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Age Dependency of Intrarenal Resistance Index (RI) in Healthy Adults and Patients with Fatty Liver Disease

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Abstract
Background: Our aim was to investigate the influence of age and gender on intrarenal resistance index (RI) measurements in 78 healthy subjects (46 males, 32 females; group 1) and 35 subjects (group 2) with fatty liver disease (28 males and 7 females).
Subjects and methods: First, each subject underwent a conventional abdominal ultrasound examination. Then, intrarenal RI values were determined from three distinct interlobar and cortical arteries respectively on both kidneys. The correlation of intrarenal RI with age and gender as a variable was statistically evaluated by linear regression.
Results: In group 1, the variables gender, kidney region and comparison of right versus left kidney had no significant effect on intrarenal RI ($p>0.05$). The variable age, on the other hand, showed a significant positive correlation on all four defined measuring points ($p<0.01$) with linear correlation coefficients of $r = 0.26$ (left kidney, central) to $r = 0.37$ (right kidney, cortical). Therefore normal RI values at ages 25, 45, 65 years could be defined as 0.59, 0.61 and 0.63, respectively. Age dependency can thus be expressed as a function with the formula $y = 0.565 + 0.001\,x$. Patients with fatty liver disease showed age dependency on renal RI ($p<0.01$) as well.
Conclusion: In accordance with other studies, the influence of age on intrarenal RI measurement is significant in healthy subjects. Intrarenal RI values from subjects with a fatty liver disease showed age dependency as well. Therefore it is necessary to consider the age of the examined person to interpret RI values correctly.

Key words: Resisatance Index, age dependency, healty adults, fatty liver disease, ultrasound

Abbreviations: RI = resistance index, Arc = arcuate arteries, Seg = segmental arteries

Introduction

Measurement of the intrarenal resistance index has been widely applied in the evaluation of renovascular changes. Previous studies have shown that age may alter intrarenal RI in normal adults. But no standardized values have been evaluated till now. A reason may be that the results are quite different. Some investigators maintain that the influence of age on RI is weak and may be of no clinical importance (Lin et al. 2002). In some other studies, intrarenal RI values were compared without taking the age of the different groups into account. On the other hand, other investigators found a considerable correlation between age and RI and maintain that age is an important variable in regarding normal RI values. Most investigators define a value lower than 0.7 as normal in the adult population.

The point of departure for this study was to evaluate reference RI values while taking age into account. For that reason, we examined the resistance index in a group of healthy adults. In doing so we established normal ranges and were able to investigate their variability in the right and left kidney in relation to parameters such as age and gender. We also compared the renal RI of the people with an normal abdominal ultrasound (group 1) in contrast to a group of subjects with fatty liver disease (group 2). It is described in the existing literatur on patients with cirrhosis that they show increased intrarenal RI values (Colli et al. 1993, Celebi et al. 1997, Platt et al. 1994, Sacerdoti et al. 1993). This is pathophysiologically explained by a renal constriction. Intrarenal RI values of subjects with a fatty liver have not, to our knowledge, been previously published.

Subjects and Methods

We enrolled 78 consecutive healthy adults (group 1) with a mean age of 46 years ± 13 (range 18 to 74 years) and 35 consecutive subjects with a fatty liver disease (group 2) with a mean age of 49 years ± 10 (range 26 to 70 years). They had no past or current history of renal disease, hypertension, diabetes mellitus or abdominal surgery. Fatty liver disease was diagnosed by occurrence of hyperechogenic hepatomegaly with dorsal hypoechogenicity and elevated liver enzymes. There were 46 males and 32 females in group 1 and 28 males and 7 females in group 2. We stratified the population by age and gender, respectively. In addition, we subdivided the subjects in steps of decades. In all cases, renal function, evaluated by GFR and serum creatinine, was in the normal range. After fasting for at least four hours, all subjects were examined by B-mode ultrasound and colour-Doppler ultrasound with a 3.5 MHz broadband convex scanner (Siemens SONOLINE Elegra, Erlangen, Germany). All mea-

