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# Renal Duplex in Children with Acute Glomerulonephritis: Diagnostic Utility, Laboratory and Pathological Correlation

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## Abstract

*Background:* Acute glomerulonephritis is a specific renal pathology, that is induced by immunologic response to inflammation with proliferation of glomeruli with subsequent damage. It remains a health problem that is common in developing countries with increased prevalence in school age. It is diagnosed mainly by renal biopsy, yet the radiological investigations, namely routine ultrasound and Doppler, can suggest the diagnosis.

*Aim of Study:* To assess the changes in the renal Doppler parameters, in children with acute glomerulonephritis and correlating them with the laboratory and pathological findings.

*Patients and Methods:* This case control analytical study was carried on 20 pediatric patients ranging in age from 3 to 13 years presenting with acute nephritic syndrome with 10 other age and sex matched children were studied as control group. We performed renal ultrasound and Doppler study of the renal vasculatures with correlation with the laboratory and pathological data.

*Results:* The morphological changes as renal parenchymal echogenicity is positively correlated in cases of acute glomerulonephritis when compared to control group. No correlation was found between main renal and parenchymal RI indices and the different pathological affection. RI is positively correlated with creatinine level and the systolic blood pressure percentile. No significant statistical correlation between RI indices and proteinuria.

*Conclusion:* Renal Duplex can be used as pediatric complementary tool in the diagnostic work up of patients with acute glomerulonephritis. RI index of the main renal artery may assist to predict renal dysfunction severity but cannot differentiate different pathological affection.

***Key Words:*** *Acute glomerulonephritis – Renal Duplex – RI – Nephritic syndrome – Renal biopsy.*

## Introduction

**ACUTE** glomerulonephritis (GN) is a disease diagnosed clinically by the classic triad of hypertension, edema and hematuria. It occurs secondary to immunological inflammation of the glomeruli **[1]**.

It may occur as post infectious sequel to streptococcal infection, due to the deposition of the immune complexes within the glomeruli, resulting in renal volume enlargement in about half of the cases. Complete recovery is noted in most of the cases, with few cases progressing to the chronic form **[2]**.

Noninfectious causes can be either primary renal disease or secondary to systemic diseases such as Vasculitis or Collagen-vascular diseases, mainly systemic lupus erythematosus (SLE) **[2]**.

Renal duplex sonography is a noninvasive ,radiation free imaging method to evaluate hemodynamic changes in the renal blood flow via examining renal and intrarenal arteries in patients with various renal diseases **[3]**.

However, Differentiation between specific types of renal medical disorders cannot be achieved by routine ultrasound findings as renal length and renal cortical echogenicity **[4]**.

Duplex ultrasound quantitative parameters such as resistivity index (RI) can be used in different

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***List of Abbreviations:***

A/C ratio : Albumin-to-creatinine ratio.
ACR : American College of Rheumatology.
BMI : Body mass index.
EULAR : European League Against Rheumatism Executive Committee.
GFR : Glomerular filtration rate.
GN : Glomerulonephritis.
PI : Pulsatility index
RI : Resistive index.
SLE : Systemic lupus erythematosus.

medical disorders and usually it is increased in about half of the patients presenting with renal insufficiency [4].

Additionally, routine ultrasound, with assessment of the renal arteries by renal Doppler, has an important role in the assessment of post-renal biopsy complications that occur in about one third of the cases. These complications vary from minor hematoma to major complications as severe perinephric hemorrhage [5].

## Patients and Methods

*Study population:*

- Over a 7 months period we conducted this observational descriptive study at the Pediatric Radiology Department, including twenty patients, ten males and ten females, ranging between (3 years up to 13 years) of age. They were recruited from the nephrology clinic of Pediatric Hospital of Cairo University, after being diagnosed clinically as nephrotic syndrome (sudden onset of hematuria, proteinuria, oedema, hypertension, impaired renal function with nephritic urinary sediments). They were all examined at the radiology department.
- Ten age-matched and sex-matched control subjects were studied as a reference for Doppler parameters.
- We excluded other causes of acute renal injury, in which the primary pathology is not in the glomeruli (as a hemolytic uremic syndrome and tubulointerstitial nephritis), cases with known reno-vascular lesion (as renal artery stenosis or renal vein thrombosis) or obstructive uropathy.
- Informed consent was obtained from their legal guardians.

*Clinical examination:*

History taking, focusing on age, sex, the onset of renal illness and preceding infection.

Clinical assessment focusing on height, weight, body mass index (BMI), systolic blood pressure percentile and diastolic blood pressure.

*Laboratory investigations:*

Blood urea nitrogen, serum creatinine within 24 hours of admission.

Glomerular filtration rate (GFR) which is calculated by the original Shwartz equation, eGFR = k x (height in cm) ÷ serum Cr.

Where k = 0.55 in children to 13 years of age.

Albumin-to-creatinine ratio (A/C ratio), which is the preferred method for detecting albuminuria. It is calculated by dividing the Albumin concentration in milligrammes by creatinine concentration in grammes.

Complement C3 and C4, Anti nuclear antibody (ANA), ANTI-DNA.

Pathological findings review with the medical management plane review (need for dialysis, pulse steroid therapy or other immunosuppressive treatment), were also included.

*Imaging:*

The examination was done using an ultrasound machine, equipped with curvilinear transducer (2-5 MHz) probe, 2-3 days of admission and before the renal biopsy, with the same technique applied to both kidneys, after assessment of the patient general condition and clinical data.

Grey scale imaging of the kidney in longitudinal and transverse views to assess three dimensions of the kidney. Also, the renal parenchymal thickness was measured (Fig. 1).

