DOI: 10.7860/JCDR/2020/43095.13490

Original Article

Radiology Section

Impact of Diabetes Mellitus and Ischaemic Heart Disease on the Blood Resistivity Index of Renal Arteries in Hypertensive Patients

MOAWIA GAMERADDIN[1], WALAA HIDIRBI[2], SUZAN ABDELMABOUD[3], ABDULAZIZ QURASHI[4], SULTAN ALSHOABI[5]

ABSTRACT

Introduction: Hypertension (HTN) is considered as one of the most common health problems. Doppler sonography plays an effective role in haemodynamic assessment of renal arteries in patients with essential HTN.

Aim: To assess renal vascular Resistive Index (RI) in patients with essential HTN in co-existence with Diabetes Mellitus (DM) and Ischaemic Heart Disease (IHD).

Materials and Methods: This was a cross-sectional study which involved 100 hypertensive patients selected by a simple, convenient sampling method from June 2014 to August 2016. The participants were categorised into four groups; 55 patients with controlled HTN while the uncontrolled HTN groups included 20 with HTN coupled with DM, 18 with HTN and IHD, and seven patients of HTN accompanied by both DM and IHD. The patients were investigated using Duplex Doppler ultrasonography to assess the RI of the renal arteries. Analysis of variance and Student's t-test were performed to compare renal RI values between controlled and uncontrolled hypertensives.

Results: The mean renal RI in patients with controlled HTN was 0.59±0.093, 0.71±0.035 in DM, 0.70±0.029 in IHD, and 0.72±0.029 in patients with IHD and DM. Controlled hypertension revealed a stable blood RI across the renal arteries (RI=0.59±0.093). The renal RI was significantly higher in patients with DM, IHD and DM+IHD group compared to patients with controlled HTN (p-values=0.004, 0.014 and 0.001).

Conclusion: The renal RI is an important parameter which provides useful information about haemodynamics of renal arteries in essential HTN complicated with DM and IHD.

Keywords: Cardiovascular, Doppler, Kidney disease, Vascularity

INTRODUCTION

HTN is one of the most common health related problems and it affects more than 100 million people worldwide. It leads to cardiovascular end-organ damage, which leads to increased morbidity and mortality that is related to high costs to the community, thus making a significant public health challenge [1]. Ultrasound Doppler plays a significant role in the diagnosis of acute or chronic nephropathies and nephrovascular disease, as well as predicts early renal damage in hypertensive patients [2]. Ultrasound imaging is a non-invasive, widely available, and accepted imaging modality that provides reasonably accurate images about the structural changes within the kidney [3]. The Doppler RI has been utilised for many years in the assessment of a variety of renal diseases such as renal artery stenosis, risk progression in chronic kidney disease and to differentiate acute from chronic obstructive renal disorders. Recently, renal RI is considered as a predictor marker of renal histological damage and a prognostic indicator [4]. More recently, evidence has shown that an increased renal RI, not only reflects the changes in renal blood supply but is also found to correlate with systemic haemodynamics and the presence of atherosclerosis. This relationship may provide useful clinical information in patients affected with primary HTN [5]. Therefore, renal RI has been recommended to evaluate patients with primary HTN and signs of renal disorders.

DM and IHD have an increased risk for kidney disease. There is a close correlation between HTN and DM with Cardiovascular Disease (CVD), which is responsible for the leading cause of morbidity and mortality [6]. Therefore, in these situations, renal RI will play a vital role in characterising haemodynamic significance, which provides useful information in prognosis and management. The present study explores the impact of DM and IHD on the haemodynamics of the renal arteries in hypertensive patients. The study would demonstrate, how much IHD and DM change, the RI in HTN. One of the previous studies had demonstrated renal RI in HTN alone without other complications such as CVD [7]. Furthermore, no studies have found to demonstrate the impact of IHD on the blood RI of the renal arteries in hypertensive patients. The study aimed to evaluate the significance of renal RI in hypertensive patients with co-morbidity of DM and IHD.

