

RESULTS

Group 1. RENAL HYPOTHERMIA

The results of the clearance tests show the average actual values and the average percentage as compared to the controls which are considered to be a 100 per cent. After iced-saline was applied to the experimental kidney, the intrarenal temperature decreased gradually and then remained relatively constant between approximately 8 and 12 °C during the occlusion period as shown in Table 1 and Figure 1. The average intrarenal temperature during the occlusion period was 9.4 ± 0.8 °C. After removal of the occlusion and iced-saline, the temperature rose promptly to 27.9 ± 1.3 °C within 15 minutes and maintained relatively constant between 28.5 ± 0.8 and 29.4 ± 0.5 °C.

Table 2 and 3 present the mean values of all parameters before and after occlusion of the left renal artery and vein plus renal hypothermia for 60 minutes. Changes in the arterial blood pressure may occur as a result of the operation and consequently influence the clearance values. Therefore, the arterial blood pressure was taken each time when the function of the kidney was estimated. In this group, the arterial blood pressure was slightly but not significantly decreased and the hematocrits did not change appreciably throughout the experiment ($P > 0.05$).

a) Renal Plasma Flow (RPF)

Renal plasma flow was shown to be significantly decreased

Table 1. Renal temperature recording before, during and after left renal hypothermia in 6 dogs

Time (min)	Renal temperature (°C)
Before hypothermia	32.3 ± 0.4 *
During hypothermia	
15	12.3 ± 1.4
30	8.8 ± 1.4
45	8.1 ± 1.8
60	8.5 ± 1.8
After hypothermia	
15	27.9 ± 1.3
30	28.7 ± 0.7
45	28.7 ± 0.7
60	28.7 ± 0.7
75	28.6 ± 0.8
90	28.5 ± 0.8
105	29.4 ± 0.5
120	29.3 ± 0.5

* Mean and S.E.

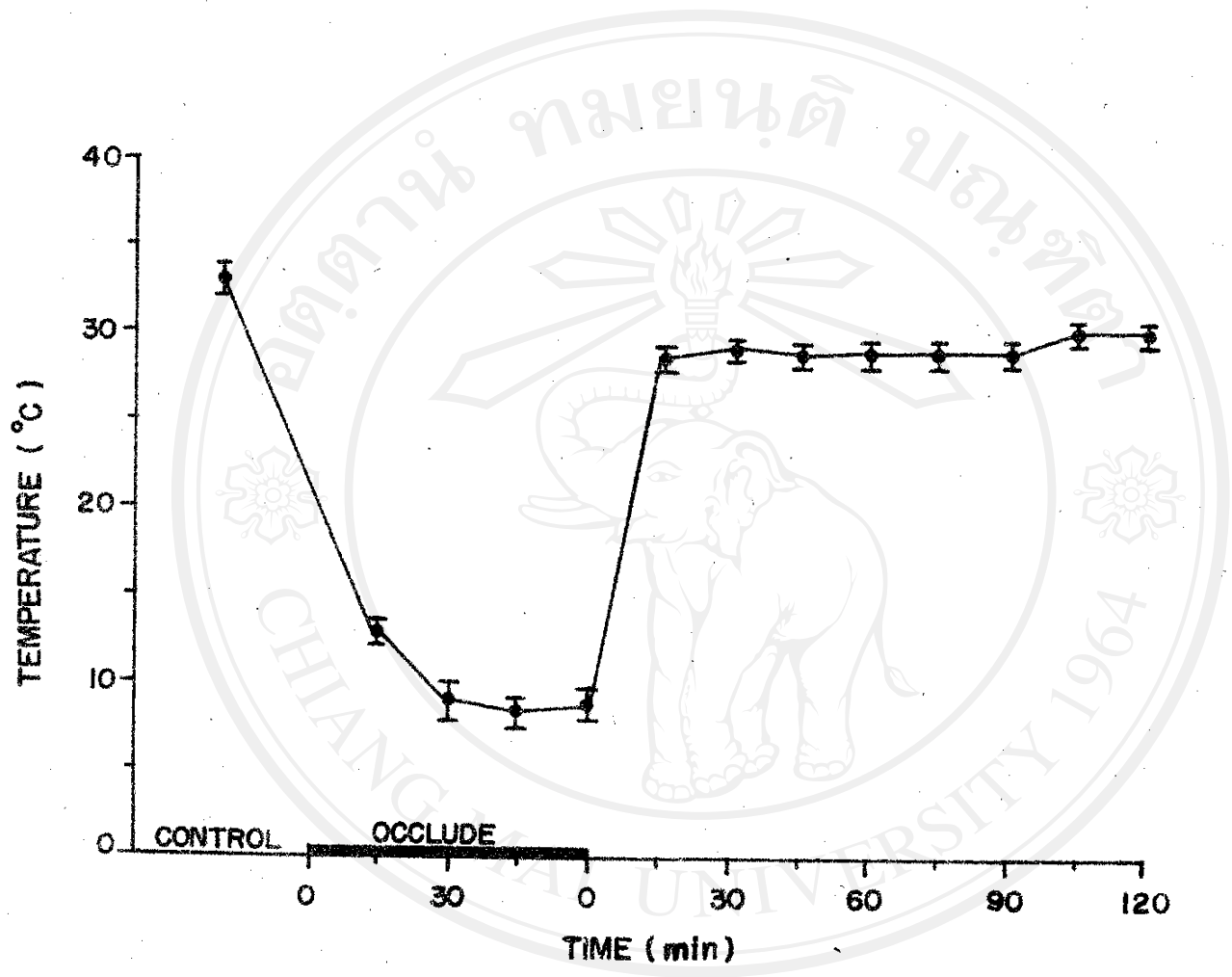


Figure 1. Left renal temperature recording before, during and after renal hypothermia for one hour

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from the control ($P < 0.05$). At 15 minutes after release the occlusion, RPF of the experimental kidney decreased from 51.6 ± 4.2 ml/min to 30.1 ± 2.7 ml/min. It slightly increased to 31.5 ± 2.0 ml/min at 30 minutes. In the latter period throughout the experiment it varied inconsiderably and at 90 minutes it was 26.8 ± 1.1 ml/min which was 51.9 per cent of the control. The results are shown in Table 2 and Figure 2.

b) Renal Blood Flow (RBF)

The control of RBF was 74.8 ± 6.3 ml/min. Because the hematocrits did not change appreciably throughout the experimental period, changes in RBF were shown in similar pattern and in the same degree as RPF. The results are presented in Table 2 and Figure 2.

c) Glomerular Filtration Rate (GFR)

The glomerular filtration rate during control and after release the occlusion are shown in Table 3. It decreased markedly ($P < 0.05$) from 17.6 ± 0.9 ml/min to 10.1 ± 0.3 ml/min which was 57.4 per cent of the control at 15 minutes. Then, afterward, GFR remained relatively constant and reached 11.4 ± 0.3 ml/min at 90 minutes ($P < 0.05$). The results are illustrated in Figure 3.

d) Urine Flow Rate

After release the occlusion, there was a slightly decrease of urine flow rate from the control of 0.8 ± 0.3 ml/min to 0.6 ± 0.2 ml/min at 30 minutes. This value was insignificantly different from the control ($P > 0.05$). In the latter periods it tended

Table 2. Renal plasma flow (RPF) and renal blood flow (RBF) after release the occlusion of left renal artery and vein plus renal hypothermia for one hour in 6 dogs

Time (min)	RPF		RBF	
	ml/min	%	ml/min	%
Control	51.6 ± 4.2 *	100.0	74.8 ± 6.3 *	100.0
After release the occlusion				
15	30.1 ± 2.7 **	58.3	43.5 ± 2.5 **	58.2
30	31.5 ± 2.0 **	61.0	45.5 ± 2.6 **	60.8
45	35.1 ± 5.8 **	68.0	50.7 ± 8.1 **	67.8
60	31.6 ± 4.2 **	61.2	45.8 ± 5.7 **	61.2
75	30.1 ± 2.6 **	58.3	43.2 ± 3.6 **	57.8
90	26.8 ± 1.1 **	51.9	38.7 ± 2.6 **	51.7

* Mean and S.E.

** P < 0.05

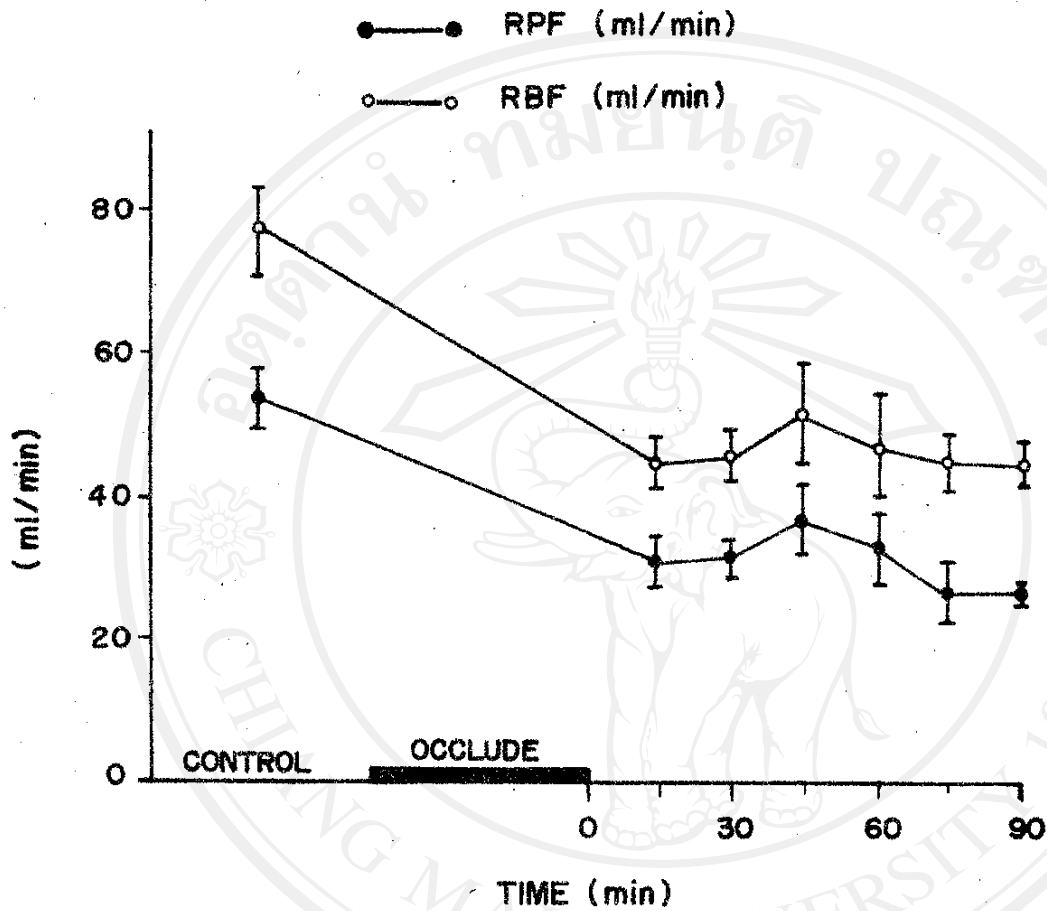


Figure 2. Renal plasma flow (RPF) and renal blood flow (RBF) after release the occlusion of left renal artery and vein plus renal hypothermia for one hour

Table 3. Glomerular filtration rate (GFR) and urine flow rate after release the occlusion of left renal artery and vein plus renal hypothermia for one hour in 6 dogs

Time (min)	GFR		urine flow rate (ml/min)
	ml/min	%	
Control	17.9 ± 0.9 *	100.0	0.8 ± 0.3 *
After release the occlusion			
15	10.1 ± 0.3 **	57.4	0.8 ± 0.3
30	11.3 ± 1.4 **	64.2	0.6 ± 0.2
45	10.9 ± 1.2 **	61.9	0.7 ± 0.3
60	11.2 ± 1.0 **	63.6	0.6 ± 0.2
75	11.2 ± 0.8 **	63.6	0.6 ± 0.1
90	11.4 ± 0.3 **	64.8	0.6 ± 0.1

* Mean and S.E.