The echogenicity of the kidney is assessed in comparison to the adjacent solid organ, namely liver and spleen, and considered abnormal if the renal cortex is more echogenic than the liver/spleen (assuming that there is no fatty infiltration of the liver). In addition, the echogenicity of both kidneys should be similar to each other. Also assessment of the cortico-medullary differentiation was done. Grading of renal echogenicity was: Grade 0: The renal echogenicity was less than that of the liver; grade 1: The renal echogenicity equaled that of the liver; grade 2: The renal echogenicity was greater than that of the liver. Grade 3: Reduced renal length, cortical echogenicity is more than that of liver/spleen, with poorly maintained corticomedullary differentiation.

The study of the renal vasculature by Doppler, starts with the patient lying supine to assess the aorta and the main renal arteries. Then, for examining the right renal vasculature, the patient is placed in the right lateral decubitus position ,tracing the main renal artery back towards the aorta. Also in this position we can trace the division of the main renal artery into anterior and posterior branches, that further divide into segmental and then interlobar arteries. The interlobar arteries further divide into a network of arcuate arteries that run at the corticomedullary junction and give off the cortical (interlobular) branches, which run radially

towards the periphery, and the medullary branches, which supply the renal pyramids.

For examining the left renal vessels, the patient is turned to the opposite decubitus and the same procedure was repeated.

The sample volume was set at 2-5mm. Doppler signals were in general obtained from main renal artery at the renal hilum, arcuate arteries at the corticomedullary junction and/or interlobar arteries along the border of medullary pyramids.

The patient should be calm as crying and continuous movement can disturb Duplex wave.

Intestinal bloating was reduced by drinking water before the examination and fasting for about 4 hours prior to the examination.

Multiple Doppler waves are obtained and the grey scale examination of the kidney was done and recorded.

The RI (defined as [peak systolic frequency shift - minimum diastolic frequency shift/peak systolic frequency shift) was determined manually and automated tracing of the waveform was also done. Three to five waveforms were needed for RI measurement.

We calculated the mean RI for each kidney and each patient (averaging both kidneys). To correlate RI with other parameters, we considered an RI of 0.7 or higher as elevated. This value for a discriminatory RI level is based on our and others' experience with obstructed, medically diseased, and normal native kidneys.

Also, pulsatility index (PI) = (Peak systolic velocity- end diastolic velocity /time-averaged velocity) and flow velocities in interlobar and main renal arteries were obtained.

*Statistical analysis:*

All the data were saved and recorded in a spread sheet for analysis, also clinical data (patient blood pressure percentile), laboratory findings (creatinine, GFR, A/C ratio - BUN - c3, c4 levels - ANA, anti DNA) were tabulated.

The sonographic and pathologic data were analyzed separately and blindly and correlated with the clinical history and laboratory Studies. As regards the creatinine level, it is considered abnormal if it is higher than the expected age-corrected levels in children, where the normal level for the age 2-5 years is 0.20 to 0.43mg/dL. Children aged 5-12 years, the creatinine level should be 0.31 to 0.61mg/dL. And for the age 12-15 years, its level is 0.45 to 0.81mg/dL **[6]**.

The statistical tool SPSS (Statistical Package for the Social Sciences) version 25 was used to code and enter the data. In quantitative data, mean, standard deviation, median, minimum, and maximum were used, while categorical data were summarized using frequency (count) and relative frequency (%). The non-parametric Mann-Whitney test was used to make comparisons between quantitative variables **[7]**. The Chi-square ($x^2$) test was used to compare categorical data. When the anticipated frequency is less than 5, an exact test was applied instead. The Spearman correlation coefficient was used to calculate correlations between quantitative variables. Statistical significance was defined as a *p*-value of less than 0.05.

## Results

Through the scheduled study period, twenty patients were examined by conventional ultrasound curvilinear transducer. Ten age-matched and sex-matched children were examined as controls. Ten of our patients were males. While the other ten, were females with age ranging from three to thirteen years.

Three of our cases had a history of preceding infection in the form of acute gastroenteritis and respiratory tract infection. The other seventeen patients had no history of preceding infections.

There were 5 cases diagnosed clinically as SLE and 2 cases were probable SLE by pathological data for further assessment to confirm the diagnosis of SLE (Fig. 2). Only 1 patient had positive anti DNA ,this could be explained as the clinical diagnosis of the SLE doesn't depend only on anti DNA, but we are taking into consideration the EULAR/ACR [European League Against Rheumatism (EULAR) Executive Committee and the American College of Rheumatology (ACR)] diagnostic criteria for SLE where diagnosis of renal affection secondary to SLE depends on the clinical presentation, laboratory data and renal biopsy results. Each criterion is assigned points, ranging from 2 to 10. Patients with at least one clinical criterion and 10 or more points are classified as having SLE. For example, proteinuria >0.5g/24h (4 points), renal biopsy class II or V lupus nephritis (8 points) and renal biopsy class III or IV lupus nephritis (10 points).

Clinical and laboratory findings are shown in Table (1), while serological markers are demonstrated in Table (2).

