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Reno vascular alterations through Doppler echography in patients with arterial hypertension

Abstract

Background: Renal color Doppler ultrasound is used to obtain rapid information on renovascular parameters of special importance when a vascular disease is suspected and its relation with arterial hypertension.

Objective: To determine renal renovascular parameters in variable degrees of stenosis patients with arterial hypertension by means of renal Doppler ultrasound.

Method: An observational, descriptive, prospective, cross-sectional, cross-sectional investigation of a series of cases was carried out by means of B Mode and Doppler in patients with arterial hypertension. The following parameters were determined: renal intraparenchymal resistance index, renal systolic velocity, renal/aorta index, spectral wave morphology and presence or absence of early systolic peak. The data corresponding to the sampling were recorded for each kidney.

Main results: Morphological and functional alterations of the renal artery were identified in patients with arterial hypertension, showing that age, time of arterial hypertension greater than 10 years and BMI>30 (obese) correlate with an elevated resistance index. Resistance index values greater than 0.70 correlate with functional alterations of the renal arteries demonstrating in the patients studied.

Conclusions: The study showed that renal Doppler ultrasound is an important tool for monitoring and decision making in the treatment of patients with arterial hypertension, allowing the identification of morphological and functional alterations of the renal artery in these patients.

Keywords: arterial hypertension, renal Doppler ultrasound, intraparenchymal resistance index

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Introduction

The intimate relationship between arterial hypertension, structural and functional alterations make the monitoring of renal function an important tool in the care of patients with arterial hypertension.[1] Renal color Doppler ultrasound is used to obtain rapid information on morphological characteristics related to parenchymal size, thickness and echogenicity, corticomedullary differentiation, urinary flow obstruction, perirenal collections, blood flow characteristics inside renal arteries and veins that are of special importance when vascular disease is suspected.[2]

The resistance index has predictive value and in the diagnosis kidney disease. Colour Doppler ultrasound is the imaging technique of choice for the early diagnosis and follow-up of clinical complications of the kidney, which contributes to the timely treatment of complications, preservation and improvement of the patient's quality of life.[3] One of the methods used for this purpose, relatively simple, inexpensive and non-invasive, is renal Doppler ultrasound, which provides important information not only for the diagnosis of renovascular arterial hypertension (renal stenosis), but it is also useful for the assessment of the aforementioned alterations.[4]

Doppler techniques have become fundamental tools in the study of the renovascular tree. These duplex systems make it possible to simultaneously obtain a two-dimensional morphological image and a recording of the Doppler curve of the vessel under study. The velocity curves obtained present two main forms: one of low resistance, characterized by a continuous antegrade flow, both in systole and diastole, reflecting a low distal vascular resistance found in arteries supplying organs such as the brain (internal carotid artery) and the kidney (renal artery); and another of high resistance, which presents a reverse diastolic component given by an increase in distal impedance (resistance) and is observed in peripheral arteries.[5,6]

Renal Doppler ultrasound (duplex) allows direct visualization of both kidneys and their vasculature (B-mode and color) and measurement of flow velocity (Doppler), both in the renal artery and in its main intraparenchymal segments, providing both anatomical and functional information.[7,8] Of the spectral measurements that can be obtained with renal Doppler ultrasound, the resistive index is the most widely recognized as being related to the intrarenal functional and structural changes produced by arterial hypertension. Thus, hypertensive patients have a higher renal vascular resistance, even without added nephropathy, and show a uniform decrease in renal perfusion.[8]

This is a useful tool for assessing renal function in patients with arterial hypertension, aimed at identifying narrowing of the renal arteries, in order to prevent their natural progression to occlusion through revascularisation and delay the compromise of the renal parenchyma and the onset of renal failure.[8–11] It allows early diagnosis of renal artery stenosis through extrarenal methods such as: maximum systolic velocity, renal/aortic index. By means of the intrarenal parameter: through the intraparenchymal resistance index, intrarenal vascular sclerosis and renal dysfunction can be monitored.[12–15] The monitoring of renal function and structural alterations constitute a main objective in the prognosis and follow-up of patients diagnosed with arterial hypertension.

