ORIGINAL ARTICLE

A study of evaluation of renal artery measurements using computed tomography angiography in adult Aswanian population

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ABSTRACT

Keywords: Renal artery, length, diameter, variations.

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Background: Morphometric studies are important as they increase our knowledge of anatomical relationships and facilitate treatment planning and device development. **Aim of Study:** to determine a reference range of renal artery measurements by using MDCT angiography and to find association of renal artery measurements with side of artery and gender in Aswanian population. **Patients and Methods**: The study includes 106 patients who underwent abdominal MDCT angiography. Images were evaluated for the level of origin, length, diameter, gender& side variations of renal arteries. **Results**: the most frequent level of origin of the renal arteries was lower third of L1, followed by disc between L1-L2. The diameter of main renal artery was (4.83±0.88 on right side& 5.04±0.82 on left side), the renal artery diameter in males was wider than females (p-value = 0.022). The length of the right renal artery was (3.57±1.07) longer than the left (2.87±0.83). The diameter of the main renal artery in kidney with single renal artery was wider than kidneys having multiple renal arteries (p-value < 0.000). **Conclusion:** The renal arteries present a broad spectrum of variability in their morphological expression respecting their length, level of ramification, diameter and emergence.

INTRODUCTION

Each kidney is supplied by a single renal artery in approximately 70% of population. As we know, the right and left kidneys have different anatomical positions with differing proximity to other organs and the aorta, which may affect their vascular anatomy. Recent advances in computed tomography (CT) technology now provide better vascular assessment [1] .The renal arteries are branches of the abdominal aorta and arise just below the origin of the superior mesenteric artery at the level of L1 vertebra and intervertebral disc between L1 and L2 vertebra [2]. Each renal artery divides into anterior and posterior branch, which in turn divides into number of segmental arteries supplying the different renal segments [3]. The right renal artery is longer and often arises a little higher than the left renal artery. Renal arteries measure between 4-6 cm in length and 5-6 mm in diameter [4]. Decrease in luminal diameter of renal artery leads to renal artery stenosis that will cause renovascular hypertension and ischemic nephropathy [5].In this study we report on the anatomy of the renal arteries in patients referred to the CT angiography unit for renal or abdominal artery evaluation, and the right and left renal arteries are compared anatomically.

PATIENTS AND METHODS

Patients:

A descriptive cross-sectional study was conducted on 106 patients (53 male and 53

female), who referred to radiology department-Aswan university hospital and underwent abdominal MDCT angiography for imaging of the abdominal aorta and its branches for various reasons, from 2018 till 2019. Their ages ranged from (21- 60y) with a mean value was (39.51 ± 10.24). All cases are having normal kidney function with no previous history of allergic reaction to contrast material nor uncontrolled diabetic mellitus. The study protocol was approved by the local ethics committee of faculty of medicine in Aswan University. All steps of the test, including the benefits and the risks were explained to the patients before doing it. No written informed consent was required for retrospective review of imaging examinations.

Methods:

1-MDCT protocol

MDCT angiography was performed on 212 kidneys, with a 160- slice MDCT scanner (AQUILION PRIME; Toshiba Medical Systems, Tokyo, Japan) by using the same protocol in all patients. Region of interest was placed over the suprarenal abdominal aorta obtained from the single-slice reference image. The patients were injected with 100 mL of non-ionic iodinated contrast material (Iopromid; Ultravist 300 mgI/mL, Schering AG, Germany) through an 18 gauge intravenous cannula at a rate of 3–4 mL per second using bolus tracking technique and followed by the delivery of 40 mL saline with an automatic injector.

2-Image analysis

The data acquired from the MDCT angiography study were transferred to a separate workstation for processing and analysis. A computer program (Radiant Dicom viewer) was used to evaluate and interpret images that taken by MDCT, using axial, coronal sections in maximum intensity projections (MIP) and various thicknesses (5-15 mm) 3D images.

-The following values were also assessed:

a. Diameter of the right and left main renal arteries: measuring of the diameter of the renal artery that occurred about 1 to 1.5 cm from the aortic ostium (figure 2).
b. Level of origin of the right and left main renal artery
c. Length of the right and left main renal arteries. The length was measured from the point of origin to the emergence of first branch (figure 3).
d. The mean diameter of the main renal artery in absence and presence of multiple renal arteries.
e. Gender variations and side variations for all parameters of the study.

