Research Article

Anatomical Variations, Parameters, and Morphometric Evaluation of Renal Arteries by using Computerized Tomography Angiography

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ABSTRACT

Background: Renal arteries originate from the abdominal aorta below the origin of the Superior Mesenteric Artery (SMA). Anatomical variations of renal arteries are common in the general population and the frequency of these variations differ geographically and ethnically. knowledge of renal vascular anatomy and vascular variant is very important in the pre surgical workup of renal surgeries.

Objectives: To illustrate the normal morphometric and parameters of renal arteries and determine the common anatomical variations of renal arteries among Libyan patients.

Methods: Renal Computed Tomography Angiography (CTA) of 100 adult patients (48 males and 52 females) were examined. The level of origin, the location of renal ostium on abdominal aorta, length and diameter of renal arteries as well as the course of renal arteries were estimated. Additionally, the anatomical variations were also described. After collection and checking of data, Statistical Package for Social Sciences (SPSS) was used for data entry and analysis.

Results: A total of 100 patients were evaluated in this study. Their age ranged from 24 to 75 years, median age was 56 years. A single renal artery was present in 94% of patients and 6% have an accessory renal artery. 42% of right renal artery the level of origin was L1-L2 inter vertebral disc and 39% for the left renal artery and the most common origin of renal ostium on abdominal aorta for the right renal artery was antero-lateral aspect of the abdominal aorta (56%) and was the lateral aspect (44 %) for the left renal artery. The mean length of right renal artery was 4.4 cm (SD ± 1) and its mean diameter was 3.8 mm (SD ± 0.86). The mean length of left renal artery was 5.34 cm (SD ± 0.97) and its mean diameter was 5.66 (SD ± 0.94). The diameter of main renal arteries in presence of accessory artery was significantly smaller than the diameter of the arteries in absent of accessory artery.

No significant difference cross with gender in level of origin and the origin renal ostium on the abdominal aorta.

Conclusion: Renal arteries anatomical variations appear not uncommon among Libyan patients, CTA is highly accurate for detecting vascular variation and providing anatomical para-meters for renal arteries and could be useful in pre-surgical planning of renal surgeries.

Keywords: Computed tomography angiography; Renal arteries; Measurement; Anatomical variation

Abbreviations: CTA(Computed Tomography Angiography); RRA(Right Renal Artery); LRA(Left Renal Artery); SMA(Superior Mesenteric Artery); ARA(Accessory Renal Artery); SPSS(Statistical Package for Social Sciences); SD(Standard Deviation)

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Introduction

Variations in patterns of blood supply and ramification of abdominal vessels are common in the vascular bed of genitourinary system and knowledge of these variations is important and called "normal" variants [1]. Renal artery variations are common and occur because the embryological development of the kidney [2]. Changes in the origin of the renal arteries have been reported since Bartholin in the 17th century. Each kidney is supplied by a single artery, named

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main renal artery with position and course are relatively constant up to the hilum. Its originated from abdominal aorta at the level of L1/L2 intervertebral disc [3-5]. However, the classical description of the renal vasculature, formed only by one artery and one renal vein occurs in less than 25% of cases [6, 7]. Apparently, anatomical variations of renal arteries do not interfere in renal function and should be differentiated from vascular malformations or anomalies that cause renal or systemic functional disorders. Currently Anatomical variation in renal arterial system has significant clinical implication in Endoscopic surgery, Radio-diagnostic procedure including renal angiography, renal vascular interventions such as those required for transplantation surgery [8]. Knowledge of variations in renal vessels is also essential for exploring renal trauma, vascular reconstruction procedures, repair of abdominal aortic aneurysms, and treating systemic diseases such as renal artery stenosis and renal hypertension [9-11]. CTA becomes mandatory for the surgeons to understand the abnormality or variations in the renal vasculature [12-14].