Studies on renal Doppler ultrasound (duplex) in patients with essential arterial hypertension in Cuba are scarce, in the Cienfuegos General University Teaching Hospital Dr. Gustavo Aldereguía Lima (GAL) there are no precedents of research related to this topic, which prevents early intervention in this problem, which is why the present research has been proposed, constituting a useful imaging technique in the monitoring and treatment of patients with hypertension. The objective of the study was to determine renal renovascular alterations by means of renal Doppler ultrasound (duplex) in patients with arterial hypertension.

Material and method

Type of study: An observational, descriptive, prospective, cross-sectional study of a series of cases was carried out to describe the alterations in renal echographic renovascular parameters, using B-mode and Doppler in patients with arterial hypertension.

Setting: GAL Diagnostic Imaging Center, Cienfuegos.

Study period: 01/01/ 2022 to 31/12/ 2022

Study population: 45 patients with Arterial Hypertension, Grade III. According to the Cuban guidelines on arterial hypertension.[2] Attended in consultation of Internal Medicine, Cardiology and Nephrology, referred to the Diagnostic Imaging Center for renal Doppler ultrasound.

Investigation procedures

- The ultrasound approach was lateral or translumbar to avoid interposition of hepatic or splenic tissue and to correct the angle of incidence (<60º). To optimize spectral analysis, the following parameters were applied: 3.5 MHz transducer; Doppler angle <60º; wall filter as low as possible (50-100 Hz); velocity scale as low as possible; power output 60-100%; sample volume 1-3 mm. Color (DCI) and angio (power) modes were used for localization of intrarenal arteries. A tracing of at least 3 wave complexes of similar morphology was obtained for calculations. The segmental and interlobar arteries were studied, obtaining at least 3 samples in each kidney, one in the upper pole, another in the middle third, and another in the lower pole. This method was intended to avoid overlooking possible stenosis in accessory arteries or distal branches of the renal artery.
- The following parameters were determined: renal intraparenchymal resistance index (IR), renal systolic velocity (RSV), renal/aorta index (RAI), spectral wave morphology (MORFO) and presence or absence of early systolic peak (ESP). The data corresponding to the sampling were recorded for each kidney. In the study, IR values greater than 0.70 were considered as indicators of renal damage, and a renal artery stenosis criterion was a renal/aorta ratio greater than 3 and a systolic velocity greater than 200cm/seg.
- Stenosis criteria according to peak systolic velocity, <220cm/sec correlates with percentage stenosis 0 - 59%, between 220 - 300cm/sec, percentage stenosis 60 - 79% and >300cm/sec, percentage stenosis 80 - 99%.
- **Study variables:**

a) Age

b) Sex

c) Body mass index BMI: (Weight Kg / Stature m2)

Underweight	<18.6
normal weight	25.0 - 29.9
Obese	>30

d) Time of hypertension:

<5 years
5- 10 years
>10 years

e) Comorbidities: diabetes mellitus, cerebrovascular events, myocardial infarction, dyslipidemia, renal disease, and others.

f) Time on antihypertensive treatment:

<5 years
5-10 years
>10 years

g) Renal dimension

Longitudinal diameter: <10cm, 10 - 11cm and >11cm

Anteroposterior diameter: <3cm, 3 - 4cm and >4cm

Transversal diameter: <5cm, 5 - 6cm and >6cm

h) Renal echogenicity: normal, grade I, grade II and grade III

i) Sinus/parenchyma ratio: good and bad

j) Intraparenchymal resistance index: {(Peak systolic velocity - peak velocity at end-diastolic) / (peak systolic velocity)} less than 0.65, 0.65 to 0.70 and greater than 0.70

k) Renal Artery/Aorta Artery Ratio: less than 3, greater than 3

l) Renal systolic velocity: less than 74cm/sec, from 74 to 127cm/sec, from 128 to 179cm/sec and greater than 180cm/sec.

Mathematical and statistical method

In the statistical analysis, the mean and standard deviation were used as summary measures for quantitative data, while percentages and rates were used to summarize qualitative variables. The results are presented in contingency tables and graphs for a better understanding of the results.

Obtaining the information: The source of information was direct through patient questioning and medical records, a survey was conducted to record the necessary data in the form according to the specific objectives. These data were stored in a database designed for this purpose.