3-Statistical study:

Statistical analysis was performed by the Statistical Package for the Social Sciences (SPSS) program (version 23). Frequency tables were done for analysis of the results for categorical variables. The results were presented as mean ± standard deviation for continuous variables. Comparison between the arterial pattern of the right and left kidney will be analyzed using an independent sample t-test. The results were considered significant when the p value was < 0.05.

RESULTS

A- Level of origin of the main renal artery:

The level of origin of the right renal artery extends around the upper third of L1 till the middle third of L2, while that of the left renal artery extends around the middle third of L1 till the lower third of L2, except for one case that originates at the level of the disc between L3-L4, as it is diagnosed as left ectopic pelvic kidney (figure 4). the most frequent level of origin of the renal arteries was the lower third of L1 (35.3% right side& 32.1% left side), followed by disc between L1-L2 (26.4% on right side& 32.1% on left side), then followed by the upper third of L2 (20.8% on right side& 16.0% on left side), and then middle third of L2 (5.7%on right side& 7.5 % on left side) (table 1 &figure 1).

Table (1): showing the frequency of the level of origin of the main renal arteries in both kidneys.

Level of origin	Right main renal arteries (n= 106)		Left main renal arteries (n= 106)	
	No.	(%)	No.	(%)
Upper third of L1	1	0.9%	0	0.0%
Middle third of L1	11	10.4%	11	10.5%
Lower third of L1	38	35.8%	34	32.1%
Disc between L1-L2	28	26.4%	34	32.1%
Upper third of L2	22	20.8%	17	16.0%
Middle third of L2	6	5.7%	8	7.5%
Lower third of L2	0	0.0%	1	0.9%
Disc between L2-L3	0	0.0%	0	0.0%
Disc between L3-L4	0	0.0%	1	0.9% (pelvic kidney)

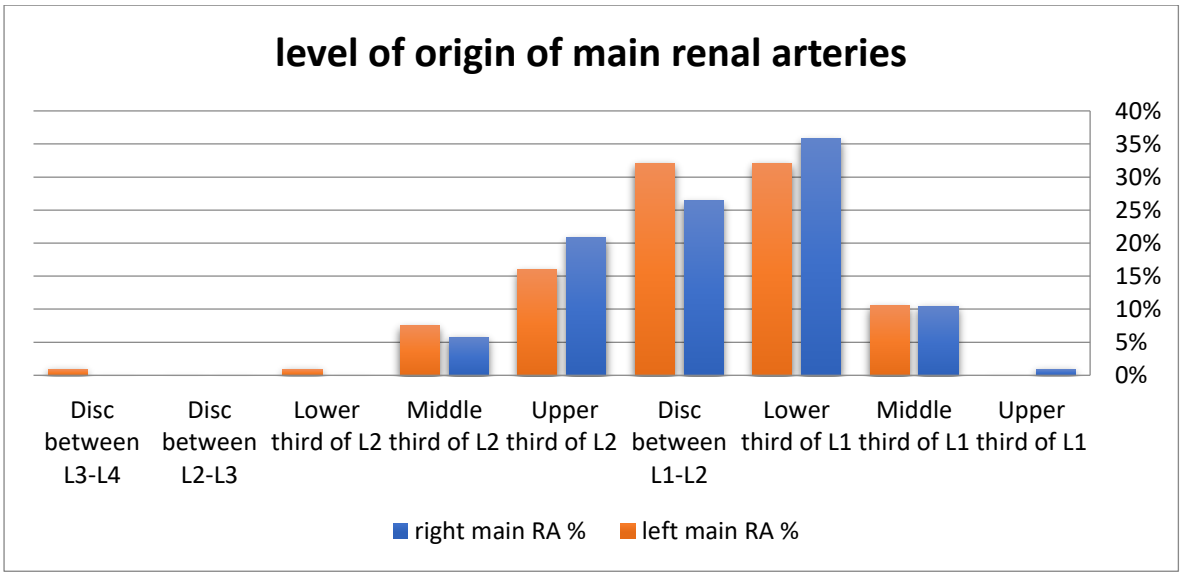

Fig. (1): Percentage of the level of origin of main renal arteries in right and left kidneys

B- The mean diameter (mm) of the main renal arteries:

The mean diameter of the main renal artery was (4.83±0.88 on right side& 5.04±0.82 on left side), According to the laterality, no significant differences were detected in this result between the mean

diameter of right and left renal arteries (p-value = 0.733) (table 2).

Table (2): Comparison of average measures of the renal arteries according to the side.

