Morphometric Study of the Renal Arteries in Saudi Population from Aseer Region Using 3-D MDCT Angiography

Mohamed Atif A Said Ahmed [1,*], Hamed A Gobran [2]

Departments of Anatomy[1] and Radiology[2], College of Medicine, Zagazig University, Egypt.

ABSTRACT

The renal artery exhibits wide spectrum of origin variation. The renal artery anatomy plays a considerable role in selecting donors. 3-D angiotomography is the best modality for vascular anatomic evaluation. The aim of the present study was first, to provide morphometric data concerning the renal arteries in people of Aseer region, K.S.A. and second, to establish relationships between those arteries. Methods: Data from a retrospective review were performed using 3-D MDCT angiography of 100 consecutive Saudi patients fulfilled all research criteria and had a readable CTA were selected (54 males and 46 females) with mean age 54.7±5.2 years. Results: The median level of the origin of right renal artery and left renal artery is at the level of the lower third of L1 and the disc between L1 and L2, respectively. The mean of the measured angle of the right renal and left renal arteries is 55º±7º and 85º±8º, respectively. There was no difference between the diameters of the main renal arteries. The renal artery diameter had a direct correlation with the angle of origin. The renal artery diameter in kidneys with extra renal artery was significantly lower than those without an extra renal artery. Renal arteries associated with extra renal artery showed greater length. The length of the segment between celiac trunk and the renal arteries was significantly correlated with the length of the abdominal aorta. Conclusion: Understand the position, calibre and angle of the renal arteries, were advantageous to make use of selective arteriography, arterial embolism therapy and plan stent grafts.

Key Words

Morphometric, Renal artery, CT Angiography, Saudi population.

1 Introduction

Great technological advances in the field of diagnostic imaging of urology have better morphological referents for the renal vascularization pattern. Angiotomography (Angio-CT) has high sensitivity in the identification of renal arteries.(1) Multi-slice Angio-CT has replaced the conventional arteriography in the evaluation and study of vascular anatomy and diagnosis of vascular diseases of the kidney. El Fettouh and others (2), concluded that the 3-D Angio-CT correctly identified the number and caliber of renal arteries.

It is imperative for the surgeon to know the exact positions of the origin of renal arteries (RAs) and the range of lengths, diameters and the metric relations for care of the renal patients. Anatomical morphometric data could be useful for 1- Selecting donors in renal transplant.(3) 2- Guiding the radiologists during arterial catheterizations. 3- In robotic surgery, where the surgeon does not have the ability to identify the arteries by palpation. 4- Those who design arterial stent grafts and for those who place such a stent.(4) 5- Endovascular, laparoscopic urologic procedures and for medical device development.(5).

The RA emerges from the lateral surface of the aorta in most cases.(6) There is a variation in the RA origin. It emerges from the posterolateral, anterolateral and posterior surfaces with less frequency.(7) It has also been proposed that the origination angle and diameter of the blood vessels share and minimize the forces and maximize fluid conduction.(3) The distance from the RAs origin to the celiac trunk have been taken as reference in determining the level of emergence.(8) Both extra RA and early branching must be examined in patients being evaluated for donor nephrectomy, because of their importance during the procedure. The vast majority of published anatomical data on the origin of RA is based on finding at post-mortem examination.(9,10) To the best of available literature, there are few studies in the literature about detailed morphometric renal arteries have been done in the past(11,12), but not to this extent and not by 3 dimensions multi-detector computed tomography (3-D MDCT) angiography.

The aim of the present study was first, to determine the origin, angle and dimensions of the RAs to provide morphometric data concerning the RAs in Aseer central hospital, K.S.A. and second, to establish existing correlations between those arteries, to enrich knowledge concerning renal vascularization, thereby serving as referent in teaching and clinical practice.

Correspondence to:

Mohamed Atif A Said Ahmed
Departments of Anatomy,
College of Medicine,
Zagazig University,
Egypt.
E-mail: Mohamedatif2000@yahoo.com

Mohamed Atif A Said Ahmed, Hamed A Gobran. 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. (ISSN 2324-7290) © ZolCat Academic House. www.zolcat.com

