Original Article

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Anatomy Section

Estimating Lengths of Renal Arteries and Infrarenal Aorta on Contrast CT Scans- A Retrospective Study

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ABSTRACT

Introduction: Anatomy of renal arteries and length of infrarenal aorta play a vital role in various renal and aortic vascular interventions and surgical procedures including renal transplantation.

Aim: To estimate mean lengths of renal arteries, the vertical distance between origins of both renal arteries, infrarenal aortic lengths, and presence of accessory renal arteries on contrast Computed Tomography (CT) scans.

Materials and Methods: A retrospective hospital-based study was conducted at KVG Medical College and Hospital, Sullia, Karnataka, India in which contrast enhanced CT scans of the abdomen was performed between October and December 2021. The CT image datasets of 61 individuals were evaluated in the study, of which 45 were males and 16 were females. The arterial phase images were anonymised and loaded in the curved Multiplanar Reformatted (MPR) algorithm. The lengths of both Renal Arteries (RA), vertical distance between origins of both Renal Arteries (RAD), infrarenal Aortic Lengths (AL), and presence of accessory renal arteries were noted. For statistical analysis Statistical Package for the Social Sciences (SPSS) software version 22.0 was used and Pearson's Chi-square test and independent t-test were used for calculation.

Results: The mean age of the participants was 50.7±7.5 years. Mean right RA was 3.75±1.25 cm and left RA was 2.89±0.98 cm. Right RA was significantly longer than left RA (p=0.019). Mean RAD was 0.61 cm. In 35 cases of (57%) right RA originated at a higher level than the left RA. The mean AL was 9.68±1.18 cm. Accessory renal arteries were seen in nine of cases (14.8%).

Conclusion: The mean measurements obtained can provide vital guidance during renal and aortic surgeries and vascular interventions.

Keywords: Accessory renal artery, Computed tomography, Curved multiplanar reformatted, Renal artery branching

INTRODUCTION

The anatomy of the renal arteries and length of infrarenal aorta plays a vital role in various interventions and surgical procedures including renal vascular interventions, aortic aneurysmal repair, selection of kidney donors for renal transplant. Renal arteries arise as lateral branches of the abdominal aorta at the level of L1-L2 and divide close to the hilum. Around 70% of individuals, the kidney is supplied by a single renal artery arising from the abdominal aorta. Infrarenal aorta is the segment of the aorta extending from the origin of the renal arteries to its bifurcation at the L4 vertebral level [1]. Length of the renal artery, presence of accessory renal arteries, and the exact site of origin of renal arteries from the abdominal aorta are crucial factors for many interventional procedures and surgeries [2-4]. The ideal donor of kidney is the one with a single renal artery with good length and diameter for the ease of vascular anastomosis. However, renal artery variations are common regarding their origin and number [5-9]. The present study was done to estimate the mean lengths of Renal Arteries (RA) and infrarenal Aortic Length (AL) on contrast Computed Tomography (CT) scans. A secondary objective was to determine whether any correlation exists between the presence of accessory renal arteries and the length of main RA till their first branching point.

MATERIALS AND METHODS

A retrospective hospital-based study was conducted at KVG Medical College and Hospital, Sullia, Karnataka, India, on individuals who had undergone contrast CT between October to December 2021. The study procedure followed the guidelines provided by declaration of Helsinki and prior Institutional Ethical Committee Clearance was taken for the study.

Sample size calculation: The sample size was calculated using power based sample size calculation formula with a confidence interval of 95% which yielded a sample size of 54.

Inclusion criteria: Initially the CT requisition forms of the study period were screened to include those individuals who had undergone contrast CT of the abdomen in the arterial phase for various indications other than aortic and renal pathologies.