Results

The results of the series of cases studied are presented, which consisted of 45 patients with arterial hypertension. They were seen in consultation of Internal Medicine, Cardiology and Nephrology, referred to the diagnostic imaging center to perform a renal Doppler ultrasound in order to describe the findings of renal echographic renovascular renal parameters, by means of B Mode and Doppler. In relation to the general characteristics of the patients, the male sex predominated with 23 patients for 51% of the cases, followed by the female sex with 22 patients for 49%. Table 1 shows the results of the mean and standard deviation in relation to age and sex of the series studied.

Table 1 Mean and standard deviation results by age and sex

	Mean	Standard deviation
Age	52.36	18.26
Female	58.36	17.27
Male	54.43	1935

Source: Prepared by the authors

When analyzing the distribution of the patients according to BMI, shown in Table 2 & Figure 1, patients with >30 (Obesity) predominated with 22 patients for 49%, followed by patients in the range of 18.6 - 24.9 (Normopeso) with 12 patients for 27%, followed by the range of 25.0 -29.9 (Overweight) with 10 patients for 22% and the range of <18.5 (Underweight) with 1 patient for 2%.

Table 2 Distribution of the patients according to BMI

BMI	Absolute frequency No.	Relative frequency (%)
<18,5 (Underweight)	1	2
18,6-24,9 (Normopeso)	12	27
25,0-29,9 (Overweight)	10	22
>30 (Obesity)	22	49
Total	45	100

Source: Prepared by the authors

In relation to the time of illness, the range of more than 10 years predominated with 35 patients for 78%, followed by the range of 5 to 10 years with 10 patients for 22%, when analysing the time of antihypertensive treatment, the range of more than 10 years predominated with 33 patients for 74%comorbidities were predominantly diabetes mellitus (44%), followed by cerebrovascular events (19%), renal disease (15%), dyslipidaemia (12%) and acute myocardial infarction (10%).

The distribution of patients according to longitudinal diameter (Table 3), anteroposterior diameter and right and left renal transverse diameter. With respect to the longitudinal diameter, the predominant diameter was 10 to 11cm, in both kidneys with 39 patients for 87%, followed by the diameter greater than 11cm with 4 patients for both kidneys and less than 10cm with one patient for 2% for both kidneys, anteroposterior diameter predominated from 3 to 4cm, with 39 cases for 87% in the right kidney and 41 cases for 89% in the left kidney, followed by diameter greater than 4cm, with 4 patients for 11% in both kidneys, diameter less than 3cm was found in 1 patient for 2% in the right kidney, not recorded in the left kidney. When reviewing the transverse diameter of 5 to 6cm, 40 patients were found for 89% in the right kidney and 39 patients for 88% in the left kidney, followed by the diameter greater than 6cm with 5 patients for 11% in both kidneys.

Table 3 The distribution of patients according to longitudinal diameter

	Renal dimension right		Renal dimension left	
Diameter	Absolute frequency No.	Relative frequency (%)	Absolute frequency No.	Relative frequency (%)
Longitudinal diameter				
<10cm	1	2	1	2
10-11cm	39	87	39	87
>11cm	4	11	4	11
Anteroposterior diameter				
<3cm	1	2	0	0
3-4cm	39	87	41	89
>4cm	4	11	4	11
Transverse diameter				
<5cm	0	0	0	0
5-6cm	40	89	39	88
>6cm	5	11	5	11

Source: Prepared by the authors

The distribution of patients according to renal echogenicity and sinus/parenchyma ratio (Table 4), right renal echogenicity was predominantly Grade II with 22 patients for 49%, followed by Normal echogenicity with 15 patients for 33%, Grade I with 4 patients for 8% and Grade III with 3 patients for 7%. For the left kidney, Normal echogenicity predominated with 22 patients for 50%, followed by Grade II with 13 patients for 29%, Grade III with 6 patients for 14% and Grade I with 3 patients for 7%. The sinus/parenchyma ratio for the right kidney was predominantly bad with 29 patients for 64%, followed by good with 15 patients for 33%. In the left kidney, the bad ratio also predominated with 24 patients for 53%, followed by the good ratio with 20 patients for 44%.