Variable	Rt (n=106)	Lt (n=106)	P-value
Mean diameter of renal artery (mm):	4.83±0.88 (2.48-6.78)	5.04±0.82 (2.63-7.65)	0.733
Mean length of renal artery (cm):	3.57±1.07 (0.90 - 6.68)	2.87±0.83 (0.83 - 5.09)	0.955

According to the gender; the mean diameter of the right (5.09 ± 0.92) and left (5.28 ± 0.86) renal arteries in males was wider than the mean diameter of the right (4.58± 0.76) and left (4.79± 0.71) renal arteries in females and it was statistically significant difference (p-value = 0.022) (table 3).

C-The mean length (cm) of the main renal arteries:

The mean length was (3.57±1.07 on right side & 2.87±0.83 on the left side). The length of the right renal artery was longer than the left but it was statistically non-significant (p-value = 0.955) (table 2). According to the gender; the mean length of the right (3.64± 1. 10) and left (3.04± 0.93) renal arteries in males was longer than the mean length of the right (3.50 ±1.04) and left (2.71± 0.68) renal arteries in females and it was statistically significant only on the left side (p-value = 0.036) (table 3).

Table (3): Comparison of average measures of the renal arteries according to gender.

Variable	Male (n=53)	Female (n=53)
Mean Rt renal artery diameter (mm):	**5.09 ± 0.92 (2.70-6.78)**	**4.58± 0.76 (2.48 -5.89)**
Mean Lt renal artery diameter (mm):	**5.28 ± 0.86 (2.63-7.65)**	**4.79± 0.71 (3.25-6.30)**

D- Mean diameter of the main renal artery in kidneys with single and multiple renal arteries:

In the present work there were 81.1% of the cases show single pattern of renal irrigation and 18.9% showing multiple renal pattern of irrigation. the mean diameter of the main renal artery in kidney with single renal artery was 5.05 ± 0.78 mm and the diameter of the main renal artery in kidney having multiple renal artery was 3.89 ± 0.71 mm and it was statistically significant (p-value < 0.000) (table 4).

Table (4): Mean diameter of the main renal artery (mm) in kidneys with single and multiple renal arteries pattern.

Variable	Mean ± SD	p-value
Diameter of the main renal artery in kidney with single renal artery	5.05 ± 0.78	**< 0.000**
Diameter of the main renal artery in kidney having multiple renal artery	3.89 ± 0.71	

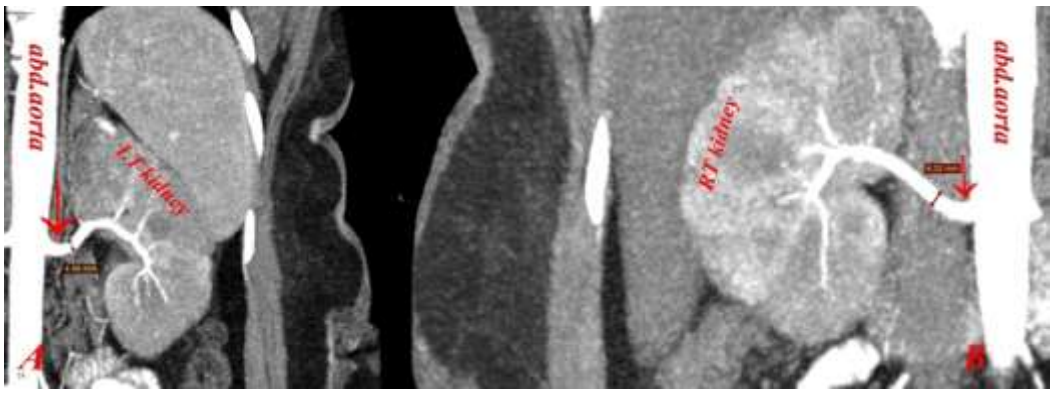

Fig. 2 (A& B): 3D MIP images showing the normal pattern of renal arterial supply. Each kidney (RT Kidney, LT kidney) is supplied by a single renal artery (↓), originated from the abdominal aorta, entering the hilum of corresponding kidney and divided into branches inside the kidney. The diameter of the right and left renal arteries was measured about 1cm from their origin from the abdominal aorta.