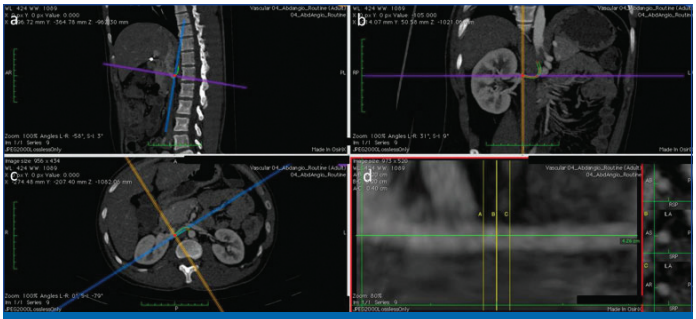
Exclusion criteria: Any case in which there was a gross distortion of anatomy due to large masses, moderate to severe ascites, and vascular thrombosis was excluded from the study.

Study Procedure

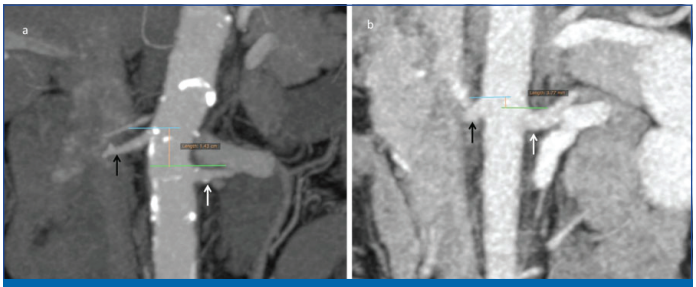
The department follows a standard protocol of injecting iohexol contrast agent (300 mg/mL of iodine) intravenously (1-1.5 mL/kg body weight) using a single head pressure injector. Bolus tracking method was used by drawing a 1 cm^2 circle (Region Of Interest-ROI), in the centre of the lumen of aorta just below its diaphragmatic hiatus. A Hounsfield Units (HU) of 100 was set as a trigger for the scan with a minimum delay of four seconds to acquire images in the arterial phase.

The personal identification data of the Digital Imaging and Communication in Medicine (DICOM) image datasets of the eligible individuals were anonymised and retrieved on the Osirix application in an Apple workstation. Thin 1 mm image datasets were used and curved Multiplanar Reformatted (MPR) images were generated. A radiologist with nine years of experience in abdominal radiology evaluated the images and assessed the following in each case:

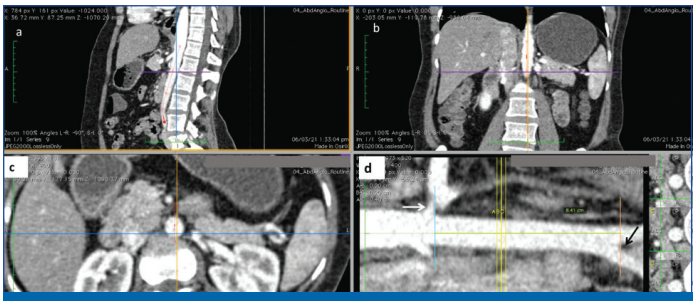
- Distance between origin from the abdominal aorta to first branching of renal artery on both sides (length of the renal artery) right and left RA [Table/Fig-1].
- Vertical distance between origin of both the renal arteries from aorta (RAD) [Table/Fig-2].
- Length of the aorta between origin of the lower renal artery and aortic bifurcation AL [Table/Fig-3].



[Table/Fig-1]: (a-c) Right RA has been traced in all three planes on curved multiplanar reformatted images of contrast CT; (d) The tortuous renal artery has been virtually uncoiled and measured (right RA) as depicted by green line.



[Table/Fig-2]: Coronal curved multiplanar reformatted contrast CT image of the aorta for measurement 0f the vertical distance between origins of bilateral renal arteries (RAD). Blue and green lines have been drawn at the level of superior margins of ostia of right (black arrow) and left renal (white arrow) arteries respectively and orange line is the perpendicular distance between those two lines.
The origin of right RA is higher than left RA



[Table/Fig-3]: (a-c) Abdominal aorta is traced in all three planes on curved multiplanar reformatted images. (d) The tortuous aorta is virtually uncoiled and the length of infrarenal aorta (AL) is measured as depicted by green line from the inferior margin of the origin of the inferiorly placed renal artery (blue line represents this level) to aortic bifurcation (orange line represents this level). White arrow shows the left RA whereas black arrow points to the aortic bifurcation.

