

# Renal extracapsular hypoechoic rim and kidney cortical thickness

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**Summary** *Objectives: A renal extracapsular hypoechoic rim was previously recognized and interpreted as a typical sonographic finding of renal failure. Subsequently it was hypothesized that the hypoechoic rim could be produced by a state of sodium retention and oedema caused by nephropathy but not necessarily associated with renal failure. In order to get this cleared we performed a retrospective analysis of 80 renal ultrasound examinations, carried out at our center, in 41 of which it was found a renal extracapsular hypoechoic rim.*

*Materials and methods: For each patient we recorded the glomerular filtration rate, the diameters in the longitudinal axis, the resistive indexes and the cortical thickness of each kidney, the possible presence and thickness of the hypoechoic rim and yet the possible coexistence of diabetes mellitus, proteinuria and clinical signs of fluid overload as peripheral oedema, distended jugular veins, ascites, increased caliber and reduced respiratory excursion of the vena cava.*

*Results: The F value calculated to assess the weight/influence on the hypoechoic rim of each of the variables showed as all variables, except the sex, significantly weighed on the hypoechoic rim although the greatest weight was reached by a glomerular filtration rate < 60 ml/min/1.73 m<sup>2</sup> and a renal cortical thickness between 7 and 12 mm. The hypoechoic rim was found only when cortical thickness was between 7 and 12 mm while it was absent if the cortical thickness was less than 7 or greater than 12 mm. We also found numerous cases of sidedness of the hypoechoic rim.*

*Conclusions: It is our opinion that in case of unilateral finding of an hypoechoic rim, the association between the hypoechoic rim and the cortical thinning is consistent and therefore more accurate than the correlation between the presence of the hypoechoic rim and the reduction of the glomerular filtration rate.*

**KEY WORDS:** Renal ultrasonography; Renal extracapsular hypoechoic rim; Cortical thinning; Kidney failure; Retrospective analysis.

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## INTRODUCTION

The presence of a renal extracapsular hypoechoic rim (that was called “kidney sweat” sign) (Figures 1, 2) for the first time was recognized by Yassa *et al.* (1) in 1999 by a series of 502 ultrasound examinations, 330 of those were performed in patients with renal insufficiency. Yassa *et al.* (1)

interpreted renal extracapsular hypoechoic rim as an ultrasound finding exclusive of patients with renal impairment because they didn't find any trace of it in any of 172 kidney ultrasound scans performed in patients who had no clinical or laboratory signs of kidney failure.

Subsequently Haddad *et al.* (2) by a series of only 9 patients advanced the hypothesis that the renal extracapsular hypoechoic rim could be constituted by a transudate that may occur in patients suffering from a state of sodium retention and oedema resulting from some form of nephropathy although not necessarily associated with renal impairment. However, Haddad *et al.* (2) observed the hypoechoic rim also in patients affected by parenchymal renal disease but without renal failure.

In order to find more evidence to settle, if possible, this different interpretations we performed a retrospective analysis of 41 renal ultrasound examinations, carried out over the last six months at our center and reporting the presence of an unilateral or bilateral renal extracapsular hypoechoic rim, in association with a retrospective analysis of 39 controls, randomly selected, among the patients who underwent renal ultrasound exam in the same six months and who didn't show any renal extracapsular hypoechoic rim.

Of these 80 patients we recorded sex and age, the actual glomerular filtration rate estimated from the serum creatinine by the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation (3), the longitudinal axis diameters of each of the two kidneys, the resistive indexes of both kidneys, the cortical thickness of each of the two kidneys, the presence or not, for each kidney, of an extracapsular hypoechoic rim and, if present, its thickness, presence of diabetes mellitus, presence of proteinuria and its amount, presence of any clinical signs of fluid overload such as peripheral oedema, distended jugular veins, ascites, increased caliber and reduced respiratory excursion of the vena cava.

## MATERIALS AND METHODS

From June 2016 to December 2016 we found at renal ultrasound examination an unilateral or bilateral renal extracapsular hypoechoic rim in 41 patients. Subsequently we randomly selected 39 patients as control group, among who underwent renal ultrasound

No conflict of interest declared.

examination in the same six months and who didn't show any renal extracapsular hypoechoic rim.