Table 4 The distribution of patients according to renal echogenicity and sinus/parenchyma ratio

Echogenicity and sinus/parenchyma ratio	Absolute frequency No.	Relative frequency (%)
Renal Echogenicity		
Right kidney	15	33
Normal	4	8
Grade I	22	49
Grade II	3	7
Grade III		
Left kidney	22	50
Normal	3	7

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Table 4 Continued...

Echogenicity and sinus/parenchyma ratio	Absolute frequency No.	Relative frequency (%)
Grade I	13	29
Grade II	6	14
Sinus / parenchyma ratio		
Right kidney	15	33
Good	29	64
Poor		
Left kidney	20	44
Ecogenecidad renal	24	53

Source: Prepared by the authors

The distribution of patients according to intraparenchymal resistance index is shown. The right renal intraparenchymal resistance index was found to be greater than 0.70 in 42 patients (92%), followed by values of 0.65 to 0.70 in 2 patients (5%). The left renal intraparenchymal resistance index predominated with values of 0.70 in 33 patients for 77%, followed by values of 0.65 to 0.70 in 8 patients for 18% and values of 0.65 in 3 patients for 7% (Figure 1).

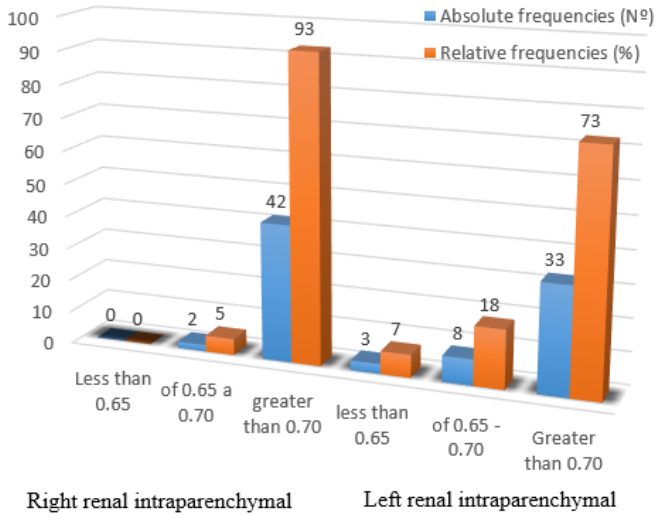

Figure 1 Distribution of patients according to interparenchymal resistance.

When analyzing the patients according to renal artery and aorta ratio, data reflected in Table 5, in the right kidney the ratio greater than 3 predominated with 43 patients for 96%, followed by a ratio of less than 3 in 1 patient for 4%, in the left kidney the ratio less than 3 predominated with 43 patients for 96%, followed by a ratio greater than 3 with 1 patient for 4%.

Table 5 Renal artery and aorta ratio

Renal artery / Aorta ratio	Absolute frequency No.	Relative frequency (%)
Right kidney		
<3	1	4
>3	43	96
Left kidney		
<3	43	96
>3	1	4

Source: Prepared by the authors

The distribution of the patients was analyzed according to renal systolic velocity. With a similar behavior of the systolic velocity ranges for both the right and left kidneys, with a predominance of the systolic velocity range of 74 to 127cm/sec with 21 patients for 47%, followed by the systolic velocity range of 128 to 179cm/sec with 14 patients for 32%, the systolic velocity range greater than 180cm/sec with 7 patients for 16% and the systolic velocity range of less than 74cm/sec with 2 patients for 3%.

Distribution of patients according to renal systolic velocity. With a similar behavior of the systolic velocity ranges for both right and left kidney, predominating the systolic velocity range from 74 to 127cm/sec with 21 patients for 47%, followed by the systolic velocity range from 128 to 179cm/sec with 14 patients for 32%, the systolic velocity range greater than 180cm/sec with 7 patients for 16% and the systolic velocity range less than 74cm/sec with 2 patients for 3% (Figure 2).

