The Blood Sugar Content of the Rabbit after the Ligation of the Renal Vessels.

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CONTENTS.

	Page
I. Methods	227
II. Some control experiments	228
III. The blood sugar content of the normal rabbit after the ligation of the renal vessels on both sides	233
(a) The ligation of the arteries and veins	236
(b) The ligation of the veins only	242
IV. The blood sugar content of the bilaterally splanchnectomized rabbit after the ligation of the renal vessels on both sides	247
(a) The ligation of the arteries and veins	248
(b) The ligation of the veins only	252
V. The blood sugar content of the rabbit, of which the kidneys had been pre- viously denervated, after the ligation of the renal veins.....	257
VI. Summary	264

The influence of the extirpation of both the kidneys or the ligation of their blood vessels upon the carbohydrate metabolism has been studied by U. Rose, by H. F. Grünwald and further by T. Itakura.

The estimation of the blood sugar in the experiments of Rose¹⁾ was limited to within a few hours only after the extirpation or ligation. It is, therefore, very difficult to decide whether the hyperglycaemia evoked by the bilateral extirpation of kidney, etc. was really the result of the

1) U. Rose, Schmiedeberg's Archiv, 1903, 50, 15.

loss of the functions of the kidney, as Rose himself thought, or merely the result of the operation itself, as E. Neubauer¹⁾ and Itakura²⁾ have already doubted. Contrary to Rose, Grünwald³⁾ estimated the liver glycogen content in two or three days after the operation and Itakura³⁾ also estimated the blood sugar content daily several times during three or four days after the ligation of the renal vessels.

The increase of the blood sugar content cannot be taken as an invariable concomitant of the diminution of the liver glycogen store. Notwithstanding, in the research of Grünwald nobody would hesitate to assume that they varied hand in hand.

But, since in their experimental results there are controversies on several points, I have attempted to repeat the ligation of the renal vessels under several conditions, in order to get a clearer idea about this problem.

I. METHODS.

Matured male rabbits of good nutrition were used only.

The feeding of the animals, the drawing of blood samples and their estimation, the measurement of the body temperature, and the splanchnectomy were made as usual in our Laboratory.

The ligation of the renal vessels was made extraperitoneally, being guided by a straight incision on the loin, behind the last rib and parallel to the dorsal mid-line. To isolate the renal vein from the renal artery without any bleeding some practices are necessary.

The ligation of the renal vessels or veins was made without narcotising the animals.

The section of the renal plexus: The rabbit was anaesthetized with a mixture of chloroform and ether. After the laparotomy, the abdominal viscera was covered by a gauze wet with a warm saline solution, and pushed to the opposite side from the operator. The nerve plexus on the blood vessel wall of the kidney was divided carefully and as long as possible. The nerve fibres in the outer layer of the vessels, which were detectable by the naked eye, were divided too. Notwithstanding the use of great care, an injury of the vessel wall could not seldom be avoided.

The rabbit, of which the renal plexus was divided, was brought to

1) E. Neubauer, *Bioch. Ztschr.*, 1910, **25**, 284.

2) T. Itakura, *Mittel. med. Fakult. Univers. Tokyo*, 1915, **15**, 197.

3) H. F. Grünwald, *Schmiedeberg's Archiv*, 1914, **64**, 147.

the experiment first three weeks after the division, when the nutrition had already been quite restored.

The correctness of the ligation was verified by the autopsy.

II. SOME CONTROL EXPERIMENTS.

My research is designed to see the effect of the arrest of the renal circulation or the elimination of the kidney function on carbohydrate metabolism in the long run. The manipulations of the animal till the arrest of the renal circulation are superfluous, but really unavoidable. It is a well known fact, that such a manipulation, such as fixing or operation necessarily causes hyperglycaemia. In this respect the control observation is indispensable.

Further, since the appetite of the rabbit, of which the renal vessels had been ligated, was dull and variable, food was not given to it. Therefore, it must be examined too, whether fasting for several days has any influence upon the blood sugar content of the rabbit.

A.

The control observation concerning the effect of fixing, operation etc. was made on some normal rabbits.

The control experiment was sometimes also made for each rabbit; these may, however, be reported in their proper place.

The blood samples were drawn from the vein of the denervated ear

TABLE

The effect of fixing, operation etc. on the

No.	Date	Body weight (kilos)	Initial blood sugar (%)	Max. b. s. after operation (%)	Duration of hyperglycaemia (hours)	Hours after operation to the max. b. s.	Min. b. s. after operation (%)
1	13. I. 1919	1.69	0.11	0.17	2 $\frac{1}{4}$	1	0.10
2	22. I. 1919	2.27	0.11	0.23	5 $\frac{1}{4}$	$\frac{3}{4}$	0.11
3	10. II. 1919	1.32	0.10	0.15	1 $\frac{1}{2}$	1	0.10
4	17. II. 1919	1.81	0.14	0.30	4 $\frac{3}{4}$	{ $\frac{3}{4}$ $\frac{3}{4}$	0.12
5	28. IX. 1919	1.67	0.11	0.14	4 $\frac{2}{3}$		0.09

of the rabbit which was sitting freely in a large pan. They were drawn three times successively with an interval of half an hour ; each time two specimens. Then, the animal was fixed prone on the table, and the urine was collected by catheterization. After clipping off the hair from the loin bilaterally and washing the skin with soap and then with alcohol, the renal vessels were exposed extraperitoneally, as described in the former chapter. A silk thread moistened with a warmed saline solution was passed closely under the vessels by means of a silver eye-pointed packing-needle, but it was left untied. This procedure was made first on the right side, and then on the left.

The isolation of the right renal vein was sometimes difficult and led to bleeding, which spoiled the result of the experiment. In such a case no further experiment was made.

The wounds were sewed up. The rabbit was then set free. No narcotic was used.

The blood samples were then taken first in half or an hour after the operation, and then every one or two hours. From the next day, they were drawn every three hours. The urine was collected by catheterization twice after the operation on that day; from the next day the estimation was made once every day with the urine collected up till that morning.

All the experiments are shown in a table and one of them shall be illustrated in detail.

L.

blood sugar content of the normal rabbit.

[illegible]

EXPERIMENT II.

Date	Body weight (kilos)	Time	Blood sugar (%)	Body temperature (°C.)	Urine				
					Quantity (c.c.)	Reaction	Specific gravity	Protein	Sugar (%)
21. I. 1919	2.25	9.30 A.M.	0.11	38.8					
		10.00	0.11	38.9					
		10.30	0.11	38.8					
		10.45	Fixed on the table and catheterized.						
					60	neutral	1014	—	0.026
		10.53–11.15	Control operation.						
		11.30	0.19	36.3					
		11.45	Catheterized.						
		11.47	Set free.			5	acid	trace	0.351
		12.00 M.	0.23	36.2					
		12.30 P.M.	0.21	37.1					
		1.00	0.20	37.7					
		2.00	0.15	38.5					
		2.15			40	neutral	1012	trace	0.141
		3.00	0.14	38.9					
23. I. "	2.25	4.00	0.14	39.7					
		5.00	0.12	39.7					
		5.10			20	acid	1016	trace	0.013
		6.00	0.11	39.6					
24. I. "	2.25	8.00 A.M.	0.11	39.3					
		11.30	0.12	39.0					
		1.30 P.M.	0.12	39.3					
		3.30	0.11	39.2					
		3.40			30	neutral	1014	—	0.013
25. I. "	2.25	6.30	0.10	39.0					
		8.30 A.M.	0.10	39.0	65	acid	1017	—	0.013
		12.00	0.11	39.2					
		3.00 P.M.	0.11	39.2					
26. I. "	2.24	6.00	0.12	39.2					
		8.30 A.M.	0.11	39.0					
		12.00 M.	0.11	39.0					
		3.00 P.M.	0.12	39.0					
26. I. "	2.24	6.00	0.10	38.9					
		8.00 A.M.	0.11	38.9	90	neutral	1020	—	0.013
		12.00 M.	0.10	39.1					
		6.00 P.M.	0.11	38.2					

Immediately after the control operation, the blood sugar level began to rise and reached the maximum (0.14–0.30 %). On an average 0.20 % (5 examples) which exceeded the initial value (0.10–0.14 %, on an average 0.11 %) by 0.03–0.16 % (on an average 0.09 %), in about one hour after the operation. The hyperglycaemia continued about 1–5 hours (on an

average 4 hours). In 4-7 hours after the operation the blood sugar level became a little lower than the initial value (0.09-0.12 %, on an average 0.10 %). On the following days, the blood sugar level varied only within the physiological limit.

The urine sugar content also increased, though only a little. 0.026-0.6% → 0.33-0.35 %. And it seemed to run parallel with the course of the blood sugar content. On the following days it was quite normal.

The urine after the control operation contained a trace of protein in most cases [with one exception (No. 1) out of five cases]. On the next day albuminuria disappeared entirely. The manipulation of passing a thread closely under the renal vessels might check the renal circulation, but for only a very short time, as about fifteen seconds. Shin Ochi¹⁾ failed to find any albuminuria in the rabbit after the arrest of the renal circulation for a short time, e. g. 45 seconds. He also exposed the renal vessels extraperitoneally.

B.

Of the rabbit, whose renal vessels were tied up, the appetite is sometimes in the beginning already seriously affected, and it takes food in a very variable amount. To avoid complications, no food was given to the rabbit so operated on.

To know the influence upon the blood sugar level of the rabbit of fasting for a long period, experiments were made on eight normal rabbits, as the following example and table (p. 234-235) show.

EXPERIMENT VIII.

Date	Body weight (kilos)	Time	Blood sugar (%)	Body temperature (°C.)	Urine				
					Quantity (c.c.)	Reaction	Specific gravity	Protein	Sugar (%)
23. IV. 1920	2.24	8.10 A.M.	0.13	38.6	110	alkaline	1018	—	0.024
		12.10 P.M.	0.14	38.6					
		3.40	0.15	38.4					
		7.10	0.15	38.7					
24. IV. "	2.18	8.40 A.M.	0.14	38.8	130	alkaline	1020	—	0.024
		12.10 P.M.	0.14	38.7					
		3.40	0.14	38.9					
		7.10	0.13	38.9					
25. IV. "	2.04	9.10 A.M.	0.11	38.2	No urine.				
		12.10 P.M.	0.11	38.0					
		3.10	0.12	38.2					
		6.10	0.12	38.3					
26. IV. "	1.97	8.00 A.M.	0.11	38.3	40	acid	1036	—	0.036
		12.10 P.M.	0.11	38.2					
		3.30	0.12	38.2					
		7.10	0.11	38.7					

1) Shin. Ochi, Kyoto Igaku Zasshi, 1918, 15, 699. (Jap.)