** P < 0.05

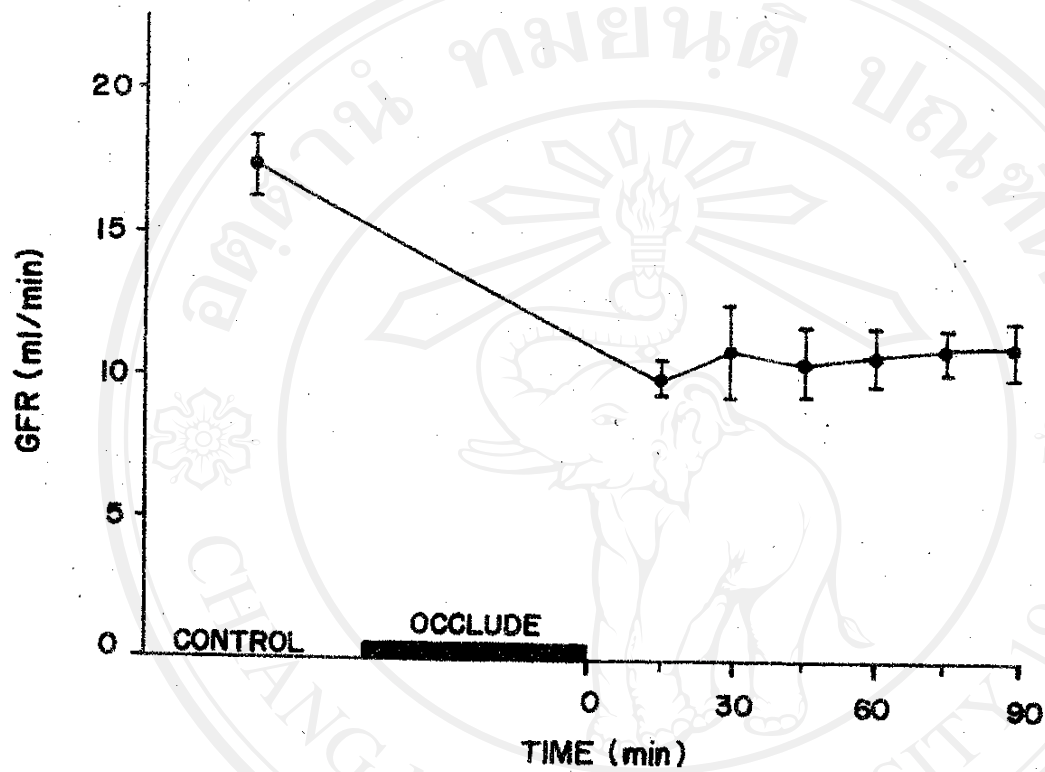


Figure 3. Glomerular filtration rate (GFR) after release

the occlusion of left renal artery and vein plus
renal hypothermia for one hour

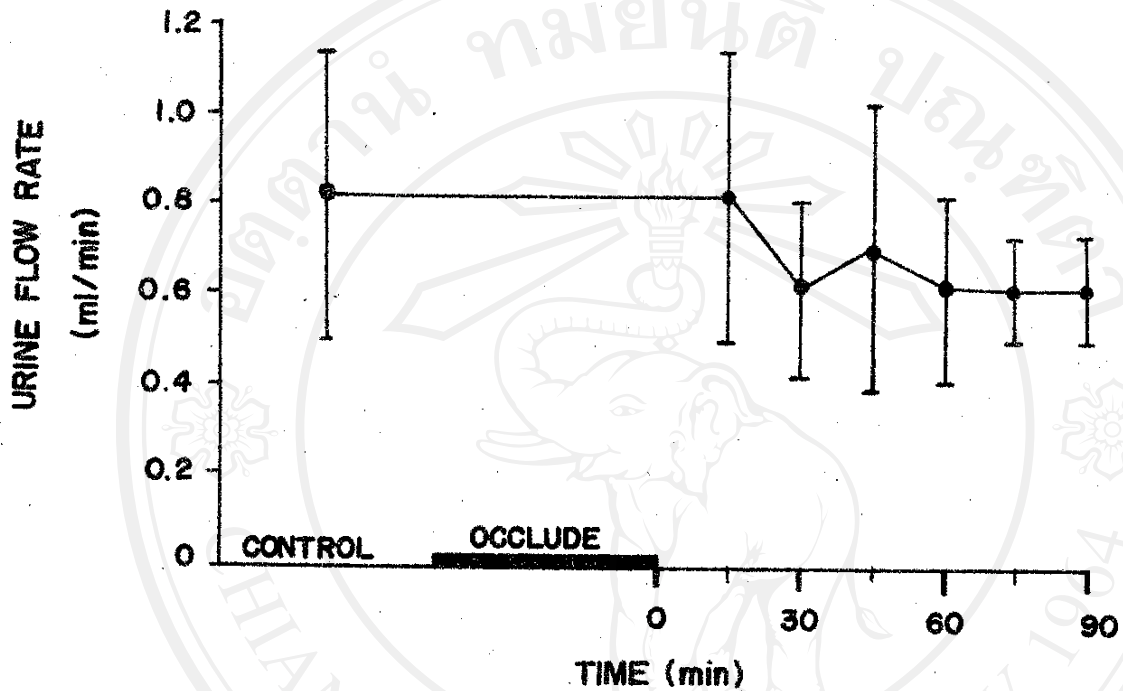


Figure 4. Urine flow rate after release the occlusion of left renal artery and vein plus renal hypothermia for one hour

to remain constant throughout the experimental period (Table 3 and Figure 4). All of the urine flow rates were not significantly different ($P > 0.05$) comparing with the control.

Group 2. RENAL NORMOTHERMIA

The results of left renal artery and vein occlusion at normal body temperature are shown in Table 4 and 5 and Figure 5, 6 and 7. The experimental animals were neither accompanied by significant changes in hematocrits nor followed by any appreciable changes in arterial blood pressure. Changes of all parameters are also expressed as a percentage of the control values determining before the occlusion.

a) Renal Plasma Flow (RPF)

The greatest and markedly ($P < 0.05$) decrease in RPF occurred in early period immediately after release of occlusion. It tended to increase gradually throughout the experiment and were approximately between 10 and 20 per cent of the control (65.9 ± 4.3 ml/min). At the end of the experimental period, RPF was 23 per cent which was significantly different from the control ($P < 0.05$). The results are shown in Table 4 and Figure 5.

b) Renal Blood Flow (RBF)

As shown in Table 4 and Figure 5, the marked reduction ($P < 0.05$) of RBF after release of occlusion was observed. The control value of RBF was 97.3 ± 5.3 ml/min. It was approximately 85 per cent lower than the control at the end of the experiment.

Table 4. Renal plasma flow (RPF) and renal blood flow (RBF) after release the occlusion of left renal artery and vein for one hour in 6 dogs

Time (min)	RPF		RBF	
	ml/min	%	ml/min	%
Control	65.9 ± 4.3 *	100.0	97.3 ± 5.3 *	100.0
After release the occlusion				
15	5.8 ± 1.6 **	8.8	8.3 ± 2.4 **	8.5
30	6.5 ± 1.3 **	9.8	9.6 ± 1.9 **	9.8
45	7.9 ± 1.4 **	12.0	11.6 ± 2.0 **	11.9
60	12.1 ± 1.6 **	18.4	17.6 ± 2.2 **	18.1
75	12.8 ± 1.2 **	19.4	19.0 ± 1.8 **	19.5
90	15.2 ± 3.3 **	23.0	23.2 ± 5.7 **	23.8

* Mean and S.E.

** P < 0.05

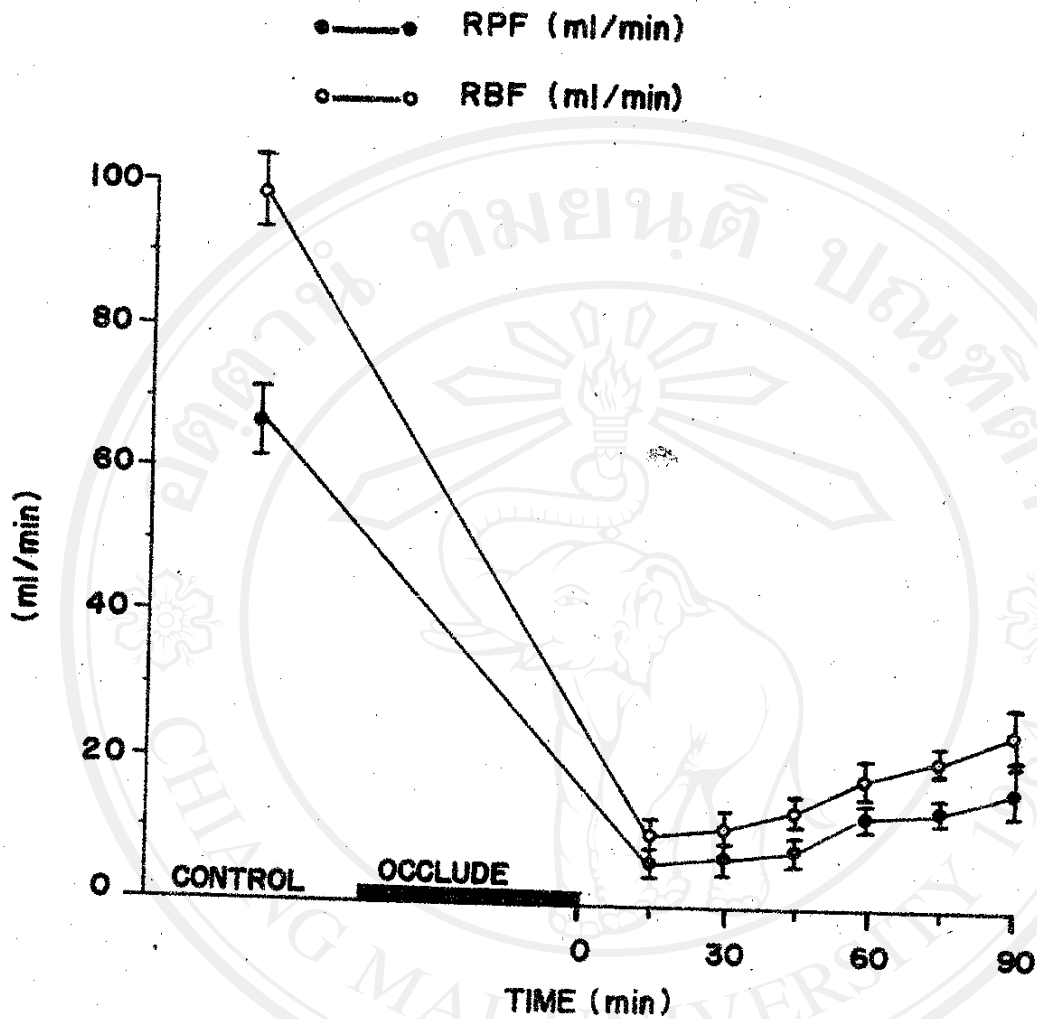


Figure 5. Renal plasma flow (RPF) and renal bleed flow (RBF) after release the occlusion of left renal artery and vein for one hour

c) Glomerular Filtration Rate (GFR)

Following release of the occlusion, at 15 minutes GFR dropped greatly ($P < 0.05$) from the control of 22.2 ± 1.5 ml/min to 1.4 ± 0.1 ml/min. During the first 30 minutes, GFR was average only 6.3 per cent of the control. Then, GFR increased slightly and at 90 minutes was about 16 per cent (3.6 ± 0.4 ml/min) of the original value as presented in Table 5 and Figure 6.

d) Urine Flow Rate

Immediately after removal of the clamp, anuria was observed from the experimental kidney. In the subsequent period, urine flow rate re-established and gradually rose. As demonstrated in Table 5 and Figure 7, urine flow rate during 30 minutes was not more than 10 per cent of the control (1.07 ± 0.13 ml/min). It gradually increased to about 25 per cent (0.25 ± 0.05 ml/min) at the end of the experiment. Undoubtedly, urine flow rate was significantly different ($P < 0.05$) from the control at any periods of time throughout the experiment.

