FUNCTION OF A RENAL AUTOGRAFT AFTER EXTIRPATION OF THE OTHER KIDNEY

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Previously [3] we have summarized studies of kidneys which have been preserved and then autografted into dogs in which the remaining kidney was undisturbed. The value of the diuresis, and the amounts of urea and creatinine excreted, and the ability to respond to a water and milk load by an enhanced diuresis was less in such kidneys than it was in the intact kidney of the same animal, and less too than in kidneys (of other dogs) which had been transplanted but not preserved.

In the present work we have experimented on eight dogs by transplanting one kidney into the neck, and then after various time-intervals removing the remaining kidney, and studying the function of the transplant.

METHOD

For the investigation we used dogs from experiments made by A. G. Lapchinskii [1]. The kidneys were preserved at a temperature of 2-4°.

Before and after removal of the kidneys from dogs we studied the following indices: diuresis, excretion of urea and creatinine, specific gravity of the urine, and response to a water and milk load. In the plasma we determined the residual nitrogen, urea, creatinine, and alkali reserve. From the endogenous creatinine we calculated the filtration and tubular reabsorption rates.

There is considerable evidence transplanted preserved kidneys can maintain life after removal of the others. Various lengths of life in such dogs have been claimed, and varied from one to six years [5, 6].

Extended survival of dogs supplied only with transplanted preserved kidneys was first observed in the experiments of A. G. Lapchinskii [1]. One such dog survived for two years seven months, another for 2½ years, and the others for shorter times.

RESULTS

The most striking feature of the transplanted preserved kidneys after the others have been removed is the rapidity and extent of the alteration of function.

Spontaneous diuresis increased many times in the first 3-7 days, and sometimes as early as the first day (Table 1). Subsequently diuresis varied according to nutrition, temperature and many other variables. In some of the dogs, after 3-15 days, a polyuria developed and lasted for various times. During this period, 50-100 ml per hour was passed spontaneously, many times more than was excreted from the two kidneys (one in situ and the other preserved and transplanted) before the former had been extirpated.

The concentration of urea and creatinine, and the amount of these substances excreted per hour by the preserved transplanted kidneys increased sharply during the spontaneous diuresis on the first day after extirpation. This effect was observed in all the eight dogs studied. For example, in Meduza the concentration of urea in the urine of the transplanted kidney on the second day after extirpation of the kidney in situ was 1747.4 mg%, and was 12.4 times more than was found in the urine of the other kidney before extirpation, while the urea excreted per hour was 244.63 mg, i.e., twice as much as had been excreted on the day before by both kidneys, one transplanted and the other

in situ. On this day, the concentration of creatinine in the urine of the preserved transplanted kidney was 67.57 mg%, which was five times more than in the urine of this kidney before extirpation of the other, and was actually slightly greater than the concentration of creatinine in the urine of the in situ kidney before its extirpation.

On this day during spontaneous diuresis in one hour 9.45 mg of creatinine was excreted from the preserved kidney of Medusa, i.e., 1.3 times more than from both kidneys on the day before extirpation.

Subsequently the concentration of urea and creatinine in the urine of the single remaining transplanted preserved kidney varied over wide limits according to the extent of the diuresis, the diet, and many other factors.

When one kidney remained in situ, a water and milk load was excreted chiefly through it. Of the fluid which had been drunk, 40-60% was excreted through this kidney in three hours and 3-15% through the transplanted organ.

TABLE 1. Spontaneous Diuresis before and after Removal of the Untransplanted Kidneys (in ml per hour)

Weight of dog (in kg)	Time in hours for which the transplanted kidney had been preserved	Before extirpation		At various times after extirpation (in days)							
		intact kidney	trans-planted kidney	1st	3rd	5th	7th	15th	30th	60th	90th
Kukla, 12	6	24	13.9	2.7	9.2	8.4	18.4	27.2	21	25.8	34.9
Kuma, 21	18	18.6	0.7	3.2	6.8	12	3.1	8.5	–	–	–
Pesnya, 14.5	25	10.9	0.7	1.2	1.6	13.9	18.4	66.6	31.7	62	29
Meduza, 8	25	9.6	7.4	8.7	12.5	13	not exam.	23	7.6	106	21
Strekoza, 13.8	27	10	0.2		13.1	17.1	10.1	45.5	15.7	31	31.8
Ingo, 11	24	–	0.2	5	10		13.7		25.2	12.1	25.5
Malysh, 9	24	–	1.4	0.5	11.8	9.2	4	4.7	4.4	7.8	13.3
Johnny, 12.5	25	–	5.3	5.6	42	57	101.9	22.6	30.6	38.8	22.6

TABLE 2. Filtration Per Minute (in ml) Before and after Extirpation of the In Situ Kidneys

Weight of dog (in kg)	Time in hours for which the transplanted kidney had been preserved	Before extirpation		At various times after extirpation (in days)							
		intact kidney	trans-planted kidney	1st	3rd	5th	7th	15th	30th	60th	90th
Kukla, 12	6	18.63	2.07	10.41	10.03	12	32.4	9.76	21.19	10.87	8.21
Kuma, 21	18	30.99	0.26	2.52	4.25	7.13	2.24	18.8	Died 20 days after extirpation of the intact kidney		
Pesnya, 14.5	25	18.71	0.16	1.08	1.22	5.26	7.8	23.18	13.20	7.045	14.11
Meduza, 8	25	6.94	0.99	6.7	9.18	8.68		6.73	3.97	10.08	11.02
Strekoza, 13.8	27	10.6	0.12		5.84	9.6	8.94	11.05	8.21	9.61	7.74
Ingo, 11	24	–	0.35	4.27	1.2	–	–	4.54	6.73	12.54	12.44
Malysh, 9	24	–	1.64	1.34	13.82	9.13	3.44	6.44		12.7	10.8
Johnny, 12.5	25	–	3.37	5.72	23.8	25	22.27	109	12.49	18.2	17.39