Date	Body weight (kilos)	Time	Blood sugar (%)	Body temperature (°C.)	Urine				
					Quantity (c.c.)	Reaction	Specific gravity	Protein	Sugar (%)
27. IV. "	1.90	8.40 A.M.	0.10	38.2	40	acid	1036	—	0.024
		12.10 P.M.	0.11	38.3					
		3.40	0.10	38.2					
28. IV. "	1.86	7.10	0.10	38.5	—				
		8.00 A.M.	0.10	37.9					
		12.00 M.	0.11	37.1					
29. IV. "	1.78	6.00 P.M.	0.12	37.5	18	acid	1045	—	0.024
		8.00 A.M.	0.13	37.5					
		12.00 M.	0.12	37.0					
30. IV. "	1.74	3.30 P.M.	0.12	37.5	40	acid	1055	—	0.024
		7.00	0.12	38.0					
		8.00 A.M.	0.10	37.2					
1. V. "	1.69	12.00 M.	0.11	37.0	20	acid	1055	—	0.024
		3.30 P.M.	0.12	37.2					
		7.00	0.10	38.3					
2. V. "	1.65	8.00 A.M.	0.11	37.5	25	acid	1055	—	0.024
		12.00 M.	0.13	37.3					
		3.40 P.M.	0.12	37.5					
3. V. "	1.60	7.10	0.12	38.1	25	acid	1055	—	0.024
		8.30 A.M.	0.12	37.6					
		12.10 P.M.	0.12	36.6					
4. V. "	1.55	3.40	0.13	37.2	20	acid	1055	—	0.024
		7.10	0.12	38.2					
		8.10 A.M.	0.12	37.3					
5. V. "	1.50	12.10 P.M.	0.12	37.3	23	acid	1055	—	0.024
		3.40	0.12	37.4					
		7.10	0.13	37.9					
6. V. "	1.46	8.10 A.M.	0.13	37.2	25	acid	1055	—	0.024
		12.10 P.M.	0.13	37.6					
		3.10	0.12	37.3					
7. V. "	1.41	7.10	0.13	38.2	30	acid	1055	—	0.024
		8.40 A.M.	0.13	37.7					
		12.10 P.M.	0.13	36.5					
8. V. "	1.36	3.40	0.13	36.8	30	acid	1055	—	0.024
		7.10	0.12	37.3					
		8.00 A.M.	0.13	36.9					
9. V. "	1.30	12.00 M.	0.13	37.2	35	acid	1042	—	0.024
		3.30 P.M.	0.13	37.2					
		7.00	0.12	38.1					
10. V. "	1.23	8.00 A.M.	0.14	37.3	20	acid	1037	—	0.024
		12.00 M.	0.14	37.2					
		7.00 P.M.	0.14	38.3					
11. V. "	1.15	9.00 A.M.	0.14	37.0	30	acid	1055	—	0.024
		12.10 P.M.	0.14	36.8					
		3.30	0.12	37.1					
		7.10	0.12	37.8					
		9.10 A.M.	0.13	36.2					
		12.10 P.M.	0.13	36.6					
		3.30	0.13	36.5					
		8.40 A.M.	0.20	35.9					
		6.10 P.M.	0.19	35.4					
		9.00 A.M.	0.03	32.6					
		10.05	Died.						

The examination was made on five rabbits (except Nos. 1, 2 and 7) till the death of the animals. Of them, only one rabbit (No. 6) died on the fourth day of fasting. The remaining four were able to bare mishandling for seven to sixteen days.

In the case of some rabbits, the blood sugar level rose a little in two to three days before death. Generally speaking, it tended to decrease finally.

A. Imamura and G. Kira¹⁾ observed a noticeable hypoglycaemia in fasting rabbits without exception on the day of death. In the majority of my cases, their finding was also confirmed; but not without exception. The rabbit No. 4, which died on the eleventh fasting day, is a good example. Its blood sugar content was 0.18 % in one hour before death.

Cl. Bernard on the whole came to the same conclusion as my statement. v. Mering²⁾ and J. G. Otto³⁾ could not detect any remarkable influence of fasting for some days upon the blood sugar content of dogs. Fasting for a long period in the experiments of Otto caused a decrease of the blood sugar content, though only a little.

The rabbit, of which the renal vessels were tied up, lived from four to six days after the ligation. So, it may be reasonably concluded from the experiments of Imamura and Kira and of mine, that hunger has no influence upon the variation of the blood sugar level after the ligation of the renal vessels. Imamura and Kira detected also a fair constancy of the blood sugar level before the hypoglycaemia phase on the last day of starving.

III. THE BLOOD SUGAR CONTENT OF THE NORMAL RABBIT AFTER THE LIGATION OF THE RENAL VESSELS ON BOTH SIDES.

After the bilateral ligation of the renal vessels or the renal veins alone, the rabbit lost appetite sooner or later, became gradually stupified, motionless, lethargic, and further somnolent and then dyspnoëic, and finally died. The behavior of the animal is just as that of the nephrectomized rabbit described by R. v. Limbeck⁴⁾ and others⁵⁾. Trembling of the trunk, etc. during the lethargic state was seen more frequently when the animal was removed. During the somnolent or dyspnoëic

1) A. Imamura and G. Kira, *Nippon Naikwa Gakkwai Zasshi*, 1919, **7**, 677 (Jap.).

2) v. Mering, *Arch. f. Physiol.*, 1877, 388.

3) J. G. Otto, *Pflüger's Arch.*, 1885, **35**, 492.

4) R. v. Limbeck, *Schmiedeberg's Archiv*, 1892, **30**, 183.

5) Shin. Ochi, *Kyoto Igaku Zasshi*, 1918, **15**, 657 (Jap.).

TABLE
The influence of fasting upon

No.	Date of the beginning of starvation	On the day before the beginning of starvation		On the day of the beginning of starvation		1. Fasted day		2. Fasted day	
		Max. b. s. (%)	Min. b. s. (%)	Max. b. s. (%)	Min. b. s. (%)	Max. b. s. (%)	Min. b. s. (%)	Max. b. s. (%)	Min. b. s. (%)
1	24. V. 1919	0.10	0.10	0.11	0.10	0.11	0.10	0.10	0.09
2	9. VII. "	0.11	0.11	0.11	0.10	0.10	0.06	0.14	0.09
3	28. IX. "	0.12	0.11	0.13	0.10	0.12	0.10	0.11	0.09
4	28. IX. "	0.11	0.11	0.12	0.09	0.11	0.09	0.11	0.10
5	8. II. 1920	0.12	0.11	0.11	0.10	0.12	0.10	0.12	0.10
6	19. II. "	0.11	0.11	0.12	0.11	0.12	0.09	0.13	0.11
7	26. II. "	0.13	0.12	0.13	0.11	0.12	0.11	0.12	0.11
8	24. IV. "	0.15	0.13	0.14	0.13	0.12	0.11	0.12	0.11

No.	8. Fasted day		9. Fasted day		10. Fasted day		11. Fasted day		Fasted
	Max. b. s. (%)	Min. b. s. (%)	Max. b. s. (%)	Min. b. s. (%)	Max. b. s. (%)	Min. b. s. (%)	Max. b. s. (%)	Min. b. s. (%)	Max. b. s. (%)
3	0.12	0.12	0.12	0.11	0.13	0.11	0.13	0.12	0.13
4	0.13	0.12	0.16	0.13	0.21	0.14	0.18	0.11	
8	0.13	0.12	0.13	0.12	0.13	0.12	0.13	0.12	0.14

phase convulsion was observed, though only a little. Contrary to Limbeck, T. Itakura¹⁾ noticed it also in rabbits of which the renal veins were tied up.

The behavior of the rabbit after the operation is common in the normal rabbit as well as in one bilateral splanchnectomized.

The duration of life of the rabbit after the ligation may be summarized as follows :

	Number of Rabbit	Bilateral Ligation of	Duration of life (hours)		
			Max.	Min.	Average
Normal rabbit	16	Renal vessels	116	56	81
" "	7	Renal vein	86	37	67
Splanchnectomized rabbit	12	Renal vessels	83	49	73
" "	4	Renal vein	84	81	81
R. of which ren. n. was divided	10	Renal vein	110	57	83

1) T. Itakura, Mitteil. med. Fakult. Univers. Tokyo, 1915, 15, 213.

II.
the blood sugar content.

3. Fasted day		4. Fasted day		5. Fasted day		6. Fasted day		7. Fasted day	
Max. b. s. (%)	Min. b. s. (%)	Max. b. s. (%)	Min. b. s. (%)	Max. b. s. (%)	Min. b. s. (%)	Max. b. s. (%)	Min. b. s. (%)	Max. b. s. (%)	Min. b. s. (%)
0.10	0.10	0.11	0.10						
0.12	0.09	0.12	0.11	0.12	0.11	0.11	0.10		
0.12	0.11	0.12	0.10	0.12	0.11	0.13	0.11	0.13	0.12
0.12	0.11	0.11	0.11	0.12	0.11	0.11	0.11	0.12	0.12
0.12	0.10	0.13	0.12	0.12	0.12	0.13	0.12	0.14	0.12
0.14	0.12	0.10	0.04						
		0.13	0.11	0.11	0.10	0.10	0.09		
0.11	0.10	0.12	0.10	0.13	0.12	0.12	0.10	0.13	0.11

12. day	13. Fasted day		14. Fasted day		15. Fasted day		16. Fasted day	
Min. b. s. (%)	Max. b. s. (%)	Min. b. s. (%)	Max. b. s. (%)	Min. b. s. (%)	Max. b. s. (%)	Min. b. s. (%)	Max. b. s. (%)	Min. b. s. (%)
0.11	0.13	0.12	0.13	0.09				
0.14	0.14	0.12	0.13	0.13	0.20	0.19	(0.02)	0.02)

In such cases where I could not know the time of death, "the duration of life" is estimated provisionally till to the last drawing of the blood samples. One of the bilaterally splachnectomized rabbits lived 176 hours after the ligation of the renal veins. This is omitted from the table, only by reason of an abnormal length of the life duration. The autopsy showed neither incompleteness of the operation nor any other abnormality. If this case is not omitted, the average duration in the last column of the table should be 100 hours.