The results of occlusion of renal artery and vein for one hour (Renal normothermic group) are compared with the renal hypothermic group. The comparisons are shown in Figure 8, 9, 10 and 11. All of parameters of renal normothermic group were undoubtedly significantly lower than those of renal hypothermic group ($P < 0.05$).

Group 3. RENAL COMPENSATION

The effects of exclusion of the left kidney by occlusion

Table 5. Glomerular filtration rate (GFR) and urine flow rate after release the occlusion of left renal artery and vein for one hour in 6 dogs

Time (min)	GFR		urine flow rate (ml/min)
	ml/min	%	
Control	22.2 ± 1.5 *	100.0	1.07 ± 0.13 *
After release the occlusion			
15	1.4 ± 0.1 **	6.3	0.10 ± 0.01 **
30	1.4 ± 0.3 **	6.3	0.10 ± 0.01 **
45	2.3 ± 0.6 **	10.4	0.15 ± 0.02 **
60	3.3 ± 0.5 **	14.9	0.23 ± 0.02 **
75	3.5 ± 0.6 **	15.8	0.26 ± 0.03 **
90	3.6 ± 0.4 **	16.2	0.25 ± 0.05 **

* Mean and S.E.

** P < 0.05

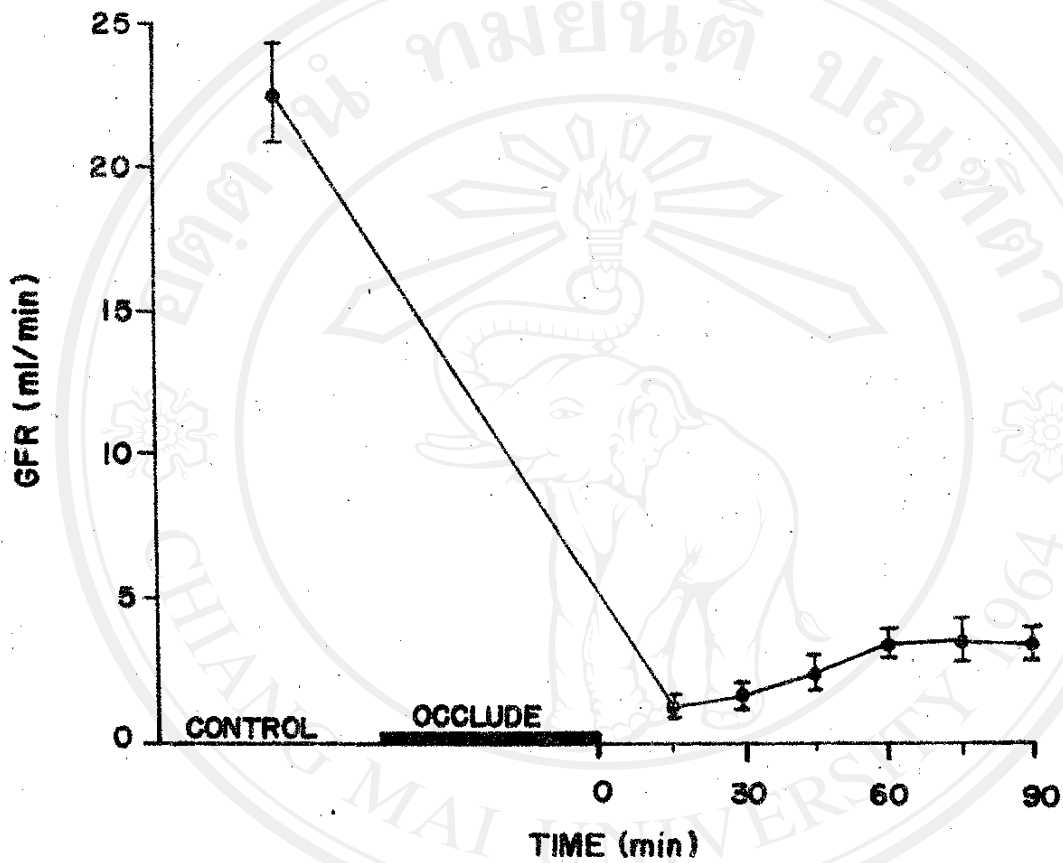


Figure 6. Glomerular filtration rate (GFR) after release the occlusion of left renal artery and vein for one hour

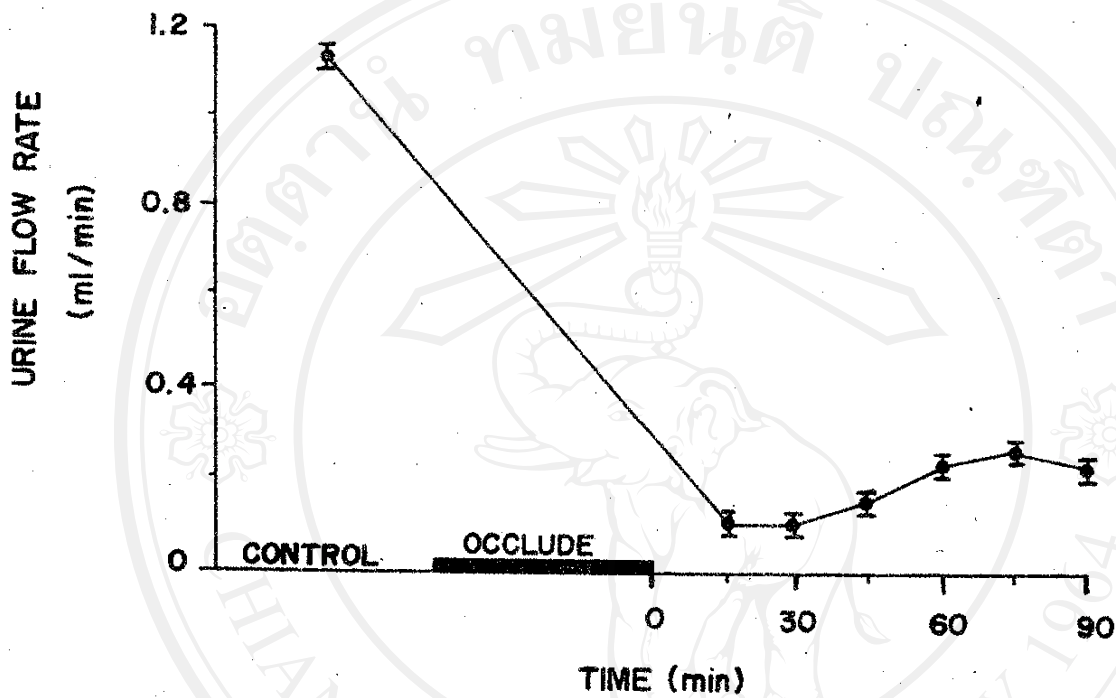
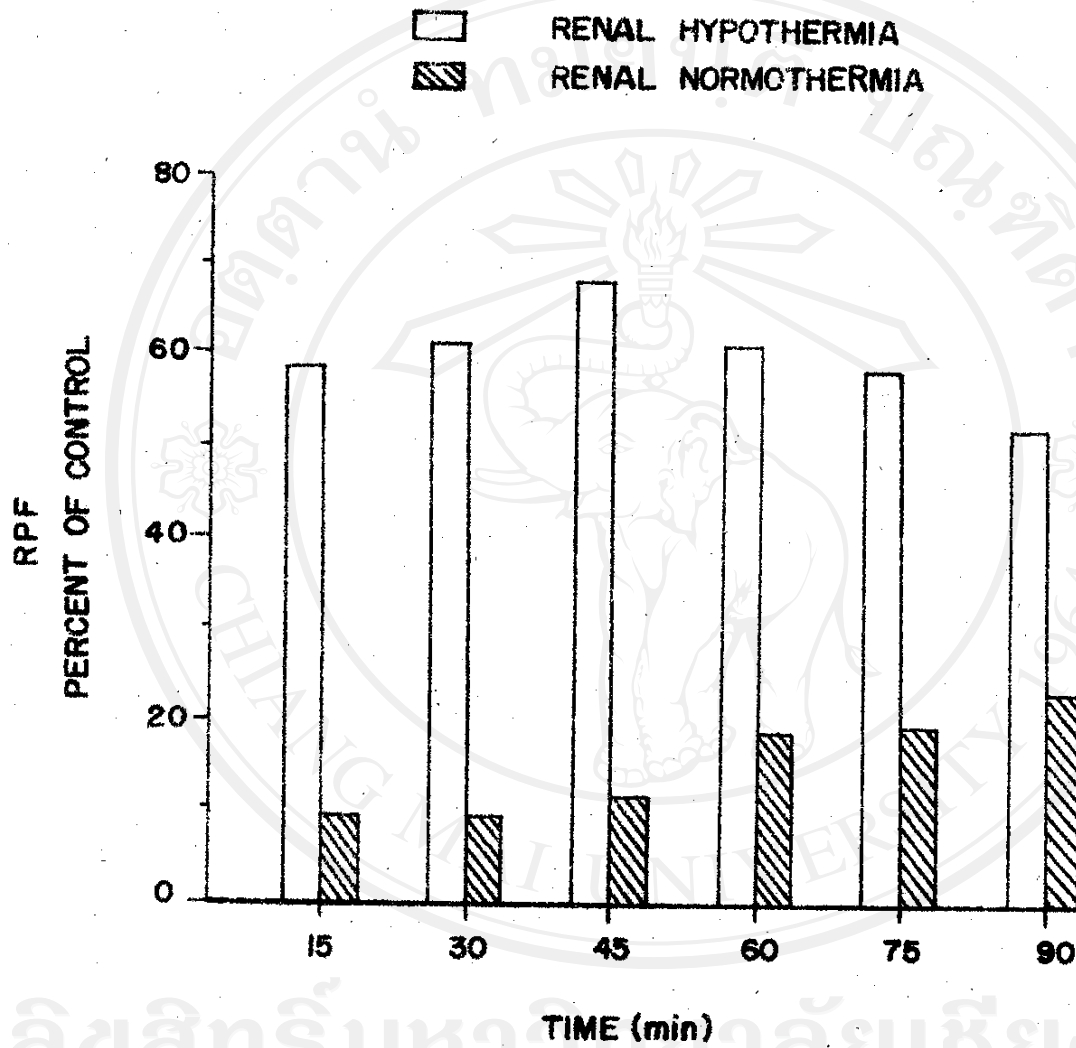
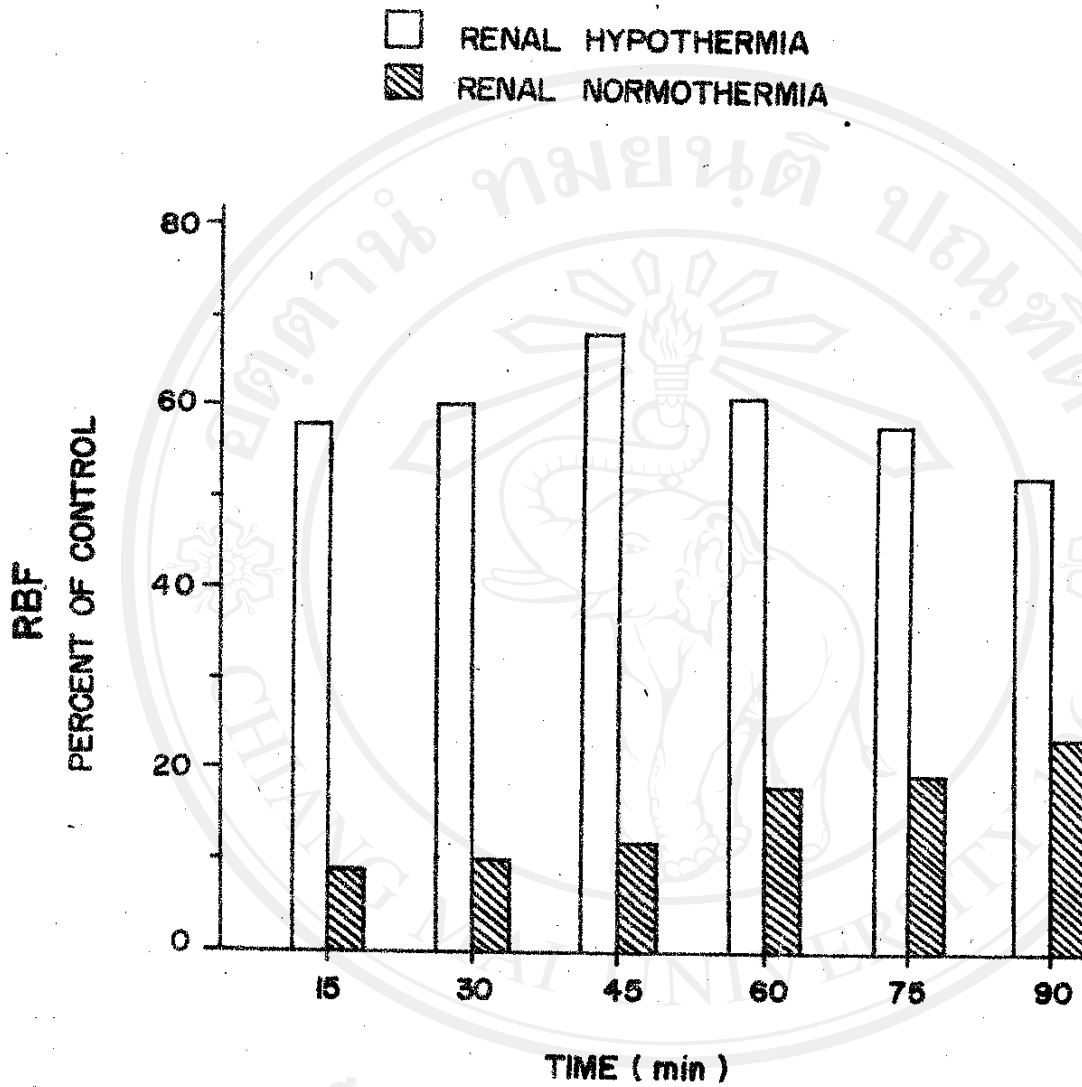


