Evaluation of renal arteries in hypertensive patients by multi-detector computed tomography

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ABSTRACT

Introduction: Among various causes of hypertension, only 1 to 2% is renovascular hypertension which may be characterized by the various reasons in renal vascular supply. Multi-detector computed tomography is used to know about the details of the vascular structures in patients. This study aims to evaluate the renal arteries in hypertensive patients. **Methods:** A prospective observational study was conducted among 93 hypertensive patients. Contrast-enhanced computed tomography of the abdomen and pelvis was conducted, and measurements were obtained from the axial section of the maximum intensity projection image. Data were analyzed using SPSS version 23.0. Independent t-test and Pearson's Correlation were used. The level of statistical significance was set at $p<0.05$. **Results:** The study found mean lengths for the right and left main renal arteries to be 40.33±10.26 mm and 32.36±9.55 mm, and diameters were 4.31±0.86 mm and 4.16±0.81 mm. No significant sex-based differences were observed. However, a significant age-related difference was noted in the length ($p=0.012$) and diameter ($p=0.036$) of the right main artery within the 20 to 29 and 80 to 89 years age groups. Weak correlations were observed between left renal artery length and age ($r=0.221$, $p=0.33$) and mean right renal artery diameter and age ($r=-0.218$, $p=0.036$). Prevalence of accessory renal arteries and early branches was 19.35% and 16.10% respectively. **Conclusions:** This study found that there were no statistically significant differences in renal arteries dimensions of hypertensive patients with different age groups and genders. Although the proportion of early renal artery branching and accessory arteries are found to be similar to previous studies there may be other associated factors for all hypertensive patients who don't have early renal branches or accessory arteries.

Keywords: Angiography, hypertension, multidetector computed tomography, renal artery.

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INTRODUCTION

Hypertension (HTN) is defined as an average blood pressure more or equal to 140/90 mmHg and/or the use of antihypertensive drugs as stated by the seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure.[1] There are various cause of the HTN, the cause of 90% of it is unknown, and among the rest only 1 to 2 % of it is renovascular hypertension (RVHT) which may be characterized by the various reasons in renal vascular supply.[2]

There are variations seen in the renal artery. One of them is an early arterial branch or pre- hilar branch diagnosed as the first branch within 1.5 cm of renal artery ostium. The incidence of early branches is about 12%.[3] However studies suggest the relation of RVHT with the presence of accessory arteries.[4] A recent study done by Shen et.al found the prevalence of the accessory arteries ranged from 14.8% to 17.1% and was an independent factor of hypertension in the hypertensive patients.[5] Many reports suggest a correlation of the diameter of the renal artery has more influence

on the HTN. In addition to this, articles have mentioned the stenosis of renal artery diameter with increasing age. The hemodynamics of the renal artery may or may not be affected due to plaque deposition or atherosclerotic changes in the old age group.[6,7] Regardless a recent study by Elrahim et al. reported the reduction of the diameter of the renal artery was assigned to aging.[8]

Evaluation of the RVHT ranges from various modalities such as Angiotensin Converting Enzyme inhibitor Scintigraphy, Conventional angiography, Doppler studies, Magnetic Resonance Imaging, and multidetector computed tomography (MDCT).[9,10] MDCT is a non-invasive imaging that plays an important role in evaluating the renal vessels and their abnormalities or any variants. Many articles have confirmed the reliability and validity with interpretability of MDCT to rule out Renal Artery stenosis (RAS) and variants.[11,12] MDCT has abilities to successfully describe the morphology of the renal arteries such as caliber, length, plaque location, branching patterns, and presence of accessory or polar arteries.[13] Because of the superior spatial resolution and with the help of the post-processing tools and techniques such as Maximum Intensity Projection (MIP), Curved Planar Reformation (CPR), and Volume Rendering Technique (VRT) it is easier for the measurement of the tortuous structures as well. MIP images are formed with the selection of the higher density voxel hence when the iodinated contrast fills the renal artery, it highlights the arteries against the adjacent structures helping in better visualization in any plane.[14,15]

Numerous studies have focused on individuals with normal blood pressure, but due to the distinct treatment and management approach for RVHT, this study aimed to assess renal arteries in hypertensive patients. The study seeks to understand measurements, variations, and their associations with age and gender.