Table (1): Shows the clinical and laboratory assessment of cases.

| | Cases | | | | |
|---|---|---|---|---|---|
| | Mean | Standard Deviation | Median | Mini-mum | Maxi-mum |
| Height (cm) | 129.60 | 17.68 | 132.50 | 90.00 | 155.00 |
| Weight (kg) | 32.75 | 9.27 | 30.00 | 15.00 | 50.00 |
| BMI | 19.16 | 2.34 | 18.70 | 15.80 | 23.80 |
| SBP (mm Hg) | 118.90 | 11.54 | 120.00 | 100.00 | 130.00 |
| DBP (mm Hg) | 79.00 | 8.37 | 80.00 | 70.00 | 90.00 |
| Systole percentile | 84.80 | 21.29 | 95.00 | 25.00 | 99.00 |
| Diastole percentile | 88.15 | 11.47 | 92.50 | 70.00 | 99.00 |
| Creatinine (mg/dL) | 2.20 | 1.76 | 1.40 | 0.40 | 7.70 |
| GFR (ml/min/$m^2$) | 43.97 | 37.21 | 39.90 | 6.40 | 149.70 |
| A/c ratio (Mg/g) | 4.97 | 4.10 | 5.20 | 0.50 | 17.50 |
| C3 (mg/dL) | 42.24 | 35.96 | 20.00 | 8.70 | 104.00 |
| C4 (mg/dL) | 26.06 | 27.94 | 25.00 | 4.00 | 135.00 |

Table (2): Shows complement levels (C3 and C4) and (ANA, ANTI-DNA).

| | | | |
|---|---|---|---|
| C3 (mg/dL) | Low | 15 | 75.0% |
| | Normal | 5 | 25.0% |
| C4 (mg/dL) | High | 2 | 10.0% |
| | Low | 6 | 30.0% |
| | Normal | 12 | 60.0% |
| ANA | No | 15 | 75.0% |
| | Yes | 5 | 25.0% |
| Anti-DNA | No | 19 | 95.0% |
| | Yes | 1 | 5.0% |

During the period of our study, we divided the pathological findings in our cases into 2 main groups; according to pathological evidence of crescents or not and the type of these crescent cellular, fibrocellular or fibrous as shown in Fig. (3). 60% of our cases had crescents with the fibrocellular type being the most common of them.

Also renal biopsy ,pathological results were divided according to affection (glomerular affection, number of obsolescent glomeruli, the presence of crescent and its type, tubular, interstitial, fibrotic and vascular affection) in Table (3) and Fig. (4). The obsolescent glomeruli, means the glomeruli in which the Bowman's space was occupied by collagenous material, and the tuft was retracted, in other words solidified or sclerosed glomeruli. It was found in 35% of our cases.

The types of the crescent in histopathological data of study cases.

Table (3): Shows different pathological affection.

| | | Cases | |
|---|---|---|---|
| | | Count | % |
| *Obsolescent glomeruli:* | No | 13 | 65.0 |
| | Yes | 7 | 35.0 |
| Crescent | Yes | 12 | 60.0 |
| | No | 8 | 40.0 |
| Type of crescent | Fibrous | 3 | 25.0 |
| | Fibrocellular | 5 | 41.7 |
| | Cellular | 4 | 33.3 |
| Tubular | No | 10 | 50.0 |
| | Yes | 10 | 50.0 |
| Interstitial | No | 12 | 60.0 |
| | Yes | 8 | 40.0 |
| Fibrotic | No | 15 | 75.0 |
| | Yes | 5 | 25.0 |
| Vascular | No | 16 | 80.0 |
| | Yes | 4 | 20.0 |

*Main lines of treatment:* It was steroids in all cases (100% of cases), some cases needed immunosuppressant drugs (20% of cases) and some cases were on Capoten (35% of cases) for arterial blood pressure control.

Comparison between cases and control regarding grade of the renal parenchymal echogenicity was statistically significant (*p*-value <0.001) is shown in the Table (4).

Table (4): Shows a comparison between cases and control regarding parenchymal echogenicity grade.

| | Group | | | | *p*-value |
|---|---|---|---|---|---|
| | Cases | | Control | | |
| | Count | % | Count | % | |
| *Echogenicity:* | | | | | |
| G0 | 0 | 0.0 | 8 | 80.0 | <0.001 |
| G1 | 5 | 25.0 | 2 | 20.0 | |
| G2 | 9 | 45.0 | 0 | 0.0 | |
| G3 | 6 | 30.0 | 0 | 0.0 | |

Comparison between cases and control regarding US and Duplex examinations in Table (5).

Comparison between cases and control groups in average renal volume in Table (6).

Comparison between patient subgroups according to the presence of crescent in renal biopsy pathological results, is shown in Table (7).

Table (5): Shows a comparison between cases and control in parenchymal thickness, average renal length and RI indices.

| | Group | | | | | | | | | | *p*-value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cases | | | | | Control | | | | | |
| | Mean | SD | Median | Minimum | Maximum | Mean | SD | Median | Minimum | Maximum | |
| Average parenchymal thickness | 1.55 | 0.52 | 1.61 | 0.70 | 2.60 | 1.65 | .122 | 1.65 | 1.49 | 1.87 | 0.812 |
| Average renal length | 9.95 | 1.31 | 10.30 | 5.60 | 11.65 | 8.71 | 1.07 | 8.65 | 7.10 | 10.30 | 0.004 |
| Average RI Parenchymal | 0.60 | 0.07 | 0.58 | 0.46 | 0.72 | 0.60 | 0.05 | 0.62 | 0.50 | 0.64 | 1.000 |
| Average RI main renal | 0.61 | 0.09 | 0.62 | 0.45 | 0.78 | 0.63 | 0.05 | 0.63 | 0.57 | 0.69 | 0.650 |

Table (6): Shows average renal volume in cases and control groups.

| | Group | | | | | | | | | *p*-value |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cases | | | | | Control | | | | |
| | Mean | SD | Median | Minimum | Maximum | Mean | SD | Median | Minimum | Maximum | |
| Average renal volume | 130.50 | 56.16 | 127.73 | 20.38 | 269.43 | 141.14 | 13.67 | 140.60 | 120.00 | 160.00 | 0.328 |

Table (7): Shows Comparison between patient subgroups according to the presence of crescent in pathological results.