Aim of the study

To illustrate the normal morphometric and parameters of the renal artery and to determine the common anatomical variations of renal arteries.

Methodology

Study design

A case series descriptive study using the revision of renal CTA records of patients was applied in this research.

Study setting

The study was applied at National Cancer Center-Benghazi, Libya. The center includes radiological department where patients are referred from other health care facilities for radiological examination and diagnosis.

Duration of study

The records of renal CTA during the period from 1st April 2018 to 1st April 2019 were reviewed.

Inclusion criteria of cases

Male and female patients aged 18 years and above for whom abdominal CTA scan was recommended by their physicians.

Exclusion criteria of cases

Any male and female patients aged less than 18 years and other patients with renal disease , congenital anomaly or history of renal trauma.

Tools

CT machine: Fast acquisition and high-quality multi-slice CT (Philips Brilliance 6 Slice CT).

Equipment and measurements

All patients were examined using a 6 Slice-MDCT scanner. The scanning volume extended from the diaphragm to the iliac crest, and the images were reconstructed using a section thickness of 1.0 mm without overlap. A total volume of 100 mL of high-concentration IV contrast (Ultravist 370) with an injection rate of 3 mL/sec were injected via a 20-gauge peripheral . A scout topogram was obtained. Then, in every case, arterial and venous phase volumetric data sets were acquired at 25 seconds and 55 seconds, respectively from the start of the IV injection. The 1.0 mm thickness reconstruction images were sent to the workstations.

The collected data included Age, gender, vertebral level of origin, origin of renal ostium on abdominal aorta for both renal arteries, length, diameter, course of both renal arteries, if there is branch before bifurcation in hilum, if there is accessory renal artery, and the following measurements were ascertained from the CT angiography images:

1. The Length of renal artery: the distance from the site of origin to the hilum of kidney.
2. The diameter of renal artery: the vertical distance was measured near to its origin.

Data collection

A record sheet was used to collect data, which included: age, gender, vertebral level of origin, origin of renal ostium on abdominal aorta for both sides of renal arteries, course of both renal arteries, length of renal artery, diameter of renal artery, if there is branch before bifurcation in hilum, if there is accessory renal artery.

Administrative approval

The approval of the director of the center was taken before reviewing the records and collection of required data.

Statistical analysis

The collected data were entered and analyzed using Statistical Package for the Social Sciences (SPSS) version 25 for windows. Continuous

variables were expressed as mean ± Standard Deviation (SD). Categorical variables were expressed as frequencies and percentages. Categorical data was compared using Chi-square test. Summary tables and figures as appropriate. Whereas variables were compared using student t-test. Level of significance of less than 0.05 was considered cut off for judging statistical importance.

Results

■ Personal characteristics

This study included 100 patients, their age between 24 years-75 years, with mean ± SD was 55.35 ± 12.6. The median age of the sample was 56 years (Table 1). Male represented 48% of the patients compared to 52% female (Figure 1).

■ The level of origin of renal arteries

The origin of renal arteries in all patients were from the abdominal aorta. The vertebral Level of origin of renal arteries was variable, inter vertebral disc space between the first and second lumbar vertebrae (L1-L2) level was the most frequent origin, 42% of patients were observed for the RRA and 39% of patients were observed for the LRA. The second most frequent level was the first lumbar vertebra which observed in 37% of patients for both right and left arteries, then the second lumbar vertebra level which observed in 10% of patients for RRA and 20% of patient for LRA, the rest originated from the 12th thoracic and 1st lumbar inter vertebral level ,were 7% of patients observed for the RRA and 3% of patients were observed for the LRA , and finally the level of the 12th thoracic vertebra for 4% of patients RRA and 1% for LRA (Figures 2).

Table 1: Age distribution of the sample Age statistics.

Age statistics	
Mean	55.35
Median	56
Mode	45.00*
SD	12.5886
Minimum	24
Maximum	75

*Multiple modes exist. The smallest value is shown.