MATERIALS AND METHODS

This was a prospective, cross-sectional study performed at Khartoum State hospitals, namely in Soba University Hospital, Sharq El-Niel, Khartoum North, and Umdorman Military Hospital, Sudan from June 2014 to August 2016. IEC approval has been applied for the present study and the study was judged to be having less than minimal risk. Hundred Sudanese participants diagnosed with essential HTN documented in their records were selected by the method of simple, convenient sampling and obtaining informed consent. The participants were categorised into four groups; 55 patients with controlled HTN while the uncontrolled HTN groups included 20 with HTN coupled with DM, 18 with HTN and IHD, and seven patients of HTN accompanied by both DM and IHD. The uncontrolled DM was defined as those patients who were not regular on diabetes medicines and did not follow the meal plan or the instructions. Patients with IHD were those with cardiac problems caused by narrowed coronary arteries [8]. On the other hand, controlled hypertension was defined as blood pressure below 140/90 mm Hg or, if the participant had diabetes or chronic renal disease, below 130/80 mm Hg, while uncontrolled HTN was defined as a blood pressure ≥140/90 mm Hg [9]. The clinical data was taken from the patients' records. The patients were investigated with Doppler ultrasound to assess the renal RI. The exclusion criteria were pregnant, previous history of renal surgery, and atrophy of kidneys.

Doppler sonographic investigation was performed using Toshiba Nemio 20 (Toshiba, Japan) and Mindray DC-N3 (Mindray, China). A

3.5 MHz curvilinear array transducer with a variable focal zone was used. Patients were fastened for three hours to get rid of gases and then examined in supine positions, following the renal ultrasound protocols. The patients were scanned in the supine and oblique positions. Each kidney was examined with a B-mode ultrasound in at least two planes to maintain the renal length for each kidney. The average length of the kidneys was considered 8.5 up to 12 cm; renal length lesser than 7 cm was considered a small kidney. The RI was measured at the interlobular or arcuate artery in the upper, middle, and lower portions of the kidney and the mean values were calculated for each kidney. The renal RI values > 0.70 were considered high [10].

STATISTICAL ANALYSIS

Data entered and analysed by utilising the Statistical Package for the Social Sciences (SPSS), version 23. Descriptive statistics used Mean±Standard Deviation (SD). Pearson's correlation was used to find a relationship of renal RI with the sonographic findings and characteristics of the participants. Analysis of Variance (ANOVA) test was used to compare the mean RI values of the controlled hypertensive with DM and IHD. The significant statistical value was p<0.05.

RESULTS

Out of the 100 involved patients, the average age was 40.4±5 years, and the duration of HTN was 7.72±3 years. In controlled group of HTN, the number of males was 35 and 20 females, while in the uncontrolled group, there were 16 males and 29 females.

The mean renal RI was significantly associated with patient age, gender, and duration of HTN, and renal length. The mean renal RI was considerably higher in females than males. There was a significant negative correlation between renal RI and renal length (p-values=0.02 and 0.009 for lengths of the right and left kidneys, respectively). The negative correlation indicated that the renal RI increased as renal length decreased [Table/Fig-1]. The renal RI was estimated in the age groups, and it was observed that it was significantly different among the groups (p-value <0.001). The age group 41-70 years revealed a higher incidence of HTN and elevated RI compared to the other groups [Table/Fig-2].

Characteristics and findings	Mean±SD	Correlation coefficient (r)	p-values
Age (in yrs.)	40.4±5	0.23	<0.001
Duration of HTN (in yrs)	7.72±3	0.32	<0.001
Male (n=51)	RI=0.60±0.092	0.34	<0.001
Female (n=49)	RI=0.65±0.047		
Length of the right kidney (cm)	8.9850±1.01	-0.18	0.02
Length of the left kidney (cm)	9.4760±0.98	-0.20	0.009

[Table/Fig-1]: Correlation of the renal RI with demographic data of the participants and renal length.
SD: Standard deviation; RI: Resistive index. Pearson correlation was used to find the correlations

Age groups	Frequency	RI values Mean±SD	Significance between groups
<20 years	22	0.62±0.045	<0.001
20-40 years	30	0.57±0.11	
41-70 years	41	0.66±0.033	
>70 years	7	0.63±0.019	
Total	100	0.62±0.077	

[Table/Fig-2]: Comparison of mean renal RI value in age groups of the participants.
ANOVA test was applied to compare between the groups

The mean renal RI was 0.59±0.093, 0.71±0.035, 0.70±0.029, and 0.72±0.029 in controlled HTN patients group, HTN with DM, HTN with IHD, and in both DM and IHD groups, respectively. The mean renal RI was significantly elevated in DM and IHD more than the controlled hypertension group [Table/Fig-3].