- Presence/absence of accessory renal arteries [Table/Fig-4]. The smaller vessels arising from the aorta and supplying the kidneys were considered accessory renal arteries [10].

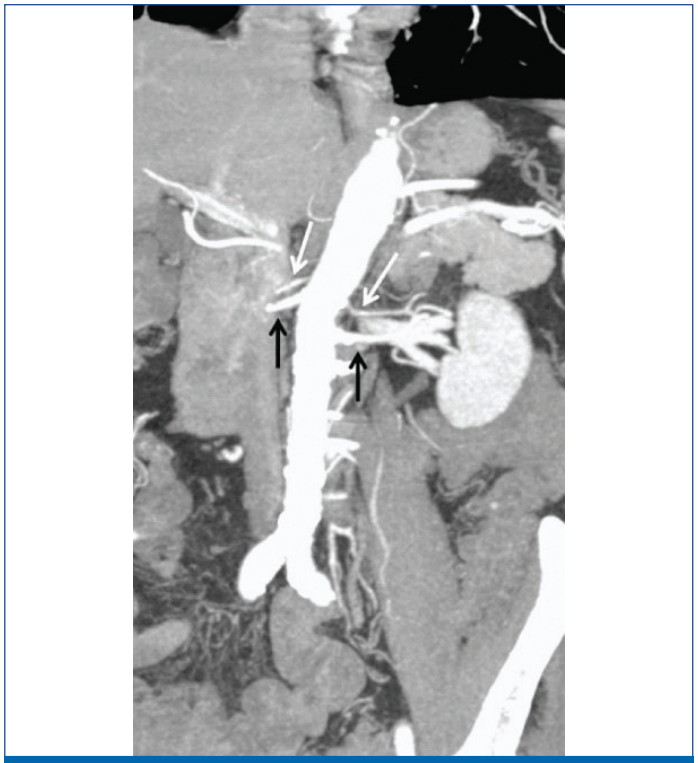
The distances were measured using digitised calipers on curved MPR images using straight line or curved line tools. In the case of tortuous anatomy, the parts were virtually uncoiled to obtain images for accurate measurements.

STATISTICAL ANALYSIS

The values obtained were tabulated in Statistical Package for the Social Sciences (SPSS) software version 22.0. Mean values and standard deviations were obtained. Independent sample t-test was used to find out the association between the length of the right and left RA and Pearson's Chi-square test was used to determine dependence of branching pattern of renal arteries on the presence of accessory renal arteries.

RESULTS

Contrast CT image datasets of 61 individuals were evaluated in the study, of which 45 were males and 16 were females. The mean age of the participants was 50.7±7.5 years. The indications for contrast CT ranged from suspected bowel pathologies including appendicitis (n=12), inflammatory (n=15), infective conditions (n=20), liver lesions (n=10) and miscellaneous (n=4) etc. The mean length of the right



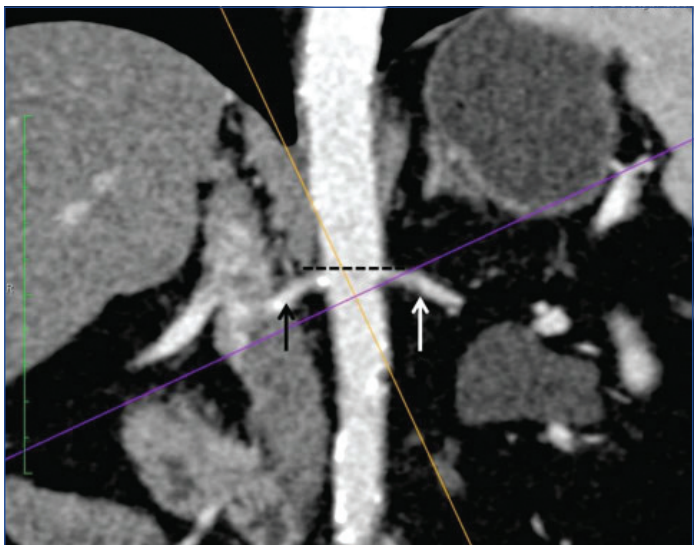
[Table/Fig-4]: Coronal contrast CT maximum intensity projection image of aorta depicting bilateral smaller accessory renal arteries (white arrows) and the larger main renal arteries (black arrows) arising from the aorta.