surements were performed during suspended respiration. Renal length and parenchymal width were determined. In B-mode ultrasound, no anatomical abnormality of the kidney or urinary tract was detected. The subject's kidneys had normal sizes (90 – 130 mm) on both sides depending on body size. Parenchymal width was normal (13-20 mm) as well. Patients with a cortical hyperechogenicity (greater than that of the liver or spleen) were excluded. Colour-flow-doppler signals were taken from segmental arteries near hilum (seg) and arcuate arteries of the cortex (arc) in the right and left kidney, respectively. Before starting the study, the results of the experienced investigators were compared to each other to rule out the possibility of a significant interobserver variability. Intrarenal RI was determined from analysis of the spectral waveform as follows: the peak systolic velocity minus the lowest diastolic velocity divided by the peak systolic velocity (RI = [V_{max}Systole-V_{min}Diastole] / VmaxSystole). The height of the pulsed Doppler waveform was maximized to facilitate measurement. The mean RI was calculated as an average of three measurements. Each measurement was done on condition that at least three waveforms followed each other (Fig. 1).

Statistical Analysis

The data were evaluated with Excel 2000 (Microsoft Corp., Redmond, USA) and expressed as mean ± standard deviation. Afterwards renal RI-values were analyzed with BMDP (Biomedical Computer Programs). The effect of age on the RI was evaluated by linear regression. The coefficient of linear correlation was expressed as an r-value. Statistical significance was considered as $p<0.05$

Results

The mean values of the vital parameters are shown in Table 1, they were all in normal range. The mean renal length in group 1 was 11.2 cm ± 0.8 for the right and 11.2 cm ± 0.7 for the left kidney. In group 2 the mean values were 11.1 cm ± 0.7 for the right and 11.2 cm ± 0.6 for the left kidney. Renal laboratory values (serum creatinine, BUN and GFR) were normal in both groups and are shown in Table 1. The basline data showed no significant difference.

There were no significant differences between the RI values of the right versus the left kidney and of

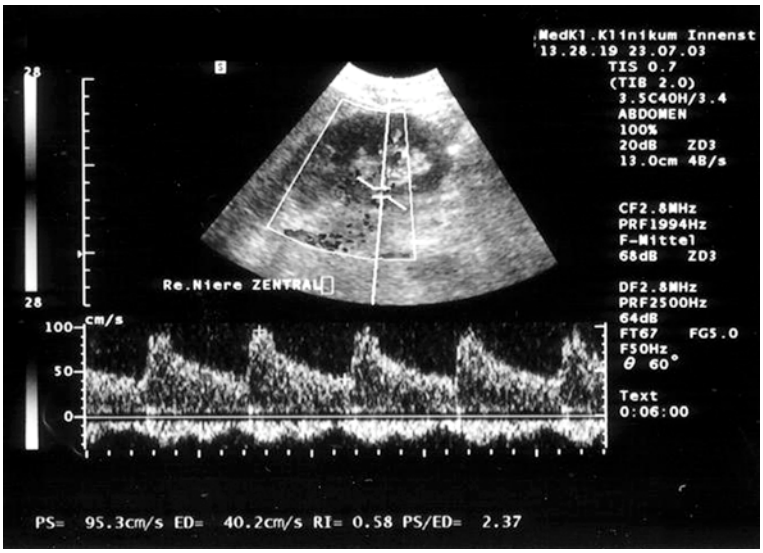

Fig. 1. Doppler ultrasonographic measurement of RI in intrarenal interlobar arteries. Figure 1 shows a normal value of 0.58 in a healthy adult (25 years old).

