Original Article

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Evaluation of Diameter of Main Hilar Renal Artery to Predict the Presence of Supplementary Renal Artery by Contrast-enhanced MDCT: A Retrospective Study in Northern India

Anatomy Section

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ABSTRACT

Introduction: Accessory renal arteries are non anastomotic end arteries that correspond to a single renal artery's segmental branch. It is the most common anatomic variation of renal artery, with an incidence ranging from 8.7-75.7%.

Aim: To determine the normal reference range of diameter of the main hilar renal artery in presence or absence of supplementary renal arteries and using contrast-enhanced Multidetector Computerised Tomography (MDCT) in North Indian population.

Materials and Methods: This retrospective study was conducted in the Department of Anatomy in collaboration with the Department of Radiodiagnosis at Santosh Medical College and Hospital, Ghaziabad and Dr. O.P Gupta Imaging Centre, Meerut, Uttar Pradesh, India, from April 2019 to October 2021. Data analysis was done from November 2021 to December 2021. Contrast-enhanced MDCT scan images were reviewed for measurement of the diameter of main hilar and supplementary renal artery. A total of 108 patients were recruited through consecutive sampling. The diameter of the main hilar and supplementary renal artery on each side was measured at the site of origin from the abdominal aorta with the help of an electronic calliper in axial view of MDCT images. The mean differences among the groups with and without supplementary renal artery were evaluated using the student's t-test.

Results: The mean diameter of the main hilar renal artery in the absence of the supplementary renal arteries on the right and left side were 5.99±1.13 mm and 6.07±1.25 mm, respectively. The mean diameter of the main hilar renal artery with supplementary renal arteries on the right side was 5.11±1.096 mm and on the left was 5.18±1.08. The mean diameter of the main hilar renal artery was smaller in kidneys with a supplementary renal artery than in those without a supplementary renal artery, statistically significant difference was evaluated (p-value <0.001 on the right and left side).

Conclusion: The diameter of the main hilar renal artery can indicate whether supplemental renal arteries exist or not.

Keywords: Contrast-enhanced multidetector computed tomographic, Hilar supplementary artery, Renal transplant

INTRODUCTION

Each kidney is supplied by the single renal artery on each side, which arises from the Abdominal Aorta (AA), corresponding to the disc between the L1 and L2 vertebrae [1]. In addition, accessory renal arteries are also present, which seems to be the most common anatomic variation, with an incidence ranging from 8.7-75.7% [2].

According to Stephens FD, accessory renal arteries are non anastomotic end arteries that correspond to a single renal artery's segmental branch. Clinically, the presence of these accessory renal arteries increases the operative time and complexity of the surgeries for both donor and recipient, with a resultant risk of arterial thrombosis [3]. During renal transplant surgery, a luminal diameter of atleast 3 mm is necessary to create a safe anastomotic site for both the main and accessory renal arteries. So, awareness of the normal reference range for the diameter of the renal artery and its anatomical variants is very essential [4].

Renal artery variations show social, ethnic and racial differences [5]. The racial distribution of renal artery variation is as follows: Africans (37%), Caucasians (35%), Hindus (17%), Chinese (14.5%), Caribbean (36.5%), Columbian (33.3%) and Greek population (11.2%) [5,6]. Various terminologies have been given to the variable number of renal arteries, such as: aberrant, supplementary, multiple, extra, accessory, and supernumerary [6,7].

Bordei P et al., introduced three new terms [8]:

1. The main hilar renal artery is the largest hilar artery.
2. The hilar supplementary artery is the smaller one.
3. The superior and inferior polar arteries supply blood to the renal poles.

In the current time period, due to a variety of factors, the prevalence of End-Stage Renal Disease (ESRD) is steadily rising. For ESRD, renal transplantation is considered the ideal choice of treatment modality [9]. A complete renal vasculature assessment of donor is mandatory before transplant surgery [10].

To achieve success in renal transplant surgery, it is very important to remember the anatomy of the renal artery and its anatomical variants. An awareness of the anatomical morphometric data on the diameter of the main renal artery is beneficial:

a) In selecting donors for renal transplants.

b) Guiding the radiologist during arterial catheterisation.

c) Designing an artery stent graft as well as for the surgeon who places such a stent.

d) In robotic surgery, where surgeons cannot identify the arteries by palpation.

e) During urologic procedures involving endovascular and laparoscopic techniques [11].

The aim of the study was to determine the normal reference range of diameter of the main hilar renal artery in the presence or absence of supplementary renal arteries and to predict the presence of supplementary renal artery using contrast-enhanced Multidetector Computerised Tomography (MDCT) in the North Indian population.