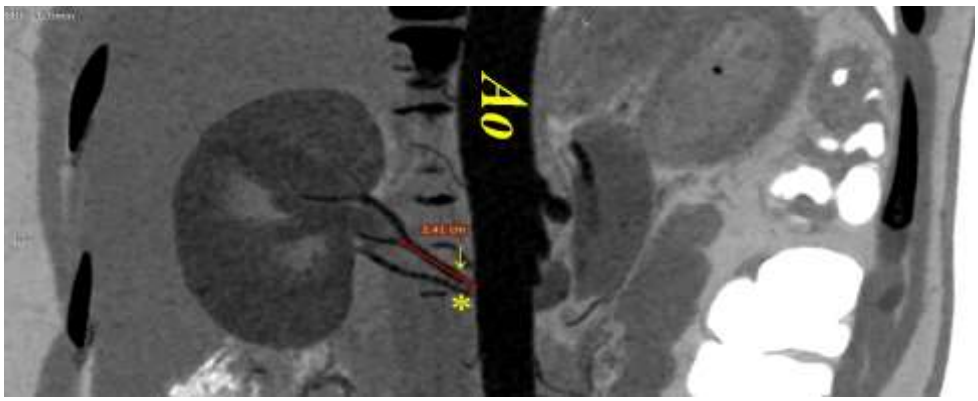

Fig. (3): 3D MIP images showed measurement of the length of the main renal artery (↓) from its origin from abdominal aorta (Ao) till its bifurcation into branches. Note the presence of accessory renal artery (*).

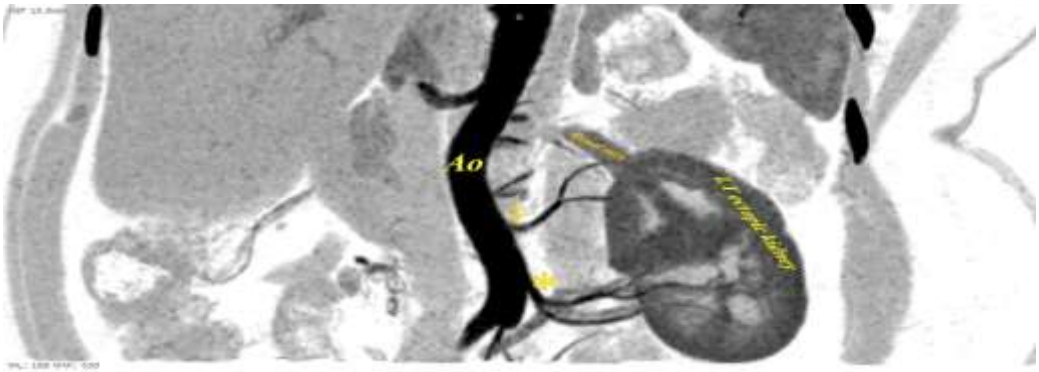

Fig. (4): 3D MIP image of MDCT angiography showed a case of left ectopic pelvic kidney, associated with an additional artery (↓) and the origin of the main renal artery (*) at lower level from the abdominal aorta (Ao).

DISCUSSION

This study showed that the main renal arteries were originated from the abdominal aorta at level extending from L1-L2, with the right renal artery level extends around the upper third of L1 till the middle third of L2, while that of the left renal artery extends around the middle third of L1 till the lower third of L2 and the most frequent level of origin of the renal arteries was the lower third of L1 (35.3% right side& 32.1% left side). There was a case with a congenital anomaly in this study which was left ectopic pelvic kidney as the left renal artery originate at the level of disc between L3-L4. Similary, **Animaw *et al.*** [6] on Ethiopian population found 46.7 % of the main renal artery originates at the level of L1, L1-L2 was (43.3%) and 10 % for L2. **Gümüş *et al.*** [7] reported that the right and left main renal arteries originated between the upper margins of L1 to the lower margin of L2 vertebrae. The most common level of origin in the right side is the lower part of L1 (44.1%) and (39.5%) in the left side followed by disc between L1-L2 in 37.0% and 38.9% of patients on the right and left sides, respectively. Moreover, **Ozkan *et al.*** [8] reported that the origin of main renal arteries from the aorta extend between the upper margin of L1 to lower margin of L2 vertebra in 98% of the cases. **Lama and Pradhan** [9] found that disc between L1-L2 was the most frequent level of origin as in 91.7% originates at Disc between L1-L2 and 8.3% originate at level of T12. On contrary to the results of the present study, **Srivastava *et al.*** [10] in India reported that only about 8% of both right and left renal arteries originated at the level of L1-L2 intervertebral disc.

