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# Influence of age on intrarenal resistive index measurement in normal subjects

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**Abstract**
*Background:* We investigated the influence of age on intrarenal arterial resistive index (RI) measurement in 135 normal subjects (71 male, 64 female; age range = 17–68 years, median age = 37 years).
*Methods:* Each subject underwent color Doppler measurement of the intrarenal RI from three distinct interlobar arteries in the superior, middle, and inferior parts of both kidneys. The mean of six RI values obtained from both kidneys was used for analysis. The correlation of RI with different variables was investigated by linear regression and stepwise multiple linear regression. Variables analyzed were age, systolic blood pressure, diastolic blood pressure, mean blood pressure, pulse pressure, and pulse rate.
*Results:* The results of linear regression showed that age had a significantly positive correlation ($r = 0.276$, $p = 0.0012$) and diastolic blood pressure had a significantly negative correlation ($r = -0.186$, $p = 0.0311$) with the RI. The results of stepwise multiple linear regression showed that the combination of age and diastolic blood pressure could explain approximately 15% of the RI changes ($r^2 = 0.1535$).
*Conclusion:* Although there is a statistically significant positive correlation between intrarenal RI and age, the correlation is weak. This suggests that the influence of age on RI measurement is small and may be of no clinical importance.

**Key words:** Kidney—Blood supply—Resistive index—Ultrasound—Doppler studies.

Measurement of the intrarenal arterial resistive index (RI) has been widely applied in the evaluation of renovascular impedance [1–20]. Previous studies have shown that aging may alter intrarenal RI in normal adults [10, 16]. However, there were several pitfalls in those studies. The RI values in one study were obtained from the interlobar or arcuate arteries [10]. Differences in the vessels studied may alter the RI results [15, 18]. One study did not mention whether the subjects were fasting [10]. Another study was performed without fasting [16]. Because renovascular resistance may increase after eating [19], whether the subjects are fasting may alter the results. Moreover, the postures of subjects for RI measurement were not consistent in one study [16]. Our previous study showed that changing the subject's posture can influence the RI results [21]. This prospective study was designed to prevent these pitfalls and to investigate the possible influence of age on intrarenal RI measurement in normal subjects.

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## Material and methods

A total of 135 normal subjects (71 male, 64 female; age range = 17–68 years, median age = 37 years) who underwent routine health examination were studied by color Doppler ultrasound (US). None of the subjects had a history of hypertension, diabetes mellitus, alcoholism, renal disease, hepatic disease, heart disease, or abdominal surgery. Each subject showed normal results on real-time US (SSA 270A, Toshiba, Tokyo; 3.75-MHz convex probe) scanning of both kidneys and the liver. The kidney with tumor, stone, cyst, pyelocaliectasis, or cortical echogenicity greater than that of the adjacent liver or spleen on real-time US was defined as abnormal, and the subject was not included. Each subject also had normal results for urinalysis, serum creatinine, blood urea nitrogen, sugar, aspartate aminotransferase, alanine aminotrasferase, and viral hepatitis markers (B and C). All subjects agreed to enter the study after being informed about the procedure and the purpose of the study.

After fasting overnight, all subjects were examined by color Doppler US (SSA 270A) with a 3.75-MHz convex probe. All measurements were performed during suspended respiration at the end of the subject's inspiratory phase. To minimize interobserver variability [9, 17], all measurements were performed by an expert who had more than 11 years' experience with Doppler US. The Doppler sample volume was set at 2, 3, or 5 mm. The wall filter was set at 100 Hz. The pulse repetition frequency was set as low as possible (usually at 3.0 kHz) to avoid aliasing. The Doppler gain was set at its optimum condition to obtain a clear outline of flow waves with minimal background noise. All interrogating angles between the Doppler beam axis and the vessel examined were less than 50°. RI was defined as: (peak systolic velocity − minimum diastolic velocity)/peak systolic velocity. The peak systolic velocity and the minimum diastolic velocity were calculated automatically from the velocity spectrum after being manually traced along the top of the Doppler signals on the monitor. The duration for recorded Doppler signals in our monitor was 2.34 s, which usually included more than two cardiac cycles. The right kidney was examined while the subject was in the left lateral decubitus position, and the left kidney was examined while the subject was in the right lateral decubitus position. Three distinct interlobar arteries in the superior, middle, and inferior parts of the kidney were examined. The mean of six RI values obtained from both kidneys was used for analysis. Systolic blood pressure, diastolic blood pressure, pulse pressure, mean blood pressure, and pulse rate were determined after RI measurement. Pulse pressure was calculated by subtracting diastolic blood pressure from systolic blood pressure, and mean blood pressure was calculated by the formula: (diastolic blood pressure + pulse pressure/3).