RA was 3.75±1.25 cm and the left RA was 2.89±0.98 cm [Table/Fig-5]. The mean sum length of right and left renal arteries was 6.64±2.23 cm. On the independent sample t-test, right RA was significantly longer than left RA (p=0.019). The mean infrarenal AL was 9.68±1.18 cm.

Parameters	Mean±SD
Right RA length	3.75±1.25 cm
Left RA length	2.89±0.98 cm
Mean vertical distance between origins of both renal arteries (RAD)	0.61±0.56 cm
Infrarenal AL	9.68±1.18 cm

[Table/Fig-5]: Mean values and standard deviations of the study parameters.

The mean vertical distance between the origins of both renal arteries (RAD) was 0.61±0.56 cm. In 11 cases (18%), both right and left renal arteries originated at the same level from the aorta (RAD≤0.1 cm) [Table/Fig-6]. In 35 (57%) cases right RA originated at a higher



[Table/Fig-6]: Coronal contrast CT maximum intensity projection image of aorta depicting origins of right (black arrow) and left main renal arteries (white arrow) from the aorta.
The origins of both renal arteries are at the same level (black interrupted line)

level as compared to the left RA [Table/Fig-7,8]. In remaining 15 cases (25%) left RA originated at a higher level as compared to right RA [Table/Fig-7,8].

[Table/Fig-7]: Coronal contrast CT maximum intensity projection image of aorta depicting origins of right (black arrow) and left main renal arteries (white arrow) from the aorta.
The origin of left RA is higher than the right RA

Parameters	Number	Percentage
Right RA origin higher than left; (n=61)	35	57.3%
Left RA origin higher than right; (n=61)	15	24.5%
Both origins at same level; (n=61)	11	18%
Accessory renal arteries present; (n=61)	9	14.8%
Bilateral accessory renal arteries; (n=9)	4	44.4%
Right accessory renal arteries; (n=9)	5	55.5%
Left accessory renal arteries; (n=9)	8	88.8%

[Table/Fig-8]: Numbers and percentages of study parameters.

Accessory renal arteries were seen in nine cases (14.8%), in four of which cases were seen bilaterally. Right accessory renal arteries were seen in five cases of which three arose superior to main renal arteries and two inferior to them. Left accessory renal arteries were seen in eight cases of which seven were superior to main renal arteries. On Pearson's Chi-square test to assess statistical independence, it was found that the presence of accessory renal arteries and lengths of main renal arteries (i.e. branching pattern of renal arteries) were statistically independent (Chi-squared probability p=0.23).

DISCUSSION

The results obtained from the present study reflect important measurements that can help guide renal and abdominal aortic vascular interventions and surgeries. The precise length of the renal arteries, their site of origin from the aorta and the presence of accessory renal arteries are critical for donor selection, renal harvesting and anastomoses during renal transplantation.

Comparing renal artery lengths and their origins [Table/Fig-9]: In this study, the mean renal artery lengths found were significantly shorter compared to the results of Mohiuddin M et al., [11] which found the mean right and left RA to be 4.5 cm and 3.5 cm respectively in Pakistan [Table/Fig-9]. All these studies found that right RA was significantly longer than left RA owing to their origin from the aorta which is located more towards the left of the midline. Ahmed MAAS et al., found the left renal arteries arose significantly lower than the right renal arteries from the abdominal aorta [2], as was found in the present study. This is inspite of the fact that the right kidney is located much inferior compared to the left kidney.