Figure 7. Urine flow rate after release the occlusion of left renal artery and vein for one hour



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Figure 8. Renal plasma flow (RPF) after release the occlusion of left renal artery and vein for one hour in renal hypothermic and renal normothermic groups



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Figure 9. Renal blood flow (RBF) after release the occlusion of left renal artery and vein for one hour in renal hypothermic and renal normothermic groups

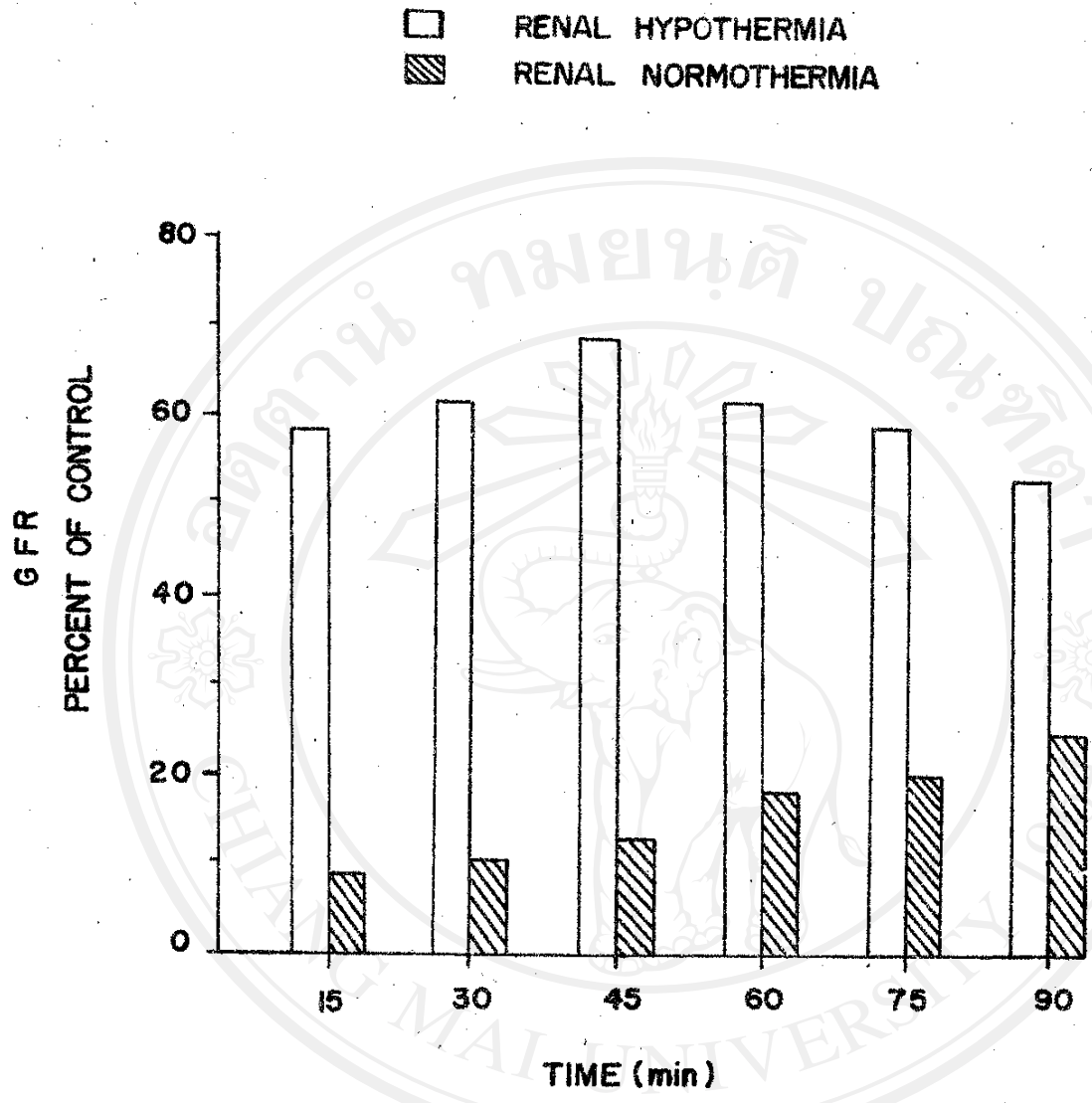


Figure 10. Glomerular filtration rate (GFR) after release the occlusion of left renal artery and vein for one hour in renal hypothermic and renal normo-thermic groups

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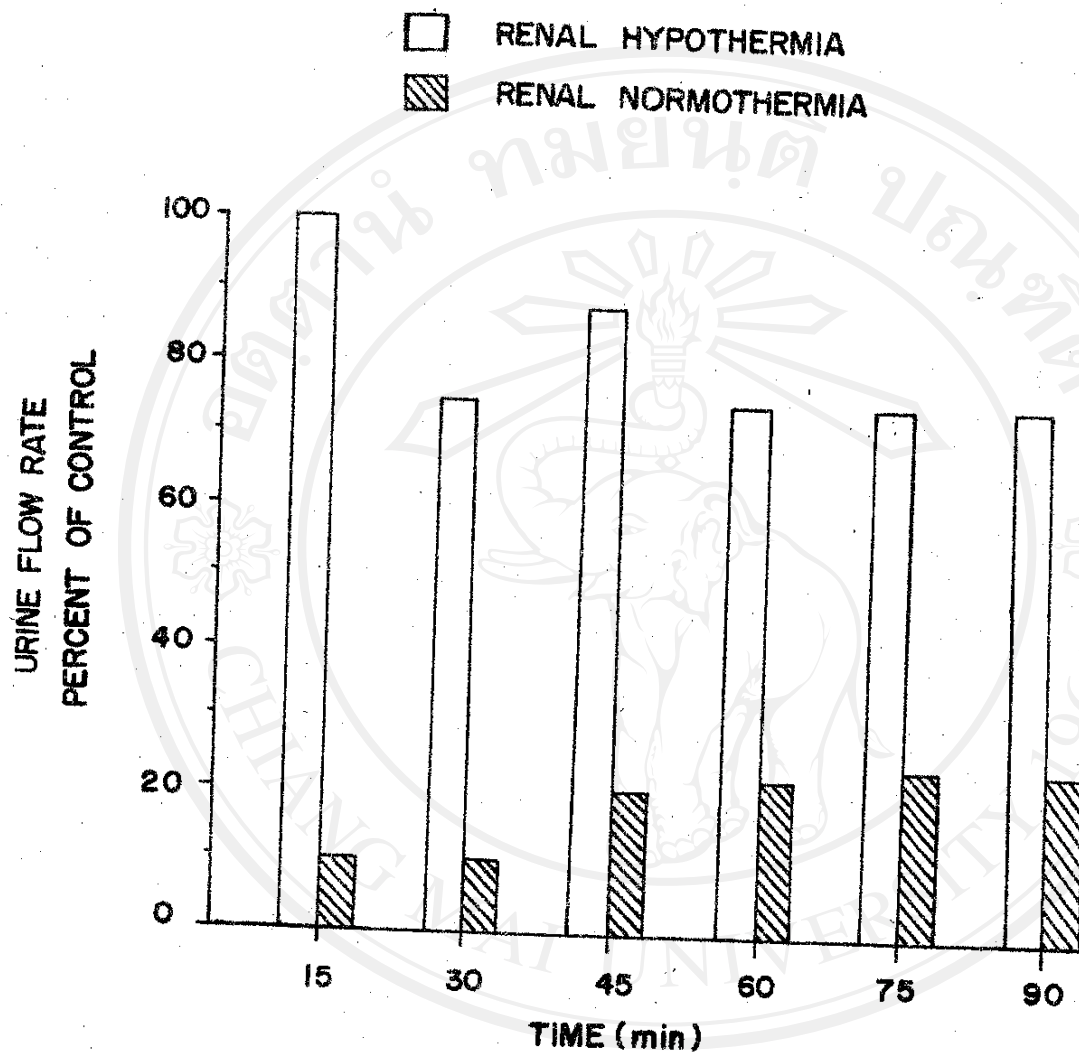


Figure 11. Urine flow rate after release the occlusion of left renal artery and vein for one hour in renal hypothermic and renal normothermic groups

of its artery and vein on the function of the right kidney was recorded for 2 hours. The results obtained in 6 dogs are shown in Table 6 to 11 and Figure 12 to 24. The arterial blood pressure did not varied appreciably, except in one dog, during control period (120/80 mm.Hg) dropped to 115/80 mm.Hg ($P > 0.05$) at 30 minutes after the contralateral occlusion and then slowly increased to 135/100 and 140/100 mm.Hg ($P > 0.05$), respectively, for the subsequent periods.

a) Renal Plasma Flow (RPF)

It was found that RPF of the right kidney during occlusion of renal artery and vein of the left kidney slightly decreased from the control of 56.4 ± 4.6 ml/min to 46.0 ± 3.4 ml/min during the first 30 minutes ($P < 0.05$). In the latter periods, it was markedly decreased ($P < 0.05$) to the appreciable levels as shown in Table 6 and Figure 12.

b) Renal Blood Flow (RBF)

The changes of RBF from the control of 80.4 ± 5.8 ml/min are shown in the same degree of reduction as RPF (Table 6). The subsequent changes are graphically illustrated in Figure 12.

c) Glomerular Filtration Rate (GFR)

From the control value of 20.2 ± 1.3 ml/min, GFR was insignificantly varied ($P > 0.05$), ranging approximately from 89 to 102 per cent (Table 6). During 30 minutes after performance of contralateral occlusion, it slightly decreased to 17.9 ± 2.3 ml/min ($P > 0.05$).

