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Variations in Renal Artery in Egyptian Population: Cadaveric and Angiographic Study

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Abstract

Background: Variations of Renal Artery (RA) are important in uroradiological procedures. Pre-operative visualization of the renal vascular anatomy is crucial for selecting the proper kidney during renal transplantation and avoiding vascular injuries.

Aim of Study: The present study aimed to describe RA variations and different branching patterns in a section of Egyptians using dissected cadavers and Multi Detector Computed Tomography Angiography (MDCTA).

Subjects and Methods: The study included 207 renal pedicles (7 kidneys and 100 CT images). The specimens were examined for morphological patterns of RA. MDCTA images were evaluated for the level of origin, length, caliber and presence of additional renal arteries.

Results: The renal arteries in the dissected specimens showed fork (duplicate and triplicate) and ladder patterns. The level of origin of RA in MDCTA images was at L1 (52%), L2 (32%), L1-L2 intervertebral disc (11%), T12-L1 intervertebral disc (3%), T12 (1.5%) and L2-L3 intervertebral disc (0.5%). The mean caliber of the left RA was greater than the right RA (left 6.99±1.47mm, right 6.55±1.51mm, p=0.003). Out of 200 renal pedicles, 21 (10.5%) additional arteries were observed in the form of 13 (6.5%) accessory renal arteries, 2 (1%) aberrant superior polar arteries, 2 (1%) superior polar arteries, 3 (1.5%) aberrant inferior polar arteries and 2 (1%) dual renal arteries. The most commonly seen branching pattern was the hilar (82%), followed by prehilar (11.5%) then intaparynchymal branching pattern (6.5%).

Conclusion: Variations of RA are common in Egyptian population. The most important are the presence of additional arteries and different branching patterns. Variations in renal vasculature in relation to population should be taken in consideration during urological interventions.

Key Words: *Renal artery – Variation – MDCTA – Branching pattern.*

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Introduction

PRE-OPERATIVE knowledge of the vascular patterns of Renal Artery (RA) is important in planning the appropriate surgical procedure to avoid vascular complications and to provide proper management in renal transplantation **[1]**. It is also important due to the marked increase in uroradiological procedures and vascular operations **[2]**.

Several variations of the RA have been shown as the different level of origin, presence of additional renal arteries (accessory, polar and double renal arteries) as well as different branching patterns, which include prehilar, hilar or intraparenchymal **[3]**.

Accessory renal arteries are additional arteries of different origin which enter the kidney with the usual renal arteries through the hilum. On the other hand, polar renal arteries are those which pass either through upper pole or lower pole **[4]**. The polar renal arteries may arise directly from the abdominal aorta (aberrant polar renal artery) or as a direct branch from the RA **[5]**. Double renal arteries are two vessels originating from the aorta with similar diameter and entering the kidney through the hilum **[6]**.

Imaging of the RA and its branching patterns is mandatory before any renal operation. Preoperative imaging of the vascular variants facilitates the dissection of these vessels and helps to avoid vascular injuries **[7]**. MDCTA is a principal imaging investigation for assessment of the renal vasculature. It provides highly accurate and detailed evaluation of normal renal vascular anatomy and variants **[8]**.

It was reported that the incidence of RA variations shows social, ethnic and racial differences [2]. Yammine [9] recommended the use of specific population of interest in studying anatomical variations, rather than following generalized incidence rates as mentioned in textbooks. This encourages the shift towards evidence-based anatomy to insure safe medical practice.

Several studies were carried out to examine the relation between ethnicity and variations in RA. However, to our knowledge, no studies were done concerning variation in RA among Egyptian population. The aim of the present work is to provide morphometric data concerning RA variants and different branching patterns using dissected cadavers and MDCTA in a section of Egyptian population.