Table 1. Baseline data of group 1 and group 2 without significant difference. Patients with a fatty liver disease showed comparable renal RI values as subjects without liver disease.

	group 1	**group 2**	**p-value**
Age (years) ± SD	46.2 ± 13.1	49.3 ± 10.1	ns
Blood pressure(mm/Hg) ± SD	123 / 78 ± 12 / 7	129 / 79 ± 9 / 5	ns
Pulse (1/s) ± SD	77 ± 8	80 ± 6	ns
serum creatinine (mg/dl) ± SD	0.8 ± 0.2	0.9 ± 0.2	ns
BUN (mg/dl) ± SD	13 ± 6	11 ± 4	ns
GFR (ml/min) ± SD	103 ± 26	104± 21	ns
RI mean ± SD	0.62 ± 0.05	0.63 ± 0.05	ns

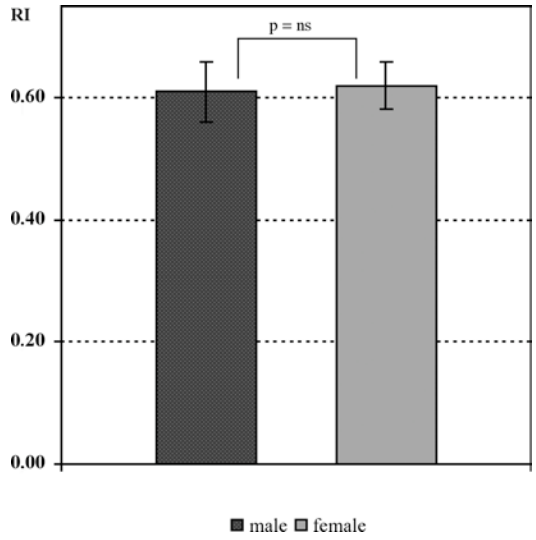

Fig. 2. Gender showed no significant difference in group1 regarding intrarenal resistance index with a mean RI value of 0.61 ± 0.05 in males and 0.62 ± 0.04 in females (p=ns).

parenchymal regions (seg or arc) within a subject belonging to group 1 and 2 (group1: RI right seg 0.62 ± 0.04, RI right arc 0.62 ± 0.04, RI left seg 0.62 ± 0.05, RI left arc 0.61 ± 0.05; group2: RI right seg 0.63 ± 0.05, RI right arc 0.62 ± 0.05, RI left seg 0.63 ± 0.05, RI left arc 0.63 ± 0.05). There is only a minor difference in cortical RI values in contrast to interlobar RI values. However the trend seems to indicate marginal lower cortical RI values in contrast to the interlobar RI values (Figs. 3, 4).

Regarding gender (Fig. 2) no significant difference in RI values could be found in group 1 between males (RI = 0.61 ± 0.05) and females (RI = 0.62 ± 0.04), whereas the analysis of variance showed a positive correlation between RI and age ($p < 0.01$, $r = 0.32$). The average RI increased by 0.001 per year of age ($p<0.01$). Therefore normal RI values at ages 25, 45, 65 years could be defined as 0.59, 0.61 and 0.63 respectively (Fig. 5). Age dependency can thus be expressed in a function with the formula $y = 0.565 + 0.001\,x$. Moreover, in group 2, the analysis of variance showed a positive correlation (Fig. 6) between RI and age (p<