The present study showed that the mean diameter of the right and left renal artery was 4.83±0.88 mm and 5.04±0.82 mm respectively; there are no significance differences between the mean diameter of right and left renal artery p-value (0.733). In agreement with the result of this study, **Agarwal *et al.*** [11] in CT study found that the mean diameter of the right renal artery was 5.1 mm and the mean diameter of left renal artery was 5.07 mm and there are no significant differences between the mean diameter of right and left renal arteries. **Majos *et al.*** [12] in CT study who reported that no significant relationship was found between the renal artery diameter in the right and left side of the body. Moreover, **Saldarriaga *et al.*** [13] in a Colombian mestizo population found that the mean diameter of the right renal artery was 4.78 ± 0.86 mm and the mean diameter of the left renal artery was 4.92 ± 0.92 mm, with no significant difference between the right and left renal arterial diameter. Wider diameter of the renal artery was found in the University of Pamplona by **Arquez** [14] in a cadaveric study

who reported that the diameter of the right renal artery found was 6.8±0.16 mm and the diameter of the left renal artery found was 6.9±0.2 mm. By using CT angiography in Brazil, **Palmieri *et al.*** [15] reported the mean diameter of the right sided renal artery was 6.8 ± 0.16 mm and the left sided renal artery was 6.9 ± 0.2 mm and there was no difference in the comparison between left and right kidneys (p = 0.592). Also in Tabriz, **Tarzamni *et al.*** [1] found that the difference was statistically not significant p-value (0.35) between the mean right renal artery diameter (6.1 ± 1.2mm) and the mean left renal artery diameter (6.2 ± 1.1mm) in a CT study.

Narrowing of the renal arteries than the normal diameter may result in hypertension. Other diseases that affect the renal arterial diameter include aneurysm and atherosclerosis [16]**.** The diameter of renal artery is of great importance in renal transplantation as when the diameter of the graft renal artery less than 3mm it becomes so difficult to make anastomosis with the recipient artery. Also high incidence of thrombosis occurs if the renal arteries were less than 3 mm [17]**.** In the present work; according to the renal artery diameter and gender variations, it was statistically significant that the right and left renal arterial diameter in males was wider than females p-value (0.022 & 0.022). These results were supported by the results of **Majos *et al.*** [12] **& Srivastava *et al.*** [10] in India and in Brazil, by **Palmieri *et al.*** [15]**.**

In this work; there is statistically significant differences between the mean diameter of the main renal artery in kidney with single renal artery (5.05 ± 0.78 mm) and the diameter of the main renal artery in kidney having multiple renal artery (3.89 ± 0.71 mm) (p-value < 0.000). In harmony with the present work, **Ramadan *et al.*** [18] reported that the main renal artery diameter was smaller in kidneys with accessory renal arteries than in those without (P < 0.001), also they put A cut-off value of 4.15 mm for the diameter of main renal artery to predict the presence of accessory renal arteries. Moreover, **Saldarriaga *et al.*** [13] found that the main renal artery diameter in kidneys having additional renal arteries was less than that of those having a single renal artery and it was statistically significant (p= 0.0000). It can be expected that the diameter of a renal artery should be smaller in a kidney supplied by more than one artery than that of a renal artery in a kidney supplied by that single artery [19]**.** Unlike that result **Palmieri *et al.*** [15] found no difference between diameter in main renal arteries in kidneys with single and multiple arteries.

In the present study, the mean length of the right renal artery (3.57±1.07 cm) was longer than the mean length of the left renal artery (2.87±0.83cm) but it was statistically non-significant p-value (0.955). The length was measured from the point of origin to the point of the emergence of the first branch. With these results, **Arquez** [14] and **Tarzamni *et al.*** [1] found a statistically non-significant differences between the right longer renal artery and the left renal artery. Unlike the present results, **Srivastava *et al.*** [10]**, Saldarriaga *et al.*** [13] & **Palmieri *et al.*** [15] reported a statistically significant difference between the mean length of the right renal artery which was longer than the mean length of the left renal artery. The anatomical explanation is that the right renal artery is longer than the left as the aorta present to the left of the mid plane of the abdominal cavity [13]**.**

In this work according to the relation between the renal artery length and gender; the mean renal artery length in males (3.64± 1. 10 cm) was longer than in females (3.50 ±1.04 cm). Also the mean left renal artery length in males (3.04± 0.93 cm) was longer than females (2.71± 0.68 cm). Similar to these results,

Srivastava *et al.* [10] in India in CT study concluded that the mean length of right renal artery in males (4.01±1.40 cm) was longer than females (2.75±1.15 cm) also they found the mean length of the left renal artery in males (3.23±.87 cm) was longer than females (2.48±1.03 cm).

CONCLUSION

The renal arteries present a broad spectrum of variability in their morphological expression respecting their length, level of ramification, diameter and emergence. The renal artery's diameter is a factor which should be considered as predicting the presence of accessory renal arteries. Such morphological aspects are important when considering a surgical approach, trauma, interpreting diagnostic images and teaching renal vascularization.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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