2 Meterials and Methods

The research was approved by the Ethics Committee of King Khaled University. Data from a retrospective review were performed using 3-D MDCT angiography of 100 consecutive Saudi patients fulfilled all research criteria and had a readable CT angiography were selected. All subjects were free of any signs of arterial pathology such as aneurysm or tumours. Subjects with these pathologies were excluded from the study. MDCT angiography were randomly selected from the records of patients visited the department of radiology, Aseer central hospital, (Abha, K.S.A) between January 2009 and June 2011. All radiographs were made using a standardized method by the same technician. For the MDCT angiography examination, a Brilliance CT (Philips) instrument was used for all patients. To cover the whole abdominal aorta in each patient, spiral CT angiography scan was made and thin slices (0.6 mm) axial images were obtained. Both sagittal and coronal images were reconstructed. 3-D reconstruction was done from the data gained by the spiral CT examination. Manipulation of the 3-D images was done by rotation to get the correct planes and deletion of unnecessary anatomical details to clarify the renal artery away from superimposed structures. Data were saved to a portable hard disk. The 3-D MDCT angiography results were analysed to study the various parameters such as: the vertebral level and the angle from the sagittal plane of the RAs and the distances between the origins of the celiac artery and the RAs. The parameters used for evaluating the main RA are: the length of main renal artery from the ostium to branching, diameter at emergence from the aorta and presence of an extra renal artery.

The vertebral bodies were divided into upper, middle and lower thirds. All the distances were measured by software program. In order to obtain the distances between the vessels, the centre of the origin of each vessel was taken as the recordable point of origin. All the angles of origin were measured from the sagittal plane with software program. The angles were measured at the transverse plane, while 0° corresponds to the sagittal plane. Angles measured clockwise from this plane were designated as positive; counter clockwise as negative.

Statistical analysis

All the measured distances of the renal arteries were compared to one another and individual with the body heights and gender. A correlation is considered significant when $p < 0.05$. Most of the possible correlations were examined.

The results were recorded in the form of tables and then were subjected to statistical analysis with the purpose of calculating the mean, and SD and finally the correlations between the observed distances. In order to correlate the measured arterial distances and lengths, Pearson's correlation coefficient (r) was used. For comparing continuous variables, the t-test was applied. All the statistical analysis was done by SPSS.

3 Results

The arteries were examined in 100 Saudi patients (54 males and 46 females) with ages ranging from 29 to 72 years (mean age 54.7 ± 5.2 years). The mean ages of the male and female groups were 52.8 ± 5.5 years and 55.9 ± 5.1 years, respectively.

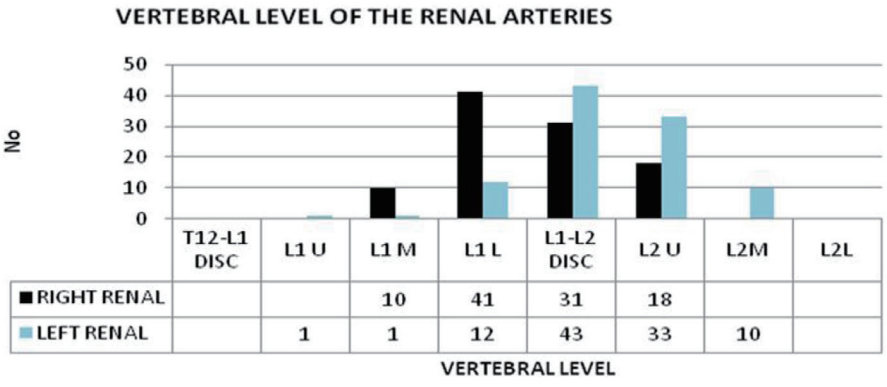
Vertebral levels

The vertebral levels of origin of the renal arteries are depicted in graph 1. The right RA arises from the aorta at the level of L1 to L2 levels, but the peak and the median is the level of the lower L1 (41%) (Graph1). The left RA arises from the aorta at the level of L1 to L2. Median level of origin of the left RA is the disc between L1 and L2. In 76% of the cases, the level of origin is in the disc between L1 and L2 and the upper part of L2 (Graph1); these correspond to a slightly lower level than the origin of the right RA (Fig.1). There is one unique case where the left RA arises higher than right RA with the same level of superior mesenteric artery at the upper third of L1, above the level of right RA by 2.6 cm (Fig.2).

Extra left RA (Fig. 3) was found in 6 patients (4 male and 2 female), whereas, extra right RA was found in 8 patients (5 male and 3 female). Overall extra RA was found in 14% of all cases. It was situated at the level between lower L2 and lower L3.

Arterial angles

The angles of origin of the RAs from the sagittal plane are shown in graph 2. The mean angle of origin of the right RA from the aorta in sagittal plane is 55°± 7° counter clockwise (range: - 41° to - 69°) with the peak point at - 60°. The mean angle of origin of the left RA from the aorta in sagittal plane is 85° ± 8° (range: 68° to 100°) with the peak point at 90° (Fig. 4).