The above table shows with certainty that, whether the rabbit is normal or splachnectomized, whether the renal vessels are bilaterally ligated or the renal veins alone, has no effect on the duration of life after the ligation.

So, roughly speaking, the rabbit can live about three to four days after the ligation.

This time agrees well with that in several former reports concerning the bilateral nephrectomy or the bilateral ligation of the renal vessels or veins on the rabbit. Comparing the report of T. Tamura¹⁾ with ours, concerning the life duration after the ligation, whether the food is given or not seems to have no influence.

1) T. Tamura, Tokyo Igakkwai-Zasshi, 1920, 34, 106 (Jap.).

In all experiments, the normal blood samples were taken early in the morning once or twice; then the animal was fixed prone on the table, the right renal vessels or vein ligated and the wound sewed, and then also the left. After the sewing of the left wound, the animal was set free. Five to ten minutes were necessary for the exposure and ligation on one side. In about one hour after the fixing, the blood samples were drawn, and half an hour later again. Then, in the forenoon they were taken every one hour, and in the afternoon every two hours. From the next day till the death of the animal, they were drawn every three to four hours.

In some examples, the control experiment on the same rabbit was made on the day previous to the principal experiment.

(a) The ligation of the renal arteries and veins.

TABLE

The blood sugar content of the normal rabbit

No.	Date	Body weight (kilos)	Initial blood sugar (%)	Max. blood sugar after ligation (%)	Hours after ligation to the max. b. s.	Duration of hyperglycaemia (hours)	Min. blood sugar after ligation (%)	Hours after ligation to min. b. s.	On
									Body weight (kilos)
1	9. VII. 1919	1.39	0.08	0.19	$\frac{1}{3}$		0.08	$\frac{5}{8}$	1.33
2	9. VII. "	1.64	0.11	0.14	$1\frac{1}{3}$	$1\frac{1}{2}$	0.07	10	1.54
3	5. X. 1921	1.80	0.11	0.21	$\frac{1}{2}$	$5\frac{1}{2}$	0.11	9	1.73
4	7. X. "	1.95	0.11	0.18	$\left\{ \begin{array}{l} 1\frac{1}{2} \\ 1\frac{1}{2} \end{array} \right.$	$3\frac{1}{2}$	0.11	9	1.82
5	7. X. "	2.12	0.10	0.16		3	0.09	7	1.98
6	11. X. "	1.65	0.13	0.17	$\frac{1}{2}$	$1\frac{1}{2}$	0.09	8	1.54
7	11. X. "	1.90	0.14	0.21	1	4	0.09	8	1.86
8	14. X. "	1.50	0.12	0.27	$1\frac{1}{2}$	$2\frac{1}{2}$	0.09	7	1.45
9	14. X. "	1.78	0.12	0.17	$\frac{3}{4}$	$2\frac{1}{4}$	0.09	7	1.61
10	18. X. "	2.40	0.12	0.22	$\left\{ \begin{array}{l} 1\frac{2}{3} \\ 1\frac{2}{3} \end{array} \right.$	$2\frac{2}{3}$	0.10	10	2.33
11	18. X. "	1.65	0.10	0.18		3	0.09	10	1.52
12	25. II. 1919	1.79	0.11	0.24	$\frac{5}{6}$	$7\frac{1}{3}$	0.14	7	1.62
13	26. X. 1921	1.80	0.11	0.21	$\left\{ \begin{array}{l} 1\frac{1}{3} \\ 1\frac{1}{2} \end{array} \right.$	$4\frac{1}{5}$	0.11	6	1.70
14	26. X. "	1.96	0.11	0.18		$2\frac{1}{2}$	0.08	10	1.90
15	2. XI. "	1.80	0.11	0.18	$\frac{1}{2}$	$2\frac{1}{2}$	0.10	4-6	1.74
16	2. XI. "	2.27	0.10	0.18	$\frac{1}{2}$	$2\frac{1}{4}$	0.12	4	2.21

The control experiments of Exp. XII—Exp. XVI of the table III a are shown in the following table.

TABLE III b.

No.	Date	Body weight (kilos)	Initial blood sugar (%)	Max. blood sugar after operation (%)	Hours after operation to the max. b. s.	Duration of hyperglycaemia (hours)	Min. blood sugar after operation (%)	Hours after operation to the min. b. s.
12	24. XI. 1919	1.74	0.11	0.19	1		0.11	5
13	25. X. 1921	1.78	0.12	0.16	$\frac{3}{4}$	$1\frac{3}{4}$	0.11	4
14	25. X. „	1.95	0.12	0.18	$\frac{1}{3}$	$2\frac{1}{3}$	0.09	9
15	1. XI. „	1.80	0.11	0.20	$\frac{2}{3}$	$2\frac{5}{8}$	0.09	5
16	1. XI. „	1.20	0.11	0.17	$\frac{2}{3}$	$2\frac{1}{2}$	0.10	9

III a.

after the ligation of renal vessels on both sides.

the next day			On the 3rd day				On the 4th day			
Min. blood sugar (%)	Max. blood sugar (%)	Min. body temp. (°C.)	Body weight (kilos)	Min. blood sugar (%)	Max. blood sugar (%)	Min. body temp. (°C.)	Body weight (kilos)	Min. blood sugar (%)	Max. blood sugar (%)	Min. body temp. (°C.)
0.07	0.08	38.8	1.33	0.10	0.11	37.1	1.30	0.09	0.09	35.1
0.07	0.11	38.7	1.50	0.12	0.15	37.9	1.43	0.13	0.15	36.7
0.11	0.12	38.6	1.70	On the 5th day		38.0	1.42	0.13	0.30	34.8
				0.12	0.16			0.23	0.27	37.2
0.11	0.12	38.0	1.80	On the 5th day		37.6	1.66	0.25	0.32	34.0
				0.18	0.25					
0.11	0.12	38.7	1.90	0.16	0.17	38.0	1.87	0.20	0.26	37.1
0.10	0.14	37.4	1.52	0.18	0.25	35.3				
0.10	0.15	38.2	1.84	0.25	0.38	36.4	1.80	0.77	1.11	29.7
0.10	0.16	38.2	1.42	0.19	0.24	35.7				
0.13	0.14	38.7	1.68	0.15	0.17	37.2	1.55	0.26	0.28	36.0
				On the 5th day		33.9	1.55	0.26	0.33	34.6
0.15	0.28	37.0	2.32	0.59	0.67		2.30			
0.11	0.14	36.3	1.50	0.44	0.63	33.7	1.48	0.51	0.51	29.2
0.12	0.14	38.1	1.60	0.15	0.18	35.8	1.57	0.36	0.47	34.8
0.16	0.23	37.9	1.65	0.33	0.45	34.7	1.60	0.60	0.60	31.1
0.11	0.14	38.3	1.85	0.10	0.15	37.2	1.80	0.33	0.46	34.7
0.11	0.13	38.4	1.65	0.12	0.15	37.5	1.60	0.35	0.43	33.4
0.11	0.12	39.7	2.10	0.11	0.12	39.0	2.05	0.12	0.14	37.5
				On the 5th day		39.0	2.00	0.14	0.19	35.8

EXPERIMENT II.

Date	Body weight (kilos)	Time	Blood sugar (°C.)	Body temperature (%)
9. VII. 1919	1.64	7.50 A.M.	0.11	38.0
		8.45	0.11	38.0
		9.05	Fixed on the table.	
		9.08-9.28	Ligation of renal vessels.	
		9.30	Set free.	
		9.50	0.10	36.9
		10.20	0.12	37.1
		10.50	0.14	37.5
		11.50	0.13	37.6
		12.50 P.M.	0.11	37.9
		1.50	0.12	37.9
		3.50	0.10	38.4
		5.50	0.10	38.9
		7.50	0.07	38.6
10. VII. „	1.54	8.10 A.M.	0.07	39.1
		11.40	0.11	38.7
		3.10 P.M.	0.09	38.8
		6.40	0.09	38.8
11. VII. „	1.50	7.40 A.M.	0.13	38.2
		11.10	0.14	37.9
		2.40 P.M.	0.12	38.4
		6.10	0.15	38.4
12. VII. „	1.43	7.40 A.M.	0.13	37.0
		11.10	0.13	36.8
		2.40 P.M.	0.17	36.7
		6.10	0.15	36.9
13. VII. „	1.42	7.40 A.M.	0.13	35.9
		11.10	0.20	35.2
		2.40 P.M.	0.24	35.1
		6.10	0.30	34.8
14. VII. „	1.40	Died in the early morning.		

EXPERIMENT XII.

Date	Body weight (kilos)	Time	Blood sugar (%)	Body temperature (°C.)
24. II. 1919	1.74	10.30 A.M.	0.11	38.5
		11.00	0.11	38.5
		11.30	0.11	38.5
		11.40	Fixed on the table. Control operation.	
		11.43-11.58		
		12.00 M.	Set free.	
		1.00 P.M.		
		5.00	0.19	37.6
25. II. "	1.79		0.11	38.5
		9.15 A.M.	0.09	39.0
		9.30	0.10	39.0
		10.00	0.10	39.0
		10.10	Fixed on the table. Ligation of renal vessels.	
		10.13-10.38		
		10.40	0.21	37.1
		11.30	0.24	37.6
		12.00 M.	0.21	37.8
		1.00 P.M.	0.17	37.3
		2.00	0.17	37.4
		3.00	0.16	37.5
		4.00	0.15	37.8
26. II. "	1.62	5.00	0.15	38.0
		6.00	0.14	38.0
		9.00 A.M.	0.12	38.1
		11.00	0.12	38.3
		1.00 P.M.	0.12	38.4
27. II. "	1.60	3.00	0.12	38.4
		5.00	0.14	38.2
		9.00 A.M.	0.15	36.2
		11.00	0.15	36.1
28. II. "	1.57	5.00 P.M.	0.18	35.8
		8.00 A.M.	0.36	35.1
		12.00 M.	0.42	34.8
1. III. "	1.55	6.00 P.M.	0.47	34.8
		7.30 A.M.	Died.	

On the day of the control operation: Five examples. Initial blood sugar content 0.11-0.12 %; Maximum blood sugar content after the operation 0.16-0.20 %, the augmentation of the blood sugar content due

to the control operation 0.04–0.09 %, the time to the maximum blood sugar after the control operation $\frac{1}{3}$ –1 hour; minimum blood sugar content 0.09–0.11 %, the diminution 0.00–0.03 %, the time to it after the control operation 4–9 hours. These results agree nearly with those of the control experiments in the former chapter.