Study	Place of study	Year of study	Mean length of right RA	Mean length of left RA
Mohiuddin M et al., [11]	Pakistan	2017	4.5 cm	3.5 cm
Palmieri BJ et al., [12]	Brazil	2011	3.96 cm	3.41 cm
Song WH et al., [13]	Korea	2020	5.16 cm	4.45 cm
Abd Alrahim E et al., [14]	Saudi Arabia	2020	4.47 cm	3.71 cm
Present study	India	2021	3.75 cm	2.89 cm

[Table/Fig-9]: Comparison of mean renal artery lengths as obtained by different studies [11-14].

Accessory renal arteries [Table/Fig-10]: Accessory renal arteries were found in 14.8% of the cases in the present study more frequently on the left side which is similar to incidences obtained by Majos M et al., (19.35%) and Ahmed MAAS et al., who found accessory renal arteries in 14%, more commonly on the right side [2,15] [Table/Fig-10] [2,12,15-17].

Study	Place of study	Year of study	Incidence of accessory renal arteries (% of all cases)	Right side (as % of cases with accessory renal arteries)	Left side (as % of cases with accessory renal arteries)	Bilateral (as % of cases with accessory renal arteries)
Ahmed MAAS et al., [2]	Saudi Arabia	2013	14%	57.14%	42.85%	-
Palmieri BJ et al., [12]	Brazil	2011	61.5%	56%	67%	41%
Majos M et al., [15]	Poland	2018	19.35%	71.88%	63.54%	35.42%
Jamkar AA et al., [16]	India	2017	27.36%	27.36% of all cases	22.63% of all cases	24.99% of all cases
Reginelli A et al., [17]	Italy	2015	31%	51.6%	74.2%	35.4%
Present study	India	2021	14.8%	55.55%	88.88%	44.44%

[Table/Fig-10]: Comparison of incidence of accessory renal arteries in different studies [2,12,15-17].

Infrarenal aorta: The mean length of the infrarenal aorta obtained in the present study was 9.68 cm. A similar dimension was obtained by Yang SS et al., (9.5 cm). A significantly lengthier infrarenal aorta (<0.7 cm) has been reported among the elderly in comparison with the younger population [18]. No other significant study was found focussed on the evaluation of AL.

Limitation(s)

The current study did not cater for gender and age related differences in the renal arteries and infrarenal aorta. Renal artery diameters and lengths of accessory renal arteries were not measured in this study which could also potentially influence the pathophysiology of renal vascular diseases and surgical interventions.

CONCLUSION(S)

Mean renal arterial lengths, presence of accessory renal arteries and lengths of the infrarenal aorta were determined, which provide vital guidance during renal and aortic surgeries and vascular interventions. The infrarenal aortic length and distance between the origin of the two renal arteries determine the length of stents and catheters are required in case of occlusions/aneurysms and to engage the ostia of renal arteries. The presence of accessory renal arteries changes the nature of renal surgeries and transplantation.

REFERENCES

[1] Standring S, Borley NR, Gray H. Gray's Anatomy: The anatomical basis of clinical practice. 40th ed. Edinburgh: Churchill Livingstone/Elsevier; 2008. p. 1183
[2] Ahmed MAAS, Gobran HA. Morphometric Study of The Renal Arteries In Saudi Population From Aseer Region Using 3-D MDCT Angiography. Sciene and Nature. 2013;2(2):41-45.