Groups of hypertension	Frequency	Mean RI values ±SD	Controlled hypertension (mean RI values ±SD)	p-values	95% confidence interval
DM	20	0.71±0.035	0.59±0.093	0.004	0.018–0.127
IHD	18	0.70±0.029	0.59±0.093	0.014	-0.123–0.010
DM and IHD	7	0.72±0.029	0.59±0.093	0.001	-0.148–-0.082

[Table/Fig-3]: Comparison of the mean RI values in controlled HTN with DM and IHD.
RI: Resistive index, SD: Standard deviation, DM: Diabetes mellitus, IHD: Ischaemic heart disease
Student's t-test was used to compare each group of uncontrolled hypertension with the controlled group

DISCUSSION

HTN is a significant risk factor affecting the renal artery RI. The present study explored the impact of DM and IHD on renal RI in hypertensive patients. In this study, renal RI was high in hypertensive patients. Furthermore, it was noted that HTN with diabetes had increased renal RI more than HTN alone. In agreement with the present study findings, Mancini M et al., reported a significant elevation of renal RI in Type 2 diabetic patients (RI=0.70±0.05) [11]. On the other hand, Andrikou I et al., reported a significant increase in renal RI in patients with essential HTN [12]. Similarly, Ohta Y et al., reported that RI was significantly increased in diabetic nephropathy [13]. Several studies have demonstrated the elevation of renal RI due to the impact of DM, which changes vascular resistance in the kidneys [14-16]. The elevation of renal RI is attributed to diabetic nephropathy. Viazzi F et al., reported that high renal RI was used as a predictor for renal damage in primary HTN is a risk factor for renal impairment [5]. The effect of IHD on renal RI was not demonstrated in the recent literature. The present study found that renal RI was high in hypertensive patients with IHD (0.70±.029), but lesser than those with DM. Consistent with this result, Komuro K et al., reported a significant elevation of renal RI in CVD [17]. The increased RI was attributed to changes in vascular compliance or because of change in a small renal vessel. Besides, blood pressure and heart rate were essential determinants of RI [18].

In this study, high values of renal RI were observed in diabetic patients. Similarly, Hamano K et al., studied the association of renal RI in type 2 diabetic patients [19]. They reported that renal RI was significantly high in diabetic patients compared to the normal ones. However, in previous studies, RI >0.8 was proven to be a significant deterioration in the Glomerular Filtration Rate (GFR) [20]. Thus, increased renal RI is useful to assess renal function in type 2 diabetes with microalbuminuria. In the current study, significant positive correlations were found between RI and gender and age (p-values <0.001). Recent studies have demonstrated that the RI correlates with age and gender [21,22]. In agreement with present study findings, Toledo C et al., reported that older age and female sex are associated with renal RI ≥0.70 [23]. Therefore, age and gender were independent factors that influenced the renal RI.

Limitation(s)

The study faced significant problems that the sample size was not large enough. Secondly, we see it challenging to find an increased number of patients with IHD.

CONCLUSION(S)

DM and IHD caused considerable elevation of renal RI in hypertensive patients. This elevation reflects the progression of renal diseases. The assessment of renal RI may have implications on the planning of HTN treatment. Further studies are recommended to confirm the initial results of the present study.

Acknowledgement

Authors would like to acknowledge the faculty members of college of Radiological sciences and medical imaging of Alzaiem Al-azhari University and the Radiologists in Khartoum State hospitals, Sudan, for providing their help and expert opinion.