MATERIALS AND METHODS

This retrospective study was conducted in the Department of Anatomy in collaboration with the Department of Radiodiagnosis, Santosh Medical College and Hospital, Ghaziabad and Dr. O.P Gupta Imaging Centre, Meerut, Uttar Pradesh, India, who were referred for contrast-enhanced MDCT examination for evaluation of various suspected abdominal complaints/conditions/pathologies from April 2019 to October 2021. Data analysis was done from November 2021 to December 2021. A proper ethical clearance was obtained from Ethical committee of Santosh Medical College, Ghaziabad (F. No.SU/2021/092/25). Informed consent was obtained from all the patients who participated in the study.

Contrast-enhanced MDCT scan images were reviewed for measurement of the diameter of main hilar and supplementary renal artery. The sample population and study period of this study is same as that of study conducted by Gupta M et al., [12]. A total of 108 patients were recruited through consecutive sampling.

Inclusion criteria

- Patients (male or female) between 18-70 years of age.
- The kidney function test revealed that the patients' kidneys are in normal functioning order.
- Two normal kidneys with good quality of reformatted contrast-enhanced MDCT images of the renal vasculature.
- Absence of morphological features of renal artery diseases.
- No history of renovascular diseases and hypertension.

Exclusion criteria

- Allergy to contrast
- Contraindication to radiation exposure (like pregnancy)
- Contrast-enhanced MDCT images with artifacts, suboptimal postcontrast arterial opacification.
- Contrast-enhanced MDCT images of patients with abnormalities that could interfere with optimum evaluation of the renal artery, aortic or renal vascular pathologies, renal masses, prior nephrectomy and other retroperitoneal lesions.

Preprocedural precaution

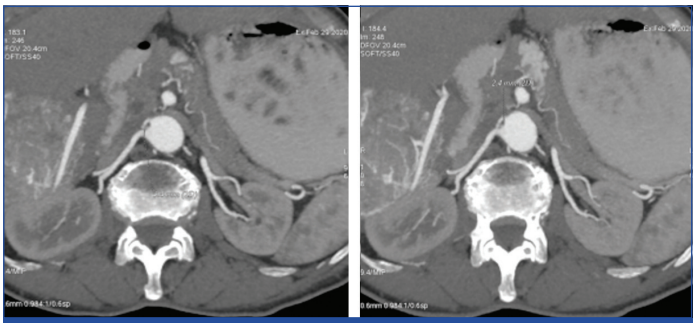
- The patient was enquired about some queries to rule out any drug allergy.
- The patient has been asked to come empty stomach (overnight fasting).
- Just before the procedure, the patient was recommended to drink only water.
- Blood urea and Creatinine levels were evaluated before the procedure.
- Females were asked about confirmed pregnancy or last menstrual period.

Computer Tomography Procedure

Ensured that the patient was properly prepared and positioned. The patients were placed in the supine position for contrast-enhanced computerised tomographic scans of abdomen, with the feet entering the gantry first. An 18-gauge venous line was placed in an antecubital vein. Pre contrast computerised tomographic scans covering both kidneys from the diaphragmatic dome to the iliac crest were obtained. Based on the pre-contrast scan, a region of interest with an area of 1 mm^2 was established in the lumen of the aorta at the level of the Superior mesenteric artery and a series of thin cuts were obtained. Following that, an automated power injector was used to inject 100-140 mL of non ionic iodinated contrast agent (iodixanol, visipaque 320 mgI/mL) at a flow rate of 4 mL/s through a cannula positioned in the antecubital vein. All contrast-enhanced computerised tomographic scans were started with the bolus tracking technique, which utilised automatic scan triggering software. At 25 and 55 seconds after the start of an intra venous infusion of contrast material, volumetric data sets for the arterial and venous phases were collected.

Image Analysis

After the raw images were obtained, post-processing was the next step, images were sent to a separate workstation after which they were analysed and interpreted. Individual volume data were loaded into the 3D program and the data were reformatted into routine 3D images. The 3D images were manipulated by rotating them to achieve the correct planes and removing unnecessary anatomical details to separate the renal artery from the overlying structures. The diameter of the main hilar and supplementary renal artery on each side was measured at the site of origin from the abdominal aorta with the help of an electronic calliper in axial view of MDCT images shown in [Table/Fig-1]. When more than one renal artery supplies to the kidney, the artery with greatest diameter was considered as the main hilar renal artery.



