

Table 1. The Change of Longitudinal Diameter (mm) of the Kidney with Time

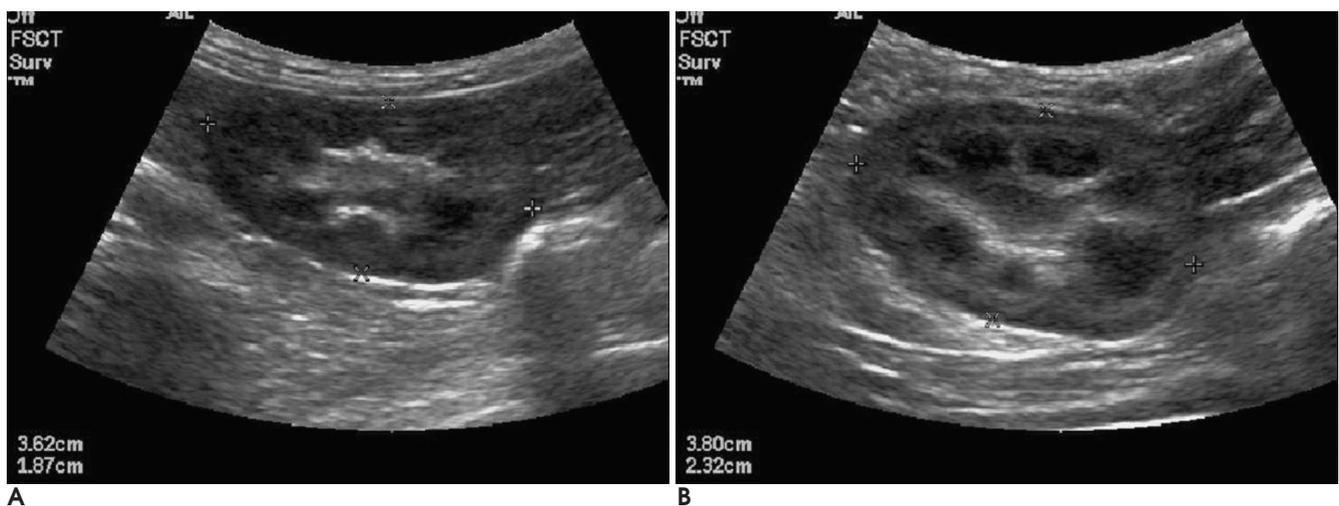
Case	Pre-Op	Immediate Post-Op	24 hrs	48 hrs	72 hrs
1	38	41	45	46	45
2	33	35	36	36	36
3	34	40	42	42	41
4	35	37	38	38	38
5	40	44	40	43	43
6	36	39	41	42	42
7	35	36	40	41	41
8	37	38	41	41	42
9	44	50	51	51	51
10	36	39	39	40	41
11	37	40	42	43	43
12	38	43	44	44	44
Average	36.9 ± 2.8	40.2 ± 3.9	41.6 ± 3.7	42.3 ± 3.7	42.3 ± 3.5

Op: renal vein ligation Unit: mm

Table 2. The Change of Resistive Index with Time

Case	Pre-Op	Immediate Post-Op	24 hrs	48 hrs	72 hrs
1	0.55	0.61	1.30	1.63	1.60
2	0.50	1.43	1.50	1.71	1.45
3	0.52	1.57	1.59	1.43	1.36
4	0.49	1.56	1.60	1.63	1.61
5	0.61	0.59	1.60	1.65	1.65
6	0.60	1.36	1.53	1.60	1.55
7	0.65	1.58	1.73	1.67	1.65
8	0.56	1.68	1.70	1.72	1.68
9	0.60	1.66	1.65	1.68	1.66
10	0.53	1.57	1.58	1.60	1.55
11	0.59	1.45	1.57	1.64	1.62
12	0.58	1.50	1.62	1.66	1.64
Average	0.57 ± 0.05	1.38 ± 0.38	1.58 ± 0.10	1.64 ± 0.07	1.59 ± 0.10

Op: renal vein ligation

**Fig. 2.** Serial follow-up of gray-scale US.**A.** Pre-ligation longitudinal US of the kidney.**B.** Post-ligation longitudinal US. The cortical echo is increased than A. Also, longitudinal and axial lengths of the kidney are significantly increased. And, the corticomedullary junction is preserved.