■ The origin of renal ostium on the abdominal aorta

The origin of renal ostium on the abdominal aorta for the right renal artery was the antero-lateral aspect observed in 56 % of patients and the lateral aspect in 44 % of patients, while the left renal artery showed more diverse sites of renal ostium on the abdominal aorta, the lateral aspect was in 79 % of patients, then antero-lateral aspect in 11 % of patients, followed by postero-lateral aspect in 8 % of patients and finally posterior aspect for 2 % of patients

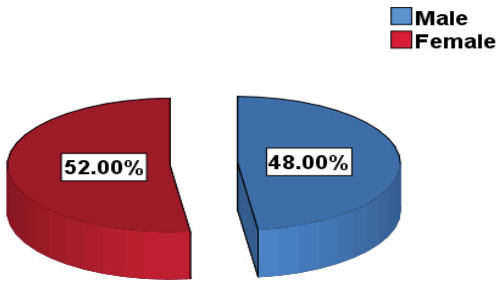

Figure 1: Gender distribution of the patients.

Table 2: The origin of right and left renal arteries ostium on abdominal aorta.

Origin of renal ostium	RRA (Frequency %)	LRA (Frequency %)
Lateral	44%	79%
Antero-lateral	56%	11%
Postero-lateral	0	8%
posterior	0	2%
Total	100%	100%

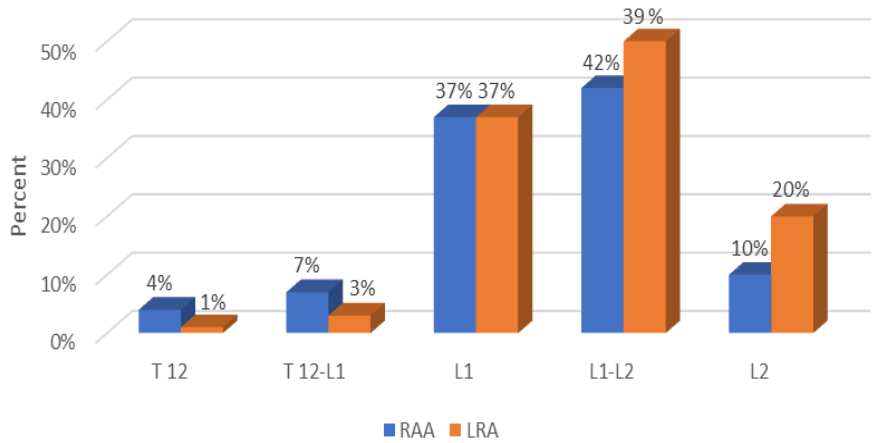

Figure 2: The level of origin of right and left renal arteries.

(Table 2 and Figure 3)

Among these cases the RRA was straight in 46% of them, and the LRA was straight in 55 of cases. Whereas tortuous course was seen in 54% and 45% in the right and the left renal arteries respectively.

■ The length and diameter of renal arteries

The mean length of the RRA was 4.4 cm (SD ± 1), and the mean diameter was 3.8 mm (SD ± 0.86). Regarding to the LRA, the mean length was 5.34 cm (SD ± 0.97). and the mean diameter about 5.66 (SD ± 0.94), (Table 3, Figure 4).

In presence of ARA was associated with significance difference in the diameter of the main arteries.

The mean diameter of RRA with accessory artery was 4.4 mm (SD ± 1.43) and without accessory artery was 5.4 mm (SD ± 0.91), so the diameter of RRA in presence of accessory artery is significantly smaller than the diameter of the artery in lack of accessory artery (t-statistics=5.12; P-value=0.019).

Similarly, on the left side, the mean diameter of LRA with accessory artery was 4.6 mm (SD ± 10.25) and without accessory artery was 5.7 mm (SD ± 0.93), so the diameter of LRA in presence of accessory artery is significantly smaller than the diameter of the artery in lack of accessory artery (t-statistics=8.6; P-value=0.004).