REFERENCES

[1] Drozdz D, Kawecka-Jaszcz K. Cardiovascular changes during chronic hypertensive states. Pediatr Nephrol. 2014;29:1507-16.
[2] Boddi M. Renal ultrasound (and doppler sonography) in hypertension: An update. Adv Exp Med Biol. 2017;956:191-208.
[3] Alshoabi SA. Association between grades of hydronephrosis and detection of urinary stones by ultrasound imaging. Pak J Med Sci. 2018;34(4):955-58.
[4] Haitsma Mulier JLG, Rozemeijer S, Röttgering JG, Spoelstra-de Man AME, Elbers PWG, Tuinman PR, et al. Renal resistive index as an early predictor and discriminator of acute kidney injury in critically ill patients; A prospective observational cohort study. PLoS ONE. 2018;13(6):e0197967.
[5] Viazzi F, Leoncini G, Derchi LE, Pontremoli R. Ultrasound doppler renal resistive index: A useful tool for the management of the hypertensive patient. J Hypertens. 2014;32(1):149-53.
[6] Leon BM, Maddox TM. Diabetes and cardiovascular disease: Epidemiology, biological mechanisms, treatment recommendations, and future research. World J Diabetes. 2015;6(13):1246-58.
[7] Cauwenberghs N, Kuznetsova T. Determinants and prognostic significance of the renal resistive index. Pulse (Basel). 2016;3(3-4):172-78.
[8] Chowdhury M, Osborn EA. Physiological assessment of coronary lesions in 2020. Curr Treat Options Cardiovasc Med. 2020;15;22(1):2.
[9] Park S. Ideal target blood pressure in hypertension. Korean Circ J. 2019;49(11):1002-09.
[10] Tublin ME, Bude RO, Platt JF. Review. The resistive index in renal Doppler sonography: Where do we stand? AJR Am J Roentgenol. 2003;180(4):885-92.
[11] Mancini M, Masulli M, Liuzzi R, Mainenti PP, Ragucci M, Maurea S, et al. Renal duplex sonographic evaluation of type 2 diabetic patients. J Ultrasound Med. 2013;32(6):1033-40.
[12] Andrikou I, Tsioufis C, Konstantinidis D, Kasiakogias A, Dimitriadis K, Leontsinis I, et al. Renal resistive index in hypertensive patients. The JCH. 2018;20(12):1739-44.
[13] Ohta Y, Fujii K, Arima H, Matsumura K, Tsuchihashi T, Tokumoto M, et al. Increased renal resistive index in atherosclerosis and diabetic nephropathy assessed by Doppler sonography. J Hypertens. 2005;23(10):1905-11.
[14] Shirin M, Sharif MM, Gurung A, Datta A. Resistive index of intrarenal artery in evaluation of diabetic nephropathy. Bangladesh Med Res Counc Bull. 2015;41(3):125-30.
[15] Maksoud AAA, Sharara SM, Nanda A, Khouzam RN. The renal resistive index as a new complementary tool to predict microvascular diabetic complications in children and adolescents: A groundbreaking finding. Annals of Translational Medicine. 2019;7(17):422. doi: 10.21037/atm.2019.08.65.
[16] Assenyi SS, Adekanmi AJ, Esan A. Renal duplex ultrasonography among adult native Nigerian diabetics and diabetic nephropathy population. West Afr J Radiol. 2019;26(1):01-08.
[17] Komuro K, Yokoyama N, Shibuya M, Soutome K, Hirose M, Yonezawa K, et al. Associations between increased renal resistive index and cardiovascular events. J Med Ultrason (2001). 2016;43(2):263-70.
[18] Tedesco MA, Natale F, Mocerino R, Tassinario G, Calabrò R. Renal resistive index and cardiovascular organ damage in a large population of hypertensive patients. J Hum Hypertens. 2007;21(4):291-96.
[19] Hamano K, Nitta A, Ohtake T, Kobayashi S. Associations of renal vascular resistance with albuminuria and other macroangiopathy in type 2 diabetic patients. Diabetes Care. 2008;31(9):1853-57.
[20] Nosadini R, Velussi M, Brocco E, Abaterusso C, Carraro A, Piarulli F, et al. Increased renal arterial resistance predicts the course of renal function in type 2 diabetes with microalbuminuria. Diabetes. 2006;55(1):234-39.
[21] Ismail A, Ademola BL, Yusuf L, Abdulmalik MA. Renal arterial doppler velocimetric indices among healthy subjects in north west Nigeria. J West Afr Coll Surg. 2018;8(1):40-49.
[22] Ponte B, Pruijm M, Ackermann D, Vuistiner P, Eisenberger U, Guessous I, et al. Reference values and factors associated with renal resistive index in a family-based population study. Hypertension. 2014;63(1):136-42.
[23] Toledo C, Thomas G, Schold JD, Arrigain S, Gornik HL, Nally JV, et al. Renal resistive index and mortality in chronic kidney disease. Hypertension. 2015;66(2):382-88.

PARTICULARS OF CONTRIBUTORS:
1. Associate Professor, Department of Diagnostic Radiologic Technology, Taibah University, Almadinah, Saudi Arabia.
2. Assistant Professor, College of Radiological Sciences and Medical Imaging, Alzaiem Alzhari University, Khartoum-Sudan, Khartoum, Sudan.
3. Assistant Professor, College of Radiological Sciences and Medical Imaging, Alzaiem Alzhari University, Khartoum-Sudan, Khartoum, Sudan.
4. Associate Professor, Department of Diagnostic Radiologic Technology, Taibah University, Almadinah, Saudi Arabia.
5. Associate Professor, Department of Diagnostic Radiologic Technology, Taibah University, Almadinah, Saudi Arabia.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Moawia Gameraddin,
Taibah University, Almadinah, KSA. P.O. 3001, Almadinah Amunawarah, Saudi Arabia.
E-mail: m.bushra@yahoo.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Oct 23, 2019
- Manual Googling: Dec 17, 2019
- iThenticate Software: Jan 20, 2020 (11%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Oct 22, 2019**
Date of Peer Review: **Nov 21, 2019**
Date of Acceptance: **Dec 27, 2019**
Date of Publishing: **Feb 01, 2020**