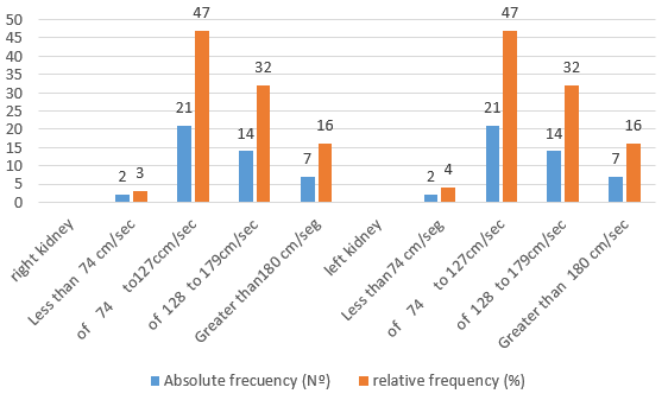

Figure 2 Distribution of patients according to renal systolic velocity.

Fountain: database.

Discussion

Colour Doppler ultrasound is the imaging technique of choice for early diagnosis and follow-up of clinical complications of the kidney, which contributes to the timely treatment of complications, preservation and improvement of the patient's quality of life. The relationship between hypertension and renal structural and functional alterations makes renal function monitoring an important tool in the care of patients with arterial hypertension; echo-Doppler, used to assess renal intraparenchymal vascular resistance through the resistance index, has proven to be useful for assessing the functional status of small renal vessels, the severity and time of evolution of the pathology, and especially as a prognostic marker of progressive renal disease and cardiovascular risk. Its real usefulness can probably be demonstrated with the inclusion of new studies.[16-19]

An investigation was carried out at the GAL Diagnostic Imaging Center, in Cienfuegos, to a series of 45 patients in order to describe the findings of renal echographic renovascular parameters, by B Mode and Doppler in patients with Arterial Hypertension Grade III, seen in consultation of Internal Medicine, Cardiology and Nephrology,

referred to the diagnostic imaging center for the performance of a renal Doppler ultrasound.

We start from the premise that the cases selected for the study were patients with arterial hypertension Grade III, classified according to the Cuban guidelines of arterial hypertension attended in consultation, it is suggested by different studies that the elevated systolic blood pressure figures correlated well with stenosis, with a mean value of 155 mm Hg , figures of, 144 mm Hg in the rest of the patients (p=0.002),20 very similar data are collected by Rihal, with TAS of 149 versus 141 mm Hg (p=0.01), and TAD of 81 versus 79 (p=0.2). 21 However, they should be interpreted with caution, as all patients were under antihypertensive treatment at the time these data were recorded.

In the series studied, the mean age was 52.36 with a standard deviation of 18.26, predominantly male, and the time of illness was greater than 10 years with 35 patients for 78%, results that partially coincide with the study of Franco Maldonado HS (2014) in which the age was similar to that reported in the study but reported the female sex with a greater predominance.[22]

An investigation published by the American Heart Association conducted in Japan that included 426 with essential hypertension, the mean age was 63.1 years (SD 13.5), 50% were female and 50% were male. The mean time of evolution of the disease was 15.5 years (SD 12); 100% received antihypertensive treatment.[23] It can be concluded that the mean ages were partially coincident, sex showed similar results to previous studies, as did the time of disease.

Certain factors or clinical conditions have been considered associated with renal artery stenosis, in the patients studied a BMI >30 (obesity) was found as a risk factor in 22 patients (49%) and the most frequent comorbidity was Diabetes Mellitus in 21 patients (44%). In studies carried out by Sawicki, who reviewed 5194 necropsies, he reported that 53% of the cases that presented renal artery stenosis had diabetes mellitus as a comorbidity, while Nicholls reported an association between renal artery stenosis and diabetes mellitus of 16%,[24–26] data that infer that obesity as a risk factor and Diabetes Mellitus as a comorbidity are related to renal artery stenosis.

As reported by Ingaramo, in arterial hypertension, kidneys with preserved echogenicity, dimensions and cortical thickness do not necessarily indicate the presence of normal kidneys and normal renal arteries.[16] In the series studied the largest number of cases presented longitudinal diameter of 10 to 11cm, in both kidneys with 39 patients for 87%, the anteroposterior diameter predominated from 3 to 4cm, with 39 cases for 87% in the right kidney and 41 cases for 89% for the left kidney, the transverse diameter of 5 to 6cm, 40 patients were found for 89% in the right kidney and 39 patients for 88% in the left kidney, similar to those reported by Franco Maldonado HS,[22] which shows that most of the measurements for both the right and left kidneys are within the normal range. It is noteworthy that within the series studied, two patients were found to be monorenal.