Material and Methods

1- Anatomical study:

Seven adult kidneys (three right and four left) was included in the study. The specimens were obtained from embalmed cadavers during routine abdominal dissection conducted for medical undergraduate and postgraduate students over a period of two months (July 2017, August 2017). The study was performed in the Anatomy and Embryology Department, Faculty of Medicine, Cairo University. Kidneys with congenital anomalies, gross pathological changes and kidneys of infants or children were excluded from the study.

The perinephric fat and renal fascia covering the kidney and the suprarenal glands were dissected and removed. The hilar region was dissected carefully and the structures and their relations were clearly defined. Careful examination of the specimens was carried out to detect accessory, polar as well as aberrant polar renal arteries and the course of each artery was traced. Record of the morphological patterns of renal arteries and their relations to the renal vein was done. The number and origin of the segmental arteries were also noted. Appropriate photographs were taken after dissection and illustrative diagrams were created by one of the authors (Doaa Shuaib) for all specimens.

2- Radiological study:

Study population:

100 Radiological images (200 renal pedicles) for Egyptian patients were examined in this study (67 males and 33 females). The patients underwent renal or Aortofemoropopliteal (AFP) angiography in the Radiology Department, Faculty of Medicine, Cairo University Hospital. MDCT images were studied retrospectively over a period of 8 months (November 2016-June 2017).

Inclusion criteria:

- Male or female.
- Kidneys of adults.
- Adequate arterial phase coverage of the abdominal aorta.

Exclusion criteria:

- Any condition likely to affect the normal vascular anatomy such as horse shoe kidney or renal cell carcinoma.
- Previous donor nephrectomy or recipients of renal transplantation.
- Inadequate arterial phase coverage.

Equipments:

MDCTA was performed by using a 16-row MDCTA system (Lightspeed Ultra, GE Medical Systems, Milwaukee, Wis., USA) with the protocol acquiring CT data in the arterial and nephrographic phases. To minimize the dose of ionizing radiation, the unenhanced or venous phase images were not usually acquired.

Scanning method and data processing:

First, an initial scout image was obtained. Subsequently, 100-140ml of nonionic iodinated contrast agent (Iodixanol, Visipaque 320mgI/ml, GE Healthcare, Milwaukee, Wis.) was injected through an 18-gauge cannula positioned in an antecubital vein at a flow rate of 4ml/second by using a power injector. The estimated dose was determined according to the body weight. Patients weighing less than 45kg received 100ml. Those who had body weight of 45-90kg received 120ml and those who had body weight greater than 90kg received 150ml.

For three dimensional MDCTA volume rendering techniques were usually used, but multiplanar and maximum intensity projection images were also used especially for evaluation of the venous system or small arteries. Renal arterial anatomy was assessed primarily on arterial phase images.

Post processing techniques:

Post processed two dimensional and three dimensional reformations (Extended Brilliance Workspace, Philips Medical systems) contributed significantly for accurate evaluation. Most commonly used post processing techniques were multiplanar and curved planar reformations (MPR and CPR), Maximum Intensity Projection (MIP) and Volume Rendering (VR).

In each radiological image, the renal artery was evaluated for:

1- The level of origin in relation to vertebral bodies.

2- Caliber (diameter in mm).

3- Distance between the origin and superior mesenteric artery.

4- Presence of accessory or polar (superior or inferior) renal arteries.

5- Length in centimeters from the aortic origin till its point of branching as well as to the hilum. The branching pattern of the RA was defined as:

- *Prehilar:* If they arise at a distance of one and half to two cm from the aortic origin [10].
- *Hilar:* If they arise more than two cm from the aortic origin [10].
- *Intraparenchymal:* If they arise inside the renal sinus distal to the hilum [10].
- *Early division of the renal artery:* Was described when it divides at a distance less than one cm from the aortic origin [11].

In case of more than one renal artery, the artery that was larger in diameter and entered the kidney through the hilum was considered as the main RA.

3- *Statistical study:*

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) Version 21.0 (IBM Corporation, Somers, NY, USA) statistical software. The data were expressed as means ± Standard Deviation (SD). The frequency of nominal data was done.