All kidney nephrology ultrasound examinations were performed by Logiq S7 (GE Medical Systems Italy S.P.A. Milan, Italy) sonographic system using 3 to 5 Mhz transducers.

For every patient were recorded sex, age and glomerular filtration rate (GFR) estimated by the CKD-EPI equation (3) from serum creatinine as found during the blood test closer to the time of the ultrasound examination.

Subsequently four classes of renal function were recognized: severe renal insufficiency when the GFR was lower than 30 ml/min/1.73 m<sup>2</sup>, moderate renal impairment when the GFR was equal or greater than 30 ml/min/1.73 m<sup>2</sup> and less than 60 ml/min/1.73 m<sup>2</sup>, mild renal impairment when the GFR was equal or greater than 60 ml/min/1.73 m<sup>2</sup> and less than 90 ml/min/1.73 m<sup>2</sup> and finally normal renal function when the GFR proved equal or greater than 90 ml/min/1.73 m<sup>2</sup>.

We recorded the diameters in the longitudinal axis of each kidney, the resistive index of each kidney by sampling intrarenal segmental and interlobar arteries and finally the cortical thickness of each kidney by measuring the portion closer to the upper pole and the lower pole of the same kidney.

Four grades of cortical thickness were recognized: severe reduction of cortical thickness when the thickness of the cortex was less than 7 mm, moderate reduction of cortical thickness when the thickness of the cortex was greater than 7 mm and less than 10 mm, mild reduction in cortical thickness when the cortical thickness was greater than 10 mm and less than 12 mm and normal cortical thickness when the thickness of the cortex was equal or greater than 12 mm.

Of course was recorded the presence or absence, for each kidney, of a renal extracapsular hypoechoic rim and, if present, its thickness; presence of diabetes mellitus or presence of proteinuria and its amount, presence of any clinical signs of fluid overload such as peripheral oedema, distended jugular veins, ascites, increased the caliber and reduced respiratory excursion of the vena cava.

Since the perirenal spaces can collect fluid collections that may be related to acute renal disorders or related to adjacent retroperitoneal structures (4) we excluded patients with renal trauma, spontaneous rupture of renal cysts, hydronephrosis or mass lesions (5) and patients with acute pancreatitis which may cause pancreatic exudates going to gather in front pararenal spaces.

Descriptive statistics of the quantitative data was reported as the mean and standard deviation, while qualitative data as frequency and/or percentage. It was used a univariate logistic regression to evaluate the weight of each variable on the presence of the renal extracapsular hypoechoic rim, using the F statistic of Fisher. The groups were statistically compared, using the analysis of variance (ANOVA) for quantitative variables distributed in a Gaussian manner. Where it had to reject the statistical assumptions of normality, checked using the Kolmogorov-Smirnov test, was used the nonparametric Kruskal-Wallis test. When the ANOVA or Kruskal-Wallis test provided statistically significant differences between the test groups, we used, respectively, the post-hoc test Bonferroni or Dunn for pairwise

comparisons. The comparison between groups for qualitative variables was performed with Fisher's exact test for 2 x 2 contingency tables, otherwise, with chi-square test for the greater dimension tables. Finally, the correlations between quantitative variables were performed by calculating the Pearson correlation coefficient and evaluating statistical significance. For all statistical analyzes, performed with the SPSS software package version 10, it was chosen a significance level of 95% and thus were considered statistically significant  $p < 0.05$  values.

## RESULTS

A renal extracapsular bilateral hypoechoic rim was observed in 21 patients (18 males and 3 females), mean age  $78.1 \pm 10.1$  years with an average renal cortical thickness of  $0.52 \pm 0.17$  cm, a minimum thickness of 0.24 cm and a maximum thickness of 0.94 cm; these 21 patients had a mean glomerular filtration rate of  $34.5 \pm 12.2$  ml/min/1.73 m<sup>2</sup> and a renal cortical thickness greater of 7 mm and less than 10 mm in 31% of the cases and a renal cortical thickness greater than 10 mm and less than 12 mm in the remaining 69%.

The mean diameter in longitudinal axis was  $98.3 \pm 11.6$  mm with a maximum of 130 mm and a minimum of 71 mm. The average of resistive indexes were  $0.73 \pm 0.06$ ; proteinuria was found in 62% of patients (13 of 21 patients) and the average amount was  $0.33 \pm 0.59$  g/24h. Finally signs of fluid overload were observed in 19% of patients while diabetes was present in 33% of the same patients.