[3] Turba UC, Flacker R, Bozlar U, Hagspiel KD. Normal renal arterial anatomy assessed by multidetector CT angiography: Are there differences between men and women? Clin Anat. 2009;22(2):236-42.
[4] Thatipelli MR, Sabater EA, Bjarnason H, McKusick MA, Misra S. CT angiography of renal artery anatomy for evaluating embolic protection devices. J Vasc Interv Radiol. 2007;18(7):842-46.
[5] Shakeri AB, Tubbs RS, Shoja MM, Pezeshk P, Farahani RM, Khaki AA, et al. Bipolar supernumerary renal artery. Surg Radiol Anat. 2007;29(1):89-92.
[6] Rao M, Bhat SM, Venkataramana V, Deepthinath R, Bolla SR. Bilateral prehilar multiple branching of renal arteries: A case report and literature review. Kathmandu Univ Med J (KUMJ). 2006;4(3):345-48.
[7] Satyapal KS, Haffejee AA, Singh B, Ramsaroop L, Robbs JV, Kalideen JM. Additional renal arteries incidence and morphometry. Surg Radiol Anat. 2001;23(1):33-38.
[8] Gumus H, Bukte Y, Ozdemir E, Cetincakmak ML, Tekbas G, Ekici F, et al. Variations of renal artery in 820 patients using 64-detector CT-Angiography. Ren Fail. 2012;34:286-90.
[9] Tarzamni MK, Nezami N, Rashid RJ, Argani H, Hajealioghli P, Ghorashi S. Anatomical differences in the right and left renal arterial patterns. Folia Morphol 2008; 67(2):104-10.
[10] Gulas E, Wysiadecki G, Szymański J, Majos A, Stefańczyk L, Topol M, et al. Morphological and clinical aspects of the occurrence of accessory (multiple) renal arteries. Arch Med Sci. 2018 Mar;14(2):442-53. PMID: 29593819; PMCID: PMC5868651.
[11] Mohiuddin M, Manzoor A, Ali M, Hassan N. Analysis of renal artery morphometery in adults: A study conducted by using Multidetector computed Tomography Angiography. Pak J Med Sci. 2017;33(4):943-947. Doi: 10.12669/pjms.334.13063. PMID: 29067070; PMCID: PMC5648969.
[12] Palmieri BJ, Petroianu A, Silva LC, Andrade LM, Alberti LR. Study of arterial pattern of 200 renal pedicle through angiotomography. Rev Col Bras Cir. 2011;38(2):116-21. English, Portuguese. Doi: 10.1590/s0100-69912011000200009. PMID: 21710050.
[13] Song WH, Baik J, Choi EK, Lee HY, Kim HH, Park SM, et al. Quantitative analysis of renal arterial variations affecting the eligibility of catheter-based renal denervation using multi-detector computed tomography angiography. Sci Rep. 2020;10(1):19720. https://doi.org/10.1038/s41598-020-76812-w.
[14] Abd Elrahim E. Computed tomography evaluation of renal artery morphometry in adults. The impact of age and gender. Saudi Med J. 2020;41(1):34-37. Doi: 10.15537/smj.2020.1.24795. PMID: 31915792; PMCID: PMC7001056.
[15] Majos M, Stefańczyk L, Szemraj-Rogucka Z, Elgalal M, De Caro R, Macchi V, et al. Does the type of renal artery anatomic variant determine the diameter of the main vessel supplying a kidney? A study based on CT data with a particular focus on the presence of multiple renal arteries. Surg Radiol Anat, 2018;40:381-8. https://doi.org/10.1007/s00276-017-1930-z.
[16] Jamkar AA, Khan B, Joshi DS. Anatomical study of renal and accessory renal arteries. Saudi J Kidney Dis Transpl. 2017;28(2):292-97. Doi: 10.4103/1319-2442.202760. PMID: 28352010.
[17] Reginelli A, Somma F, Izzo A, Urraro F, D'Andrea A, Grassi R, et al. Renovascular anatomic variants at CT angiography. Int Angiol. 2015;34(6 Suppl1):36-42. PMID: 26498890.
[18] Yang SS, Yun WS. Changes in the Normal Infrarenal Aortic Length and Tortuosity in Elderly People. Vasc Specialist Int. 2020;36(1):15-20. Doi: 10.5758/vsi.2020.36.1.15. PMID: 32292764; PMCID: PMC7119148.

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