The quantitative data was examined by Kolmogorov Smirnov test for normality. The independent "*t*" test was performed to compare between the different variables regarding side. p-value<0.05 was considered to be significant.

Results

Anatomical results:

A- *Early division of the main renal artery:*

In one kidney, the left RA arose from the left lateral aspect of the abdominal aorta and divided early into anterior and posterior divisions. At the hilum, the anterior division was subdivided into two segmental branches running parallel to each other (fork duplicate) pattern, while the posterior division was subdivided into three segmental branches at the hilum (fork triplicate) pattern. Two left renal veins were observed in this case; inferior and superior. They were connected to each other by two connections. The arrangement of the structures at the hilum anteroposteriorly was the anterior division of the left RA, superior renal vein, posterior division of the left RA and pelvis of the ureter. The inferior renal vein was running at a lower level below these structures Fig. (1A,B).

B- Main renal artery with superior polar artery:

In one kidney, the left RA gave a superior polar branch. The latter pierced the parenchyma of the upper pole of the left kidney away from the hilum, while the left RA continued to divide near the hilum into three segmental branches (fork triplicate pattern). At the hilum, the structures were arranged anteroposteriorly as follows; the three segmental branches of the left renal artery, the left renal vein and the pelvis of the left ureter Fig. (2).

C- Main renal artery of fork branching pattern (duplicate or triplicate):

Fork branching pattern (duplicate and triplicate) was observed in three kidneys. In one case, the left main RA divided into two segmental branches (fork duplicate pattern) close to the hilum. The upper segmental branch subdivided into three branches. The arrangement of the structures at the hilum from anterior to posterior was the left renal vein, the four segmental branches of the left main renal artery and the pelvis of the left ureter Fig. (3).

In the second case, the right main RA divided into three segmental branches (fork triplicate pattern), then the middle segmental artery was further subdivided into three branches. The arrangement of the structures at the hilum from anterior to posterior was the right renal vein, the three segmental branches of the right main RA, the two accessory renal veins and the pelvis of the right ureter Fig. (4).

In the third case, the right RA divided into three segmental branches (fork triplicate pattern) at the hilum. The superior segmental artery was further subdivided into two arteries which entered the kidney through the upper end of the hilum. The arrangement of the structures at the hilum was the right renal vein, the segmental branches of the right RA and pelvis of the right ureter Fig. (5).

D- Main renal artery of ladder branching pattern:

In one kidney, the left RA divided into four segmental branches at the hilum, which were arranged one above the other like a ladder (ladder pattern). The structures at the hilum were arranged anteroposteriorly as follows; the four segmental branches of the left main RA, the left renal vein and the pelvis of the left ureter Fig. (6).

E- *Main renal artery with six segmental branches:*

In one kidney, the right RA divided into six segmental branches, which entered the kidney through the hilum. The arrangement of the structures at the hilum was the right renal vein, the six segmental branches of the right main RA and the pelvis of the right ureter Fig. (7).

2- *Radiological and statistical study:*

A- *Level of origin of the main renal artery according to the vertebral bodies:*

The level of origin of the main RA ranged from the body of the 12th thoracic vertebra (T12) to the intervertebral disc between the second and third lumbar vertebrae (L2-L3). Out of 200 renal pedicles, three arteries (1.5%); two right and one left were seen arising at the level of T12 vertebra. Six arteries (3%); two right and two left arose at the level of the intervertebral disc between T12 and L1. Total 104 renal arteries (52%); 53 right and 51 left were seen at the level of L 1 vertebra. Twenty two renal arteries (11 %); 13 right and 9 left were recognized at the level of L1-L2 intervertebral disc. Sixty four renal arteries (32%); 29 right and 35 left were found arising at the level of L2 vertebra. Only one renal artery on the left side (0.5%) was observed at the level of L2-L3 intervertebral disc Fig. (8).