| | Crescent | | | | | | | | | | *p*-value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Yes | | | | | No | | | | | |
| | Mean | SD | Median | Minimum | Maximum | Mean | SD | Median | Minimum | Maximum | |
| Average parenchymal thickness | 1.64 | 0.54 | 1.66 | 0.80 | 2.60 | 1.43 | 0.48 | 1.60 | 0.70 | 2.00 | 0.384 |
| Average renal length | 10.33 | 0.60 | 10.38 | 9.45 | 11.50 | 9.38 | 1.87 | 9.45 | 5.60 | 11.65 | 0.181 |
| Average RI Parenchymal | 0.59 | 0.06 | 0.58 | 0.46 | 0.67 | 0.62 | 0.09 | 0.64 | 0.50 | 0.72 | 0.473 |
| Average RI main renal | 0.61 | 0.09 | 0.65 | 0.45 | 0.70 | 0.61 | 0.11 | 0.61 | 0.50 | 0.78 | 0.910 |

The Correlation of tubulointerstitial affection with average parenchymal thickness, average renal length, average parenchymal RI and average main renal RI, shows no statistical correlation is shown in Table (8).

Table (8): Shows Correlation of tubulointerstitial affection with average parenchymal thickness, average renal length, average parenchymal RI and average main renal RI.

| | Tubulointerstitial affection | | | | | | | | | | *p*-value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Yes | | | | | No | | | | | |
| | Mean | SD | Median | Minimum | Maximum | Mean | SD | Median | Minimum | Maximum | |
| Average parenchymal thickness | 1.54 | 0.59 | 1.61 | 0.70 | 2.60 | 1.57 | 0.46 | 1.62 | 0.80 | 2.20 | 0.912 |
| Average renal length | 9.60 | 1.63 | 10.30 | 5.60 | 11.05 | 10.31 | 0.83 | 10.21 | 9.45 | 11.65 | 0.481 |
| Average RI Parenchymal | 0.62 | 0.08 | 0.62 | 0.46 | 0.72 | 0.58 | 0.06 | 0.57 | 0.50 | 0.67 | 0.165 |
| Average RI main renal | 0.59 | 0.12 | 0.58 | 0.45 | 0.78 | 0.62 | 0.06 | 0.65 | 0.51 | 0.68 | 0.353 |

The correlation between the presence of obsolescent glomeruli and average parenchymal thickness is shown in the Table (9).

The Correlation of Duplex resistivity indices (RI) with clinical, laboratory and pathological data is shown in Table (10) and Fig. (5).

Table (9): Shows the correlation between obsolescent glomeruli and average parenchymal thickness.

| | Obsolescent glomeruli | | | | | | | | | | *p*-value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Yes | | | | | No | | | | | |
| | Mean | SD | Median | Minimum | Maximum | Mean | SD | Median | Minimum | Maximum | |
| Average parenchymal thickness | 1.22 | 0.42 | 1.20 | 0.70 | 1.70 | 1.74 | 0.48 | 1.77 | 0.80 | 2.60 | 0.030 |

Table (10): Shows the correlation of Duplex resistivity indices with laboratory and pathological data.

| | Average RI Parenchymal | Average RI main renal |
|---|---|---|
| *Creat:* | | |
| Correlation Coefficient | 0.377 | 0.564 |
| *p*-value | 0.101 | 0.010 |
| N | 20 | 20 |
| *GFR:* | | |
| Correlation Coefficient | –0.355 | –0.563 |
| *p*-value | 0.125 | 0.010 |
| N | 20 | 20 |
| *C3:* | | |
| Correlation Coefficient | 0.277 | 0.003 |
| *p*-value | 0.237 | 0.990 |
| N | 20 | 20 |
| *C4:* | | |
| Correlation Coefficient | 0.426 | 0.351 |
| *p*-value | 0.061 | 0.129 |
| N | 20 | 20 |
| *A/c ratio:* | | |
| Correlation Coefficient | 0.265 | 0.155 |
| *p*-value | 0.272 | 0.528 |
| N | 19 | 19 |
| *Glomerular %:* | | |
| Correlation Coefficient | –0.171 | 0.160 |
| *p*-value | 0.471 | 0.500 |
| N | 20 | 20 |
| *Obsolecent glomeruli %:* | | |
| Correlation Coefficient | 0.303 | 0.295 |
| *p*-value | 0.194 | 0.206 |
| N | 20 | 20 |
| *Crescent %:* | | |
| Correlation Coefficient | –0.088 | 0.117 |
| *p*-value | 0.713 | 0.624 |
| N | 20 | 20 |
| *Fibrotic %:* | | |
| Correlation Coefficient | –0.301 | –0.379 |
| *p*-value | 0.197 | 0.099 |
| N | 20 | 20 |

| | Average RI Parenchymal |
|---|---|
| *Systole percentile:* | |
| Correlation Coefficient | 0.455 |
| *p*-value | 0.044 |
| N | 20 |
| *Diastole percentile:* | |
| Correlation Coefficient | 0.398 |
| *p*-value | 0.082 |
| N | 20 |
| *Creat:* | |
| Correlation Coefficient | 0.377 |
| *p*-value | 0.101 |
| N | 20 |
| *GFR:* | |
| Correlation Coefficient | –0.355 |
| *p*-value | 0.125 |
| N | 20 |
| *Average renal length:* | |
| Correlation Coefficient | –0.580 |
| *p*-value | 0.007 |
| N | 20 |