Data were expressed as mean ± standard deviation and range. The correlation between RI and different variables was investigated by linear regression and stepwise multiple linear regression. Variables for analysis were age, systolic blood pressure, diastolic blood pressure, mean blood pressure, pulse pressure, and pulse rate. The coefficient of linear correlation was expressed as an $r$ value. Statistical significance was set at $p < 0.05$.

## Results

The RI values for all subjects ranged from 0.47 to 0.69 (0.59 ± 0.04). The results of linear regression showed that age had a significantly positive correlation ($r = 0.276$, $p = 0.0012$; Fig. 1) and diastolic blood pressure had a significantly negative correlation ($r = -0.186$, $p = 0.0311$) with RI. There was no significant correlation between RI and systolic blood pressure, mean blood pressure, pulse pressure, and pulse rate. The results of stepwise multiple linear regression also showed that only age and diastolic blood pressure significantly correlated with RI. However, the combination of these two variables explained approximately 15% of the RI changes ($r^2 = 0.1535$).

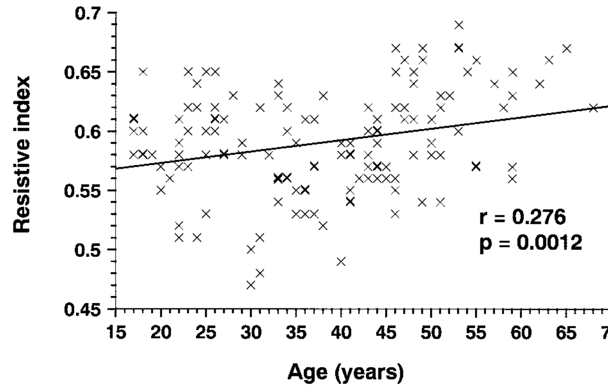


**Fig. 1.** Correlation between the resistive index and age.

## Discussion

In the present study, there was a statistically significant positive correlation between RI and age. This result was in agreement with those of previous studies [10, 16]. However, the correlation between age and RI in our study was very weak. This suggests that the influence of age on RI measurement is very small and thus may be of no clinical importance. The actual mechanism for the positive correlation between RI and age needs further investigation. Mostbeck et al. reported that the intrarenal RI values correlated significantly with the prevalence of arteriolosclerosis, glomerular sclerosis, arteriosclerosis, edema, and focal interstitial fibrosis of the kidney [5]. In their study, the RI increased as the patient's age advanced because of increased incidence of arteriosclerosis. Although the RI data in their study were not obtained from normal subjects, their results imply that the incidence of arteriosclerosis and/or arteriolosclerosis of the kidney also increase with advancing age in normal adults. This may be one explanation for the positive correlation between RI and age.

There were few potential pitfalls in our study design. Unlike the study performed by Keogan et al. [16], none of our subjects underwent angiography. Although we had performed extensive evaluation with normal findings in our subjects, the possibility of occult renal vascular disease could not be completely excluded. Moreover, our study did not perform renal biopsy because of ethical considerations. We could not confirm that all kidneys studied were actually normal. This is also the reason we did not want to include subjects older than 70 years because of the high probability of occult renal disease in that age group. Nevertheless, the number of the subjects in our study was very large. The possible influence of occult renal disease on the statistical results of total RI values were minimized. However, we cannot exclude the effect of intraobserver variation on RI measurement. Our results might have been influenced significantly if the intraobserver variation for the operator were unacceptable. In our experience, the coefficient of variation for two intrarenal RI measurements obtained from a time span of 1 month in 16 normal volunteers measured by the same operator is acceptable ($2.03 \pm 1.77\%$, range = 0–5.09%; unpublished data). In the present study, the operator was not blinded to the RI readings, which may be a source of bias in that the measurements were made by an operator who was aware of the subjects' ages. However, the influence of this factor likely was minimized by our strict method for measuring RI.

Several studies have shown that systolic blood pressure, diastolic blood pressure, pulse pressure, and pulse rate can significantly influence the RI measurement [20, 22, 23]. However, our results showed that only diastolic blood pressure had a significantly negative correlation with RI. The discrepancy between our and previous results is due to differences in the subjects studied. The influences of systolic blood pressure and pulse pressure on RI measurement occurred in patients with moderate to severe hypertension rather than in normal subjects [20]. However, the influence of pulse rate on RI measurement was significant only in subjects with remarkable tachycardia or bradycardia [22, 23]. With rapid pulse rate, the diastolic component of the cardiac cycle becomes shortened with a concomitant increase in the end-diastolic frequency shift on the velocity spectrum of Doppler US. Because the systolic component remains relatively stable, this increase in the end-diastolic component decreases the RI value [22]. Conversely, bradycardia increases the RI value. None of the subjects in the present study had tachycardia or bradycardia, so we found no correlation between pulse rate and RI.