Graph 1. Distribution of origin of the renal arteries in relation to vertebral levels and intervertebral discs.

All the measured distances, including means and SD value of each one are depicted in Table 1. Anatomical variations were not included, except extra renal arteries.

Relationships and correlations

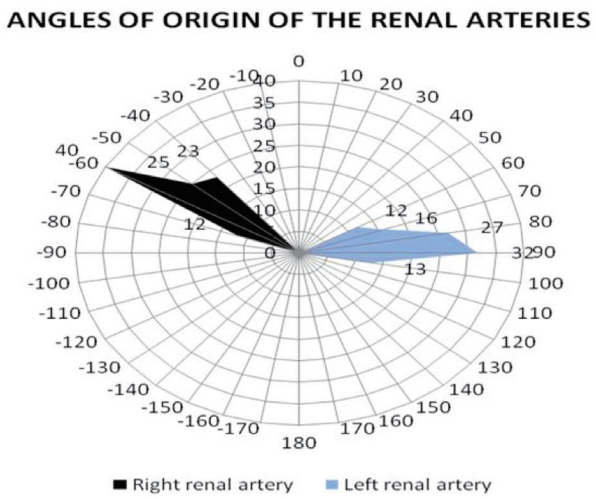
There were no significant differences found in the studied levels or angles of the renal arteries according to gender or height ($p > 0.05$). There is symmetry between the left and right renal arteries diameters ($p < 0.001$). The RA diameter had a direct correlation with the origination angle (i.e. RA with smaller origination angle showed smaller diameter). The RA diameter in kidneys with extra RA was significantly lower than those without an extra RA ($p < 0.05$) and the RAs associated with extra RA showed greater length and greater distances to branching ($p < 0.05$).

All the segments between celiac trunk and renal arteries were significantly correlated with the length of the abdominal aorta ($r = 0.490$ and $r = 0.510$, $p < 0.1$). The aortic length and the height were found to be significantly greater in male than in female ($p < 0.05$).

4 Discussion

To date there is no complete description of the position of the RAs in relation to the vertebral bodies in normal subjects. Most published anatomical studies regarding renal arteries are based on autopsies or anatomical parts. Knowledge of the normal location of the RA ostia in relation to the vertebra is necessary to appreciate pathology of the RAs such as RA pseudoaneurysms. Some investigators have shown that the use of 3-D MDCT angiography enables accurate identification of RA anatomy with high sensitivity.(1)

The present study revealed that the peak and the median of the origin of the right RA is the level of lower third of L1 in 41% of cases. In agreement with this study, the median level of origin of the right RA is the lower part of L1 in cadaveric studies(12) and by digital



Graph 2. Angle from the sagittal plane of the aorta at the transverse plane. 0°, sagittal plane; 0–180°, clockwise; 0° to −180°, counter clockwise. The number of specimens coming under the corresponding angle range is indicated in the radar network presented with a scaling of 5 cases. The angles were measured at the transverse plane..

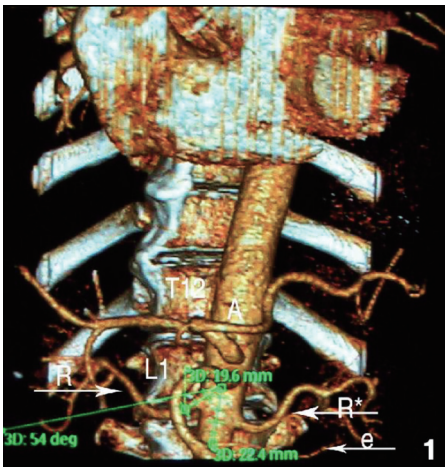


Fig.1. 3-D MDCT angiography shows abdominal aorta (A) and the origin of the right renal artery (R) at the level of intervertebral disc L1/L2, left renal artery (R*) origin at the level of upper L2. Extra left renal artery (e). Angle of right renal artery with the sagittal plane of aorta is 54º at transverse plane.

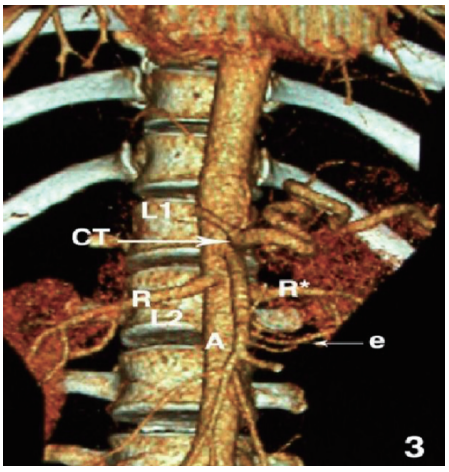


Fig.3. 3-D MDCT angiography shows celiac trunk (CT), right renal artery (R) origin at the upper level of L2, left renal artery (R*) origin at the middle level of L2. Note that the extra left renal artery (e) on the left side arises from the aorta (A) at the lower L2 level and enters into the kidney outside the hilum..