METHODS

This was a prospective cross-sectional study done in the Department of Radiology and Imaging at Bir Hospital, Kathmandu, Nepal. The data collection was done in three months (December 2022 to February 2023) and included a Philips Ingenuity 128-slice CT scanner and IntelliSpace Portal (v9.01.20850) as tools. The non-probability purposive sampling method was used. The study included all adult patients previously diagnosed as hypertensive, referred for renal angiography, dual or triple phase Contrast-enhanced computed tomography (CECT) abdomen and pelvis. The study excluded patients with nephrectomy, renal transplantation, abnormal renal function, uncooperative patients, images with artifacts, trauma patients, and patients with renal mass or any mass abutting the renal arteries. Ethical approval was obtained from the Institutional Review Committee (Reference Number: 499/2079/80), and written informed consent was secured from participants.

Sample size

The sample size was calculated using the following formula $n = z^2p\,(1\text{-}p)/d^2$ where, n=required sample size, z=statistical value for a level of confidence (for 95% level of confidence, z=1.96) p=estimated proportion of accessory renal artery in hypertensive patients 59%,[4] d=precision or maximum tolerable error 10% $n=1.96^2\times0.59(1\text{-}0.59)/.1^2$ n=92.92=93.

Study details

The scan was performed by a Radiography Technologist and interpreted by a senior consultant Radiologist with more than five years of experience. Bolus tracking was used with Hounsfield (HU) set to 100 HU with region of interest (ROI) kept at the descending aorta.

The scanning range for the arterial phase included from the dome of the diaphragm to the iliac crest. And remaining phase was taken from the dome of the diaphragm to the symphysis pubis as a basic protocol. After the scan was completed measurement of the diameter and length of the renal arteries were measured on axial sections of the image slices taken during the arterial phase by reconstructing the axial slices in thin section MIP images where thickness was varied (5-30 mm) with the help of digital caliper.[16] The measurement of the renal artery diameter was performed in the proximal segment of the renal artery at a distance of 1 to 1.5 cm from the ostium, where the renal artery reached a uniform width.[17] If the renal artery showed early branching (which is any branch within 2.0 cm from the aorta), the caliber was measured before the level of branching. If the kidney had a single renal artery, this was accepted as the main renal artery. Similarly, if there were multiple arteries, the largest one was accepted as a main renal artery.[18]

Data analysis was done in Statistical Package for the Social Sciences (SPSS) version 23.0, employing an independent sample t-test and Pearson's correlation. The level of significance was set at $p<0.05$.

RESULTS

A total of 93 participants were taken in the study. Age of the participants were distributed from 20 years to 89 years. The majority of the patients were from the age group of 60-69 years with 21.5% and the minimum was from the age

group of 20 to 29 years with only 4.3%. The mean age ± SD was 56.37 ± 14.97 years. There were 58 male and 35 female participants.

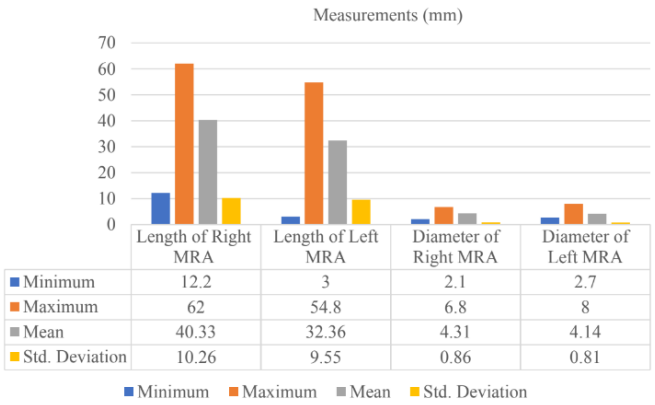

Figure 1: Measurements of main renal artery

In the study, mean length of right main renal artery was found to be 40.33±10.26 mm. Similarly, the length of left main renal artery was 32.36±9.55 mm. Diameter of right main renal artery was 4.31±0.86 mm, and left main renal artery was 4.16±0.81 mm (Figure 1).