Instead a renal extracapsular unilateral hypoechoic rim was found in 20 patients (10 males and 10 females), mean age  $81.1 \pm 7.2$  years, with an average renal cortical thickness of  $0.27 \pm 0.29$  cm, a minimum of 0.24 cm and a maximum of 0.79 cm; these patients had a mean glomerular filtration rate of  $34.7 \pm 12$  ml/min/1.73 m<sup>2</sup> while cortical thickness was greater than 7 mm and less than 10 mm in 55% of kidneys with unilateral hypoechoic rim and greater than 10 mm and less than 12 mm in the remaining 45% of the same kidneys, while in the other 20 kidneys without extracapsular hypoechoic rim was found a renal cortical thickness smaller than 7 mm in a percentage of 55% and a cortical thickness equal or greater than 12 mm in the remaining 45%. The average diameter of the kidneys with an unilateral hypoechoic rim in the longitudinal axis was  $90.6 \pm 17.8$  mm with a maximum of 126 mm and a minimum 55 mm. The mean resistive index was  $0.76 \pm 0.07$ ; proteinuria was found in 63% of patients and the average amount was  $0.21 \pm 0.35$  g/24h. Finally signs of fluid overload were found in 10% of patients with unilateral hypoechoic rim while diabetes was found in a 30% of these same patients.

The patients without both unilateral or bilateral extracapsular hypoechoic rim were 39, 22 males and 17 females, with a mean age of  $57.5 \pm 15.1$  years while the glomerular filtration rate was  $77 \pm 22.8$  ml/min/1.73 m<sup>2</sup>. The mean diameter in the longitudinal axis was  $108.1 \pm 16.6$  mm with a maximum of 143 mm and a minimum of 92 mm; the average resistive index was  $0.63 \pm 0.06$ . The cortical thickness was less than 7 mm in 18% of the total of the kidneys and equal or greater than 12 mm in

**Table 1.**  
Weight/influence of the variables on the hypoechoic rim (unilateral and/or bilateral).

Variables	Score (Fisher F)	Statistical significance (p-value)
Age (years)	28.219	.000
Sex	2.262	.133
GFR (ml/min/1.73 m <sup>2</sup> )	37.556	.000
Right kidney diameter (mm)	7.305	.007
Left kidney diameter (mm)	13.262	.000
Right kidney cortical thickness (mm)	42.134	.000
Left kidney cortical thickness (mm)	50.699	.000
Right kidney resistive indexes	28.916	.000
Left kidney resistive indexes	26.900	.000
Proteinuria (gr/24h)	4.590	.032
Right kidney hypoechoic rim thickness (cm)	32.259	.000
Left kidney hypoechoic rim thickness (cm)	41.944	.000
Clinical findings of fluid overload	5.628	.018
Diabetes mellitus	13.867	.000
Right kidney cortical thickness > 7 < 12 (mm)	45.490	.000
Left kidney cortical thickness > 7 < 12 (mm)	49.568	.000
GFR < 60 (ml/min/1.73 m <sup>2</sup> )	49.568	.000

the remaining 82%. Signs of fluid overload and diabetes were not found in anyone of the patients.

The F value calculated to assess the weight on the presence of unilateral or bilateral renal extracapsular hypoechoic rim of each of the variables taken into account (age, sex, glomerular filtration rate, diameter of each kidney, cortical thickness of each kidney, resistive index of each kidney, presence of proteinuria, presence of signs of fluid overload, presence of diabetes mellitus) allowed us to demonstrate that all the variables except gender (which showed a p-value > 0.05) weighed significantly on the presence of an hypoechoic rim (Table 1).

However the greater weight on the presence of the renal extracapsular hypoechoic rim was equally reached by both the presence of a glomerular filtration rate lower than 60 ml/min/1.73 m<sup>2</sup> and by the presence of a cortical thickness greater than 7 and less than 12 mm (Table 1).