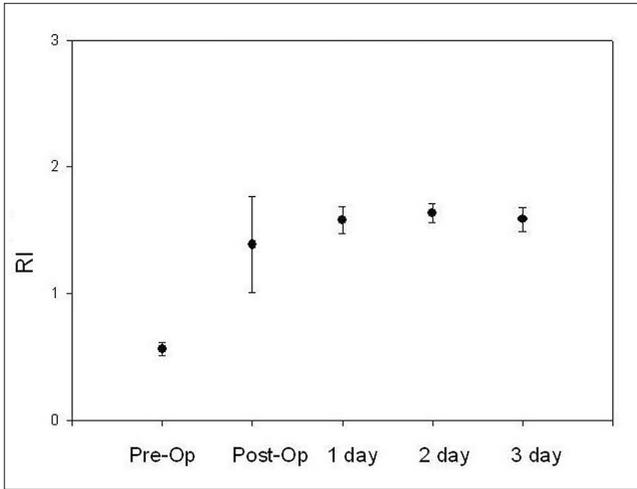


Fig. 3. Time to resistive index curve (2 standard deviation). RI is rapidly increased, just after ligation of renal vein. Thereafter, the rate of increase becomes blunt. RI attains to the peak value at post-ligation 2nd day. RI of post-ligation 3rd day is lower than that of 2nd day.

: 가

가

(Fig. 2).

Table 2, Fig.

3
 0.57, 1.38, 1 1.58, 2 1.64, 3
 1.59 2 가 . 가 Fig.
 3 가 가 가
 가 2.5 가 , 2
 가 가 가 2
 2.9 가 가 . 3
 2.8 가 2

(Fig. 4).