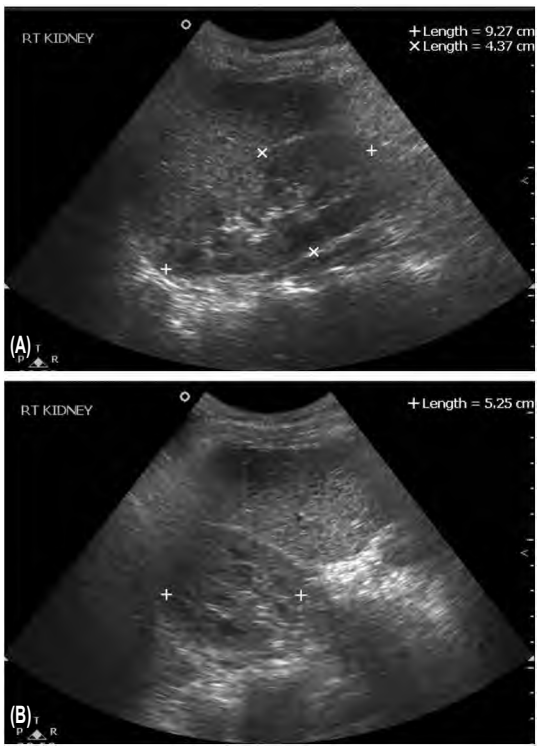



Fig. (1): Grey scale images showing assessment of the three dimensions of the right kidney in the (A) Longitudinal view (B) Transverse view.

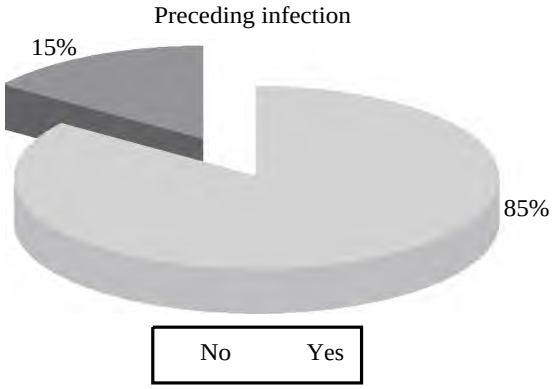



Fig. (2): The percentage of patient with preceding infection.

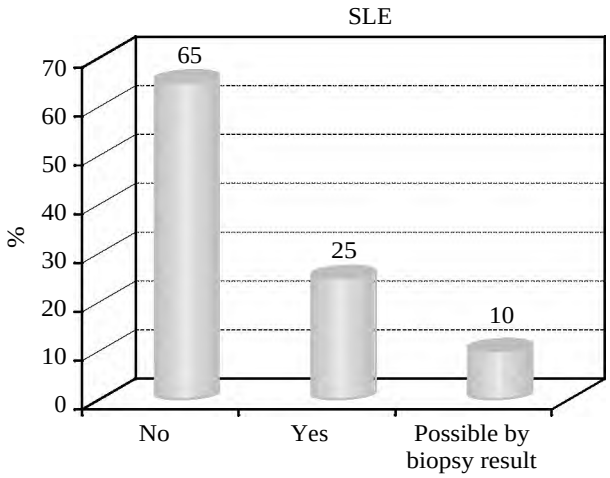



Fig. (3): The percentage of SLE patients among our cases.

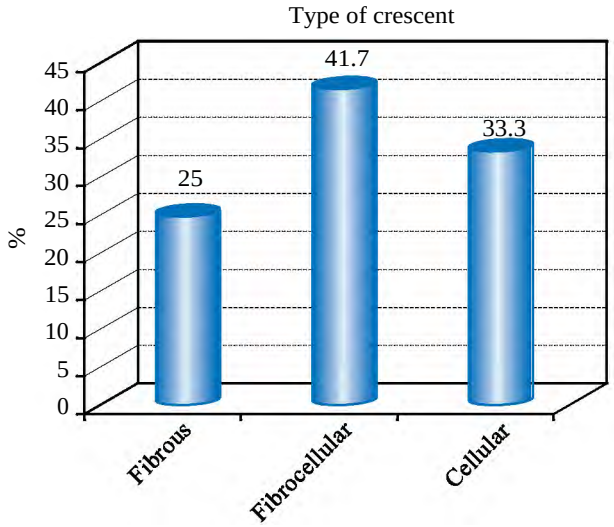



Fig. (4): The types of the crescent in histopathological data of study cases.

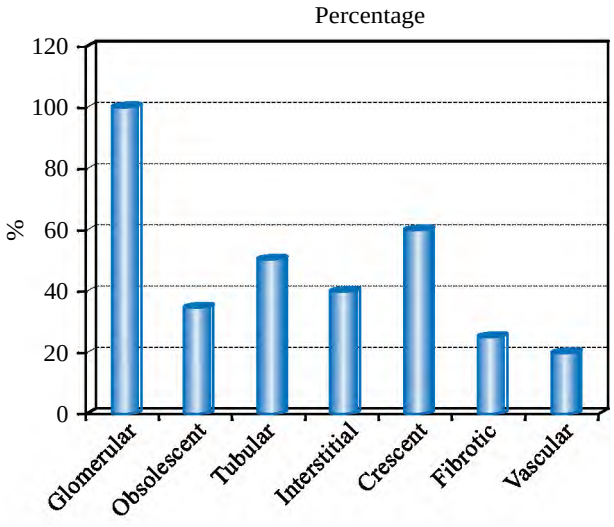



Fig. (5): The different pathological affection.