Table 6. Renal plasma flow (RPF), renal blood flow (RBF) and glomerular filtration rate (GFR) of the right kidney before and during occlusion of renal artery and vein of the left kidney in 6 dogs

	RPF (ml/min)	RBF (ml/min)	GFR (ml/min)
Control	56.4 ± 4.6 *	80.4 ± 5.8 *	20.2 ± 1.3 *
Occlusion			
30	46.0 ± 3.4 **	65.2 ± 4.0 **	17.9 ± 2.3
60	42.6 ± 4.1 **	59.4 ± 4.9 **	20.6 ± 1.7
90	41.2 ± 3.6 **	58.2 ± 4.6 **	18.4 ± 1.6
120	39.5 ± 4.9 **	54.8 ± 5.3 **	18.5 ± 0.5

* Mean and S.E.

** P < 0.05

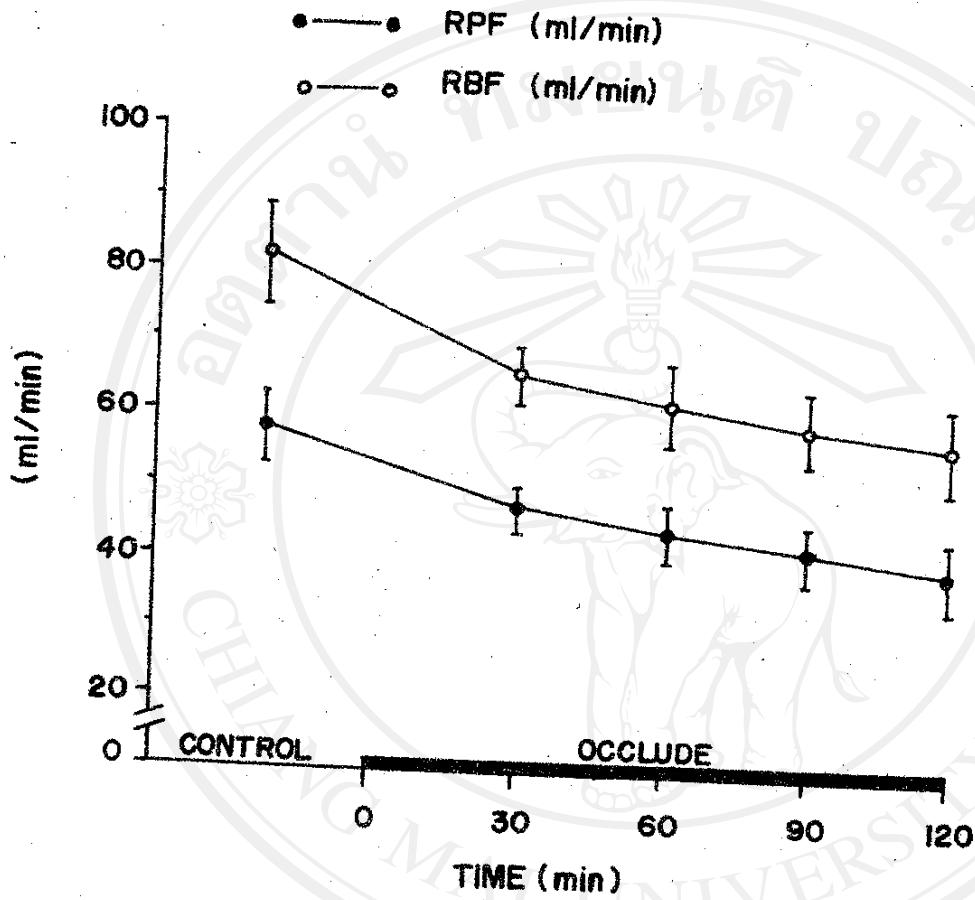


Figure 12. Renal plasma flow (RPF) and renal blood flow (RBF) of the right kidney before and during occlusion of renal artery and vein of the left kidney

At 60 minutes it was 20.6 ± 1.7 ml/min and in the latter two periods it was 18.4 ± 1.6 and 18.5 ± 0.5 ml/min, respectively. The subsequent changes can be demonstrated in Figure 13.

d) Urea Nitrogen

There was a slight increase of the plasma urea nitrogen concentration from the control value of 7.6 ± 0.9 mg % to the highest value of 8.7 ± 1.1 mg % at the end of the experiment. The values obtained at any periods still remained in the normal range and were not significantly different ($P > 0.05$) from the control as present in Table 7 and Figure 14. The clearance, filtration rate, excretory rate and reabsorption rate (and/or secretory rate) of urea nitrogen (Table 8 and Figure 15 and 16) were unchanged ($P > 0.05$). The clearances of urea nitrogen were approximately ranging from 94 to 99 per cent of the control (12.7 ± 1.1 ml/min). The filtration rates of urea nitrogen inconsiderably varied ($P > 0.05$) from the control of 1.5 ± 0.2 mg/min to 1.4 ± 0.1 mg/min at 30 minutes and 1.6 ± 0.2 mg/min at the end of the experiment. The urea nitrogen excretory rates were approximately between 100 and 110 per cent of the original value (1.0 ± 0.1 mg/min). The reabsorption rates of urea nitrogen slightly decreased from the control of 0.5 ± 0.06 mg/min to 0.4 ± 0.09 mg/min at 30 minutes, and then inconsiderably increased to 0.6 ± 0.08 mg/min at 60 minutes. However, these values were not significantly different from the control even at the end of the experiment ($P > 0.05$).

e) Potassium

In accordance with Table 7 and Figure 17, the plasma

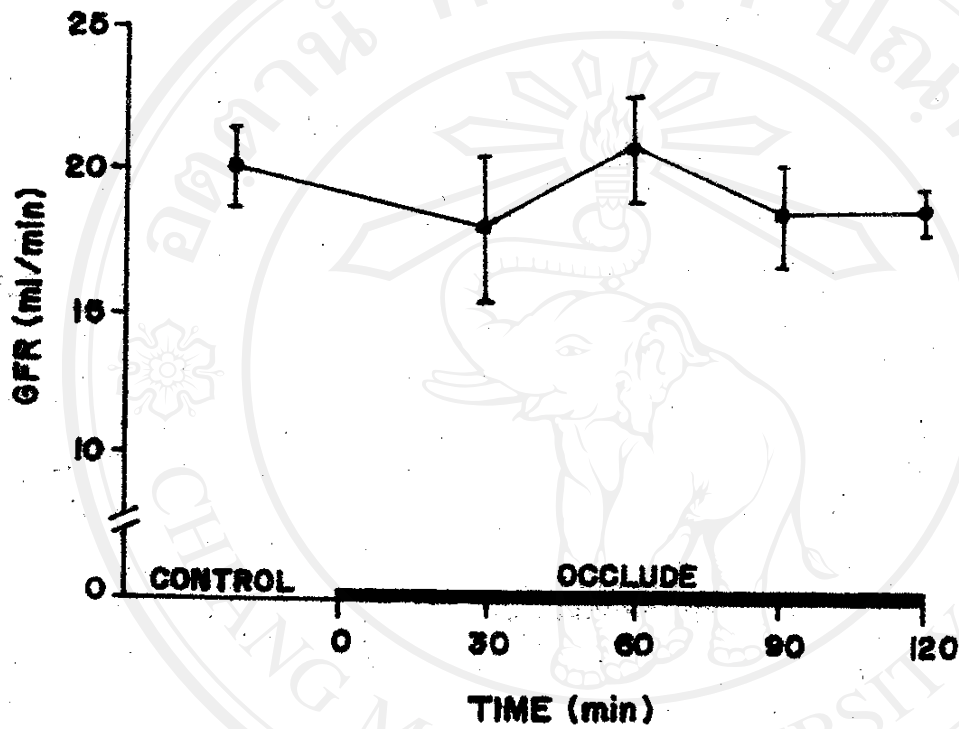


Figure 13. Glomerular filtration rate (GFR) of the right kidney before and during occlusion of renal artery and vein of the left kidney

Table 7. Plasma urea nitrogen (PUN), plasma potassium (K^+) and plasma osmolality (Osm) before and during occlusion of renal artery and vein of the left kidney in 6 dogs

Time (min)	PUN (mg %)	K^+ (mEq/L)	Osm (mOsm/L)
Control	7.6 ± 0.9 *	3.4 ± 0.1 *	298 ± 3 *
Occlusion			
30	8.0 ± 0.9	3.8 ± 0.1	299 ± 3 *
60	8.2 ± 0.9	3.7 ± 0.1	300 ± 2
90	8.4 ± 1.1	3.7 ± 0.1	299 ± 2
120	8.7 ± 1.1	3.9 ± 0.1 **	300 ± 2

* Mean and S.E.

** $P < 0.05$

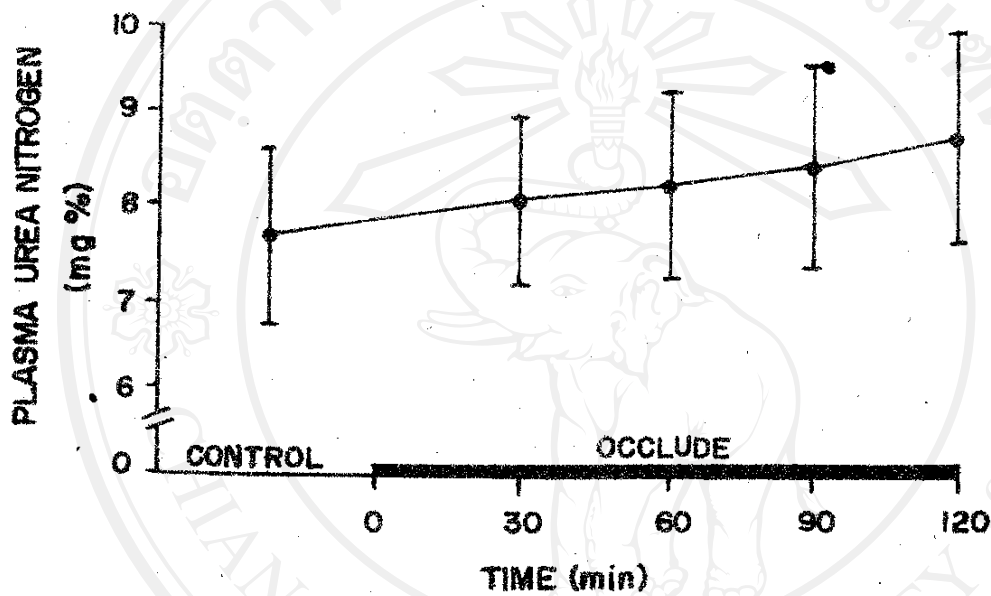


Figure 14. Plasma urea nitrogen concentrations before and during occlusion of renal artery and vein of the left kidney

Table 8. Clearances (C), filtration rates (F.R.), excretory rates (E.R.) and reabsorption rates (R.R.) of urea nitrogen of the right kidney before and during occlusion of renal artery and vein of the left kidney in 6 dogs

Time (min)	C (ml/min)	F.R. (mg/min)	E.R. (mg/min)	R.R. (mg/min)
Control	12.7 ± 1.1 *	1.5 ± 0.2 *	1.0 ± 0.1 *	0.5 ± 0.1 *
Occlusion				
30	12.0 ± 0.8	1.4 ± 0.1	1.0 ± 0.1	0.4 ± 0.1
60	12.5 ± 1.0	1.6 ± 0.2	1.0 ± 0.2	0.6 ± 0.1
90	12.5 ± 1.3	1.5 ± 0.2	1.1 ± 0.2	0.5 ± 0.1
120	12.6 ± 1.2	1.6 ± 0.2	1.1 ± 0.2	0.5 ± 0.1

* Mean and S.E.