In conclusion, the influence of age on intrarenal RI measurement is small and may be of no clinical importance for subjects aged 17 to 68 years.

## References


1. Gottlieb RH, Luhmann K, Oates RP. Duplex ultrasound evaluation of normal native kidneys and native kidneys with urinary tract obstruction. *J Ultrasound Med* 1989;8:609–611
2. Platt JF, Rubin JM, Ellis JH. Distinction between obstructive and nonobstructive pyelocaliectasis with duplex Doppler sonography. *AJR* 1989;153:997–1000
3. Platt JF, Ellis JH, Rubin JM, et al. Intrarenal arterial Doppler sonography in patients with nonobstructive renal disease: correlation of resistive index with biopsy findings. *AJR* 1990;154:1223–1227
4. Platt JF, Rubin JM, Ellis JH. Acute renal failure: possible role of duplex Doppler US in distinction between acute prerenal failure and acute tubular necrosis. *Radiology* 1991;179:419–423
5. Mostbeck GH, Kain R, Mallek R, et al. Duplex Doppler sonography in renal parenchymal disease. *J Ultrasound Med* 1991;10:189–194
6. Platt JF, Marn CS, Baliga PK, et al. Renal dysfunction in hepatic disease: early identification with renal duplex Doppler US in patients who undergo liver transplantation. *Radiology* 1992;183:801–806
7. Platt JF. Duplex Doppler evaluation of native kidney dysfunction: obstructive and nonobstructive disease. *AJR* 1992;158:1035–1042
8. Colli A, Cocciolo M, Riva C, Martinez E. Abnormal renovascular impedance in patients with hepatic cirrhosis: detection with duplex US. *Radiology* 1993;187:561–563
9. London NJ, Aldoori MI, Lodge VG, et al. Reproducibility of Doppler ultrasound measurement of resistance index in renal allografts. *Br J Radiol* 1993;66:510–513
10. Mastorakou I, Lindsell DRM, Piepoli M, et al. Pulsatility and resistance indices in intrarenal arteries of normal adults. *Abdom Imaging* 1994;19:369–373
11. Platt JF, Rubin JM, Ellis JH. Diabetic nephropathy: evaluation with renal duplex Doppler US. *Radiology* 1994;190:343–346
12. Brkljacic B, Mrzljak V, Drinkovic I, et al. Renal vascular resistance in diabetic nephropathy: duplex Doppler US evaluation. *Radiology* 1994;192:549–554
13. Platt JF, Ellis JH, Rubin JM, et al. Renal duplex Doppler ultrasonography: a noninvasive predictor of kidney dysfunction and hepatorenal failure in liver disease. *Hepatology* 1994;20:362–369
14. Maroto A, Ginès A, Saló J, et al. Diagnosis of functional kidney failure of cirrhosis with Doppler sonography: prognostic value of resistive index. *Hepatology* 1994;20:839–844
15. Knapp R, Plötzeneder A, Frauscher F, et al. Variability of Doppler parameters in the healthy kidney: an anatomic–physiologic correlation. *J Ultrasound Med* 1995;14:427–429
16. Keogan MT, Kliewer MA, Hertzberg BS, et al. Renal resistive indexes: variability in Doppler US measurement in a healthy population. *Radiology* 1996;199:165–169
17. Sacerdoti D, Gaiani S, Buonamico P, et al. Interobserver and interequipment variability of hepatic, splenic, and renal arterial Doppler resistance indices in normal subjects and patients with cirrhosis. *J Hepatol* 1997;27:986–992
18. Rivolta R, Maggi A, Cazzaniga M, et al. Reduction of renal cortical blood flow assessed by Doppler in cirrhotic patients with refractory ascites. *Hepatology* 1998;28:1235–1240
19. Iwao T, Oho K, Nakano R, et al. Effect of meal induced splanchnic arterial vasodilation on renal arterial haemodynamics in normal subjects and patients with cirrhosis. *Gut* 1998;43:843–848
20. Malatino LS, Polizzi G, Garozzo M, et al. Diagnosis of renovascular disease by extra- and intrarenal Doppler parameters. *Angiology* 1998;49:707–721
21. Lin ZY, Dai CY, Chang WY, et al. Influence of posture change on intrarenal arterial resistive index measurement. *Abdom Imaging* 2002;27:626–628
22. Yarlagadda P, Willoughby L, Maulik D. Effect of fetal heart rate on umbilical arterial Doppler indices. *J Ultrasound Med* 1989;8:215–218
23. Mostbeck GH, Gössinger HD, Mallek R, et al. Effect of heart rate on Doppler measurements of resistive index in renal arteries. *Radiology* 1990;175:511–513