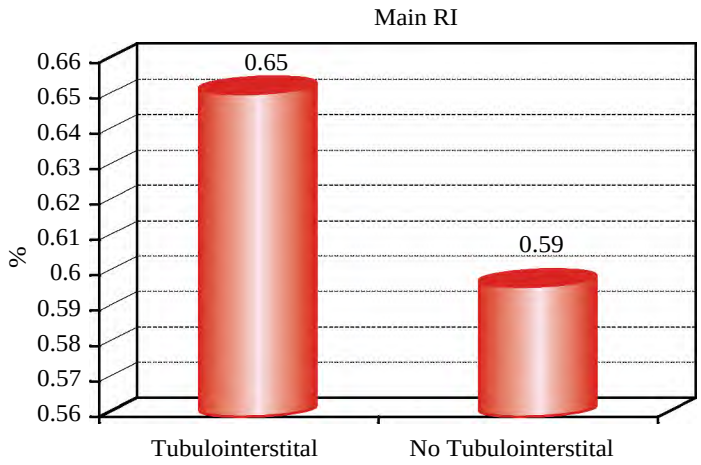
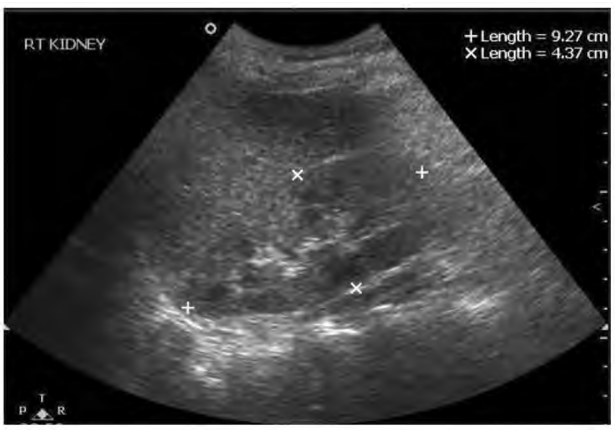
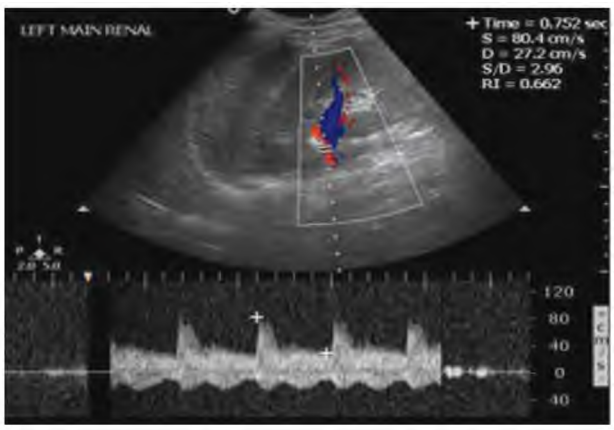



Fig. (6): Mean value of the main renal artery RI in tubulointerstitial affection and cases without tubulointerstitial affection.




(A)




(B)

Fig. (7): A-13- year old male patient with hypertension and hematuria. No history of preceding infection. Normal Creatinine, BUN, C3, C4 with negative ANTIDNA, ANA. Ultrasound showing grade II nephropathy (A): Shows right kidney in LS view and (B): Shows Doppler waveform of left main renal artery. The biopsy showing light microscopic, membranoproliferative pattern, 30% show cellular crescent.

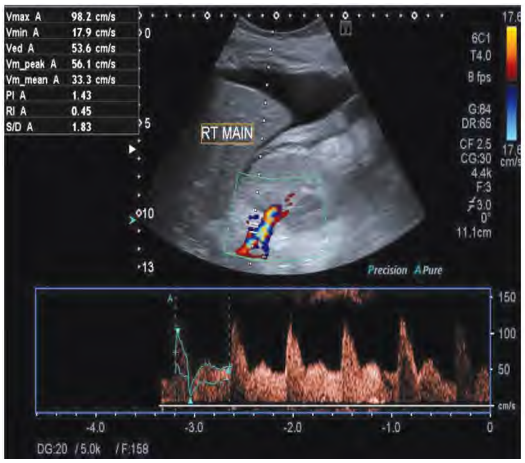



Fig. (8): The right main renal Duplex wave with its indices in a -13- year old female patient presented with hypertension, eye puffiness and generalized edema (mixed nephritic and nephrotic syndromes). Normal C3 and increased C4 with bilateral grade I nephropathy and biopsy showing minimal change glomerulonephritis, resolving acute diffuse proliferative glomerulonephritis.

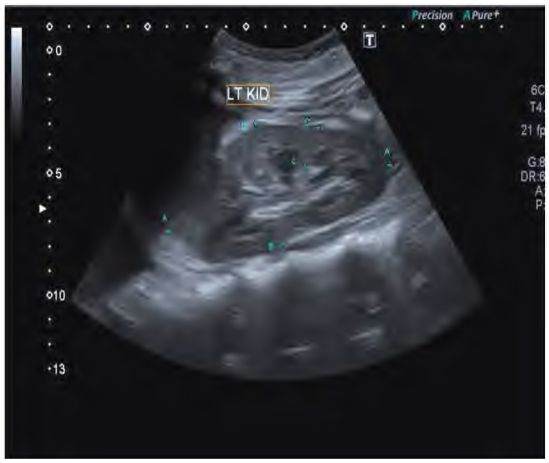



Fig. (9): The left kidney in LS view and its parenchymal thickness in the same patient of Fig. (8).