■ Normal variant

Accessory renal arteries were seen in 6% of all patients and arise from the abdominal aorta, no

Figure 3: CTA of renal arteries illustrate the site of renal ostium on abdominal aorta, both renal arteries originated from lateral aspect.

Table 3: Measurements of right and left renal arteries.

Statistics	Length of RRA before division (cm)	Length of LRA before division (cm)	Diameter of RRA (mm)	Diameter of LRA (mm)
Mean	4.4	3.8	5.34	5.66
SD	1	0.86	0.97	0.94
Minimum	1.48	2.29	2.15	3.34
Maximum	7.56	7.12	7.69	8

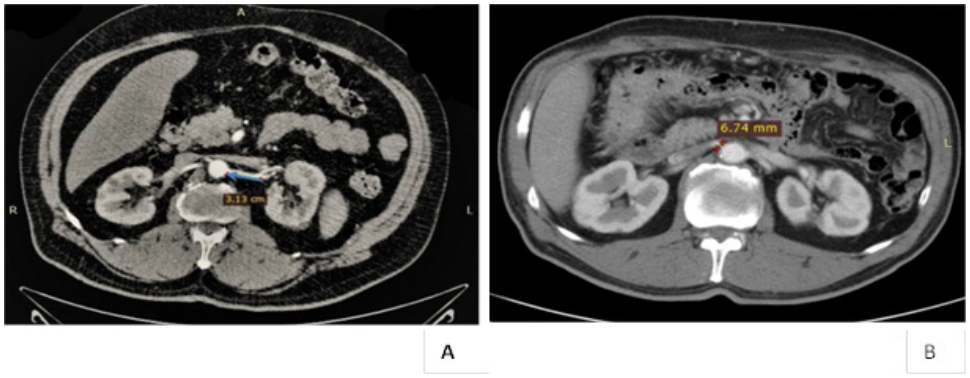

Figure 4: CTA of renal arteries A-B, measurement the length of LRR (A), measurement the diameter of RRA (B).

early branching seen (Figure 5).

Figure 5: Maximum Intensity Projection (MIP) image from the anterior view A-B, depicting multiple RRA (white arrows) (A), multiple LRA (red arrows) (B).

Discussion

The anatomical variations, parameters, and morphometric evaluation of renal arteries had been studied by many investigators. Based on the findings of our study, the level of origin of renal arteries is variable, the L1-L2 inter vertebral disc space is the most frequent origin as (42%) of the patients for the RRA and (39%) of the patients for the LRA. The s econd m ost common level is the L1 vertebral body (37%) of the patients for both right and left arteries, Edsman G, demonstrated that the right and left renal arteries originate at the disc between L1 and L2 in 31.5% and 34.4% [15], also Ozkan U etal. reported that, the percentage of the left main renal arteries originating at level of the first lumber vertebra were 37% [3], which are compatible with our study.

Kadir S declared that in 75% of the general population, main renal arteries originate from the level of the L1-L2 intervertebral disc and the other 25% originate somewhere between the lower endplates of T12 and L2 [5] which is quite different than our study. A wide range of variation had been reported with individual case report documenting the level of origin of renal artery as higher as the thoracic vertebrae [2].

The origin of renal ostium on the abdominal aorta for the RRA was the antero-lateral aspect which observed in 56% of patients and the lateral aspect in 44% of patients, while the LRA showed more diverse sites of renal ostium on the abdominal aorta, the lateral aspect was in 79% of patients, then antero-lateral aspect in 11% of patients, followed by postero-lateral aspect in 8% of patients and finally posterior aspect for 2% of patients, P Odman and K Ranniger ,reported that the origin of renal ostium on the abdominal aorta for the RRA was the ventral aspect which observed in 86 of patients and from the lateral aspect in 60 of patients and the LRA ostium on the abdominal aorta from the lateral aspect was in 96 of patients and ventral aspect 38 of patients [16], Also H. Ozan et al reported that the ostium of the RRA was more cranial than the ostium of the LRA (53.3%) and the locations of the ostia of the renal arteries were usually on the lateral and anterolateral regions of the aortic wall [17], both studies are relatively compatible with our study.

