or that various levels of the brain exert an action on the kidneys, or that both of these mechanisms are involved.

The shorter time required for restoration of renal function after repeated spinal transection (about one-fifth of the time needed after the first operation) also supports the view that restoration of renal function depends not only on changes proceeding within the spinal cord itself, but also on the participation in this process of various formations of the brain.

SUMMARY

Experiments were performed on 2 dogs with chronic fistulae of the ureters. Hemisection of the spinal cord was previously performed in these dogs on the level of the segments and later the disturbed function of the kidney was re-established. After repeated hemisection, as well as after the first one, the degree of disturbance depended on the level of the section. Re-establishment of the kidney function following the second operation took place 5 times faster than after the first operation.

TABLE

Diuresis and Urea and Chloride Contents of 30-Minute Portions of Urine Before and After Repeating a Right-sided Hemitransection of the Spinal Cord at the Level of the 5th Cervical Segment of the Dog Zolushka, with Water Loading

Diuresis, in ml			Urea, %			Chloride, %		
left kidney	right kidney	ratio	left kidney	right kidney	ratio	left kidney	right kidney	ratio
Before the second operation (98th day after the first, level of C_1)								
7.5	8.5	100 : 113	3.26	2.886	100 : 88	0.435	0.395	100 : 90
Load 400 ml water								
11.5	14.0	100 : 121	1.843	1.606	100 : 87	0.242	0.201	100 : 84
37.0	46.0	100 : 124						
43.6	51.0	100 : 116						
42.0	46.0	100 : 109	0.437	0.437	100 : 100	0.035	0.032	100 : 91
16.5	19.5	100 : 128						
7.5	8.2	100 : 109	1.417	1.417	100 : 100	0.163	0.146	100 : 90
2nd day after operation								
4.5	3.2	100 : 71	2.691	6.247	100 : 232	0.189	0.292	100 : 154
Load 400 ml water								
4.9	3.4	100 : 69	2.499	4.854	100 : 194	0.213	0.347	100 : 163
5.0	3.5	100 : 70						
4.3	3.0	100 : 69	2.835	5.478	100 : 193	0.137	0.265	100 : 191
5.0	3.5	100 : 79						
4.5	3.2	100 : 71	2.806	4.998	100 : 178	0.078	0.154	100 : 187
5th day after operation								
5.5	3.6	100 : 65	1.422	2.631	100 : 185	0.163	0.128	100 : 78
600 ml water load								
5.7	5.4	100 : 94	1.47	2.75	100 : 180	0.146	0.07	100 : 48
9.0	6.5	100 : 72						
14.0	9.0	100 : 64	0.853	1.588	100 : 186	0.029	0.023	100 : 79
13.0	8.7	100 : 66						
11.0	7.4	100 : 67						
9.0	6.0	100 : 66						
7.4	5.3	100 : 82	1.28	2.465	100 : 197	0.216	0.137	100 : 63
13th day after operation								
5.0	7.0	100 : 140	2.628	2.26	100 : 86	0.263	0.219	100 : 83
Load 400 ml water								
5.5	6.7	100 : 121	2.699	2.482	100 : 91	0.21	0.192	100 : 91
11.0	15.7	100 : 142						
40.0	51.5	100 : 128						
51.5	57.7	100 : 112	0.355	0.307	100 : 86	0.04	0.04	100 : 100
27.5	32.5	100 : 117						
13.5	18.0	100 : 133						
7.0	9.5	100 : 135	1.515	1.478	100 : 97	0.245	0.213	100 : 87

LITERATURE CITED

[1] V. F. Askerov, Biull. Eksptl. Biol. i Med., 43, 5, 55-61 (1957).*

[2] E. A. Asratian, Physiology of the Central Nervous System,** Moscow, 1953.

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* Original Russian pagination. See C. B. Translation.

** In Russian.