On the day of the ligation of the renal vessels: Sixteen examples. Initial blood sugar content 0.08–0.14 %, on an average 0.11 %; Maximum blood sugar content after the ligation 0.14–0.27 %, on an average 0.19 %; the augmentation due to the procedure 0.03–0.15 %, on an average 0.08 %; the time to the maximum blood sugar content after the ligation $\frac{1}{3}$ –1 hour; the duration of the hyperglycaemia 1–5.5 hours, on an average 2.5 hours (except Nos. 1 and 12). These numbers agree fully with the results in the control experiments in the foregoing chapter as well as in this chapter. The five examples (Nos. 12–16), where the control as well as the principal experiment was made on one and the same individual, show more definitively that the scale of the hyperglycaemia after the ligation of the renal vessels is almost exactly the same as that after the control operation.

In some cases, the blood sugar content decreased later (in 4–10 hours after the procedure), but only little. The diminution did not exceed 0.05 %. Such a scale of diminution was detected also after the control operation.

Supposing U. Rose's¹⁾ finding (the hyperglycaemia after nephrectomy, etc.) as not to be due to the elimination of the kidneys, but merely to the operation shock, narcosis and bleeding themselves, E. Neubauer²⁾ maintained to find the hypoglycaemia in nephrectomized rabbits, directly contrary to Rose. He experimented only on three rabbits. And only in one case, the blood sugar content in twelve hours after the operation was a little smaller than the initial value. In the remaining two, there was no change in the blood sugar content. Whether his hypoglycaemia is of the same nature as those after the control operation as well as the ligation of the renal vessels (generally speaking, after an operation of any sort or other certain manipulations) or due to any other circumstances cannot be decided here. At any rate this hypoglycaemia cannot be regarded as a sequence of the elimination of the kidney function.

On the second day: In the forenoon, the blood sugar content was in physiological limit.

In two cases (Nos. 1 and 2), it was 0.07 %. No. 1 was a solely exceptional case, which showed no inclination of the increase of the blood sugar content till death. (The blood sugar content on the third day was a little higher than on the second day.) No. 2 with No. 16 showed a distinct hyperglycaemia first on the day previous to death.

1) U. Rose, Schmiedeberg's Archiv, 1903, 50, 15.

2) E. Neubauer, Bioch. Ztschr., 1910, 25, 284.

In the afternoon, it began to increase already in most cases, though only a little. In nine cases out of sixteen, it became 0.14-0.28 %.

On the third day : In fourteen cases out of sixteen, the hyperglycaemia was clearly detected. In Nos. 4, 6, 8 and 10, which died during that night, and No. 11, which died the next morning, the hyperglycaemia was remarkably high (0.24-0.67 %). Minimum blood sugar content of the sixteen rabbits on the day was 0.10-0.59 %, on an average 0.21 %; Maximum value 0.11-0.67 %, on an average 0.25 %.

On the fourth day : In eight cases out of eleven (except Nos. 1, 2 and 12), hyperglycaemia was quite remarkable (0.26-1.11 %). That of No. 7 was really over one percent. That of Nos. 2 and 12 was 0.15 % and 0.14 %.

No. 1, which died this night, not only showed no hyperglycaemia till death, but sometimes also an inclination to hypoglycaemia. This exception may be due, therefore, to an insufficiency of the glycogen store. The blood sugar value on the third day may be taken as a token of a tendency to hyperglycaemia, though forced.

On the fifth day : Nos. 2 and 12, which showed a hyperglycaemia of a low degree till the fourth day, revealed a somewhat distinguished one in the afternoon of their last day (0.30 % and 0.19 %). The blood sugar content of the remaining two was 0.32 and 0.33 %.

So, immediately after the bilateral ligation of the renal vessels, the blood sugar content of the rabbits increased a little (0.03-0.15 %), temporarily. This temporary hyperglycaemia is, however, nothing other than the operation and "Fesselung" hyperglycaemia. After the lapse of one to two days after the ligation, the blood sugar content began to increase. The increase was rather slow, but steady. While in half of the cases, it increased till the death of the animal (blood samples were drawn every three to six hours), in the other half, in some hours before the death, it began to decrease a little. In fifteen cases out of sixteen (except No. 1, which revealed no hyperglycaemia), the maximum blood sugar value was 0.19-1.11 %, on an average 0.43 %.

U. Rose estimated the blood sugar content of twelve rabbits, of which the renal vessels were extraperitoneally tied round, as 0.126-0.366 %, on an average 0.507 % in 1-3½ hours after the ligation. In No. 43, he found it also to be 0.353 % in 6 hours after the ligation. The initial value of the blood sugar content was determined in four of these cases. The excess of the blood sugar content after the ligation over the initial value was 0.04-0.25 %, on an average 0.125 %. The degree of hyperglycaemia in his cases was distinctly greater than in my cases (the hyperglycaemia immediately after the ligation). The difference may presumably be due to a light narcosis, bleeding, etc. in his experiments. He observed also a decrease of the hyperglycaemia in the course of time (No. 36). As a control experiment, he made a ligation of the femoral vessels. No clear evidence of the

hyperglycaemia was detectable there.

But, the temporary hyperglycaemia immediately after the ligation of the renal vessels is nothing other than the operation-fixing-hyperglycaemia, as already clearly illustrated above.

The body temperature decreased a little temporarily ($0.2-1.9^{\circ}\text{C}$, on an average 1.3°C). This is also due to the operation itself. On the next day, it remained as usually normal; from the third day it descended gradually till the death of the animal. Roughly speaking, the blood sugar level ascended as the body temperature descended. Comparing the results on the last days in this experiment with the cases of the hyperglycaemia of central mechanism, the hyperglycaemia of the former is of a quite different degree to that in the latter, while the temperature fall is of nearly the same scale in both of them.

The body temperature descended below 30°C ., only in one case out of sixteen.

R. v. Limbeck¹⁾ observed also the body temperature fall on the bilaterally nephrectomized dogs; T. Itakura³⁾ paid attention to the body temperature fall of rabbits after the ligation of the renal arteries or veins.

(b) The ligation of the renal veins only.

U. Rose,³⁾ as well as T. Itakura²⁾, found that the carbohydrate metabolism is highly affected by the ligation of the renal veins, but not by that of the corresponding arteries. The fact seems quite beyond doubt, and of great interest.

TABLE
The blood sugar content of the normal rabbit

No.	Date	Body weight (kilos)	Initial blood sugar (%)	Max. blood sugar after ligation (%)	Hours after ligation to the max. b.s.	Duration of hyperglycaemia (hours)	Min. blood sugar after ligation (%)
1	14. VII. 1919	1.40	0.10	0.33	2 $\frac{5}{8}$	7	0.09
2	16. VII. "	1.69	0.12	0.45	5	10	0.08
3	16. VII. "	1.07	0.11	0.32	{ 1 1 $\frac{1}{2}$ 4	5	0.10
4	22. VII. "	2.04	0.10	0.45	5	8	0.13
5	22. VII. "	1.17	0.11	0.21	2 $\frac{1}{4}$	6	0.11
6	20. III. "	1.77	0.12	0.37	5	>9	0.19
7	13. X. "	1.88	0.12	0.22	{ 1 2	5	0.13

1) R. v. Limbeck, Schmiedeberg's Archiv, 1892, **30**, 184.

2) T. Itakura, Mitteil. med. Fakult. Univers. Tokyo, 1915, **15**, 197.

3) U. Rose, Schmiedeberg's Archiv, 1913, **50**, 15.

The finding of the former is restricted, however, to a few hours after the ligation, while the latter observed the blood sugar content till the death of the animals. Both agreed in finding a hyperglycaemia of a much greater degree some hours immediately after the ligation of the renal veins, but Itakura found also again a severe hyperglycaemia in later days, compared with cases of the arterial ligation. They, especially Itakura, suggested that this event should be illustrated by the absence of the endocrinological function of the kidney.

Looking at it from the endocrinological point of view, the bilateral ligation of the renal vessels (artery and vein altogether) should yield exactly the same result as that of the renal veins only.

Yet, my finding, that the temporary hyperglycaemia after the ligation of the renal vessels is merely evoked by the fixing of the animals and the operation itself, seems not to coincide closely with this assumption.

One half of the protocols of Rose confirms this assumption, but the other half denies it.

V.

after the ligation of renal veins only on both sides.

Hours after ligation to the min. b.s.	On the next day				On the 3rd day			
	Body weight (kilos)	Min. blood sugar (%)	Max. blood sugar (%)	Min. body temp. (°C.)	Body weight (kilos)	Min. blood sugar (%)	Max. blood sugar (%)	Min. body temp. (°C.)
11	1.34	0.12	0.15	38.3	1.33	0.13	0.15	38.2
12	1.56	0.06	0.10	37.6				
11	1.06	0.08	0.13	37.1	1.04	0.16	0.21	33.7
11	1.88	0.14	0.19	38.3	1.85	0.19	0.23	37.6
		On the 4th day . . .			1.78	0.23	0.27	36.6
7	1.11	0.08	0.11	38.6	1.03	0.12	0.15	38.1
9	1.71	0.12	0.13	38.3	1.63	0.20	0.35	37.0
7	1.79	0.15	0.16	38.2	1.72	0.14	0.19	37.5
		On the 4th day . . .			1.67	0.15	0.16	36.1

To test the correctness of their hypothesis, we must analyse the fact more clearly.

EXPERIMENT IV.

Date	Body weight (kilos)	Time	Blood sugar (%)	Body temperature (°C.)
22. VII. 1919	2.04	7.30 A.M.	0.10	38.6
		8.30	0.10	38.6
		8.38	Fixed on the table. Ligation of renal veins. Set free.	
		8.42-8.58		
		9.00		
		9.10	0.16	37.2
		10.00	0.26	36.0
		11.00	0.31	35.6
		12.00 M.	0.41	35.9
		1.00 P.M.	0.40	36.3
		2.00	0.45	36.5
		3.00	0.42	36.6
		4.00	0.34	36.8
		6.00	0.23	37.2
		8.00	0.13	36.7
23. VII. "	1.88	8.00 A.M.	0.14	38.4
		11.30	0.18	38.3
		3.00 P.M.	0.19	38.3
		6.30	0.14	38.1
24. VII. "	1.85	7.30 A.M.	0.19	38.1
		11.00	0.23	37.6
		2.30	0.22	38.3
		6.00	0.22	38.3
25. VII. "	1.78	11.00 A.M.	0.24	37.2
		2.30 P.M.	0.23	36.8
		6.00	0.27	36.6
		10.45	Died.	

