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Evaluation of Renal Artery Anatomical Variations Using Multi-Detector Computerized Tomographic Scan in Sudan

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Abstract

Evaluation of Renal vascular anatomical variations Using Multi-Detector Computerized Tomographic scan in Sudan, the total number of patients studied is 400, 202 (50.5%) male and 98 (49.5%) females, and their ages ranged between (3 - 94) years. The types of Accessory renal arteries were 1.8% (7/24) upper pole, 1.8% (7/24) lower pole and 2.5% (10/24) hilus. In males, 4 upper pole, 4 lower pole and 7 hilus. In females, 3 upper pole, 3 lower pole and 3 hilus. The percentage of right accessory renal arteries is almost twice that of the left and more than twice the bilateral accessory arteries. Accessory renal artery is a common but a significant anatomical variant of the renal vascular system, due to their clinical importance. In our sample, the accessory renal artery presence was detected in 6% and displayed a greater variation on the right than the left side. Because this abnormality plays an important role in kidney transplantations, in radiological, vascular and urological interventions, a detailed presentation of accessory renal artery incidence was conducted, gathering from the literature a large number of relevant studies in order to create a classification according to population, gender, side and specimen. The study concluded that the renal arteries present a broad spectrum of variability in their morphological expression regarding their length, diameter and entrance to the kidney parenchyma, additional arteries' morphological expression was higher in men than women. This is statistically not significant and variation in the right side was found greater frequency than the left side.

Keywords

Renal Arteries, Computerized Tomographic Scan, Anatomical Variant, Renal Hilum

1. Introduction

Renal diseases affect more than 750 million people globally [1] [2]. The renal arteries (RAs) are important arteries that usually arise from the abdominal aorta and supply the kidneys. Knowledge of the anatomy and the pathologic entities related to the RAs is vital for diagnostic and interventional radiologists alike, given their role in the management of a considerable number of disease processes. Although invasive catheter angiography traditionally has been the mainstay of investigation of RA disease, this is now the case for only select conditions such as polyarteritis nodosa (PAN). CT angiography is now widely used in the evaluation of RA disease, given the high spatial resolution, rapid examination time, and capability to detect extravascular structures and readily depict anatomic variants that might be missed at angiography. Doppler US and MR angiography also have roles in the evaluation of RA disease. Each kidney is normally supplied by a single renal artery which divides into segmental arteries near the hilum. Anatomical variations in the number and origin of the renal arteries were first reported by Bartholin (1665-1738) [1]. In approximately 25% - 30% of individuals, more than one renal artery is present [2]. Different origin and variations of renal arteries are explained by the development of the mesonephric arteries. During embryogenesis, the kidneys ascend from the pelvis to lumbar region. During their ascent, they are supplied by several mesonephric arteries. Overtime, the preceding caudal vessels usually regress and disappear, leaving only one mesonephric artery. However, failure of regression leads to anomalous renal arteries [3]. The superficial iliac circumflex, the superior shameful external pudendal, the inferior external shameful pudendal [4]. Clinically, the identification of renal vascular variants is important especially for transplant surgeons, vascular surgeons and for intervention radiologists [5] [6]. Conventional angiography is the gold standard method to examine vascular structures; however, it is an invasive procedure and it is not adequate to determine renal vein variations in detail [7] [8]. Multidetector computerized tomographic scan (MDCT) is a highly sensitive method, allowing for the examination of the overall renal vascular anatomy along with arteries and veins together [9] [10]. When a kidney has two or more arteries with separate aortic ostium, the vessel with the greatest diameter is considered the main renal artery and others, accessory arteries [11] accessory arteries are categorized as either hilar or polar. Hilar artery enters the kidney through the hilum while polar artery enters the kidney through the capsule outside the hilum. Polar arteries perfuse the superior or inferior renal poles [12]. Pre-hilar or early branching arises less than 1.5 - 2 cm from the origin of the main renal ostium in the left kidney or in retrocaval segment at the right kidney [11]. The aim of this study is to evaluate renal artery anatomical variations using a multi-detector computerized tomographic scan in Sudan.

2. Methodology

This is a retrospective hospital record-based study was performed in Sudanese

population were the patients age ranged from 3 till 94 years (198 female and 202 males).

Study Area and Population: Study area Khartoum state populations of this study were the patients who came to the radiology department suspect to have abdominal CT scan in Dar Al Elag hospitals and Ibn Sina hospitals in Khartoum state.