B- *The mean length, caliber and distance of the origin of main RA from the superior mesenteric artery (SMA):*

The mean length of the right main RA was found to be 5.73±1.11cm and of the left main RA was 4.81±1.15cm. The difference in the length between both sides was found to be statistically significant (p=0.000). The mean caliber of the right main RA was 6.55±1.51mm and of the left main RA was 6.99±1.47mm. The difference in the caliber was found to be statistically significant (p=0.003). The mean distance of the origin of the right main RA to the SMA was 1.35±0.60cm and that of the left main RA was 1.57±0.55cm. The difference in the mean distance was found to be statistically significant (p=0.008) (Table 1).

C- *The mean caliber of the main renal artery in absence and presence of additional arteries:*

The mean caliber of the main RA was found 6.8±1.5mm in absence of additional arteries and 6.1±1.4mm in the presence of additional arteries. This difference was found to be statistically not significant (p=0.1).

D- *Branches other than the main renal arteries:*

Out of 200 renal pedicles, 13 (6.5%) accessory renal arteries were detected. They arose from the main artery or directly from the aorta and entered the kidney through the hilum Figs. (9,10). Four (2%) superior polar renal arteries had different sources of origin and entered the kidney through the upper pole. Two arteries (1%) arose from the main RA and two arteries (1%) came directly from the abdominal aorta (aberrant superior polar) Figs. (9,11,12). Three (1.5%) aberrant inferior polar arteries were also observed Figs. (9,11). Only one case showed double renal arteries on both sides Figs. (9,13).

E- *Frequency of the branching patterns of the main renal artery:*

Out of 200 renal pedicles, prehilar branching pattern was seen in 23 arteries (11.5%). The hilar branching pattern was observed in 164 arteries (82%). The intraparenchymal branching pattern was found in 13 arteries (6.5%). Early division was detected in three arteries Fig. (14), (Table 2). The hilar branching pattern was the most commonly seen pattern in this study (p=0.000).

Table (1): Comparison between the mean length, caliber and distance of the origin of main renal artery from the SMA in both sides.

	Right Mean ± SD	Left Mean ± SD	Student's "t" test p-value
• Length of main renal artery to hilum (cm)	5.73±1.11	4.81±1.15	0.000*
• Caliber of renal artery (mm)	6.55±1.51	6.99±1.47	0.003*
• Distance from the origin to the SMA (cm)	1.35±0.60	1.57±0.55	0.008*

SMA: Superior Mesenteric Artery.
*p-value <0.05 was considered statistically significant.

Table (2): Frequency of the branching patterns of the main renal artery in both sides.

	Total (n=200)		Right (n=100)		Left (n=100)	
	N	%	N	%	N	%
Prehilar	23	11.5	2	2	21	21
Hilar	164	82	91	91	73	73
Intraparenchymal	13	6.5	7	7	6	6
Early division	3	1.5	–	–	3	3

N: Number.