EXPERIMENT VI.

Date	Body weight (kilos)	Time	Blood sugar (%)	Body temperature (°C.)
19. III. 1919	1.75	10.20 A.M.	0.12	38.4
		11.00	0.12	38.5
		11.10	Fixed on the table.	
		11.13-11.38	Control operation.	
		11.40	Set free.	
		12.00 M.	0.18	36.9
		1.00 P.M.	0.15	37.7
		2.00	0.13	38.1
		3.00	0.13	38.2
		5.00	0.13	38.9
		7.00	0.11	39.2
20. III. „	1.77	8.10 A.M.	0.12	38.5
		9.30	0.12	38.5
		9.40	Fixed on the table.	
		9.42-9.54	Ligation of renal veins.	
		9.55	Set free.	
		10.00	0.17	37.4
		11.00	0.23	37.3
		12.10 P.M.	Haematic urine (40 c.c.) is purged.	
		1.00	0.33	37.7
		3.00	0.37	38.0
		5.00	0.27	38.7
21. III. „	1.71	7.00	0.13	38.9
		8.30 A.M.	0.13	38.3
		12.00 M.	0.13	38.3
		6.00 P.M.	0.12	38.5
		22. III. „	1.63	8.30 A.M.
12.10 P.M.	0.24			37.9
3.10	0.31			37.6
7.10	0.35			37.0
Died in the night.				

On the day of the ligation of the renal veins : Seven rabbits. Immediately after the ligation began an increase of the blood sugar content and reached the maximum (0.21-0.45 %, on an average 0.33 %) in one to five hours (on an average three hours) after the ligation. The duration of the hyperglycaemia was five to nine hours, on an

average seven hours. In six cases, except No. 6, the blood sugar value returned nearly to its initial value in seven to twelve hours after the ligation. In one of them (No. 2), there was detectable a tendency to hypoglycaemia.

The degree and duration of the hyperglycaemia was much greater than those in the control experiments, differing from the cases of the ligation of the renal vessels.

In one case (No. 6), a control experiment was made on the day previous to the principal one. The result was on a quite different scale compared with that on the following day.

On the next day: In three cases, there was a tendency to hyperglycaemia, though only a little. No. 2 showed a hypoglycaemia and died later in the afternoon.

On the third day: Minimum blood sugar content 0.12–0.20 %, on an average 0.15 %; maximum value 0.15–0.35 %, on an average 0.21 %. Half of them showed a somewhat marked hyperglycaemia.

On the fourth day: Four rabbits lived till this day, but one of them (No. 5) died early in the morning. The minimum blood sugar content was 0.06–0.23 %, the maximum value 0.16–0.27 %.

So, on the whole, as the results of the ligation of the renal vessels, there was hyperglycaemia in two periods, i.e. immediately after the ligation, and on the last days. *But there was a remarkable difference in the severity and duration of the temporary hyperglycaemia in the two kinds of ligation.* The average numbers of them are as follows:

Normal rabbits

Bilateral ligation of	Blood sugar content		Hours to the maximum blood sugar	Duration (hours) of hyperglycaemia
	Before the ligation	After the ligation (max.)		
Renal vessels	0.11 %	0.19 %	1.5	2.5
Renal veins	0.11 %	0.23 %	3	7

Apparently this result seems to coincide with those of Rose and Itakura concerning a special significance of the ligation of the renal veins upon the carbohydrate metabolism, contrary to the corresponding arteries.

From the endocrinological point of view, however, the ligation of the renal vessels (artery and vein altogether) should have exactly the

same significance as that of the renal veins in this respect. But the above experimental data do not show it.

Rose himself tried the ligation of the renal vessels, but his results are not conclusive, as has already been pointed out.

Moreover, the fact that the hyperglycaemia in this period begins immediately after the ligation and is really a temporary one, though the duration is somewhat long, does not harmonize with such an endocrinological hypothesis.

The course of hyperglycaemia on the last days till death of the animals was of quite the same type as that after the ligation of the renal vessels, merely in a smaller degree.

The maximum blood sugar content of each rabbit on its last days was 0.15-0.35 %, on an average 0.23 %. No. 2 is excluded here, because it showed no hyperglycaemia, but often hypoglycaemia.

This difference of the degrees of hyperglycaemia will be discussed later.

The body temperature-fall was also observed, really first immediately after the ligation (0.5-2.5° C. in $\frac{1}{4}$ -1 $\frac{1}{2}$ hours after the ligation, and it had already begun to recover when the blood sugar content was on the top and finally entirely recovered that evening) and on the last days. That on the last days was somewhat smaller in comparison with that after the ligation of the renal vessels.

IV. THE BLOOD SUGAR CONTENT OF THE BILATERALLY SPLANCHNECTOMIZED RABBIT AFTER THE LIGATION OF THE RENAL VESSELS ON BOTH SIDES.

To know the nature of the hyperglycaemia on the last days after the ligation of the renal vessels as well as of the renal veins alone, and further, that of the especially higher hyperglycaemia immediately after the ligation of the renal veins alone, some experiments of the same kind were repeated on bilaterally splanchnectomized rabbits.

An experiment of such a nature was attempted only by H. F. Grünwald, who studied the diminution or disappearance of the liver glycogen store by nephrectomy, etc. He observed that the diminution of the liver glycogen could not be prevented by splanchnectomy. Unfortunately, however, being led by an opinion prevailing at that time, he divided the left splanchnic nerve alone. Nowadays no one believes that the glycogenolytic fibres are contained solely in the left splanchnic.

Whether a kind of hyperglycaemia is of central mechanism or not is decided by bilateral splanchnectomy.

In former times, one believed that the picture hyperglycaemia could be entirely pre-

vented by the section of the splanchnics. Taking advantage of recent advancements of the technics, however, it was settled, that the fixing-hyperglycaemia can be evoked in bilaterally splanchnectomized rabbits, though only a mere trace.¹⁾ It is needless to say here, that fixing-hyperglycaemia is essentially of central mechanism.

The significance of this trace of hyperglycaemia will be discussed in the future in another place.

(a) The ligation of the arteries and veins.

On seven rabbits out of twelve, the control experiment was made on the day previous to the principal experiment.

TABLE
The blood sugar content of the bilaterally splanchnectomized

No.	Control experiment						Principal				
							On the 1st day				
	Body weight (kilos)	Initial blood sugar (%)	Maximum b. s. after operation (%)	Hours after operation to the max. b. s.	Minimum b. s. after operation (%)	Hours after operation to the min. b. s.	Date	Body weight (kilos)	Initial blood sugar (%)	Maximum b. s. after ligation (%)	Hours after ligation to the max. b. s.
1							3. X. 1918	1.90	0.10	0.13	½
2							21. X. "	1.70	0.10	0.12	{ ⅔ 1½
3							14. XI. "	2.06	0.11	0.14	¼
4							17. I. 1919	1.80	0.10	0.12	¾
5							20. I. "	2.16	0.11	0.14	{ ½ 1
6	1.45	0.11	0.12	¾	0.10	2¾	16. XI. 1921	1.46	0.11	0.15	9
7	1.87	0.10	0.12	4½	0.10	9	16. XI. "	1.96	0.10	0.11	{ 1½ 1½
8	2.07	0.10	0.12	{ ⅝ 1½	0.09	8½	22. XI. "	2.14	0.11	0.14	7
9	1.57	0.11	0.13	½	0.10	8½	22. XI. "	1.64	0.11	0.12	{ ⅝ 1¾
10	2.00	0.10	0.12	1	0.10	5	25. XI. "	2.05	0.11	0.12	{ 1 2
11	1.76	0.10	0.12	¾	0.09	5¾	29. XI. "	1.85	0.09	0.11	{ ⅔ 1¼
12	1.56	0.10	0.11	2½	0.09	5½	29. XI. "	1.61	0.08	0.10	{ 1½ 3½

EXPERIMENT VII.

Date	Body weight (kilos)	Time	Blood sugar (%)	Body temperature (°C.)
24. X. 1921	1·81	Bilateral splanchnectomy.		
15. XI. "	1·87	9.00 A.M.	0·10	39·2
		9.45	Fixed on the table. Control operation. Set free.	
		9.48-10.00		
		10.02		
		10.30	0·11	38·3
		11.30	0·11	38·4
		12.30 P.M.	0·11	38·5
		3.30	0·12	38·9
		4.30	0·11	39·1
		7.00	0·10	39·5

(continued on p. 250)

VII.

rabbit after the ligation of the renal vessels on both sides.

experiment

		On the 2nd day				On the 3rd day				On the 4th day			
Minimum b.s. after ligation (%)	Hours after ligation to the min. b. s.	Body weight (kilos)	Minimum blood sugar (%)	Maximum blood sugar (%)	Minimum body temp. (°C.)	Body weight (kilos)	Minimum blood sugar (%)	Maximum blood sugar (%)	Minimum body temp. (°C.)	Body weight (kilos)	Minimum blood sugar (%)	Maximum blood sugar (%)	Minimum body temp. (°C.)
0·10	7	1·78	0·10	0·10	37·5	1·75	0·11	0·12	36·5	1·74			
0·09	3	1·62	0·10	0·10	37·4	1·58	0·10	0·13	36·1	1·55	0·15	0·22	31·4
0·10	3	1·98	0·12	0·14	38·4	1·95	0·25	0·35	35·2	1·94	0·24	0·30	34·0
0·10	3	1·70	0·12	0·14	37·2	1·67	0·21	0·21	29·1				
0·12	5	2·00	0·11	0·12	38·5	1·97	0·12	0·14	37·5	1·92	0·16	0·23	33·1
0·10	4												
0·10	2	1·81	0·13	0·16	37·3	1·78	0·21	0·26	32·4				
0·10	5												
0·09	9	1·55	0·10	0·13	36·3	1·45	0·15	0·23	32·0				
0·09	7	1·89	0·12	0·14	38·0	1·77	0·18	0·22	36·3	1·69	0·18	0·32	34·0
0·09	5	1·70	0·12	0·23	37·8	1·68	0·18	0·22	34·0	1·61	0·26	0·32	31·5
0·09	5	1·68	0·09	0·14	37·7	1·53	0·11	0·14	34·8	1·45	0·14	0·15	31·0

Date	Body weight (kilos)	Time	Blood sugar (%)	Body temperature (°C.)
16. XI. 1921	1.96	9.00 A.M.	0.10	39.2
		9.40	Fixed on the table.	
		9.42-9.50	Ligation of renal vessels.	
		9.51	Set free.	
		10.20	0.11	38.2
		11.20	0.11	38.7
		12.00 M.	0.10	38.9
		2.00 P.M.	0.10	39.0
		4.30	0.11	39.3
		7.00	0.10	39.2
17. XI. „	1.81	9.00 A.M.	0.15	37.8
		12.00 M.	0.16	37.5
		4.00 P.M.	0.16	37.3
		8.00	0.13	36.9
18. XI. „	1.78	9.00 A.M.	0.21	32.5
		12.00 M.	0.26	33.2
		5.00 P.M.	0.26	32.5
		8.00	0.23	32.4
		Died in the night.		