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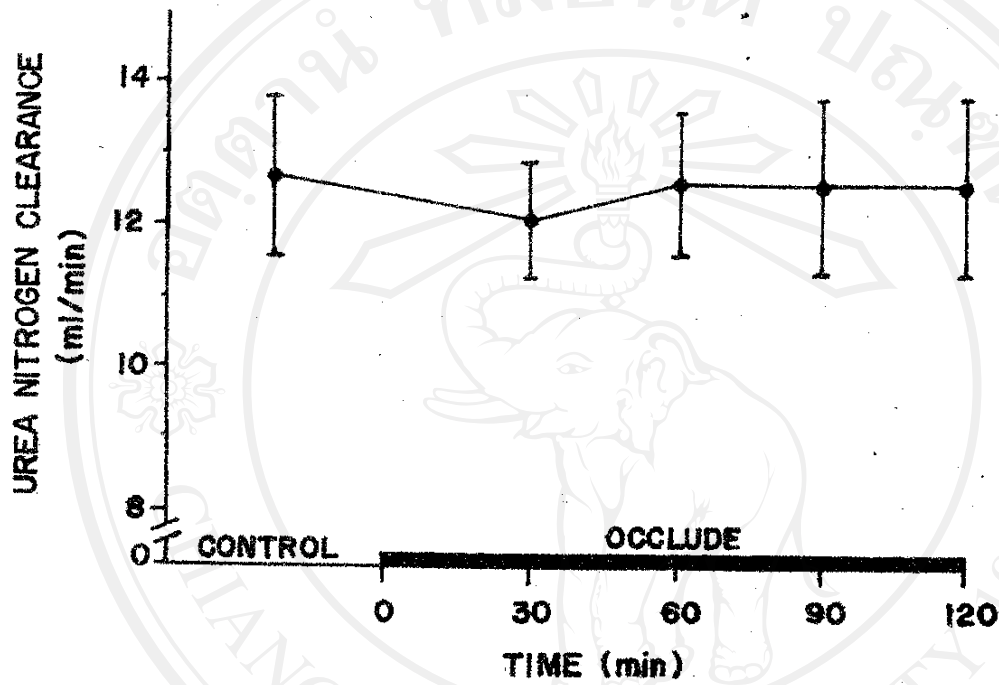


Figure 15. Clearances of urea nitrogen of the right kidney before and during occlusion of renal artery and vein of the left kidney

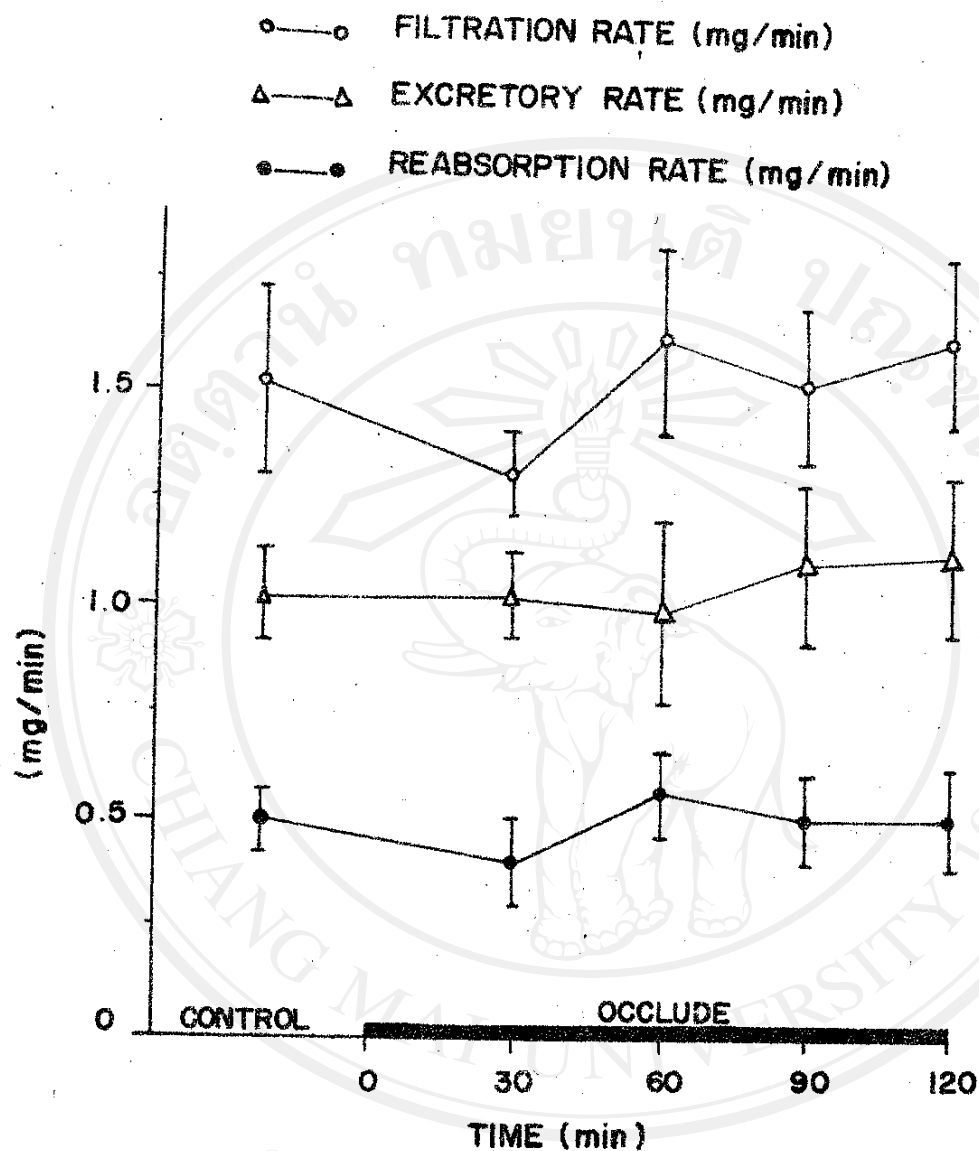


Figure 16. Filtration rates, excretory rates and reabsorption rates of urea nitrogen of the right kidney before and during occlusion of renal artery and vein of the left kidney

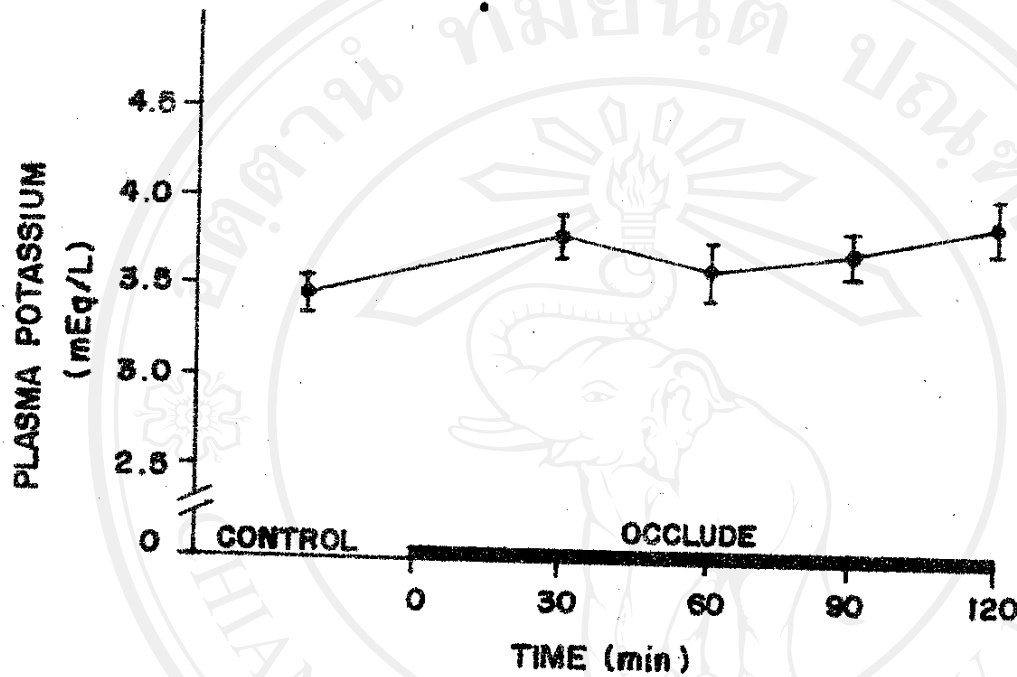


Figure 17. Plasma potassium concentrations before and during occlusion of renal artery and vein of the left kidney

potassium concentration progressively increased from the control of 3.4 ± 0.1 mEq/L to 3.9 ± 0.1 mEq/L at the end of the experiment ($P < 0.05$). The potassium clearances (Table 9 and Figure 18) at 30 minutes after the occlusion slightly decreased from the original value of 6.4 ± 0.8 ml/min to 5.0 ± 0.6 ml/min which was not significantly different ($P > 0.05$). In the latter periods, it gradually increased and then reached a peak of 6.3 ± 0.7 ml/min at 90 minutes. Potassium filtration rates appeared varying approximately between 96 and 118 per cent of the control (65.7 ± 5.7 μ Eq/min). These values were considered unchanged ($P > 0.05$). The excretory rates of potassium during the occlusion dropped to approximately 87 per cent of the control value (20.5 ± 1.8 μ Eq/min) at 30 minutes and at the end of the experiment, it slightly increased to approximately 109 per cent. P values for all of the potassium excretory rates were more than 0.05. There was no marked change of potassium reabsorption rates from the control value of 44.5 ± 7.0 μ Eq/min throughout the experiment. Table 9 and Figure 19 present filtration rates, excretory rates and reabsorption rates of potassium.

f) Osmolality

The plasma osmolality was relatively constant throughout the experiment. The control value of plasma osmolality was 298 ± 3 mOsm/L. At 30, 60, 90 and 120 minutes during the occlusion, it was 299 ± 2 , 300 ± 2 , 299 ± 2 and 300 ± 2 mOsm/L, respectively (Table 7 and Figure 20). The control value of osmolal clearance was 1.7 ± 0.2 ml/min. During the occlusion period it was inconsiderably different

Table 9. Clearances (C), filtration rates (F.R.), excretory rates (E.R.) and reabsorption rates (R.R.) of potassium of the right kidney before and during occlusion of renal artery and vein of the left kidney in 6 dogs

Time (min)	C (ml/min)	F.R. (μ Eq/min)	E.R. (μ Eq/min)	R.R. (μ Eq/min)
Control	$6.4 \pm 0.8^*$	$65.7 \pm 5.7^*$	$20.5 \pm 1.8^*$	$44.5 \pm 7.0^*$
Occlusion				
30	5.0 ± 0.6	68.4 ± 10.1	17.9 ± 1.6	49.9 ± 8.8
60	5.7 ± 0.5	77.3 ± 5.5	19.6 ± 1.3	56.6 ± 5.4
90	6.3 ± 0.7	63.0 ± 4.0	21.0 ± 2.4	40.1 ± 4.0
120	6.3 ± 0.7	71.5 ± 1.8	22.4 ± 2.2	47.8 ± 3.4

* Mean and S.E.