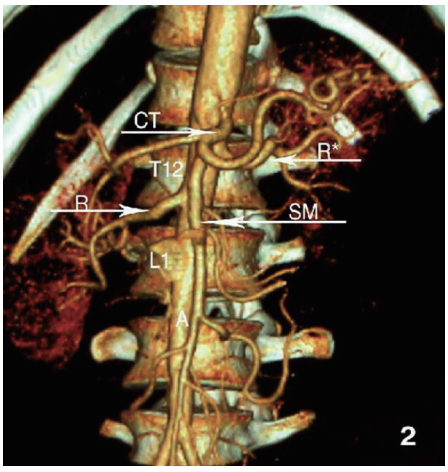


Fig. 2. 3-D MDCT angiography of abdominal aorta (A) and its branches, celiac trunk (CT), right renal artery (R) emerges at the lower level of L1, left renal artery (R*) origin at the upper level of L1 as a unique case above the level of the right renal artery and at the same level of the superior mesenteric artery(SM).

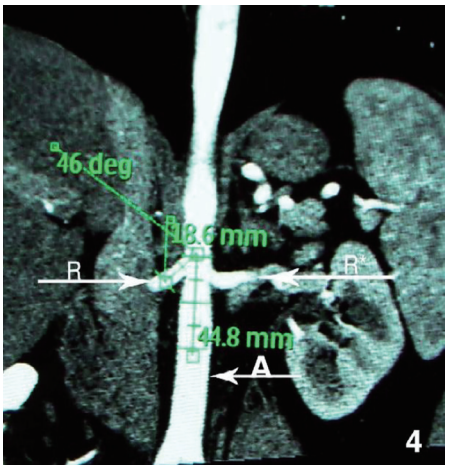


Fig.4. Reformatted coronal MDCT angiography shows right renal artery (R) forming angle 46º with the sagittal plane of the abdominal aorta (A). Left renal artery (R*).

Table 1. Mean, SD, minimum and maximum value of the measured distances.

Parameter	Mean	SD	Male (n=54)	Female (n=46)
Length of right renal artery	3.35 cm	±0.94 cm	3.35 ±0.93 cm	3.35±0.94 cm
Diameter of right renal artery	0.61 cm	±0.12 cm	0.61±0.12 cm	0.61±0.11 cm
Distance between celiac trunk and right renal artery	3.1 cm	±0.78 cm	3.2±0.80 cm	3±0.75 cm
Length of left renal artery	2.75 cm	±0.38 cm	2.75±0.39 cm	2.75±0.36 cm
Diameter of left renal artery	0.61 cm	±0.12 cm	0.62 ±0.13 cm	0.60±0.11 cm
Diameter of main renal artery in the presence of extra renal artery	0.39 cm	±0.06 cm	0.40±0.07 cm	0.38±0.06 cm
Distance between celiac trunk and left renal artery	3.4 cm	±0.72 cm	3.45±0.61 cm	3.3±0.84 cm
Distance between celiac trunk and aortic bifurcation (Fig. 6)	12.7 cm	±1.31 cm	12.8±1.24 cm	12.5±1.29 cm
Height	159.3 cm	±8.65 cm	164.7±8.25 cm	154.8±7.85 cm

subtraction angiography.(13)In other studies it arises at the level of the disc between L1- L2.(14)

In this study, the mean angle of origin of the right RA from the sagittal plane of the aorta with the transverse plane is 55º± 7º counter clockwise with the peak point at -60º. There is a variation in the renal artery origin. The median angle of origin of right RA is 60˚ counter clockwise in cadaveric study(15) and did not show much difference. The right renal artery in another cadaveric study originated under the angle of 75 degrees.(16) The right renal artery arises ventrally at an angle of 30˚ ±15˚ from a plane orthogonal to the long axis of the spinous process of the 1st lumbar vertebrae.(17) In another study, the average angle was +21.24˚ ±2.31˚.(18)

The length of the right RA in the present study is 3.35 ± 0.94 cm and its diameter is 0.61 ± 0.12 cm. The average length of the right RA is greater than the left especially in kidneys with single artery.(19) Greater length right RAs (4.4 to 11.1 cm) were described by Janschek and others.(20) such discordance could have been due to the greater number of specimen having late ramification of the right renal artery observed in the reference work. In recent study, the mean diameters for RA are 0.55 ±0.09 cm.(21) Normal renal arterial information is useful not only for planning and performing of endovascular and laparoscopic urologic procedures, but also for medical device development.(5)

The mean distance between the celiac trunk and the right RA is 3 cm in Ozan and others study(6) which can be compared to 3.1 ±0.78 cm in the present study.