In the control experiments: The increase of the blood sugar content after the operation was very little (0.10-0.11 % $\rightarrow$ 0.11-0.13 %), and in three to nine hours after the operation it decreased also a very little (to 0.08-0.10 %).

On the day of the ligation: The fluctuation of the blood sugar level after the ligation was exactly the same as that on the previous day.

Nos. 6 and 8, of which the blood sugar niveau returned to its initial value after a very slight ascent, showed a tendency to hyperglycaemia first in about seven hours after the ligation, and died during the night.

On the second day: In one of ten rabbits, there was a hyperglycaemia of a high degree, while in the other six rabbits there was detectable a tendency to hyperglycaemia.

On the third day: In six of ten rabbits, the hyperglycaemia became very marked (0.21-0.35 %), while in the remaining four the blood sugar content was still 0.12-0.14 %.

No. 1 showed scarcely any increase of the blood sugar content till death.

On the fourth day: In four of the five still living rabbits, the hyperglycaemia was distinct (0.32-0.22 %); in No. 12 it was 0.15 %. All the rabbits died in the afternoon or during the night.

Thus, on the one hand, the hyperglycaemia immediately after the ligation of the renal vessels was reduced nearly to nil. So, it is of cent-

EXPERIMENT X.

Date	Body weight (kilos)	Time	Blood sugar (%)	Body temperature (°C.)
7. XI. 1921	1.98	Bilateral splanchnectomy.		
24. XI. "	2.00	9.00 A.M.	0.10	38.7
		9.15	Fixed on the table.	
		9.18-9.30	Control operation.	
		9.31	Set free.	
		10.30	0.12	36.7
		11.30	0.11	37.4
		12.30 P.M.	0.11	37.8
		2.30	0.10	38.9
		4.30	0.11	38.9
		7.00	0.15	38.9
25. XI. "	2.05	9.00 A.M.	0.11	38.9
		9.15	Fixed on the table.	
		9.16-9.25	Ligation of renal vessels.	
		9.26	Set free.	
		10.30	0.12	37.2
		11.30	0.12	37.4
		12.30 P.M.	0.11	37.8
		2.30	0.10	38.2
		4.30	0.09	38.6
		7.00	0.10	38.8
26. XI. "	1.89	9.00 A.M.	0.13	38.1
		12.00 M.	0.14	38.1
		3.30 P.M.	0.12	38.0
		7.00	0.14	38.0
27. XI. "	1.77	9.00 A.M.	0.18	36.7
		12.00 M.	0.19	36.5
		4.00 P.M.	0.22	36.3
		8.00	0.21	36.3
28. XI. "	1.69	9.00 A.M.	0.28	34.7
		12.00 M.	0.32	34.6
		3.00 P.M.	0.30	34.2
		8.00	0.18	34.0
		Died in the night.		

ral mechanism. In the nature of things it must be so, for it is nothing other than the operation-fixing hyperglycaemia.

On the other hand, the hyperglycaemia on the last days remained still in a high degree. Its degree in these cases was, however, somewhat inferior to that in normal rabbits (the maximum value of these was 0.19-1.11 %, on an average 0.43 %).

Whether the smallness of the liver glycogen store of the bilaterally

splanchnectomized rabbit, though not distinctly¹⁾, ought to be held responsible for this difference in the degree of hyperglycaemia on the two kinds of rabbit cannot be definitively decided here. It is yet highly probable that the hyperglycaemia on the last days is mainly or entirely of a certain origin other than the central. (See also p. 256.)

That the discontinuation of the excretion of sugar by the urine due to the ligation of the renal vessels cannot be responsible for the hyperglycaemia on the last days can be easily understood.

The course of the body temperature after the ligation was of exactly the same type and scale as that in normal rabbits. Only the body temperature-fall on the last days seems a little larger than that of the latters.

(b) The ligation of the veins alone.

The control observation (a silk thread was passed closely under the vein alone.) was made in every experiment.

TABLE
The blood sugar content of the bilaterally splanchnectomized

No.	Control experiment						On the 1st day					
	Body weight (kilos)	Initial blood sugar (%)	Maximum b. s. after operation (%)	Hours after operation to the max. b. s.	Minimum b. s. after operation (%)	Hours after operation to the min. b. s.	Date	Body weight (kilos)	Initial blood sugar (%)	Maximum b. s. after ligation (%)	Hours after ligation to the max. b. s.	
1	1.85	0.08	0.11	$\frac{1}{4}$	0.09	2	4. XI. 1919	1.83	0.10	0.14	$1\frac{1}{4}$	
2	2.01	0.09	0.12	$\frac{1}{3}$	0.10	3	4. XI. „	2.03	0.08	0.11	$\frac{1}{4}$	
3	2.37	0.10	0.13	$\frac{1}{2}$	0.10	8	11. XI. „	2.35	0.10	0.14	$3\frac{1}{2}$	
4	1.97	0.12	0.14	$\frac{1}{3}$	0.11	6	17. XI. „	1.87	0.12	0.16	5	
5	1.76	0.13	0.14	$\frac{1}{3}$	0.12	6	18. XI. „	1.82	0.14	0.17	2	

1) Sachi. Morita, Tohoku Journ. of Exp. Med., 1921, 2, 436.

EXPERIMENT II.

Date	Body weight (kilos)	Time	Blood sugar (%)	Body temperature (°C.)
17. VI. 1919	1.67	Bilateral splanchnectomy.		
3. XI. "	2.01	8.40 A.M.	0.10	38.6
		10.40	0.09	38.6
		10.55	Fixed on the table.	
		10.58-11.17	Control operation.	
		11.20	Set free.	
		11.40	0.12	37.5
		12.40 P.M.	0.11	37.6
		1.40	0.11	37.7
		2.40	0.10	38.0
		3.40	0.10	38.4
		5.40	0.10	38.9
		7.40	0.10	39.0

(continued on p. 254)

IX.

rabbit after the ligation of renal veins only on both sides.

Principal experiment

		On the 2nd day				On the 3rd day				On the 4th day			
Minimum b. s. after ligation (%)	Hours after ligation to the min. b. s.	Body weight (kilos)	Minimum blood sugar (%)	Maximum blood sugar (%)	Minimum body temp. (°C.)	Body weight (kilos)	Minimum blood sugar (%)	Maximum blood sugar (%)	Minimum body temp. (°C.)	Body weight (kilos)	Minimum blood sugar (%)	Maximum blood sugar (%)	Minimum body temp. (°C.)
0.11	4¼	1.74	0.13	0.16	35.8	1.67	0.16	0.20	36.1				
0.09	1¼	1.96	0.11	0.13	38.7	1.90	0.13	0.15	38.1	1.89	0.12	0.14	36.9
						On the 5th day	1.76	0.15	0.17	1.76	0.15	0.17	35.8
						On the 6th day	1.60	0.20	0.25	1.60	0.20	0.25	34.9
						On the 7th day	1.50	0.19	0.34	1.50	0.19	0.34	33.2
						On the 8th day	1.41	0.20	0.22	1.41	0.20	0.22	31.7
0.11	½	2.27	0.09	0.11	38.2	2.23	0.12	0.15	37.2	2.21	0.15	0.19	35.6
0.13	½	1.86	0.13	0.15	38.6	1.83	0.16	0.17	36.5	1.65	0.39	0.41	27.5
0.13	9	1.64	0.15	0.16	39.2	1.63	0.13	0.17	37.9	1.62	0.17	0.18	37.6

Date	Body weight (kilos)	Time	Blood sugar (%)	Body temperature (°C.)
4. XI. 1919	2.03	8.40 A.M.	0.08	39.0
		9.15	Fixed on the table.	
		9.16-9.24	Ligation of renal veins.	
		9.25	Set free.	
		9.40	0.11	38.5
		10.40	0.09	38.9
		11.40	0.09	39.0
		12.40 P.M.	0.11	39.5
		1.40	0.10	39.5
		2.40	0.10	39.9
		4.40	0.09	39.9
		6.40	0.11	40.1
5. XI. "	1.96	8.10 A.M.	0.12	38.8
		11.10	0.12	38.7
		2.10 P.M.	0.13	38.7
		5.10	0.11	38.8
6. XI. "	1.90	8.10 A.M.	0.13	38.1
		11.10	0.14	38.9
		2.10 P.M.	0.15	39.0
		5.10	0.13	38.9
7. XI. "	1.89	8.40 A.M.	0.12	37.2
		11.10	0.12	37.1
		2.10 P.M.	0.14	36.9
		5.10	0.14	37.0
8. XI. "	1.76	8.10 A.M.	0.15	35.9
		11.40	0.17	35.8
		5.40 P.M.	0.17	36.9
9. XI. "	1.60	8.30 A.M.	0.20	35.4
		12.30 P.M.	0.22	34.9
		5.30	0.25	34.9
10. XI. "	1.50	8.30 A.M.	0.33	33.2
		12.10 P.M.	0.34	33.7
		6.30	0.19	33.5
11. XI. "	1.41	8.00 A.M.	0.20	31.7
		12.30 P.M.	0.22	31.7
		5.30	Died.	

EXPERIMENT IV.