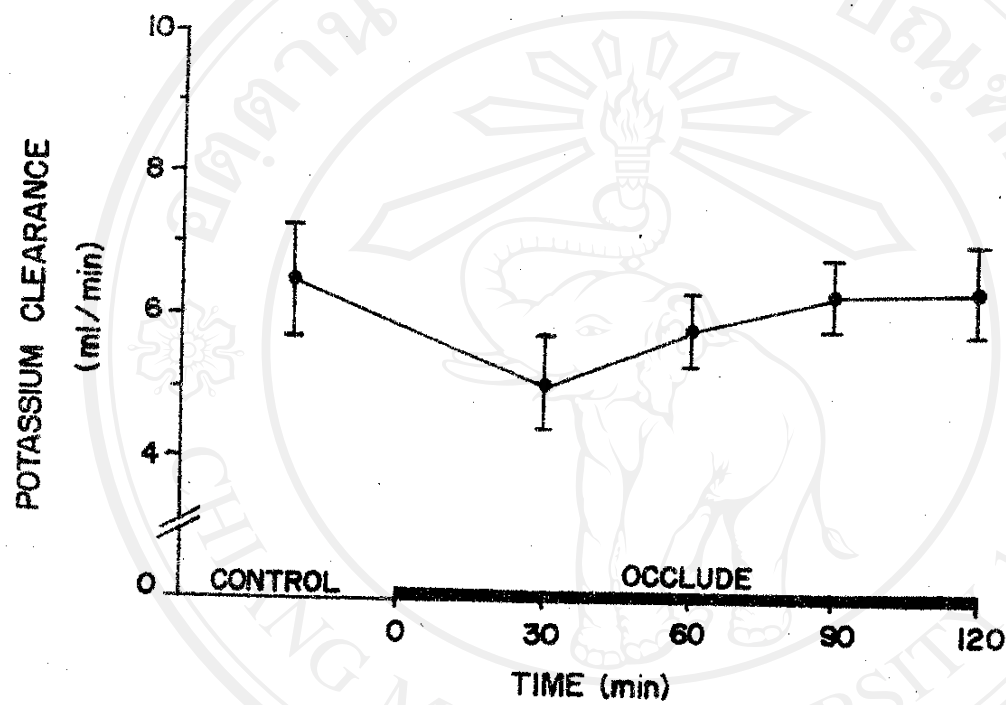


Figure 18. Clearances of potassium of the right kidney

before and during occlusion of renal artery
and vein of the left kidney

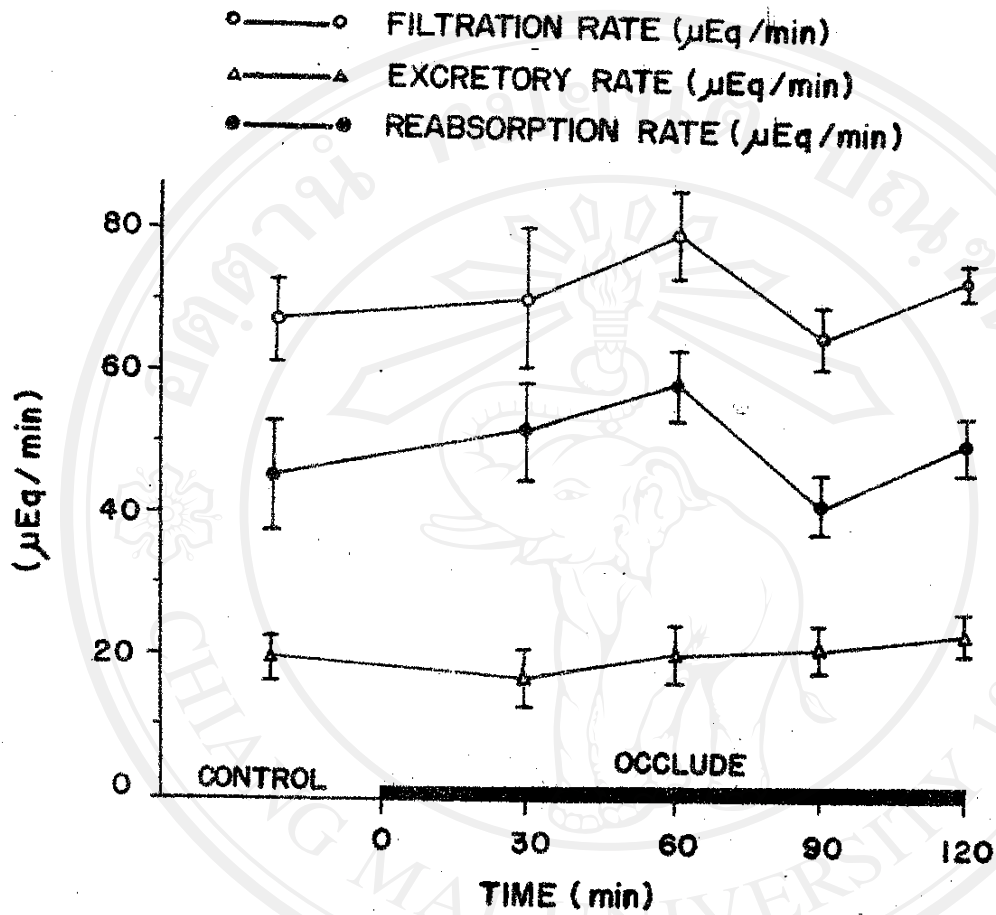


Figure 19. Filtration rates, excretory rates and reabsorption rates of potassium of the right kidney before and during occlusion of renal artery and vein of the left kidney

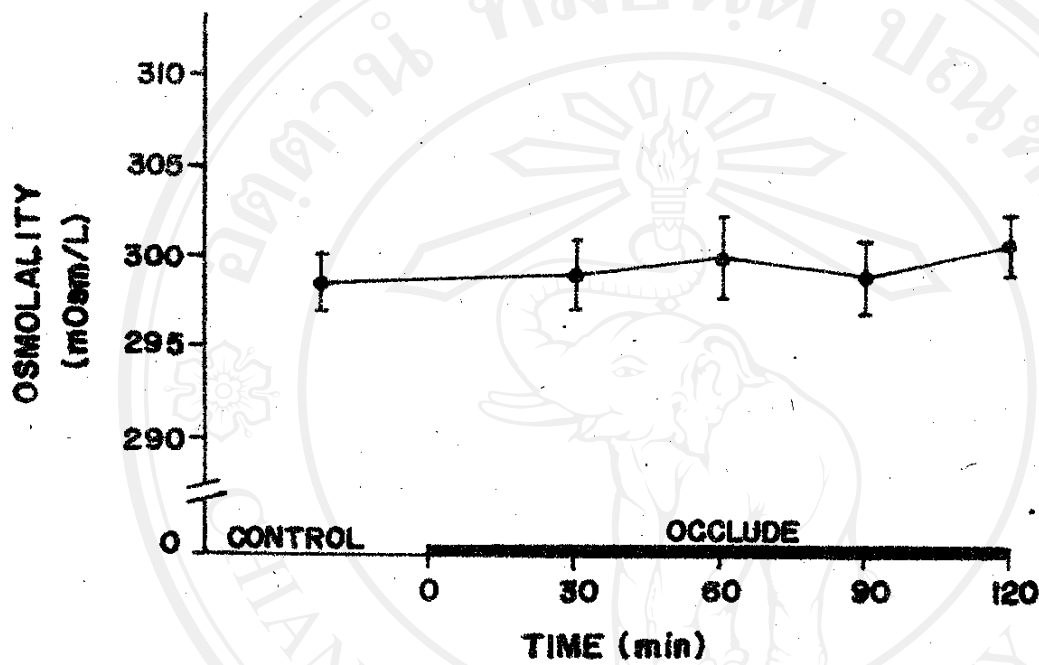


Figure 20. Plasma osmolalities before and during occlusion of renal artery and vein of the left kidney

from the control ($P > 0.05$), as shown in Table 10 and Figure 21.

g) Negative Water Clearance

During contralateral occlusion, there was a moderate increase of negative water clearance approximately 25 per cent from the control of 0.4 ± 0.08 ml/min to 0.5 ± 0.06 ml/min at 30 minutes. Then, it decreased to the original value and remained relatively constant throughout the occlusion period (Table 10 and Figure 21). These values were not significantly different ($P > 0.05$) from the control.

h) Total Solid Excretory Rate

The total solid excretory rates remained relatively constant ($P > 0.05$) throughout the experimental period. The pre-occlusive value was 42.8 ± 4.5 mg/min and the values at 30, 60, 90 and 120 minutes were 40.9 ± 4.3 , 43.1 ± 4.8 , 45.1 ± 5.7 and 45.6 ± 5.7 mg/min, respectively. The results are shown in Table 10 and Figure 22.

i) Urine pH

The control value of urine pH was 7.4 ± 0.04 but during the occlusion it was significantly decreased ($P < 0.05$). As can be seen in Table 11, at 30, 60 and 90 minutes, urine pH dropped to 7.2 ± 0.04 ($P < 0.05$). At the end of the experiment it was 7.1 ± 0.01 . The changes are graphically illustrated in Figure 23.

j) Urine Flow Rate

The occlusion of contralateral renal artery and vein do not appear to cause any appreciable change of urine flow rate.

Table 10. Osmolal clearances (C_{osm}), negative water clearances ($T_{\text{cH}_2\text{O}}$) and total solid excretory rates (TSER) of the right kidney before and during occlusion of renal artery and vein of the left kidney in 6 dogs

Time (min)	C_{osm} (ml/min)	$T_{\text{cH}_2\text{O}}$ (ml/min)	TSER (mg/min)
Control	1.7 ± 0.2 *	0.4 ± 0.08 *	42.8 ± 4.5 *
Occlusion			
30	1.5 ± 0.2	0.5 ± 0.06	40.9 ± 4.3
60	1.6 ± 0.3	0.4 ± 0.02	43.1 ± 4.8
90	1.6 ± 0.3	0.4 ± 0.02	45.1 ± 5.7
120	1.7 ± 0.3	0.4 ± 0.05	45.6 ± 5.7

* Mean and S.E.

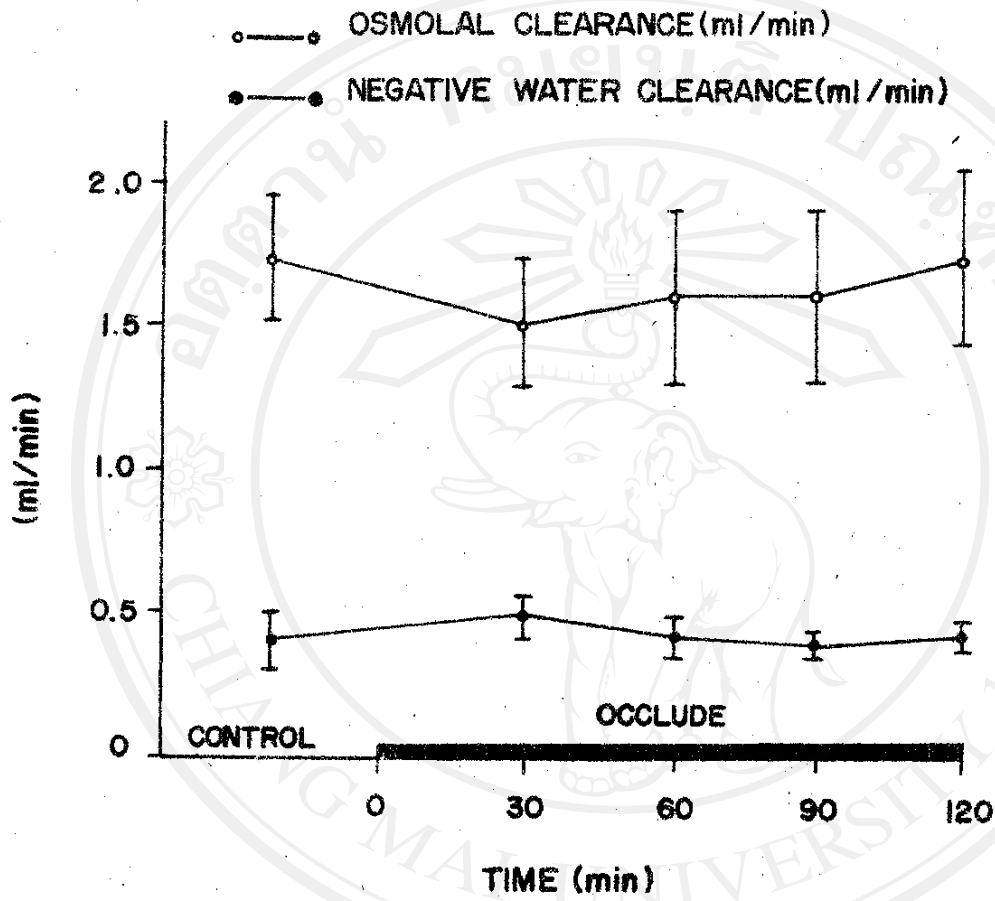


Figure 21. Osmolal clearances and negative water clearances of the right kidney before and during occlusion of renal artery and vein of the left kidney