[Table/Fig-1]: Contrast-enhanced MDCT image showing measurement of diameter of right main hilar and supplementary renal artery at their origin from the abdominal aorta in axial view.

STATISTICAL ANALYSIS

The collected data was entered into a Microsoft Excel sheet and analysed by using IBM Statistical Package for Social Sciences (SPSS) version 25.0 software. The result was expressed as the mean, Standard Deviation (SD), minimum, maximum, range. The mean differences among the groups with and without supplementary renal artery were evaluated using the student's t-test. A binary logistic regression analysis was used to predict the presence of supplementary renal arteries.

RESULTS

The mean diameter of the main hilar renal artery on the right side in the absence of the supplementary renal arteries was 5.99±1.13 mm and in the presence of one/two Supplementary Renal Arteries (SRA), it was 5.20±1.13 mm and 4.62±0.75 mm respectively [Table/Fig-2].

Number of SRA	Number of kidneys (n)	Diameter of right main hilar renal artery (mm)				
		Mean	SD	Minimum	Maximum	Range
0	77	5.99	1.13	2.30	9.30	7.0
1	26	5.20	1.13	2.6	7.10	4.5
2	5	4.62	0.75	3.9	5.7	1.80

[Table/Fig-2]: Diameter of the right main hilar renal artery with absence or presence of Supplementary Renal Arteries (SRA) (in mm).

The mean diameter of the main hilar renal artery on the left side in the absence of the supplementary renal arteries was 6.07±1.25 mm and in the presence of one/two/three supplementary renal arteries, it was 5.39±1.01 mm, 4.45±0.94 mm and 3.95±1.20 mm [Table/Fig-3].

The mean diameter of the main hilar renal artery on the right side was 5.11±1.096 mm in kidneys with supplementary renal arteries. The mean diameter of the main hilar renal artery on the left was 5.18±1.08 mm in the kidneys with supplementary renal artery. The main hilar renal artery diameter was smaller in kidneys with a supplementary renal artery than in those without supplementary renal arteries, statistically significant difference was evaluated (p-value <0.001 on the right and left side) [Table/Fig-4].

Number of SRA	Number of kidneys	Diameter of left main hilar renal artery (mm)				
		Mean	SD	Minimum	Maximum	Range
0	76	6.07	1.25	3.10	8.90	5.80
1	26	5.39	1.01	3.70	7.80	4.10
2	4	4.45	0.94	3.20	5.50	2.30
3	2	3.95	1.20	3.10	4.80	1.70

[Table/Fig-3]: Diameter of the left main hilar renal artery with absence or presence of Supplementary Renal Arteries (SRA).

Side	Diameter of MHRA in absence of SRA Mean±SD (mm)	Diameter of MHRA in the presence of SRA Mean±SD (mm)	p-values
Right	5.99±1.13	5.11±1.096 mm	0.131
Left	6.07±1.25	5.18±1.08	0.150

[Table/Fig-4]: Diameter of the Main Hilar Renal Artery (MHRA) on the right and left side with absence or presence of Supplementary Renal Arteries (SRA).

When the main hilar renal artery on the right side has a diameter of <5.11 mm, the presence of supplementary renal arteries is very likely. However, if the diameter of the main hilar renal artery on the right side is >5.99 mm, the presence of supplementary renal arteries is less likely. Similarly, if the diameter of the main hilar renal arteries on the left side is <5.18 mm, the presence of a supplementary renal artery is more likely, and if it is >6.07 mm, the presence of a supplementary renal artery is less likely.

The absence or presence of a supplementary renal artery was predicted by applying a binary regression analysis [Table/Fig-5]. After including the parameters of side and diameter of the Main Hilar Renal Artery (MHRA) in the binary logistic regression analysis to predict the absence or presence of a supplementary renal artery, the regression equation of prediction was found to be:

Pr=2.778-0.78×side-0.647×MHRA.

In the given equation side=1 if there is right side else side=0.

Validity parameters	Value	95% Confidence Interval (CI)
Sensitivity (presence of supplementary renal artery accurately predicted)	73.98%	67.25%-79.97%
Specificity (absence of supplementary renal artery accurately predicted	60.00%	36.05%-80.88%
Positive predictive value (probability of presence of supplementary renal artery)	94.77%	91.33%-96.89%
Negative predictive value (probability of presence of supplementary renal artery)	19.05%	13.29%-26.54%
Accuracy	72.69%	66.23%-78.51%

[Table/Fig-5]: Validity parameters of the logistic regression predictive model to evaluate the presence or absence of supplementary renal artery.