Furthermore it was found in a statistically significant manner that the renal extracapsular hypoechoic rim was present only when cortical thickness was greater than 7 mm and less than 10 mm or greater than 10 and less than 12 mm while it was not found any extracapsular hypoechoic rim when the cortical thickness was less than 7 mm or greater than 12 mm.

It was not found any correlation between severe reduction of the glomerular filtration rate (i.e. < 30 ml/min/1.73 m<sup>2</sup>) or moderate reduction of the glomerular filtration rate (i.e. ≥ 30 and < 60 ml/min/1.73 m<sup>2</sup>) and the respective mean thickness of the extracapsular hypoechoic rim.

It was also confirmed the presence of a statistically significant correlation between the presence of signs of fluid overload and the coexistence of renal extracapsular hypoechoic rim although this association was found in only 6 of the 41 patients with an unilateral or bilateral renal extracapsular hypoechoic rim that is the 15% of the cases.

A similar statistically significant correlation was found

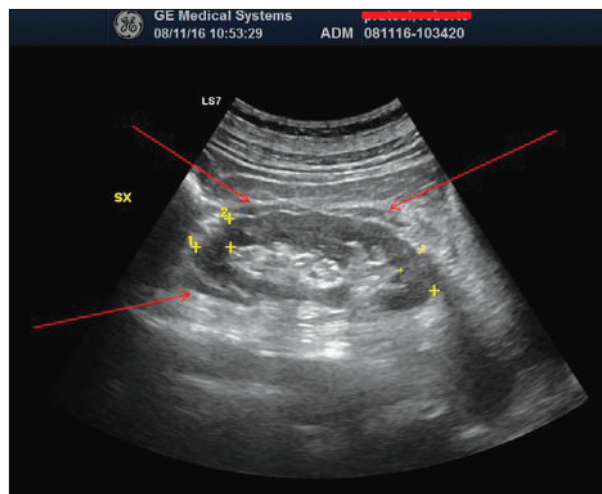
between the presence of hypoechoic rim and the coexistence of diabetes mellitus or proteinuria.

## DISCUSSION

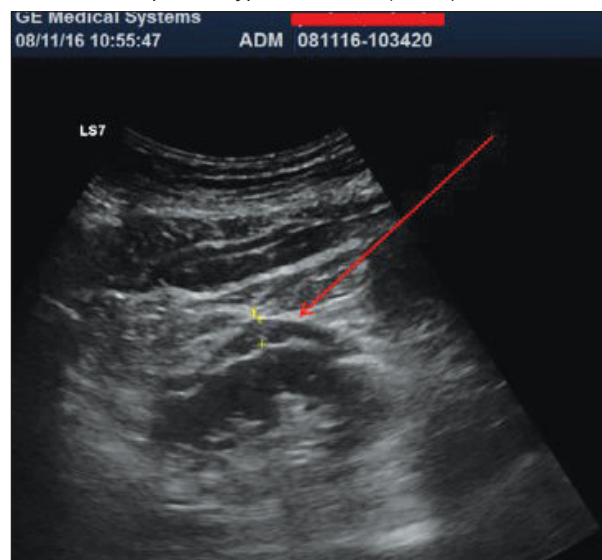
The kidney is encased by the anterior and posterior pararenal fascia, also known as Gerota's fascia, forming the perirenal space. Between the anterior pararenal fascia and the posterior peritoneum there is the anterior pararenal space while between the posterior pararenal fascia and the transversalis fascia there is the posterior pararenal space (6-8). The fascia cannot be recognized by sonography so the perirenal and pararenal spaces appear as a single compartment filled with fat (6, 7).

The fat is variable in amount and is usually hyperechoic but occasionally may become hypoechoic, when the water content of the fat tissue is low (6, 9), so appearing as a hypoechoic rim (Figures 1, 2) that mimics a perirenal fluid (6, 10, 11).

**Figure 1.**  
Renal extracapsular hypoechoic rim (arrows).



**Figure 2.**  
Renal extracapsular hypoechoic rim (arrow).



Moreover the ultrasound appearance of the kidneys under chronic renal failure (6, 12, 13) it is characterized by a reduction in renal size, thinning of the parenchyma (especially of the cortex) and increased echogenicity of the same cortex. In these cases when cortical thickness cannot be determined with precision because the medullary pyramids are not visible, thinning of the cortex can be appreciated as thinning of the entire parenchyma (6).