In males, the mean length of right main renal artery (mRA) was found to be 40.62 ±10.95 mm and left mRA was 32.86±9.87 mm. he mean diameter of right mRA was 4.37±0.833 mm and left mRA was 4.28±0.94 mm in male participants. However, in females the mean length of right mRA was 39.85±9.14 mm. and left mRA was 31.53±9.09 mm. Similarly, the mean diameter of right mRA and left mRA was 4.21±0.92 mm and 3.98±0.69mm respectively. There was no significant difference in mean lengths and diameter of both left and right mRAs between male and females. (Table 1)

Table 1: Comparison of mean length and diameter of the main renal artery on the basis of sex (N=93)

	Male(n=58)	Female (n=35)	p-value	CI (95%)
Length of Right mRA(mm)	40.62	39.85	0.72	-3.61, 5.16
Length of Left mRA(mm)	32.87	31.53	0.51	-2.74, 5.41
Diameter of Right mRA(mm)	4.37	4.22	0.40	-0.21, 0.52
Diameter of Left mRA(mm)	4.26	3.95	0.08	0.03, 0.65

Table 2: Relation of the age group with length and diameter of main renal artery

	Age-group	Frequency	Mean	Std. Deviation	p-value
Length of right main renal artery	20-29	4	30.43	4.93	0.01
	80-89	8	42.08	6.66	
Length of left main renal artery	20-29	4	27.98	10.95	0.22
	80-89	8	36.19	10.15	
Diameter of right main renal artery	20-29	4	5.26	1.10	0.03
	80-89	8	4.13	0.58	
Diameter of left main renal artery	20-29	4	4.58	0.39	0.29
	80-89	8	4.20	0.60	

Table 2 summarizes the influence of age in the dimensions of main renal artery. There was no significant difference in length and diameter with age groups. However, a significant difference between length (p= 0.01) and diameter (p=0.03) of right main artery was found in the age group of 20-29 and 80-89 years .

Correlation of main renal artery dimensions with age

Using Pearson's correlation analysis, significant weak negative correlation (r=-0.218, p=0.036) was found between mean right renal artery diameter and age. A weak positive correlation (r=0.221, p=0.33) was found between mean left renal length and age which is as shown with scatter plot in Figure 2. However, another dimension was not significant with age.

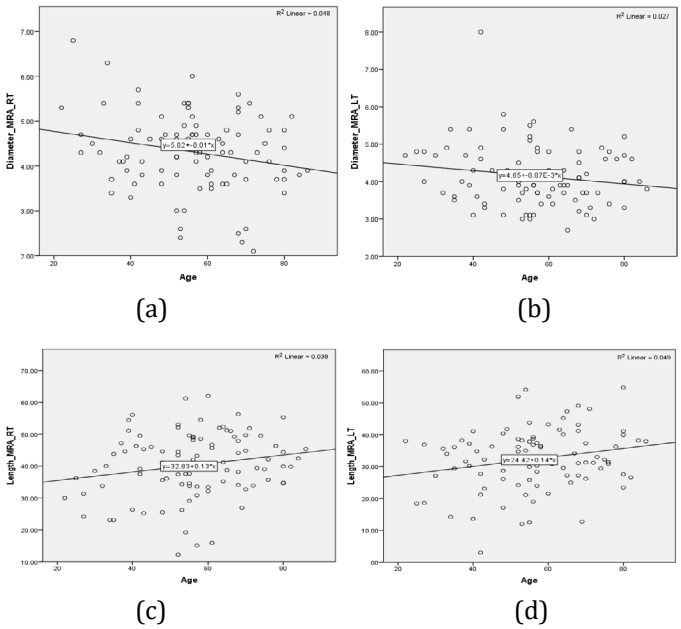

Figure 2: Scatter plot diagram a) between age and length of right main renal artery, b) between age and length of left main renal artery c) between age and diameter of right main renal artery d) between age and diameter of left main renal artery

Proportion of accessory and early branch

The study showed 18 accessories arteries and 15 early branches of main renal artery. The proportion of the right accessory artery was 8.6%, left accessory artery was 4.3% and bilateral accessory artery was 3.2%. Similarly, there were 15 early branches of main renal artery where prevalence of right early branch was 5.4% and left early branch was 10.8%.

The study showed the frequency of the accessory and early

branch with different age groups as tabulated below where most of the accessory arteries were seen in the age groups of 40 to 49 and 50 to 59, similarly most of the early branch was seen in the age group of 50 to 59 and none of them was seen in age group of 80 to 89 as shown in table 3.