In the cases studied, the relationship between the renal artery and the aorta was predominantly greater than 3, with 43 patients (96%) in both kidneys. This does not coincide with that reported by Franco Maldonado HS, who states that the most frequent ratio was less than 3.[22] No alterations of the renal artery with bilateral presentation were identified.

Leal in 2010 found in hypertensive patients alteration of peak systolic velocity in the hilum of the right renal artery in 3.3%, no alteration was observed in the left; 27 in this regard, in the series studied the renal systolic velocity showed a similar behavior of the systolic velocity ranges for both the right and left kidney, predominantly in the range of 74 to 127cm/sec with 21 patients for 47%.

IR values greater than 0.70 are indicators of renal damage and a renal artery stenosis is a criterion for renal artery stenosis if the renal/aorta ratio is greater than 3 and the renal systolic velocity is greater than 200cm/sec.28 In the study, an RI greater than 0.70 was found in the right kidney in 42 patients for 92% and in the left kidney in 33 patients for 77%, so we can affirm that these patients are carriers of renal damage; we should point out that in the course of the investigation two cases of renal artery stenosis were identified. Elevated IR >0.80 correlates with poor renal prognosis and is an independent predictor of renal disease progression.[28] Therefore, very high IR is considered a marker of poor prognosis in patients with or without renal artery disease.

Shimizu et al.[29] suggest that due to the correlation of IR >0.70 with left ventricular hypertrophy, with advanced carotid atherosclerosis, with creatinine clearance and with uremia values, they have proposed a value of 0.70 as the normal limit for the resistance index.29 Other authors have taken up these parameters in their studies.[30,31] But Derchi et al. found that the risk of mild renal dysfunction in hypertensives doubled in the presence of an IR >0.63.32 Finally, the values found in control groups suggest placing the normal value of the IR as 0.60 ± 0.03 or >0.63. 20 Thus, in clinical practice we can consider a normal IR with values <0.65, with mild to moderate renal dysfunction from 0.70 to 0.79 and with severe renal dysfunction >0.80, in the study a value above 0.70 was considered a predictor of renal dysfunction.

In the review of different investigations, it has been stated that after training, color Doppler shows a sensitivity of 88%, a specificity of 94% for the diagnosis of renal artery stenosis greater than 60%. Other authors found a sensitivity of 91 to 93% and a specificity of 95%.33-36 Data that are related to the research carried out by specifying alterations in the right kidney with 92% and in the left kidney with 77%.

Different authors mention that the resistance index correlates with the age of the patient and the duration of arterial hypertension,[20,23] in the series studied, it was found that age, the duration of arterial hypertension greater than 10 years and BMI >30 (obese) correlate with an elevated resistance index, data that coincide with those of the aforementioned authors.

We agree with different authors, [12,37–43] in stating that color Doppler ultrasound is useful to determine the degree of evolution of renovascular disease, that is, whether stenosis is moderate or severe, with the aim of instituting the necessary therapeutic measures to preserve renal function. A review of the history of the disease in these patients shows that in up to 40% of cases renal artery stenosis progresses to occlusion of the affected vessel, leading to turbulence in blood flow, thrombosis and thus progression of the stenotic lesion.

Conclusion

Doppler ultrasound of the renal arteries is a diagnostic test used to identify renovascular findings in the renal Doppler ultrasound in patients with Grade III Chronic Arterial Hypertension, allowing to assess the state of renal function, evaluate early damage of the renal target organ, monitor its evolution and detect renal parenchymal disease.

The study found an IR greater than 0.70 in the right kidney in 42 patients, for 92% of the sample studied, and in the left kidney in 33 patients, for 77%, so it is inferred that these patients are carriers of renal damage, which corroborates the objective proposed in the research.

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Conflicts of interest

The authors decalre that there are no conflicts of interest.

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