Date	Body weight (kilos)	Time	Blood sugar (%)	Body temperature (°C.)
10. XI. 1919	1·86	Bilateral splanchnectomy.		
16. XI. "	1·97	2.00 P.M.	0·12	39·5
		2.40	0·12	39·5
		2.50	Fixed on the table.	
		2.53-3.18	Control operation.	
		3.20	Set free.	
		3.40	0·14	38·6
		4.30	0·13	38·4
		5.30	0·12	38·3
		7.30	0·13	39·4
		9.30	0·11	39·2
17. XI. "	1·87	8.10 A.M.	0·12	39·5
		8.40	Fixed on the table.	
		8.41-8.52	Ligation of renal veins.	
		8.55	Set free.	
		9.00	0·13	38·8
		10.00	0·13	38·4
		11.00	0·14	38·7
		12.00 M.	0·15	38·9
		1.00 P.M.	0·14	39·3
		2.00	0·16	39·4
		4.00	0·14	39·7
		6.00	0·13	39·9
18 XI. "	1·86	8.40 A.M.	0·13	39·1
		12.10 P.M.	0·15	38·9
		3.10	0·15	38·6
		6.10	0·14	38·6
19. XI. "	1·83	8.40 A.M.	0·16	37·6
		11.40	0·17	37·1
		2.40 P.M.	0·16	37·0
		5.40	0·17	36·5
20. XI. "	1·65	8.40 A.M.	0·39	33·4
		11.40	0·39	32·3
		2.40 P.M.	0·40	30·1
		5.40	0·41	27·5
		6.10	Died.	

The variation of the blood sugar content after the control operation and that after the ligation of the renal veins alone on the next day may be compared in the following table:

	Initial blood sugar content	Maximum blood sugar content	Duration of hyperglycaemia
Control experiments	0.10% (0.08–0.13%)	0.13% (0.11–0.14%)	5 hours (2–8.5 hrs.)
Princip. experiments	0.11% (0.08–0.14%)	0.14% (0.11–0.17%)	3 hours (0.5–9 hrs.)

Therefore, there was no difference between the results in both kinds of experiment.

So, bilateral splachnectomy can abolish a marked hyperglycaemia after the ligation of the renal veins alone, without leaving any trace. Thus, this hyperglycaemia must be ranged also in that of central mechanism. The afferent path in the mechanism of this case will be fully illustrated in the next chapter of this essay.

On the second day: In three out of the five rabbits, there was an indication of hyperglycaemia.

On the third day: The hyperglycaemia was detected in all of them and the degree of hyperglycaemia increased a little. One rabbit died during the night.

On the fourth day: The hyperglycaemia became more evident (0.14–0.41 %, on an average 0.23 %). Three rabbits died this afternoon or during the night.

No. 2 lived extraordinarily long, i. e. eight days after the ligation. Its blood sugar already began to increase on the day following the ligation, but the velocity of the increase was very slow till the fifth day. On the sixth day it reached 0.22 %, on the seventh day 0.34 %, and on the last (eighth) day it was reduced somewhat (0.20–0.22 %). The autopsy showed neither failure of the ligation nor any other abnormality.

Of the five rabbits in this series of experiment, the maximum blood sugar value on the last days was 0.18–0.41 %, on an average 0.26 %.

This value agrees entirely with that of normal rabbits after the same ligation (0.15–0.35 %, an average 0.28 %). This comparison seems to verify the conclusion that the central mechanism has no share in the hyperglycaemia on the last days after the ligation of the renal veins.

The hyperglycaemia on the last days after the ligation of the renal veins alone seems of a somewhat smaller degree on the normal rabbit, in comparison with that of the renal vessels. (p. 247).

Though it may be supposed, that the marked hyperglycaemia immediately after this ligation could evoke this result, I am not in a situation to decide this question, for as yet we do not know the fate of this excess of the blood sugar in the animal, of which the urinary function has been removed.

In comparison with that of normal rabbits after the same ligation, the body temperature-fall immediately after the ligation was a little smaller, while that on the last days was somewhat greater than the former and about the same as that after the ligation of the renal vessels in normal as well as splanchnectomized ones.

Probably, such a small difference of the body temperature-fall has no special significance.

V. THE BLOOD SUGAR CONTENT OF THE RABBIT, OF WHICH THE KIDNEYS WERE PREVIOUSLY DENERVATED, AFTER THE LIGATION OF THE RENAL VEINS.

Notwithstanding the hyperglycaemia immediately after the ligation of the renal veins alone as of the renal vessels (artery and vein together) is alike of central mechanism, in point of degree the former exceeds by far the latter.

That this fact cannot be understood absolutely by endocrinological point of view has been already exhausted.

In the first place, it was called to mind, that in the case of the ligation of the renal vein alone, the renal nerve plexus remains nearly intact, the capillary pressure in the kidney becomes exceedingly high, and consequently the kidney capillaries extend greatly; while in that of the renal vessels or artery only, the conductivity of the renal nerve fibres is lost at the place of ligation.

Then such a supposition may be made, viz. that the sensible nerve endings in the kidney (in the vessel wall, in the renal capsul, etc., etc.) may be stimulated mechanically (by the abnormal extension of the blood vessel wall) or chemically (by some abnormal metabolic products, due to the stand-still of the renal circulation—though not probable), and consequently that the afferent impuls may excite the central mechanism of the sugar regulation by way of the renal nerve fibres.

The nerve fibres run chiefly on the renal artery, as usual. O. Renner¹⁾ reported by a rather bibliographical study, that the renal plexus is formed mainly by the fibres from the semilunar ganglion and in a small part by the small branches given off from the upper mesenteric ganglion, supra-renal plexus, aortic plexus and splanchnic minor. In the kidney, end-organs of sensory nerve fibres were found in the adventitia and media of all the blood vessels, etc., etc.

To test this supposition, the ligation of the renal veins alone was carried out on rabbits, of which the renal nerve fibres were previously divided.

1) O. Renner, Deutsch. Archiv. f. klin. Med., 1913, **110**, 101.

H. F. Grünwald¹⁾ detected the diminution or disappearance of the liver glycogen store of rabbits in 48-60 hours after the extraperitoneal nephrectomy (bilateral or of left side), the ligation of the renal arteries or the ureters, etc. under narcosis with morphine and ether. He came to the conclusion, that the diminution of the liver glycogen in this way is caused first by the action of a chemical agent on the liver, and secondly by the nervous path through the (left) renal nerve fibres to the liver, without passing through the centre. According to him, a lesion or section of the left renal nerves caused a temporary diminution of the liver glycogen content. His protocols do not agree closely with the statement. Furthermore, as he contended himself by dividing only the left splanchnic

TABLE

The blood sugar content of the rabbit, of which the kidneys had

No.	Date at the time of excision of renal plexus.	Body weight (kilos)	Control experiment							Date
			Body weight (kilos)	Initial blood sugar (%)	Maximum b. s. after operation (%)	Hours after operation to the max. b. s.	Duration of hypoglycaemia (hours)	Minimum b. s. after operation (%)	Hours after operation to the min. b. s.	
1	27. IX. 1919	2.26	2.34	0.13	0.25	1½	1½	0.12	3½	18. X. 1919
2	27. IX. "	1.93	1.94	0.11	0.20	¼	3¼	0.12	4¼	18. X. "
3	9. XI. "	1.92	1.94	0.11	0.30	½	4	0.10	5½	16. XII. "
4	18. XII. "	1.86	1.73	0.13	0.23	⅓	6	0.13	8½	18. I. 1920
5	18. XII. "	1.95	1.60	0.13	0.17	⅓	3	0.11	6½	22. II. "
6	26. I. 1920	1.70	2.04	0.11	0.14	4¼	6	0.11	8¼	24. II. "
7	26. I. "	2.09	2.02	0.13	0.22	¼	3¼	0.08	6¼	2. III. "
8	3. III. "	1.88	2.03	0.12	0.21	½	2½	0.13	4⅓	20. IV. "
9	3. III. "	1.65	1.41	0.12	0.25	⅓	4	0.11	8	23. IV. "
10	3. III. "	1.64	1.58	0.11	0.23	¼	3	0.12	3¼	2. V. "

1) H. F. Grünwald, Schmiedeberg's Archiv, 1914, 64, 147.

nerve instead of the bilateral splanchnectomy, as already mentioned, he was compelled to assume such a strange nerve route, though it seems apparently a little analogous to the so-called "axon" reflex.

On the day previous to the principal experiment, the control experiment was carried out on every rabbit. A silk thread was passed under the renal vein alone closely, but not tied. On the next day, the wound was opened and the thread was now tied round.

XI.

been previously denervated, after the ligation of the renal veins.

Principal experiment

On the 1st day							On the 2nd day			On the 3rd day		
Body weight (kilos)	Initial blood sugar (%)	Maximum b. s. after ligation (%)	Hours after ligation to the max. b. s. (%)	Duration of hy- perglycemia (hours)	Minimum b. s. after ligation (%)	Hours after ligation to the min. b. s.	Body weight (kilos)	Maximum blood sugar (%)	Minimum body temp. (°C.)	Body weight (kilos)	Maximum blood sugar (%)	Minimum body temp. (°C.)
2.41	0.12	0.35	$\begin{pmatrix} 2 \\ 3 \end{pmatrix}$	6	0.14	7	2.25	0.19	38.4	2.23	0.22	37.0
							On the 4th day . . .	2.19	0.31	37.0		
							On the 5th day . . .	2.16	0.52	32.5		
2.04	0.12	0.18	$\frac{1}{12}$	$\frac{2}{3}$	0.12	1	1.96	0.14	38.7	1.95	0.15	38.1
							On the 4th day . . .	1.81	0.16	37.4		
							On the 5th day . . .	1.59	0.53	35.3		
							On the 6th day . . .	1.44	0.16	30.9		
1.98	0.11	0.19	$\begin{pmatrix} 1\frac{1}{2} \\ 3\frac{1}{2} \end{pmatrix}$	5	0.12	7	1.82	0.22	37.0	1.78	0.24	36.0
							On the 4th day . . .	1.73	0.23	34.8		
							On the 5th day . . .	1.69	0.39	29.4		
1.87	0.13	0.20	$\frac{1}{3}$	5	0.13	7	1.84	0.16	35.9	1.79	0.25	34.0
							On the 4th day . . .	1.73	0.52	32.0		
1.61	0.11	0.13	$\frac{1}{6}$	1	0.12	1	1.42	0.08	35.3			
2.21	0.11	0.12	$4\frac{1}{3}$	6	0.11	8	2.06	0.17	36.8	2.05	0.18	35.9
							On the 4th day . . .	1.95	0.17	35.6		
							On the 5th day . . .	1.63	0.34	25.2		
2.08	0.10	0.16	$\frac{1}{6}$	3	0.10	10	1.98	0.11	38.3	1.89	0.15	37.0
2.08	0.12	0.16	$1\frac{1}{3}$	3	0.10	7	1.96	0.17	37.4	1.88	0.20	36.2
							On the 4th day . . .	1.87	0.23	35.1		
							On the 5th day . . .	1.82	0.60	30.2		
1.45	0.13	0.45	$2\frac{1}{6}$	>9	0.16	9	1.29	0.19	37.6	1.22	0.27	36.0
							On the 4th day . . .	1.20	0.09	32.4		
1.67	0.12	0.20	$\frac{1}{4}$	5	0.12	7	1.61	0.15	38.0	1.62	0.17	37.4
							On the 4th day . . .	1.47	0.88	32.6		

EXPERIMENT II.