With respect to normal cortical thickness, although there are limited data, a cutoff of 12 mm can be considered appropriate (6, 14) while a value of less than 7 mm is probably abnormal (6). Among the all characteristics of cortical atrophy, the most reliable is just the cortical thinning (6) since the renal size varies with body size and increased echogenicity is a subjective determination that may be affected by artifacts (6). Consequently echogenicity should not be taken into account among the parameters which can weigh on the hypoechoic rim.

More in detail the renal cortex is the subcapsular portion of the kidney composed mainly of glomeruli and convoluted tubules, extending in columns between the pyramids that constitute the renal medulla. Renal ultrafiltration, which occurs in the glomeruli, takes place therefore in the cortex of the kidney. Given the above, we note that, consistently with the findings of *Yassa et al.* (1) and *Haddad et al.* (2), also our study shows a statistically significant close correlation between the presence of the hypoechoic rim and a reduced glomerular filtration rate below 60 ml/min/1.73 m<sup>2</sup>, as well as a correlation between the presence of the hypoechoic rim and the coexistence of fluid overload although this latter correlation, in the light of the limited number of the cases of fluid overload (which were only the 15% of all patients with unilateral or bilateral hypoechoic rim), certainly weighs less in statistical terms on hypoechoic rim if compared to the presence of above-mentioned renal insufficiency as shown by the specific statistical analysis (Table 1). It is also widely known as the ascites is a common cause of widening of the space between the right kidney and the liver (6).

Indeed, quite peculiar of this retrospective analysis, it is the close correlation that was found between the presence of the hypoechoic rim and a thinning of the renal cortex between 7 and 12 mm so that the reduction in cortical thickness weighs on the hypoechoic rim as the presence of a glomerular filtration rate less than 60 ml/min/1.73 m<sup>2</sup>.

Furthermore we found in our series numerous cases of unilaterality of the hypoechoic rim equal to the 49% of all patients that showed the hypoechoic rim, quite differently from what found by *Yassa et al.* (1) who observed a bilateral hypoechoic rim in all cases but accordingly to *Haddad et al.* (2) and *Orofino et al.* (16) who reported cases unilaterality of the hypoechoic rim.

The association between the hypoechoic rim and a reduction in cortical thickness, excluding conditions of excessive reduction of cortical thickness (as when below to 7 mm or absent) or cortical thickness  $\geq$  12 mm is consistent and in the frequent cases where the presence of the hypoechoic rim is unilateral this association is undoubtedly more accurate when compared to the sim-

plest correlation between the presence of the hypoechoic rim and reduction of glomerular filtration rate below 60 ml/min/1.73 m<sup>2</sup>.

Although it is true that a reduction in the glomerular filtration rate below 60 ml/min/1.73 m<sup>2</sup> it is often accompanied by a cortical thinning it is equally true that in many cases the kidney damage (of all kinds) may be unilateral or otherwise more expressed in one of the two kidneys involving a different cortical thickness between a kidney and the other (as observed in our series, in a kidney cortical thickness may be even normal and in the other completely lost i.e. less than 7 mm) while renal function (as assessed by estimated glomerular filtration rate which is calculated from serum creatinine) it is given by the sum of the glomerular filtration rate of each kidney, one of which can compensate completely or in part to the failure of the other.

Finally our series showed that the hypoechoic rim was absent when the cortical thickness was completely lost i.e. less than 7 mm, as is the case of end-stage kidneys, in fact the hypoechoic rim, likewise the thinning of the renal cortex, may be a finding of kidney damage that will disappear when renal function will become negligible or lost and the cortical thickness, at the same time, will shrink.

## CONCLUSIONS

It is our opinion that, except in cases of fluid overload, the hypoechoic rim, accordingly to the thinning of renal cortex to which it is very well correlated, can be regarded as an expression of damage, probably chronic, of the single kidney in which it is found and therefore it is associated, of course, with a reduction of renal function.

To explain the absence of the hypoechoic rim in case of complete loss of cortical thickness (i.e. < 7 mm), we can hypothesize that the presence of the hypoechoic rim may be associated only with an initial phase of renal injury that still has not hesitated in a complete functional loss of the single kidney.

It is clear, however, that further trials are needed to confirm this hypothesis.

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