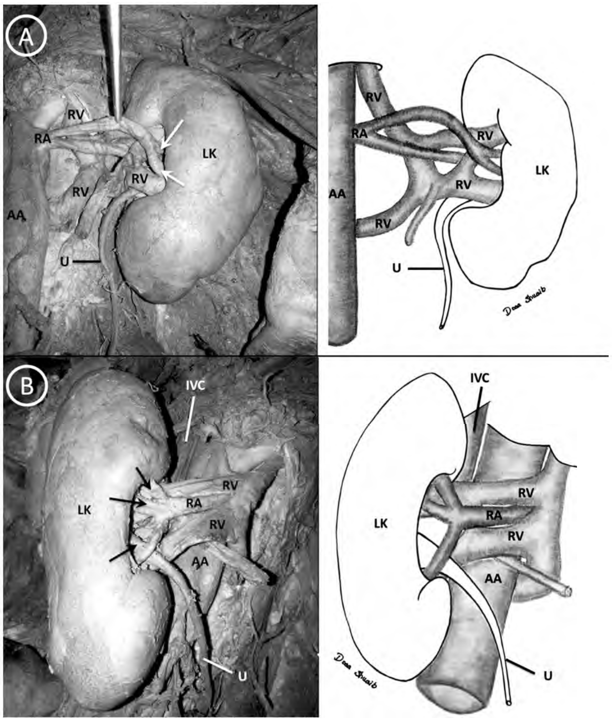

Fig. (1): Photographs and diagrams of the Left Kidney (LK) showing early division of the left Renal Artery (RA). (A): Anterior view: The anterior division is subdivided into two branches at the hilum (fork duplicate pattern) (arrows). Two Renal Veins (RV) are connected to each other. The superior vein passes through the aortic opening and the inferior vein runs behind the Abdominal Aorta (AA) to open in IVC. (B) Posterior view: (LK) the posterior division of the RA passes between the two RV. The artery divides into three branches at the hilum (fork triplicate pattern) (arrows). IVC: Inferior vana cava, U: Ureter.

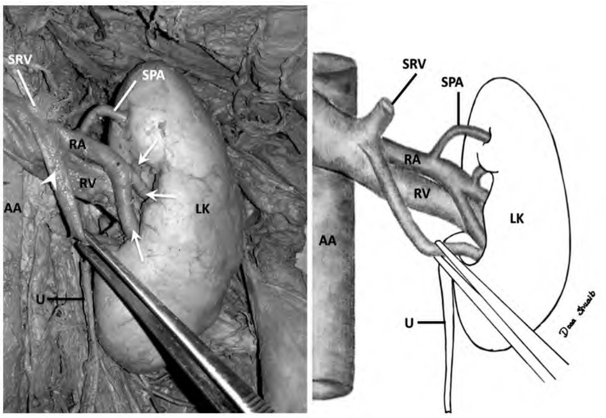

Fig. (2): A photograph and diagram of the Left Kidney (LK) showing Superior Polar Artery (SPA). At the hilum, the Renal Artery (RA) divides into three segmental branches (arrows) (fork triplicate pattern). A tributary (arrow head) emerging at the lower part of the hilum opens in the Renal Vein (RV) at the same point with the Suprarenal Vein (SRV). U: Ureter.

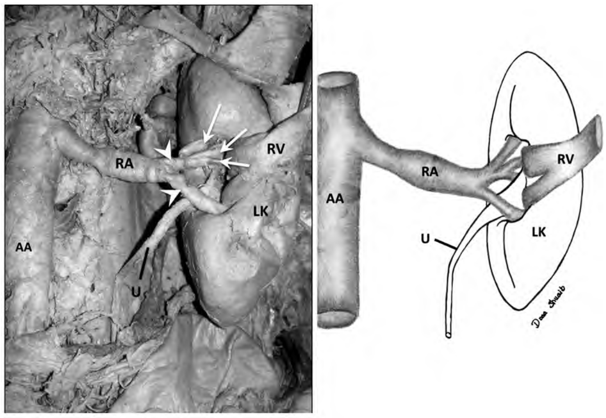

Fig. (3): A photograph and diagram of the Left Kidney (LK) showing two segmental branches (arrow heads) of the left Renal Artery (RA) (fork duplicate pattern). The upper segmental artery is subdivided into three branches (arrows). The left Renal Vein (RV) is cut and reflected. AA: Abdominal Aorta, U: Ureter.