Date	Body weight (kilos)	Time	Blood sugar (%)	Body temperature (°C.)
27. IX. 1919	1.93	Excision of renal plexus.		
17. X. „	1.94	10.30 A.M.	0.11	38.6
		12.10 P.M.	0.11	38.6
		12.25	Fixed on the table. Control operation. Set free.	
		12.29-12.54		
		12.55		
		1.10	0.20	37.3
		1.40	0.15	38.0
		2.10	0.14	38.1
		2.40	0.14	38.2
		3.10	0.14	38.5
		4.10	0.13	38.9
		5.10	0.12	39.8
		6.10	0.13	39.8
		7.10	0.13	39.8
18. X. „	2.04	8.40 A.M.	0.12	39.2
		10.10	0.12	38.9
		10.18	Fixed on the table. Ligation of renal veins. Set free.	
		10.20-10.34		
		10.35		
		10.40	0.18	38.1
		11.10	0.14	38.3
		12.10 P.M.	0.12	38.9
		1.10	0.12	39.5
		2.10	0.14	39.7
		3.10	0.15	40.2
		4.10	0.13	40.2
		5.10	0.14	39.9
		7.10	0.13	39.4
		10.10	0.12	39.2
19. X. „	1.96	8.40 A.M.	0.13	39.1
		10.40	0.14	39.0
		2.40 P.M.	0.12	38.6
		5.40	0.12	38.7
20. X. „	1.95	8.10 A.M.	0.15	38.1
		11.10	0.14	38.1
		2.10 P.M.	0.15	38.7
		5.10	0.14	38.5
21. X. „	1.81	8.40 A.M.	0.16	37.4
		11.40	0.15	37.5
		2.40 P.M.	0.15	37.6
		5.40	0.15	37.8
22. X. „	1.59	8.30 A.M.	0.39	35.5
		11.30	0.49	35.3
		5.30 P.M.	0.53	35.3
23. X. „	1.44	9.00 A.M.	0.16	30.9
		10.17	Died.	

EXPERIMENT X.

Date	Body weight (kilos)	Time	Blood sugar (%)	Body temperature (°C.)
3. III. 1920	1.64	Excision of renal plexus.		
1. V. „	1.58	10.00 A.M.	0.11	38.0
		11.00	0.11	38.0
		11.10	Fixed on the table.	
		11.13-11.43	Control operation.	
		11.45	Set free.	
		12.00 M.	0.23	36.0
		1.00 P.M.	0.16	37.4
		2.00	0.15	38.2
		3.00	0.12	38.7
		5.00	0.12	38.9
		7.00	0.12	38.7
2. V. „	1.67	9.00 A.M.	0.12	38.5
		9.25	Fixed on the table.	
		9.28-9.43	Ligation of renal veins.	
		9.45	Set free.	
		10.00	0.20	38.1
		11.00	0.15	38.2
		12.00 M.	0.14	38.7
		1.00 P.M.	0.14	39.0
		3.00	0.13	39.3
		5.00	0.12	39.4
		7.00	0.12	39.5
3. V. „	1.62	8.00 A.M.	0.12	38.6
		12.00 M.	0.14	38.4
		3.30 P.M.	0.14	38.4
		7.00	0.15	38.0
4. V. „	1.61	8.00 A.M.	0.16	37.4
		12.00 M.	0.16	37.8
		3.00 P.M.	0.16	37.8
		7.00	0.17	37.7
5. V. „	1.47	8.30 A.M.	0.44	36.3
		12.00 M.	0.65	35.7
		3.30 P.M.	0.88	35.0
		7.00	0.27	32.6
		Died in the night.		

EXPERIMENT I.

Date	Body weight (kilos)	Time	Blood sugar (%)	Body temperature (°C.)
27. IX. 1919	2.26	Excision of renal plexus.		
17. X. "	2.34	10.00 A.M.	0.13	38.8
		11.00	0.13	38.8
		11.10	Fixed on the table. Control operation. Set free.	
		11.15-11.53		
		11.55		
		12.00 M.	0.25	37.2
		12.30 P.M.	0.23	37.8
		1.00	0.20	38.1
		1.20	0.14	38.5
		2.00	0.13	38.6
		3.00	0.12	38.7
		4.00	0.13	38.9
		5.00	0.12	39.3
		6.00	0.12	39.4
		7.00	0.12	39.5
18. X. "	2.41	8.30 A.M.	0.12	39.1
		9.30	0.12	39.1
		9.38	Fixed on the table. Ligation of renal veins. Set free.	
		9.40-9.58		
		9.59		
		10.00	0.21	38.4
		11.00	0.31	37.7
		12.00 M.	0.35	37.7
		1.00 P.M.	0.35	38.5
		2.00	0.26	38.9
		3.00	0.20	39.0
		4.00	0.16	39.2
		5.00	0.14	39.4
		7.00	0.14	39.3
		10.00	0.14	39.3
19. X. "	2.25	8.30 A.M.	0.19	38.4
		11.30	0.19	38.7
		2.30	0.18	38.9
		5.30	0.15	38.7
20. X. "	2.23	8.00 A.M.	0.19	37.3
		11.00	0.21	37.1
		2.00 P.M.	0.21	37.3
		5.00	0.22	37.0
21. X. "	2.19	8.30 A.M.	0.26	37.0
		11.30	0.29	37.4
		2.30 P.M.	0.30	37.2
		5.30	0.24	37.8
22. X. "	2.16	8.00 A.M.	0.52	32.5
		8.25	Died.	

The control experiment: The initial blood sugar content of the ten rabbits was 0·11–0·13 %, on an average 0·12 % ; the maximum blood sugar content after the control operation (in ten minutes to four hours, on an average in forty minutes) 0·14–0·30 %, on an average 0·22 % ; and the duration of the hyperglycaemia was about four hours on an average. These numbers coincide closely with those in the control experiment (of the artery and vein altogether) in the third chapter. Later, the blood sugar content scarcely decreased.

On the day of the ligation: The two (Nos. 1 and 9) must be looked as exceptional cases. To be exact, another one, No. 5, may be dealt with also as an exception for the present. Then, in the remaining seven rabbits, the blood sugar content increased in ten to eighty minutes (on an average in twenty minutes) after the ligation from 0·10–0·12 % (on an average 0·12 %) to 0·16–0·20 % (on an average 0·19 %). The hyperglycaemia continued 0·5–5 hours. These numbers agree very closely with those after the ligation of the renal vessels of normal rabbits, but not with that of the renal veins. The following table shows clearly these relations.

	Number of cases	Bilateral ligation of the renal	Initial b. s. content	Maximum b. s. content after the ligation	Duration of the hyperglycaemia
Normal rabbit	16	vessels	0·11 % (0·08–0·14 %)	0·19 % (0·14–0·27 %)	2·5
	7	veins	0·11 % (0·10–0·12 %)	0·33 % (0·21–0·45 %)	7
Rabbit of which renal nerve was divided	6 (out of ten)	veins	0·12 % (0·10–0·14 %)	0·19 % (0·16–0·22 %)	3

No. 6 was excluded from the above table, because it scarcely showed any tendency to hyperglycaemia after the ligation, and lived only 25 hours after it. But, this result does not invalidate those in the table.

Nos. 1 and 9 showed a very marked hyperglycaemia, just as the normal rabbit after the ligation of the renal veins. In the nature of things it is not, however, unreasonable to explain both these cases by an incompleteness in the division of the renal nerve plexus. And the fact, that such a case has been rare, would justify us in assuming them to be exceptions.

So, the specially high hyperglycaemia immediately after the ligation of the renal veins alone is introduced by the afferent path in the renal nerve, of which endings in the kidney was excited by a closure of the renal veins. And that this hyperglycaemia does not continue

longer than some hours might be due to exhaustion, adaptation or dying of the sensible nerve endings in the kidney.

On the second day: In most of them, there was a tendency to hyperglycaemia.

On the third day: In all of them (nine in number), there was already a moderate hyperglycaemia (0.15–0.27 %).

On the fourth day: All of the still living seven rabbits showed hyperglycaemia, but in two of them it was very marked (0.52 % and 0.88 %).

On the fifth day: In all of them (five in number), there was a marked hyperglycaemia (0.34–0.60 %).

No. 2 lived alone till the next morning; its blood sugar content decreased much.

The maximum blood sugar content on the last days in the nine rabbits (except No. 5) was 0.15–0.88 %, on an average 0.45 %. This value coincides closely with that of the normal rabbits after the ligation of the renal vessels.

About the course of the body temperature after the ligation till death there is nothing to mention especially.

VI. SUMMARY.

(1) The bilateral ligation of the renal vessels (artery and vein together) or the renal veins alone causes in normal rabbits, first a temporary hyperglycaemia immediately after the ligation, and secondly the hyperglycaemia which makes its appearance on the last days, increases with time, and either increases till the death of the animal or decreases finally toward the time of death.

(2) The hyperglycaemia immediately after the bilateral ligation of the renal vessels (artery and vein together) is on a smaller scale and of shorter duration, in comparison with that after the ligation of the renal veins alone.

The former is nothing other than the fixing-operation hyperglycaemia.

The ligation of the renal veins alone in the rabbit, of which the renal nerve plexus has been previously divided, yields exactly the same result as the ligation of the renal vessels (artery and vein altogether) in normal rabbits.

For the superiority of the hyperglycaemia immediately after the

bilateral ligation of the renal veins alone over that of the renal vessels (artery and vein together), the renal nerve (as an afferent path) is responsible.

The hyperglycaemia immediately after the bilateral ligation of the renal vessels as well as of the renal veins was not evoked on the bilaterally splanchnectomized rabbit. They are, therefore, of central mechanism.

(3) Roughly speaking, on the whole the severity and duration of the hyperglycaemia on the last days after the ligation are indifferent to the circumstance whether the renal vessels (artery and vein together) or the renal vein alone be ligated bilaterally on the one hand, and whether the rabbit be normal, be bilaterally splanchnectomized or the renal nerve plexus on both sides divided on the other hand.

This form of hyperglycaemia is, therefore, of a mechanism other than the central one.

The hyperglycaemia of this form reaches not seldom a very high degree.