Table 3: Frequency of Accessories and early branch of the main renal artery with age group

Age group	Accessory Artery		Total	Early Branch		Total
	Right	Left		Right	Left	
20-29	0(0%)	2(50%)	2	0(0%)	2(50%)	2
30-39	1(10%)	0(0%)	1	0(0%)	1(10%)	1
40-49	3(21%)	1(7%)	4	0(0%)	3(21%)	3
50-59	3(12%)	1(4%)	4	3(12%)	3(12%)	6
60-69	2(10%)	1(5%)	3	1(5%)	1(5%)	2
70-79	0(0%)	1(9%)	1	1(9%)	0(0%)	1
80-89	2(25%)	1(13%)	3	0(0%)	0(0%)	0
Total	11(12%)	7(8%)	18	5(5%)	10(11%)	15

The study also showed five renal main renal arteries with lumen stenosis; two in right mRA and three in left mRA.

DISCUSSION

The use of CECT for assessing the abdominal and pelvic regions, along with arterial phase with renal angiography, has been providing detailed information in examining the renal arteries, their dimensions, and associated variants. Our study aimed to conduct a comprehensive morphometric analysis of renal arteries within a group of hypertensive patients.

A retrospective study conducted by Panta et al.[19], which included 110 patients, reported the diameter of the right main renal artery at the proximal part (10 mm from the ostium) to be 5.55±0.97 mm and 5.78±0.77 mm for males and females, respectively. Similarly, for the left main renal artery, the measurements were 5.84±0.94 mm and 6.02±0.69 mm for males and females, respectively. However, our study, focusing exclusively on hypertensive patients showed differences to it, and found the diameter of the right and left main renal arteries to be 4.37±0.83 mm and 4.21±0.92 mm for males and 4.26±0.94 mm and 3.95±0.69 mm for females, respectively. Similarly, a study by Shen et al.,[5] including both diagnosed and undiagnosed hypertensive groups, found the mean diameter and length of the right and left main renal arteries to be comparable to our study, measuring 5.1±1.4 mm, 40.2±11.5 mm, 5.1±1.1 mm, and 34.8±12.5 mm, respectively.

In a separate study by Khanal et al.,[16] excluding hypertensive patients reported the diameter of the right renal artery to be 5.70 mm for males and 5.06 mm for females, showing a significant difference compared to the current study.

Furthermore, Shen et al.[5] reported the prevalence of accessory renal arteries and early branches to be 15.3% and 14.3%, respectively which is quite similar to our study with 19.35% and 16.1 % respectively. However, a very small prevalence (6.3%) was seen in a study done by Regmi et al.[18] Meanwhile, Coulier et al.,[12] concluded that the prevalence of multiple renal arteries did not necessarily predispose individuals to hypertension.

Elrahim et al.[8] reported significant differences in the diameter and length of the main renal artery among all age groups included ($p<0.001$). However, our study noted a significant difference only in the right main renal artery dimensions (length and diameter) in the age group of 20 to 29 and 80 to 89 ($p=0.012$, $p=0.036$, respectively). Similarly, our study revealed the maximum mean diameter in the 20 to 29 age group and a decrease in the 80 to 89 age group, which is consistent with findings of Elrahim et al. with increased diameter in the 36 to 55 age group and subsequent decrease in the 56 to 75 and 76 to 90 age groups.

The limitation of this study was the small sample size for the population study. The study couldn't state the duration and types of medication of the participants for hypertension which could have resulted differently. The slice thickness for measurements wasn't uniform throughout the sample as measurements were taken in axial sections.

CONCLUSIONS

This study found that there were no statistically significant differences in renal arteries dimensions of hypertensive patients with different age groups and genders. Although the proportion of early renal artery branching and accessory arteries are found to be similar to previous studies there may be other associated factors for all hypertensive patients who don't have early renal branches or accessory arteries. All hypertensive patients don't need to go through CT scans to rule out vasculature abnormalities.

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AUTHORS CONTRIBUTION

PS designed the study, collected the data and analyzed the results and reviewed the study; SS did the analysis and editing; SS defined the intellectual content, editing and revised the data and result; RPY helped in the collection

of data; AV did data acquisition, analysis, and statistical analysis; SS did data analysis; PP collected the reference articles and RS checked the referencing and editing.

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