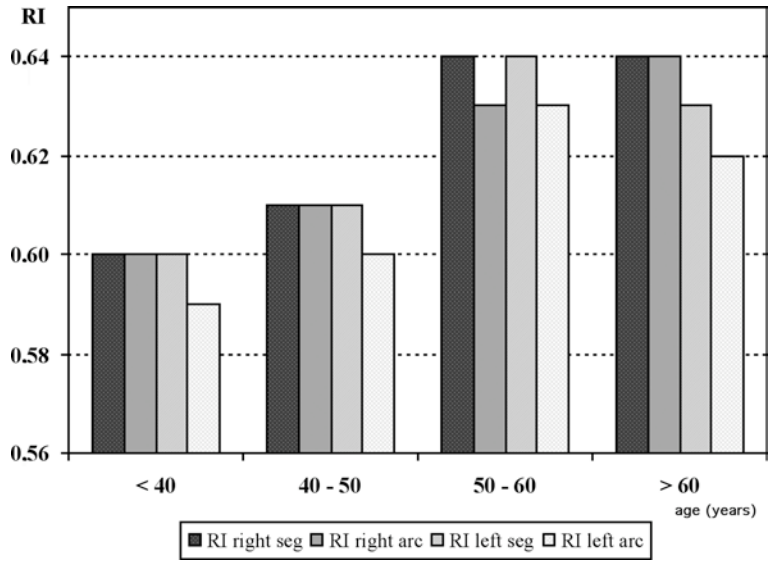

Fig. 3. Positive correlation between renal RI and age in healthy adults. There were no significant differences between the RI values of the right versus the left kidney and of parenchymal regions within a subject in group 1.

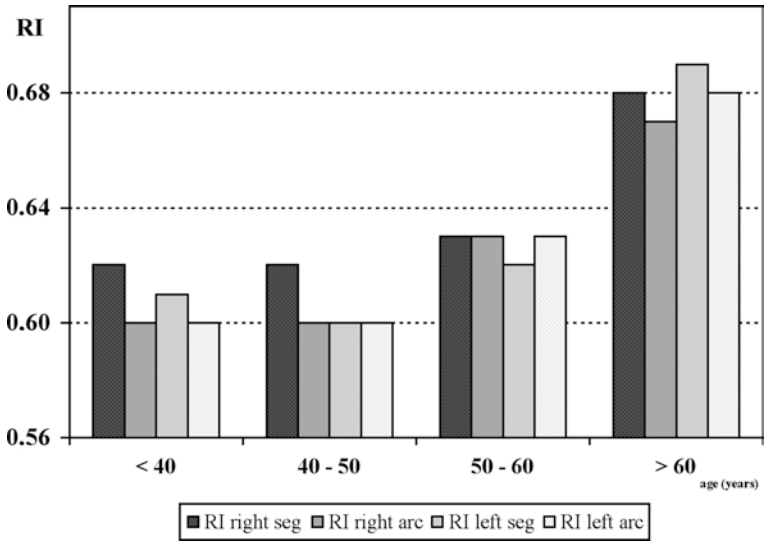

Fig. 4. Positive correlation between RI and age in patients with fatty liver disease. There were no significant differences between the RI values of the right versus the left kidney and of parenchymal regions within a subject in group 2.

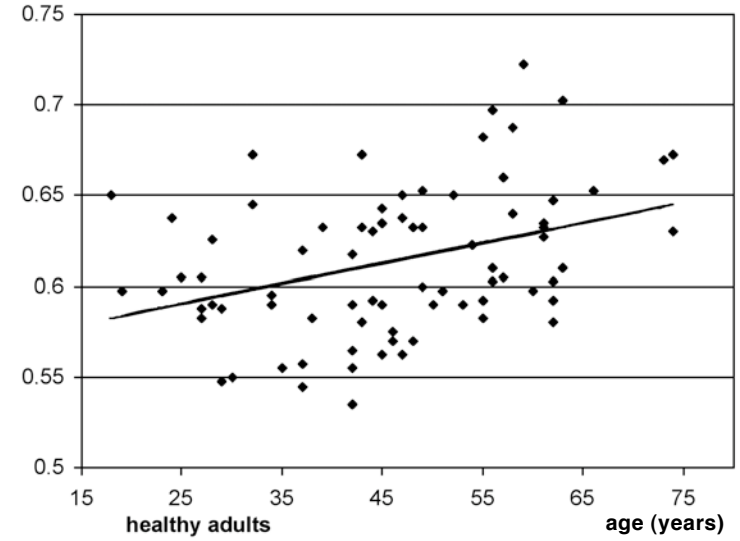

Fig. 5. Positive correlation between resistance index and age in healthy adults (group 1). The diagram shows that RI values rise with increasing age.