After removal of the undisturbed kidney, in most dogs the ability of the transplanted organ to respond to the milk and water load gradually increased. In Strekoza, before extirpation of the undisturbed kidney 6.3-7.3% of the milk and water load was excreted by the transplanted kidney in three hours, while 40-50% was excreted through the other. Ten days after removal of the intact kidney, 21.08% of the milk and water load was excreted through the preserved organ, after 25 days 31.6%, and after one month 40.8% was excreted in this way. However, in certain cases the ability to increase diuresis after a milk and water load increased sharply even in the first 7-10 days after extirpation (dogs Ingo and Johnny). The filtration per minute of the transplanted preserved kidneys increased 5-10 times during the first 1-2 days after extirpation. Subsequently this index varied over wide limits, but in many experiments the filtration volume from the single transplanted kidney was greater than the total previous filtration for both organs

(Table 2). After extirpation, tubular reabsorption approximated to the value recorded from the in situ organ previously. During the period of polyuria, filtration was increased, and reabsorption decreased by 2-3%.

Urine from the transplanted preserved kidneys almost always contained protein in greater or smaller concentration. There was a great deal in the first days after extirpation of the in situ kidney (in Johnny 10.1%, in Strekoza 2.13%). In the following days, the amount of protein in the urine was reduced, but the albuminuria did not disappear completely. The specific gravity of the urine was high in the first days after removal of the in situ organ, apparently due to the considerable albuminuria (in Kukla and Johnny it was 1045, and in Meduza 1027-1040. Subsequently the specific gravity of the urine varied over wide limits which were close to the value of the specific gravity of the urine from the intact kidneys; during the polyuria the specific gravity of the urine was very low (1001-1005).

When one kidney remained undisturbed, blood of dogs with a transplanted preserved kidney contained a normal concentration of nitrogen compounds, and the alkali reserve varied within normal limits. After removal of the undisturbed kidney, in all the dogs there was a great increase in the amount of residual nitrogen, particularly the urea fraction; subsequently, in most of the dogs which were carefully kept, the amount of residual nitrogen varied around the upper normal values, and the amount present as urea was almost always high. In three dogs (Kuma, Pesnya, Kukla) after removal of the unoperated kidney, the residual nitrogen did not completely return to normal before the dog died. The creatinine concentration of the plasma did not as a rule differ greatly from normal, although in the first days after extirpation there was some increase. Only in Kuma, who died 20 days after extirpation of the unoperated kidney, the amount of creatinine continued to increase until death. After removal of the undisturbed kidney, the curve of the alkali reserve was almost the mirror image of that for residual nitrogen. When the latter rose, the indices of the alkali reserve fell below normal limits.

Dogs who possessed only a preserved transplanted kidney shared the fate of dogs with exteriorized ureters: the duration of the functional period of the transplanted kidneys was limited by ascending infection and hydronecrosis, and when such a transplanted kidney was the only one, these conditions determined the survival time [4].

Of the eight dogs operated on by A. G. Lapchinskii in whom the in situ kidney had been extirpated, five died at various times with signs of severe uremia: before death, the plasma contained 300-600 mg% of urea, 2.5-5 mg% of creatinine, and the alkali reserve was reduced to 16-9% of the normal value. In a post-mortem examination it was found that in Kuma there was cirrhosis of the kidneys, and in Meduza an ascending purulent pyelitis; in most of the dogs there was a hydronecrosis.

It is important to emphasize that dogs who had only a transplanted preserved kidney require careful attention and a carefully adjusted regime. Severe temperature variations or a prolonged meat diet react unfavorably on their condition: they become lethargic, appetite falls sharply, the nitrogen content of the blood rises, and the alkali reserve falls. If measures are taken in time and the animal given a milk and vegetable diet and antibiotic therapy, the nitrogen of the blood may be made to fall rapidly.

When studying the function of the transplanted preserved kidneys when the other kidney remained undisturbed we suggested that the former constitute a regenerating organ. Of this we were convinced by both the prolonged postoperational anuria, and by the long recovery period during which the concentrating power of the kidneys increased. Later histological studies by N. S. Lebedeva [2] showed that we were right.

In the present work we have shown a sudden, almost step-wise increase in the functional indices in the transplanted preserved kidney after removal of the other. We may suppose that when one kidney is left undisturbed, the glandular apparatus of the transplanted preserved kidney contributes to diuresis with only a very small proportion of the nefrons of its glandular apparatus (it is known that under normal conditions only 50-90% of all the glomeruli are functional). After extirpation of the undisturbed kidney, the number of functional nefrons increases sharply; the factor responsible appears to be the increase of waste products whose elimination is arrested by the extirpation.

SUMMARY

A study was made on eight dogs of autografted preserved kidneys after extirpation of the other which was left undisturbed for some time. We found that during the first days after the removal of the undisturbed kidney, there was an increase of diuresis and of the urinary concentrations of urea and creatinine secreted by the transplanted preserved kidney. Filtration per minute increased 5-10 times, and approached the initial combined filtration of the original and transplanted kidneys, and at times even exceeded it. Tubular reabsorption approached the value of that of the undisturbed kidney. At various times after extirpation of one kidney, polyuria of various durations was observed.

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