Sample Technique and Sample Size: The sample size of this study was 400 patients (794 kidneys, as there are 6 patients with one kidney) from both gender with renal and with many other problems from 2 different hospital in Khartoum state. The sample was collected according to certain criteria.

Data Collection: Data were collected by a carefully designed Data collection Form. The Data collection Form was designed for the purpose of this study. The Data collection Form was designed in English and it is filled by me and one well trained technician. It is consisted of four pages and was designed to be answered within fifteen minutes.

The first part consisted of participant's biographical data which was the name, gender, age, and the variables related to renal artery like state of the kidney, number, length, and width of the renal artery and type of accessory artery.

Materials:

CT Scan device: CT machine: CT Siemens Somatom Sensation 64, Siemens, Germany.

Method of renal artery identification:

The Imaging method: After fasting 6 - 8 hours before examination and check patient history to deal with diabetic patient each patient ingested 800 ml of positive oral contrast, either a dilute barium suspension, or a 3% solution of gastrografin (sodium/meglumine diatrizoate. Schering) or similar water-soluble contrast which may be flavoured with fruit squash. The contrast is given 30 - 40 minutes before the scan to opacify the small bowel and a further 200 ml of the same contrast is given immediately before the scan to opacify the stomach and proximal small bowel. Intravenous contrast may be used to opacify the renal masses.

After drinking the oral contrast patient lying supine on couch First the topogram of the abdomen was scanned and then the selected region of interest from the upper margin of the Th12 vertebra to the symphysis pubis then we take the first run pre-IV contrast. Depend on patient weight we inject iv contrast media using 5 - 8 mm slice thickness with pitch of one- and 1.5-mm gap between each slice. To detect renal artery in arterial phase we get the second run using bolus tracking technique with incidence peak 120 HU. After CT angiography images were processed by using various techniques, including multi planar reconstructions (MPR), maximum intensity projection (MIP) and volume rendering techniques (VRT) on the Advantage Windows 3D workstation. For arterial phase reconstruction the images were reconstructed at 1 mm slice thickness and 50% overlap.

The following parameters were evaluated:

The length of the main renal artery (from the ostium to branching), the diameter of the main renal artery at emergence from the aorta; the number of accessory arteries, if any; the presence of early branching; Kidney length and width 1 (Figure 1).

3. Results

The total number of patients studied is 400, 202 (50.5%) of which were males and 198 (49.5%) were females, and their ages ranged between (3 - 94) years (Table 1).

The Accessory renal arteries were detected in 6% (24/400) of the patients. In 3.0% (12/24), accessory renal arteries were found on the right, in 1.8% (7/24) on the left side and in 1.3% (5/24) on the both sides (Table 2). The types of accessory renal arteries were 1.8% (7/24) upper pole, 1.8% (7/24) lower pole and 2.5% (10/24) hilus (Table 3). In males, 4 upper pole, 4 lower pole and 7 hilus. In females, 3 upper pole, 3 lower pole and 3 hilus (Table 4).