가

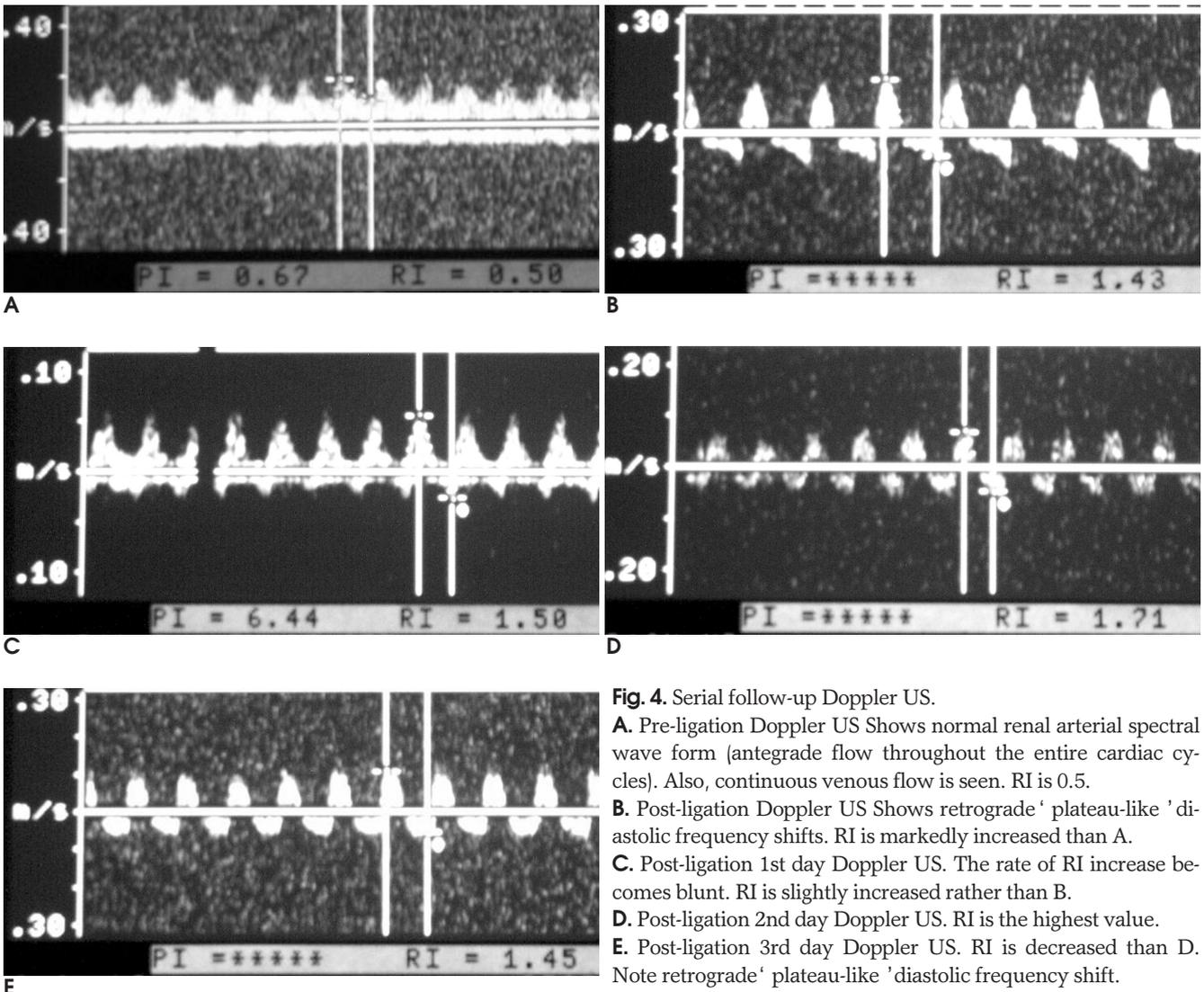


Fig. 4. Serial follow-up Doppler US.
A. Pre-ligation Doppler US Shows normal renal arterial spectral wave form (antegrade flow throughout the entire cardiac cycles). Also, continuous venous flow is seen. RI is 0.5.
B. Post-ligation Doppler US Shows retrograde ' plateau-like ' diastolic frequency shifts. RI is markedly increased than A.
C. Post-ligation 1st day Doppler US. The rate of RI increase becomes blunt. RI is slightly increased rather than B.
D. Post-ligation 2nd day Doppler US. RI is the highest value.
E. Post-ligation 3rd day Doppler US. RI is decreased than D. Note retrograde ' plateau-like ' diastolic frequency shift.

(20, 21) (Fig. 1).
 1989 Reuther (12) (peaked
 antegrade systolic frequency shift),
 (retrograde 'plateau-like' diastolic frequency shift)
 (missing venous Doppler signal)

, 1991 Baxter (17) (inverted M)
 (retrograde plateau-like)
 가
 (reverse peak)

(Fig. 6). , 48
 27

Reuther (12) 가
 1990 Kaveggia (16) 가

가 (8, 17).

가
 (17).

가

가

, 72

- Argyropoulou MI, Giapros VI, Papadopoulou F, Drougia AA, Nikolopoulos P, Vartholomatos GA, et al. Renal venous thrombosis in an infant with predisposing thrombotic factors: color Doppler ultrasound and MR evaluation. *Eur Radiol* 2003;13:2027-2030
- Voiculescu A, Pfeiffer T, Brause M, Sandmann W, Grabensee B.