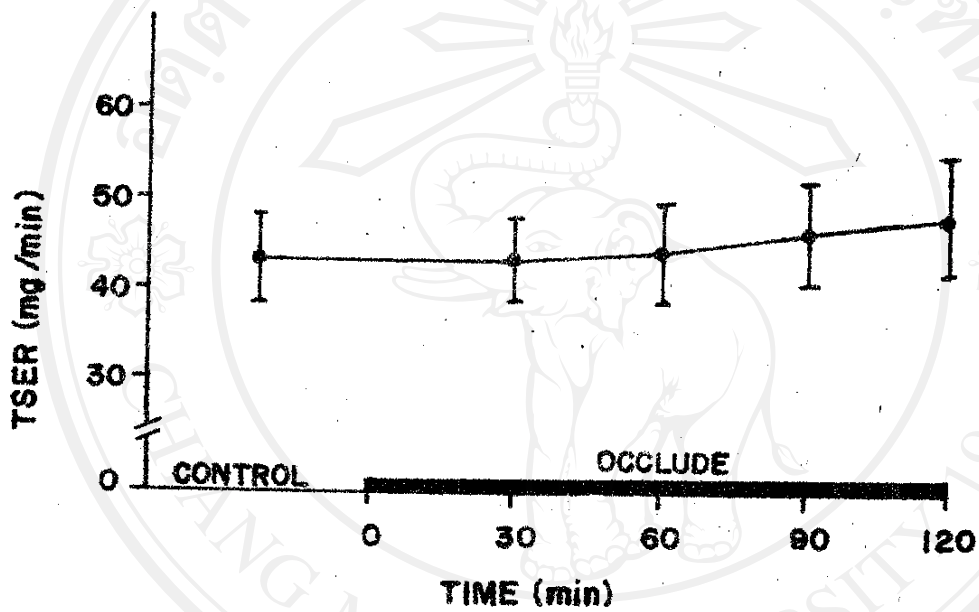


Figure 22. Total solid excretory rates (TSER) of the right kidney before and during occlusion of renal artery and vein of the left kidney

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Table 11. Urine pH and urine flow rate of the right kidney before and during occlusion of renal artery and vein of the left kidney in 6 dogs

Time (min)	urine pH	urine flow rate (ml/min)
Control	7.4 ± 0.04 *	1.3 ± 0.3 *
Occlusion		
30	7.2 ± 0.04 **	1.0 ± 0.2
60	7.2 ± 0.04 **	1.2 ± 0.2
90	7.2 ± 0.04 **	1.2 ± 0.3
120	7.1 ± 0.01 **	1.4 ± 0.3

* Mean and S.E.

** P < 0.05

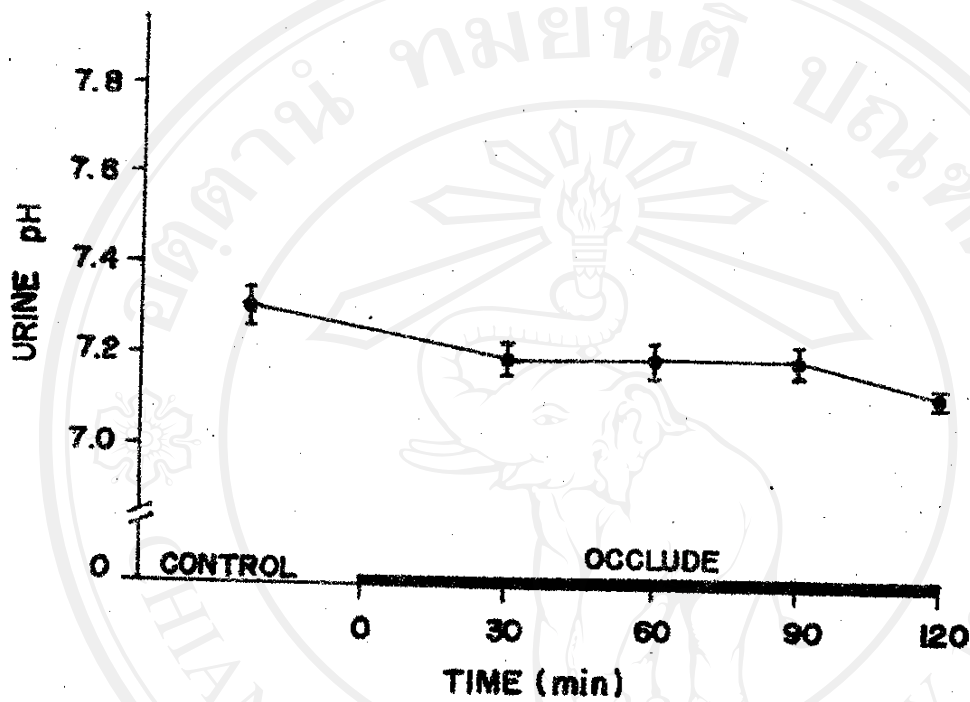
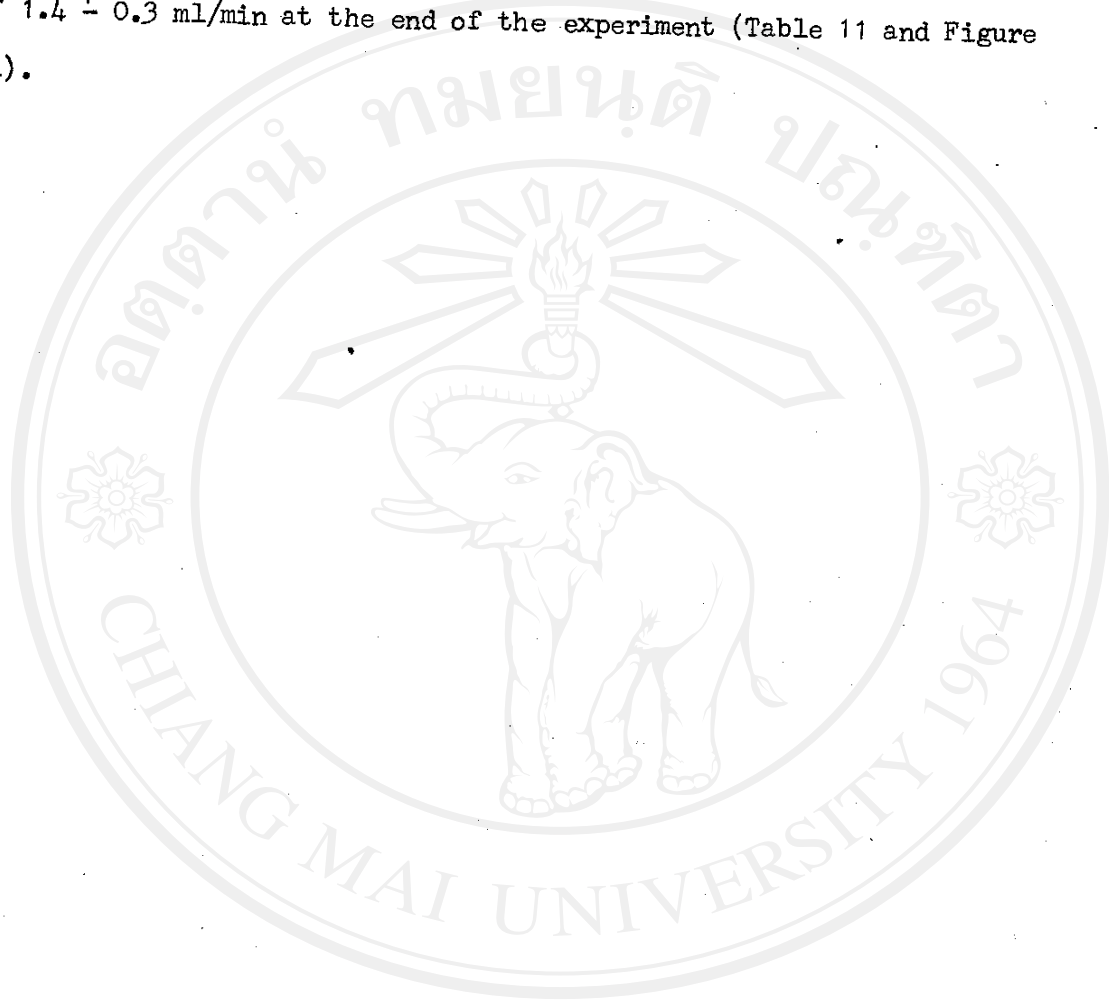


Figure 23. Urine pH of the right kidney before and during occlusion of renal artery and vein of the left kidney

There was an initial but not significant decrease of urine flow rate from the control of 1.3 ± 0.3 ml/min to 1.0 ± 0.2 ml/min at 30 minutes ($F > 0.05$). Then, it gradually increased and reached the peak value of 1.4 ± 0.3 ml/min at the end of the experiment (Table 11 and Figure 24).



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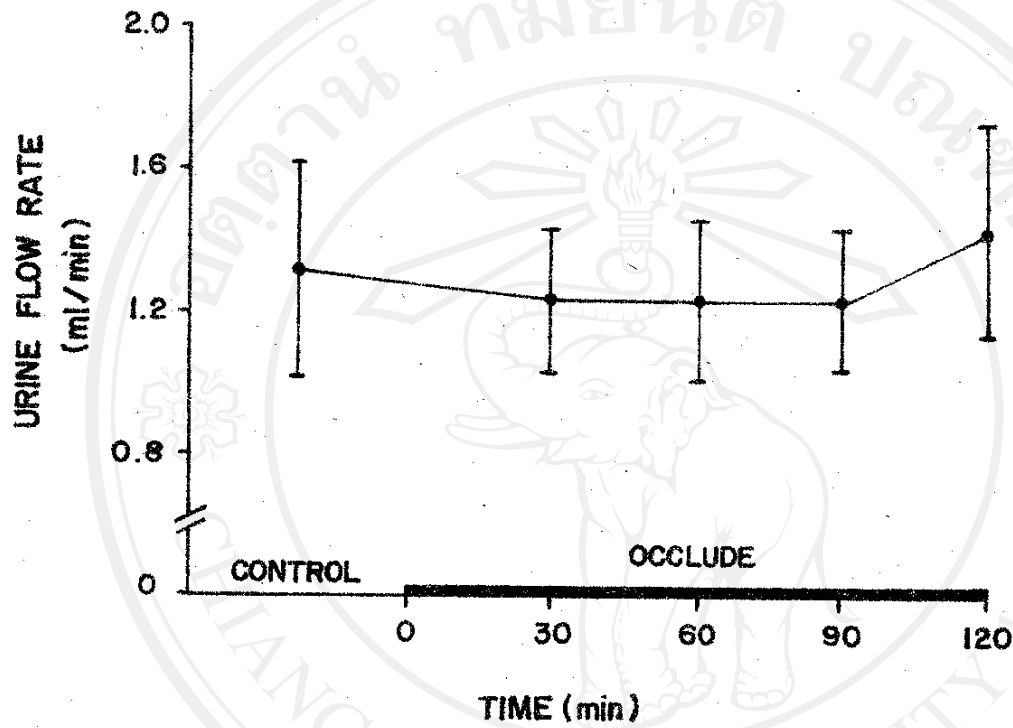


Figure 24. Urine flow rate of the right kidney before and during occlusion of renal artery and vein of the left kidney