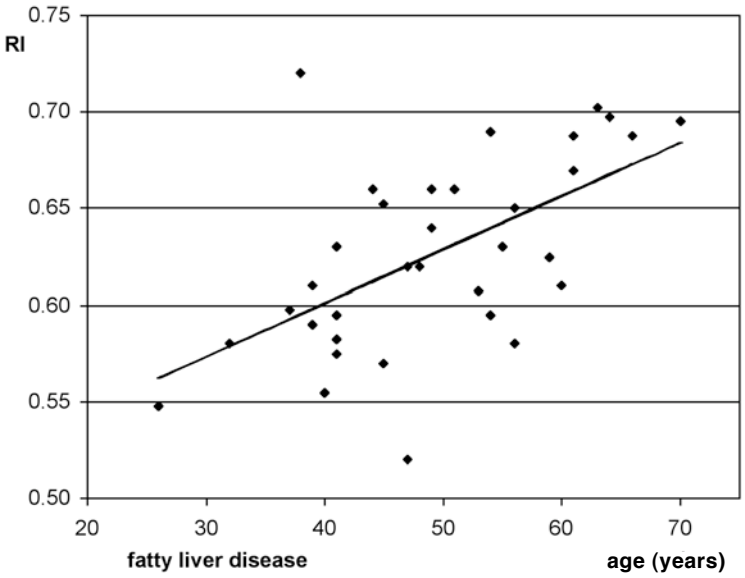

Fig. 6. Positive correlation between resistance index and age in patients with fatty liver disease (group 2). The diagram shows that RI values rise with increasing age.

0.01).

Group 1 and group 2 showed no signifticant difference concerning age, vital parameters, Serumcreatinine, BUN, and GFR (Table 1). RI values in group 1 (0.62 ± 0.05) and group 2 (0.63 ± 0.05) showed no significant differences as well.

Discussion

Current literature on RI measurement stresses two important issues in measuring RI values. Keogan and coworkers recommend averaging a number of at least three measurements in a kidney to obtain a single mean representative value in order to reduce the variability of RI measurement (Keogan et al. 1996). According to Sacerdoti et al., interobserver variability among experienced investigators trained for this method is very low (Sacerdoti et al. 1993). Keogan´s and Sacerdotis´ coworkers approach is confirmed by our study.

We confirm that at least three measurements should be done to get a representative value.

As expected, no significant difference between left and right kidney was found in our groups of patients without renal disease. Previous data had shown that RI values decrease from renal hilum to the cortex (Knapp et al. 1995). Our results also hint to a slight decrease between the two points of measurement, but the difference was not significant.

Our data confirm previous studies (Lin et al. 2002, Mastorakou et al. 1994, Keogan et al. 1996) which conclude that age has a significant effect on renal RI. In our group, the renal RI increases by 0.001 per year which is similar to the findings of Keogan and coworkers. They investigated a smaller group of 58 healthy probands and described that renal RI increases by 0.002 per year.

In addition to healthy adults, we investigated the RI values in a group of subjects with fatty liver disease. As for now, no data could be found in literature for these subjects concerning renal RI measurement. In

our study, no differences could be found between this group and the control group of healthy adults. This confirms the pathophysiologic finding that this stage of liver disease is not associated with kidney dysfunction. However our values show differences to values obtained from patients with liver cirrhosis. Literature on these patients states that RI values are higher in contrast to healthy adults (Colli et al. 1993, Celebi et al. 1997, Platt et al., Sacerdoti et al. 1993).

We conclude that the influence of age on intrarenal RI measurement is significant and has to be taken into account for further studies on RI measurements. Intrarenal RI values from subjects with a fatty liver disease showed age dependency as well.

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