The mean length of right and left renal arteries in our study were (4.4 ± 1.0 SD) cm and (3.8

± 0.86 SD) cm respectively, which found very close to the study of Mohiuddin M et al. were found the mean length of the right renal arteries was (44.69 ± 2.48 SD) mm and the mean length of the left renal arteries was (35.10 ± 2.86 SD) mm in other study Khanal UP et al, The mean values of right renal artery length were found to be (4.568751 cm ± 0.83128 cm) in males and (4.0318 cm ± 0.87575 cm) in females [18]. The mean values of left renal arteries length were found to be (3.5990 ± 0.79567cm) in males and (3.2002 cm ± 0.59207 cm) in females which also close to our study, however, there is no significant gender difference on our study [19].

The mean length of the right renal arteries in present study was found to be significantly (P= 0.00) longer than the mean length of the left renal arteries. This probably due to the location of abdominal aorta to the left of median plane in abdomen and longer pattern of renal artery on the right side as suggestive by different authors [20-22]. In our study the mean diameter of the RRA was (5.34 ± 0.97) mm and the mean diameter of the LRA was (5.66 ± 0.94) mm. Adrenal or capsular arteries. On other hand other studies was conducted by using CTA reveled that higher incidence of ARA compared to our study; Kumaresan M et al. reported that the incidence of variation of renal arteries was 51% and the study was conducting in India [26], also Gumus et al. reported that the incidence of variation of renal arteries was 54% and the study was conducting in Turkey [27], this variation could be due to racial difference.

Among the present study, the right renal artery is straight in 46% of them, and left renal artery is straight in 55%. Whereas tortuous course was seen 54% and 45% of right and left renal arteries respectively. Mishall PL observed 50% of renal arteries were tortuous and symmetrical which found close figure to our study where as Hegedus reported that the course of the artery from the aorta to hilum was either straight (38.8%) or tortuous (61.2%) [2,28].

Khanal UP et al reported the mean diameter of the right and the left renal arteries were 5.41 mm and 5.64 mm, which is compatible with our study [19].

The left main renal arteries diameter is relatively larger than the corresponding right arteries and diameters of both main renal arteries were significantly smaller in the present of the accessory renal arteries (p-value=0.004). Almost similar observation was also noted in the studies by Aytac Sk et al and Sungura R et al [23, 24]. On other hand Merklin and Michels reported that the caliber of the right and left renal artery is usually the same, the average diameter being 5.5 mm with a range of 4 mm-7 mm [25].

ARAs show dissimilarity according to society, ethnicity and mode of investigation. The incidence in our study was 6 %. K.S.Satyapal et al. reported that the incidence of additional renal arteries on cadaveric serious was 23.2 % and on renal angiogram was 4.5 % [8], the later one is close to our study ,this can be explained by ARA are detected less in angiography than anatomic dissection studies because they are thin arteries and originating directly from the aorta which may not observed in angiography, and/or arteries that enter parenchyma directly without passing the renal hilum and frequently confused with

Conclusion

The parameters of renal arteries and its anatomical variations are complex and not uncommon among Libyan patients; renal CTA plays a key role as a noninvasive preoperative method for assessment of renal vasculature. Awareness of the different variants together with a detailed report of their distribution and morphology also allows the radiologist to enlighten the surgeon and avoid significant vascular complications.

Recommendations

Further studies using a larger population size to enable us to generalize the findings for the Libyan population. Also an analytic comparative study is recommended to be done in this part to correlate the radiological finding Vs intra-operative findings of the renal vascular anatomy.

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