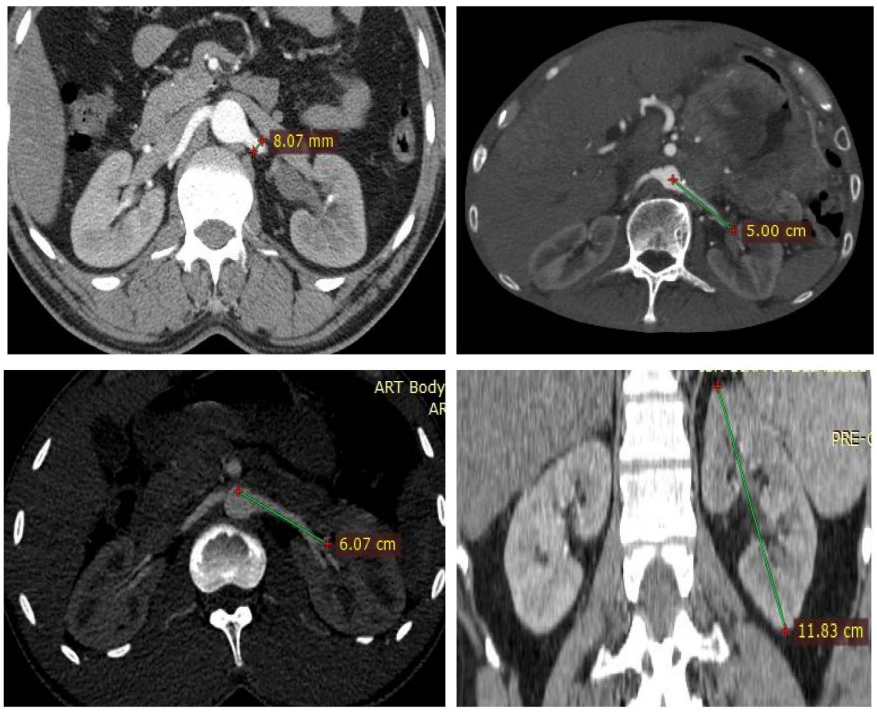

Figure 1. Method of Measurements of kidney and renal artery.

Table 1. Frequency distribution for gender.

Gender	Frequency	Percent
Female	198	49.5
Male	202	50.5
Total	400	100.0

Table 2. Frequency distribution of side of accessory renal arteries.

Accessory Renal artery	Frequency	Percent
Left	7	1.8
Right	12	3.0
Bilateral	5	1.3
Total	24	6.0

Table 3. Show frequency distribution for the type of accessory renal arteries.

Type of Accessory	Frequency	Percent
Upper Pole	7	1.8
Lower Pole	7	1.8
Hilus	10	2.5
Total	24	6.0

Table 4. Gender * Crosstabulation between the gender with the types of accessory renal artery.

GENDER	Type of Accessory			Total
	Upper Pole	Lower Pole	Hilus	
Female	3	3	3	9
Male	4	4	7	15
Total	7	7	10	24

The early divisions were detected in 5.3% (21/400) of the patients. In 1.0% (4/21), early divisions were found on the right, in 1.8% (7/21) on the left side and in 2.5% (10/21) on the left and right sides (Table 5). There were 0.75% (3/400) patients without right kidney and 0.75% (3/400) patients without left kidney (Table 6). The study showed mean of total samples of the width and length of right and left kidneys respectively measurements were 5.354 ± 0.948 and 5.571 ± 0.966 for width and 10.028 ± 1.3684 and 10.060 ± 1.5203 for length, the width and length for right renal artery 5.746 ± 1.2814 and 5.881 ± 1.1444 respectively and for left renal artery 5.894 ± 1.3175 and 4.961 ± 1.0294 respectively, in Table 7. There was no statistically significant difference was found between gender and variables ($p > 0.05$) (Table 8).

50.5% males 202 and 49.5% females 198 total of patients 400.

The percentage of males and females are almost equal.

The percentage of right accessory renal arteries is almost twice that of the left and more than twice the bilateral accessory arteries.

Hilar accessory arteries represented the highest percentage.

The frequency of occurrence of hilar accessory renal artery was more than lower and upper pole.

Table 5. For frequency distribution of side of early division renal artery.

Early Division of Renal Artery	Frequency	Percent
Left	7	1.8
Right	4	1.0
Bilateral	10	2.5
Total	21	5.3

Table 6. Crosstabulation between absence of one kidney and patients' history.

Left kidney			Right kidney		
History	Frequency	Percent	**History**	Frequency	Percent
Hypertension	1	33.3	None	1	33.3
Renal Disease	2	66.7	Renal Disease	2	66.7
Total	3	100.0	Total	3	100.0

Table 7. Represent a summary of the findings of the variables studied.

Variables	**Mean**	**Std. Dev**	**Min**	**Max**
Age	46.72	18.832	4	94
Body Mass Index	24.479	4.6471	8.9	42.5
Width of Right Renal Artery	5.746	1.2814	0.0	10.0
Length of Right Renal Artery	5.881	1.1444	0.0	10.0
Width of Right Kidney	5.354	0.9486	0.0	9.0
Length of Right Kidney	10.028	1.3684	0.0	12.7
Width of Left Renal Artery	5.894	1.3175	0.0	10.0
Length of Left Renal Artery	4.961	1.0294	0.0	9.3
Width of Left Kidney	5.571	0.9668	0.0	9.6
Length of Left Kidney	10.060	1.5203	0.0	15.0

Table 8. Group statistic for descriptive statistic for all variables.

variables	Gender	N	Mean	Std. Deviation	Std. Error Mean
AGE	Female	198	45.24	18.589	1.321
	Male	202	48.17	19.001	1.337
Body Mass Index	Female	198	24.656	4.5398	0.3226
	Male	202	24.304	4.7548	0.3345
Width of Right Renal Artery	Female	198	5.678	1.2884	0.0916
	Male	202	5.812	1.2742	0.0897