MHRA denotes the diameter of main hilar renal artery

The presence of supplementary renal artery predicted if Pr >0.5.

The above model has predictive accuracy of 72.69%.

DISCUSSION

Supplementary renal arteries are of critical clinical importance because omitting them during pre-operative preparation of patients for surgical procedures, particularly those requiring a small field of view, such as laparoscopic and retroperitoneoscopic nephrectomy, can result in fatal consequences. A proper decision regarding the planning of the nephron-sparing surgery and prevention of possible perioperative surprises can be achieved by knowing the variable number of renal arteries [13-15].

Previous studies concluded that the presence of an accessory renal artery is inversely proportional to the diameter of the main renal artery. Similarly, the statistically significant difference in the diameter of the main renal artery in kidneys without accessory renal arteries and in kidneys with accessory renal arteries shows that the renal artery diameter is a factor that should be considered preoperatively for predicting the presence of additional renal arteries [13,16-19] [Table/Fig-6].

Ramadan SU et al., evaluated the mean diameter of the renal artery in absence of accessory renal artery 5.71±0.83 mm and with the presence of one and two accessory renal arteries were 4.88±1.07 mm, 4.46±0.97 mm respectively. Likewise, in the current study, we concluded that the mean diameter of the main hilar renal artery decreased in the presence of number of supplementary renal arteries [18].

Knowledge about the presence of supplementary renal arteries are very essential for the renal transplant surgeons. Bleeding from a damage to a supplementary renal artery during a laparoscopic Living Donor Nephrectomy (LDN) can result in an open laparotomy [20]. A missing case of supplementary renal artery can result in a transplanted kidney infarction and accompanying hypertension in the recipients. It may have an impact on the kidney donation decision, post-transplantation period, and can complicate donor and recipient operations, that may increase the risk of arterial thrombosis [21,22]. Supplementary arteries, if present, need multiple anastomoses and longer ischaemia time in the recipient, thus increasing the risk of renal failure, graft reduction, and graft function reduced [12].

The present study, the dimensions of main hilar renal artery diameter in the adult North Indian population, will add more information into the body of literature and help to transmit this knowledge to enlighten the surgeons during the renal surgery practice in the same region and beyond.

Authors name	Conclusion
Aytac SK et al., (2003) [16]	The diameters of main renal arteries were significantly smaller in the presence of the accessory renal artery (p-value<0.001). When the renal arterial diameter is 4.65 mm or less, there is quite a probability of an accessory renal artery and vice versa if it is more than 5.5 mm.
Nagar A et al., (2021) [13]	The presence of additional renal arteries is very probable when the main renal artery has a diameter of <4.15 mm. Kidneys presenting a main renal artery >5.5 mm very probably do not present additional renal arteries.
Rao K EV and Battula SR (2015) [17]	Renal artery diameter of less than 4.15 mm was associated with accessory renal arteries.
Ramadan SU et al., (2011) [18]	The diameter of main renal artery is smaller in kidneys with a supplementary Renal Arteries (RA) than in those without (p-value <0.001). A cut-off value of 4.15 mm of the diameter of main renal artery is used for to predict the presence of accessory renal arteries.
Sungura RE et al., (2018) [19]	The mean arterial diameter of accessory arteries was less than that of without accessory arteries. It is statistically significant for the right sided kidney (mean=5.35 mm vs. 4.53 mm, p-value=0.016). The arterial diameter of main renal artery was less in patients presenting with accessory arteries but this difference was marginally significant (mean=5.96 mm vs. 5.21 mm, p-value=0.097).
Present study (2022)	The mean diameter of the main hilar renal artery was smaller in kidneys with a supplementary renal artery than in those without a supplementary renal artery, statistically significant difference was evaluated (p-value<0.001 on the right and left side). If the diameter of the main hilar renal arteries on the left side is <5.18 mm, the presence of a supplementary renal artery is more likely, and if it is >6.07 mm, the presence of a supplementary renal artery is less likely.

[Table/Fig-6]: Comparison of the results regarding diameter of main hilar renal artery with previous studies [13,16-19].

Limitation(s)

Present study database is limited to only limited patient's group who came to the Department of Radiology in the SMC Ghaziabad and Dr. O.P Gupta Imaging Centre. This need to be included different patient's group in the North Indian population to validate the result in the same population.

CONCLUSION(S)

The presence or absence of supplementary renal arteries can be determined by measuring the diameter of the main hilar renal artery and it can be used to detect the presence of supplementary renal arteries. This finding decreases the assessment duration and facilitates radiologist decisions concerning the requirement for advanced investigations.

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