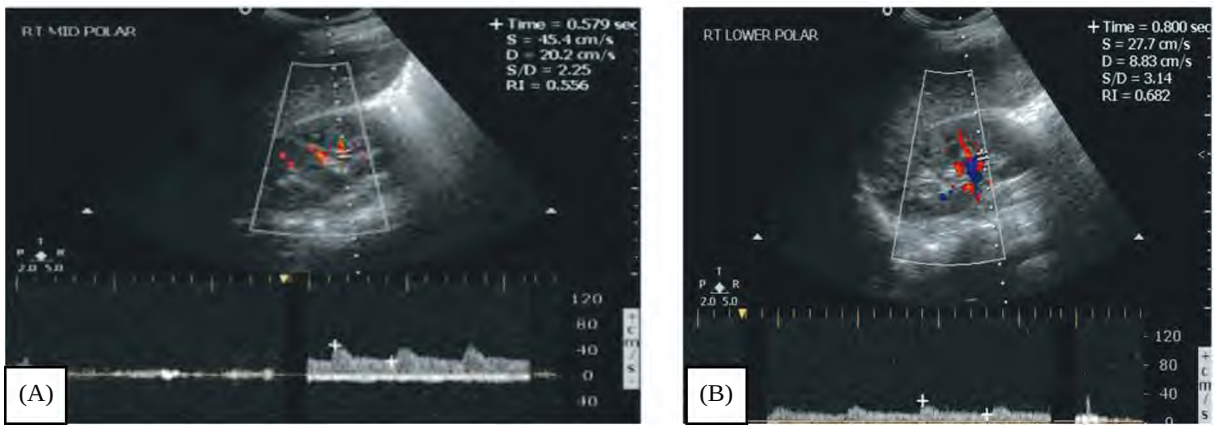



Fig. (10): (A) Doppler wave of the right mid-polar segmental artery (B) Doppler waveform of right lower polar artery in 7 years old boy with acute glomerulonephritis.

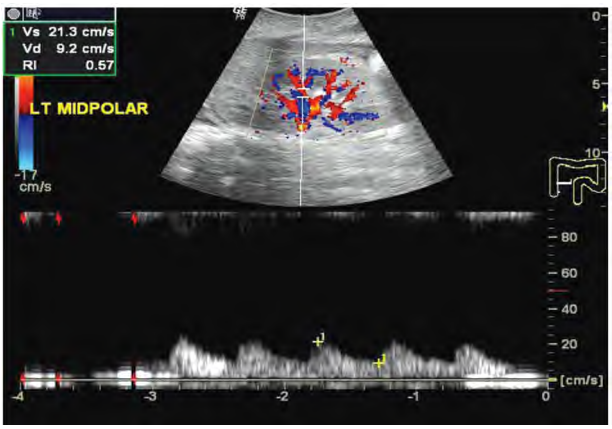



Fig. (11): Color Doppler assessment of the left main artery and its branches in a 7 years old male boy ,biopsy proven focal global glomerulosclerosis 15% and mild interstitial fibrosis 10% later on biopsy, crescentic glomerulonephritis with 2nd focal segmental glomerulosclerosis. Grey scale showed increased renal parenchymal echogenicity.

## Discussion

Acute glomerulonephritis (AGN) entails specific types of renal diseases in which an immunologic mechanism triggers inflammation and proliferation of glomeruli, that can result in damage to the basement membrane, mesangium, or capillary endothelium **[8]**.

The current study included a spectrum of pediatric patients with age ranging from 3-year-old to 13-year-old patients diagnosed clinically with acute glomerulonephritis.

According to the current study, the morphological changes as renal parenchymal echogenicity grade is positively correlated ($p$-value <0.001) in cases of acute glomerulonephritis when compared to control group. This finding is consistent with Mostbeck G.H., et al., **[4]** who studied the role of

Doppler sonography in renal insufficiency secondary to renal parenchymal disease and reported that parenchymal echogenicity is affected in 25 of his 35 cases.

In our study average renal length is increased in cases with acute glomerulonephritis and there was positive correlation ($p$-value <0.004), which is in line with Shathabish S, et al., **[9]** who concluded that kidney size is a determinant of renal prognosis, renal length is increased in acute parenchymal disease and decreased in chronic kidney disease.

However the current study is not in line with Mostbeck G.H., et al., **[4]** who concluded that renal length is statistically correlated with the presence of odema and arteriosclerosis in histopathology but not with other forms of histopathological affection as glomerular proliferation, glomerulosclerosis and fibrotic changes. Mostbeck G.H, et al., **[4]** study was involving all renal parenchymal disease but our study is targeting cases with acute glomerulonephritis.

In the current study, no statistically significant correlation in average renal volume between cases and control group was found, which is in line with Fiorini and Barozzi **[10]** who stated that some pathological conditions including kidney hypertrophy, protein deposits, fluid collections in the interstitial space or in the tubules show an increase in renal volume. In these conditions, the site of the lesion is most frequently the interstitial tubules, and since the glomerular component accounts only for about 8% of the renal parenchyma, it is not a common cause of kidney hypertrophy.

In the current study, no correlation between main renal and parenchymal RI indices with the different pathological affection (glomerular affection, obsolescent glomeruli, tubulointerstitial, fibrotic and vascular affection), which is in line with Galesi´c, K, et al., **[3]** who studied Renal vascular resistance in glomerular diseases and correlated RI with pathological findings. They reported that RI could not replace renal biopsy and Qualitative duplex sonography measure of renal arterial resistance-resistive index does not appear to be reliable in distinguishing different types of glomerulonephritis.

However, When compared to mean RI in cases without tubulointerstitial affection (mean value in main renal arteries = 0.59, mean value in parenchymal arteries = 0.57), mean RI of either main renal or parenchymal arteries is elevated in tubulointerstitial affection (mean value in main renal = 0.65, mean value in parenchymal arteries = 0.62). This goes in line with Lasya T, et al., **[11]**, who concluded that Doppler ultrasound can help differentiate interstitial from glomerular diseases. There was an elevation of resistivity indices above 0.75 in all patients who had only tubule-interstitial involvement. In patients who had only glomerular involvement, the resistivity indices were within normal range, i.e. below 0.71. RI (between 0.71 and 0.75) were found to have a combination of interstitial and glomerular disease. However, in the current study mean RI is not exceeding 0.7, but our target is acute, not chronic glomerulonephritis.