Median level of origin of the left RA is the disc between L1 and L2. In 76 % of the cases in the present study, the level of origin is the disc between L1 and L2 and the upper part of L2. The median level of origin of the left RA in one study by digital subtraction angiography is at the level of the upper part of L2.(13) Pennington and Soames(12) stated that, the level of left renal artery is the lower part of L1 vertebrae. The right RA is emerging a little higher than the left one. (13) The present study has a unique case with the left RA higher up at the same level of superior mesenteric artery in the upper third of L1 above the level of right RA by 2.6 cm. According to the classic anatomic descriptions, as well as in a research on the origin of the renal arteries in human foetuses by Çiçekcibaºi and others(22) and the study on the origin of the renal arteries by angiography by Ozkan and other researchers(13), renal arteries originating between the vertebrae L1 and L2 were more frequently found, both in the right and left sides. The RAs may arise from the aorta at a point lower than usual, according to the position of the kidneys, and they also tend to be lower in older persons.(13)

The mean angle of origin of the left RA from the aorta in sagittal plane is 85º ±8º with the peak point at 90º. In agreement with this study, the median angle of origin of left RA is 90˚ in cadaveric study(15) and under the angle of 85 degrees in another cadaveric study. (16) The left renal artery arises dorsally at an angle of 7˚±13˚ from a plane orthogonal to the long axis of the spinous process of the 1st lumbar vertebrae.(17) In another study, the average angle was +8.81˚ ±2.0˚.(18) The length of the left RA in the present study is 2.75 ± 0.38 cm and its diameter is 0.61 ± 0.12 cm. The diameter of the right and left RAs are nearly the same. Average left RA length was 2.86 cm and the RA diameter was 0.49 cm in Colombian people.(23) The lengths of the right and left RAs as observed in the present work are in agreement with the report by Dhar and Lal.(24)

Except for the main RA, the presence of extra RAs seems to be the most common anatomic variation of these arteries(25), with an incidence ranging from 8.7% to 75.7%.(3) The presence of an extra RA or short length of the RA may exclude the donor or present a challenge for the transplanting surgeons. (26) Extra RA was found in 14% of all cases in the present study. The RA diameter in kidneys with extra renal artery in the present study was significantly lower than those without an extra RA. The presence of extra RAs is very probable when the main RA has a diameter of less than 0.42 cm. Kidneys presenting a main RA with diameter greater than 0.55 cm most probably do not present extra RA.(27)

The mean distance between the celiac trunk and the left RA is 3.4 ± 0.72 cm in the present study comparing to 3.3 cm in Ozan and others study.(6) The mean distance between the celiac trunk and the aortic bifurcation is 12.7 ±1.31cm in the present study. Yahel and Arensburg reported the distance as 12.5 cm. The length of the abdominal aorta in the present study correlates with body height and gender. Yahel and Arensburg did not find any correlation between aortic length and height or gender.(11) It is interesting also to mention that the

segments between celiac trunk and the RAs were significantly correlated with the aortic length and this finding is in agreement with those of Pennington and Soames.(12)

5 Conclusion

This study, was performed using 3-D MDCT angiography of 100 Saudi patients from Aseer central hospital, showed that the renal arteries present a broad spectrum of variability in their morphological expression respecting their emergence, originating angle, and length. There was no difference between the diameters of the main renal arteries. The renal artery diameter had a direct correlation with the origination angle. The renal artery diameter in kidneys with extra renal artery was significantly lower than those without an extra renal artery. Renal arteries associated with extra renal artery showed greater length. The segments between celiac trunk and the renal arteries were significantly correlated with the length of the abdominal aorta. Such aspects are important when considering a surgical approach, trauma, interpreting diagnostic images and teaching renal vascularization. To the best of our knowledge there is no similar study in the available literature, including data about the level and angle of origin, length, diameter and the metric relationships of renal arteries or correlations between them in the human body using 3-D MDCT angiography. The present study adds to the significance and knowledge of surgical anatomy. Understanding the position, calibre, the range of lengths, and the metric relations and included angle of the RAs, were advantageous to make use of selective arteriography, renal transplant, arterial embolism therapy and plan stent grafts.

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