- Acute pain over the kidney graft and Duplex-sonographic findings mimicking complete renal transplant vein thrombosis. *Nephrol Dial Transplant* 2002;17:2268-2269
- Kawashima A, Sandler CM, Ernst RD, Tamm EP, Goldman SM, Fishman EK. CT evaluation of renovascular disease. *Radiographics* 2000;20:1321-1340
- Byun HS, Han JK, Kim SH, Park JH, Kim CW. Magnetic resonance imaging of rabbit kidney after renal vein ligation. *Journal of Korean Radiological Society* 1993;29:402-409
- Vogelzang RL, Moel DI, Cohn RA, Donaldson JS, Langman CB, Nemeck AA Jr. Acute renal vein thrombosis: successful treatment with intraarterial urokinase. *Radiology* 1988;169:681-682
- Seupaul RA, Stepsis TM, Doehring MC. Idiopathic renal vein thrombosis in a healthy young woman with flank pain and fever. *Am J Emerg Med* 2005;23:417-419
- Baxter GM, Rodger RS. Doppler ultrasound in renal transplantation. *Nephrol Dial Transplant* 1997;12:2449-2451
- Platt FJ, Ellis JH, Rubin JM. Intrarenal arterial Doppler sonography in the detection of renal vein thrombosis of the native kidney. *AJR Am J Roentgenol* 1994;162:1367-1370
- Gatewood OM, Fishman EK, Burrow CR, Walker WG, Goldman SM, Siegelman SS. Renal vein thrombosis in patients with nephrotic syndrome: CT diagnosis. *Radiology* 1986;159:117-122
- Mittelstaedt CA. *General Ultrasound*. New York: Churchill Livingstone, 1992;980-986
- Reuther G, Wanjura D, Bauer H. Acute renal vein thrombosis in renal allografts: detection with duplex Doppler US. *Radiology* 1989;170:557-558
- Rosenfield AT, Zeman RK, Cronan JJ, Taylor KJ. Ultrasound in experimental and clinical renal vein thrombosis. *Radiology* 1980;137:735-741
- Hricak H, Sandler MA, Madrazo BL, Eylar WR, Sy GS. Sonographic manifestations of acute renal vein thrombosis: an experimental study. *Invest Radiol* 1981;16:30-35
- Kim JK, Han DJ, Cho KS. Post-infectious diffuse venous stenosis after renal transplantation: duplex ultrasonography and CT angiography. *Eur Radiol* 2002;S118-120
- Warshauer DM, Taylor KJW, Bia MJ, Marks WH, Weltin GG, Rigsby CM, et al. Unusual causes of increased vascular impedance in renal transplants: duplex Doppler evaluation. *Radiology* 1988;169:367-370
- Kaveggia LP, Perrella RR, Grant EG, Tessler FN, Rosenthal JT, Wilkinson A, et al. Duplex Doppler sonography in renal allografts: the significance of reversed flow in diastole. *AJR Am J Roentgenol* 1990;155:295-298
- Baxter GM, Morley P, Dall B. Acute renal vein thrombosis in renal allografts: new Doppler ultrasonic findings. *Clin Radiol* 1991;43:125-127
- Pozniak MAA, Dodd GD, Kelcz F. Ultrasonic evaluation of renal transplantation. *Radiol Clin North Am* 1992;30:1053-1066
- Paling MR, Wakefield JA, Watson LR. Sonography of experimental acute renal vein occlusion. *J Clin Ultrasound* 1985;13:647-653
- Selkurt EE, Elpers MJ, Womack I. Effects of renal venous occlusion on renal hemodynamics and concentrating ability. *Am J Physiol* 1964;207:989-997
- Kim SH, Byun HS, Park JH, Han JK, Han MC, Lee JS. Renal parenchymal abnormalities associated with renal vein thrombosis: correlation between MR imaging and pathologic findings in rabbits. *AJR Am J Roentgenol* 1994;162:1361-1365

Ultrasonographic Findings of Acute Renal Vein Thrombosis in Experimental Rabbit Model: Focus on Renal Doppler Sonography¹

Han Jin Cho, M.D., Joo Won Lim, M.D.², Young Tae Ko, M.D.², Hoon Pyo Hong, M.D.

¹Department of Emergency Medicine, Kyunghee University

²Department of Diagnostic Radiology, College of Medicine, Kyunghee University

Purpose: To evaluate Doppler sonographic findings of acute renal vein thrombosis in rabbit model induced by renal vein ligation, with an emphasis on the changes in resistive index (RI) on serial follow-up.

Materials and Methods: Conventional and Doppler sonographies were performed immediately after ligation and 24, 48, and 72 hours after ligation in 12 rabbits weighing 4.5 - 5.0 kg. We focused on changes in kidney size and echogenicity with conventional sonography and resistive index by time interval and Doppler waveforms with Doppler sonography.

Results: Kidney size increased markedly immediately after ligation, and increased slowly until 48 hours after ligation with no change observed afterwards. Echogenicity increased both in the renal cortex and the medulla. RI increased remarkably to an average of 1.38 immediately after ligation, and increased to a peak average of 1.64 48 hours after ligation. After 72 hours RI decreased slightly to 1.59. Reverse 'plateau-like' diastolic waveform was seen in 27 trials (56%) on follow up Doppler sonograms.

Conclusion: The increase in RI was thought to be due to the increase in renal arterial vascular resistance caused by venous outflow obstruction. The decrease in RI with time suggested adaptation of intrarenal circulation to renal vascular change. Also, the reverse 'plateau-like' diastolic waveform was the predominant waveform.

Index words : Renal vein thrombosis
Doppler sonography
Experimental studies

Address reprint requests to : Hoon Pyo Hong, M.D., Department of Emergency Medicine, Kyunghee University Medical Center,
1 Hoegi-dong, Dongdaemun-gu, Seoul 130-702, Korea.
Tel. 82-2-958-8271 Fax. 82-2-958-8746 E-mail: xrayhong@hanmail.net