No statistically significant relationship between the presence of crescent and ultrasound findings (average parenchymal thickness, echogenicity and renal length). Also, the presence of crescent was not correlated with RI values in main renal and parenchymal arteries. This goes in line with Lasya T, et al., **[11]** who compared RI indices in different histopathological affection and concluded that RI indices are not elevated in other pathological affection such as the presence of crescents.

Renal Duplex examination of main renal and parenchyma arteries with measurement of resistivity indices in each, revealed that creatinine level is positively correlated ($p$-value 0.1) with RI of the main renal arteries. On the other hand, the GFR is negatively correlated with RI index of the main renal arteries, which is in line with Galesić et al., **[3]** who concluded that the renal vascular resistance (RI) significantly correlated with serum creatinine. And this was also stated by Platt et al., **[12]** who found that the degree of renal dysfunction measured by serum creatinine level probably affects the Doppler waveform to some degree, but the relationship is weak.

RI indices of parenchymal arteries are positively correlated with systolic blood pressure percentile, which is in line with Kawai T, et al., **[13]** who concluded that patients with elevated systolic blood pressure showed a significantly higher RI.

However, the current study is not in line with Galesi´c K **[3]** who reported that no statistically significant correlation between blood pressure and RI in patients with glomerular disease. However in Galesi´c, K **[3]**, RI mean values were measured collectively for main renal and parenchymal arteries, but in our study only parenchymal arteries RI were correlated with systolic blood pressure percentile. On the other hand, main renal arteries RI showed no statistically significant correlation. Also

in our study, systolic blood pressure was calculated on a curve with patient height to reach blood pressure percentile accurately as our target group in pediatric age group. RI was correlated with systolic blood pressure percentile but no correlation with systolic blood pressure.

Our study concluded that no significant statistical correlation between RI indices and proteinuria (albumin/creatinine ratio) which is concordat with Galesi´c K **[3]** who found that no statistically significant differences were found in mean RI values between groups with and without proteinuria.

We found that there is negative correlation of the GFR and the mean RI, which goes in line with Hanamura et al., **[14],** who used the RI as prognostic factor for the development of chronic kidney disease with poor response to steroid treatment.

Limitation to our study include the small sample size, also the assessment of the renal echogenicity was operator dependant. Furthermore, longitudinal observational study is needed to evaluate the effect of the treatment on the renal Doppler indices.

*Conclusion:*

Renal Duplex is an easy and safe method of investigation of acute glomerulonephritis, especially in children. RI index of the main renal artery may assist to predict creatinine level and severity of renal dysfunction but cannot help in differentiation between different pathological affection.

*Declarations:*

*Ethical approval and consent to participate:*

This study was approved by the Ethical Research Committee of Faculty of Medicine Cairo University in Egypt. The ethics committee reference number is not available.

A verbal consent was taken from the legal guardians of all patients accepting to participate in our research work.

*Consent for publication:*

The legal guardians of all patients included in this research gave written informed consent to publish the data contained within this study.

*Availability of data and materials:*

The data supporting the conclusions of this article are available upon reasonable request from the authors.

*Competing interests:*

The authors declared that they have no conflicts of interest.

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# دور الدوبلر على الشرايين الكلوية فى الأطفال المصابين بالتهاب كبيبات الكى الحاد الفائدة التشخيصية والمختبرية والارتباط المرضى

\الغرض : تقييم التغيرات فى مقاييس دوبلر الشرايين الكلوية عند الأطفال المصابين بالتهاب كبيبات الكى الحاد وربطها بالنتائج المخبرية والنتائج المرضية.

\الخلفية : التهاب كبيبات الكلى الحاد هو مرض كلوى محدد، يحدث نتيجة الاستجابة المناعية للالتهاب مع تكاثر الكبيبات مع الضرر اللاحق، ولا تزال مشكلة صحية شائعة فى البلدان النامية مع انتشار متزايد فى سن المدرسة، ويتم تشخيصها بشكل رئيسى عن طريق الخزعة الكلوية، إلا أن الفحوصات الإشعاعية، أى الموجات فوق الصوتية الروتينية والدوبلر، يمكن أن توحى بالتشخيص.

الطريقة أجريت هذه الدراسة التحليلية على ٢٠ مريضاً من الأطفال تتراوح أعمارهم بين ٣ و ١٣ عاماً يعانون من متلازمة الالتهاب الكلوى الحاد مع ١٠ أطفال آخرين من العمر والجنس تمت دراستهم كمجموعة ضابطة. أجرينا الموجات فوق الصوتية الكلوية ودراسة دوبلر لأوعية الكلى مع الارتباط مع البيانات المختبرية والمرضية.

\النتائج : التغيرات المورفولوجية مثل صدى الكلى المتنى يرتبط ارتباطاً موجباً فى حالات التهاب كبيبات الكى الحاد بالمقارنة مع مجموعة التحكم. لم يتم العثور على ارتباط بين مؤشرات RI الكلوية والمتنى الرئيسية والعاطفة المرضية المختلفة. يرتبط RI ارتباطاً إيجابياً بمستوى الكرياتينين والنسبة المئوية لضغط الدم الأنقباضى. لا توجد علاقة إحصائية ذات دلالة إحصائية بين مؤشرات RI والبروتينية.

\الخلاصة : يمكن استخدام الدوبلر على الشريان الكلوى كأداة تكميلية للأطفال فى العمل التشخيصى للمرضى المصابين بالتهاب كبيبات الكلى الحاد. قد يساعد مؤشر المقاومة للشريان الكلوى الرئيسى فى التنبؤ بشدة الخلل الكلوى ولكن لا يمكنه التفريق بين المودة المرضية المختلفة.