Continued

Length of Right Renal Artery	Female	198	5.668	1.0910	0.0775
	Male	202	6.090	1.1596	0.0816
Width of Right Kidney	Female	198	5.199	0.9210	0.0655
	Male	202	5.505	0.9530	0.0671
Length of Right Kidney	Female	198	9.867	1.4379	0.1022
	Male	202	10.186	1.2807	0.0901
Width of Left Renal Artery	Female	198	5.781	1.2554	0.0892
	Male	202	6.004	1.3697	0.0964
Length of Left Renal Artery	Female	198	4.781	0.9531	0.0677
	Male	202	5.138	1.0723	0.0755
Width of Left Kidney	Female	198	5.463	1.0096	0.0717
	Male	202	5.676	0.9132	0.0643
Length of Left Kidney	Female	198	9.842	1.5774	0.1121
	Male	202	10.273	1.4342	0.1009

According to patient's gender and there was no significant difference.

Bilateral early division was found in most of the cases studied.

The patients that have one kidney almost has disease.

4. Discussion

The total number of patients studied is 400, 202 (50.5%) of which were males and 198 (49.5%) were females, and their ages ranged between (3 - 94) years (Table 1). The types of accessory renal arteries were 1.8% (7/24) upper pole, 1.8% (7/24) lower pole and 2.5% (10/24) hilus. In males, 4 upper pole, 4 lower pole and 7 hilus. In females, 3 upper pole, 3 lower pole and 3 hilus. The percentage of right accessory renal arteries is almost twice that of the left and more than twice the bilateral accessory arteries. Hilar accessory arteries represented the highest percentage (Table 2 and Table 3).

The early divisions were detected in 5.3% (21/400) of the patients. In 1.0% (4/21), early divisions were found on the right, in 1.8% (7/21) on the left side and in 2.5% (10/21) on the left and right sides. In males, early divisions were detected in 5% (10/202), (3/10) on the left, (1/10) on the right side and (6/10) on the left and right side. In females, early divisions were present in 6% (11/198), (3/11) on the right and (4/11) on the left side and (4/11) on the left and right-side as shown in Table 4.

Table 5 shows 0.75% (3/400) patients without right kidney and 0.75% (3/400) patients without left kidney. The study showed mean of total samples of the width and length of right and left kidneys respectively measurements were 5.354 ± 0.948 and 5.571 ± 0.966 for width and 10.028 ± 1.3684 and 10.060 ± 1.5203 for

length, the width and length for right renal artery 5.746 ± 1.2814 and 5.881 ± 1.1444 respectively and for left renal artery 5.894 ± 1.3175 and 4.961 ± 1.3175 respectively **Table 6**.

The fact of the study that confirmed that the majority of Sudanese people have a single renal artery like descriptions given by texts dealing with anatomy [13]; however, considerable variations on this pattern have been reported in the literature specializing in the topic [14].

This finding supports the reports of Hlaing, *et al.*, [15], Odman and Ranniger [16], Natsis, *et al.*, [17], Santos Soares, *et al.* [18], Sungura [19], Kapoor *et al.* [20] and Oh *et al.* [21]. Differing from the previously mentioned results, this is higher than what were found by Gebremickael A, *et al.* [22], Wondmagegn, *et al.*, [23], Hekimoglu A and Ergun O, [24] Majos M, *et al.*, [25], Salih M A and Hasan MA, [26], Ahmed A Y, *et al.*, [27], Coen & Raftery [28]. In many studies, the sample was dissected cadavers or specimens from an autopsy, while in other angiographic studies, the sample was patients. It is argued that the cadaver dissection probably affords a more accurate determination of the number of renal arteries (RA), than aortography [29].

5. Conclusions

Accessory renal artery is a common but a significant anatomical variant of the renal vascular system, due to their clinical importance. In our sample, the accessory renal artery presence was detected in 6% and displayed a greater variation on the right than the left side. Because this abnormality plays an important role in kidney transplantations, in radiological, vascular and urological interventions, a detailed presentation of accessory renal artery incidence was conducted, gathering from the literature a large number of relevant studies in order to create a classification according to population, gender, side and specimen.

The study concluded that the renal arteries present a broad spectrum of variability in their morphological expression regarding their length, diameter and entrance to the kidney parenchyma, additional arteries' morphological expression was higher in men than women. This is statistically not significant and variation in the right side was found greater frequency than the left side.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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