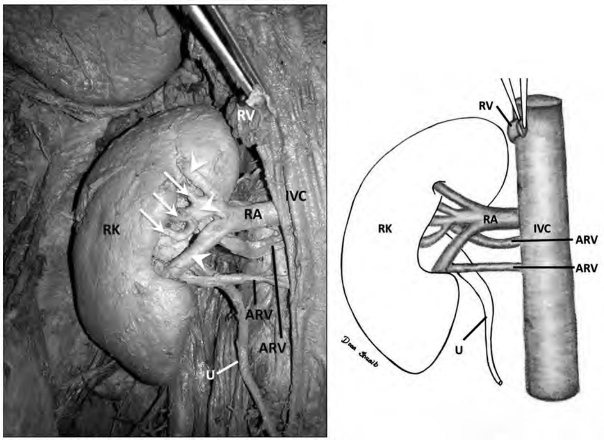

Fig. (4): A photograph and diagram of the Right Kidney (RK) showing three segmental branches (arrow heads) of the right main Renal Artery (RA) (fork triplicate pattern). The middle segmental artery is further subdivided into three branches (arrows). The right renal vein (RV) is cut and reflected. ARV: Accessory Renal Veins, IVC: Inferior Vana Cava, U: Ureter.

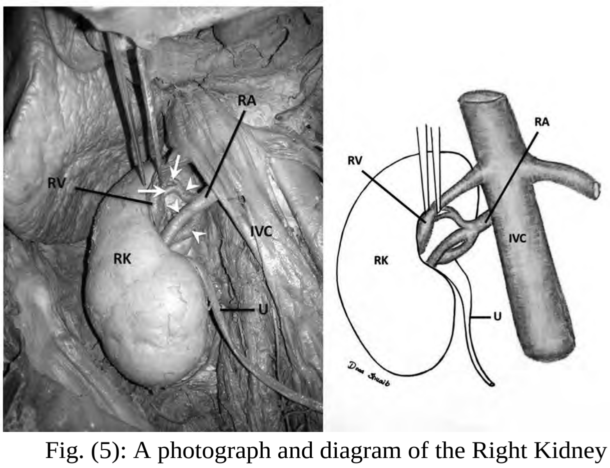

Fig. (5): A photograph and diagram of the Right Kidney (RK) showing three segmental branches (arrow heads) of the right main Renal Artery (RA) (fork triplicate pattern). The superior segmental artery is subdivided into two branches (arrow). RV: Renal Vein, IVC: Inferior Vena Cava, U: Ureter.

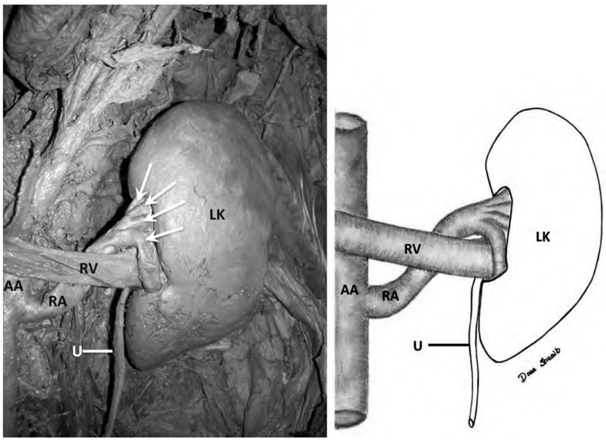

Fig. (6): A photograph and diagram of the Left Kidney (LK) showing four segmental branches (arrows) of the left main Renal Artery (RA) (Ladder pattern). RV: Renal Vein, AA: Abdominal Aorta, U: Ureter.

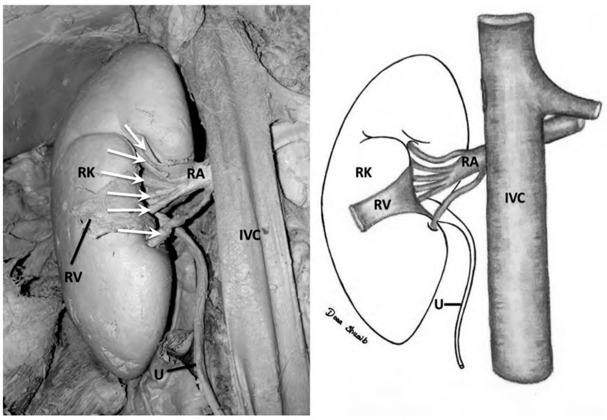

Fig. (7): A photograph of the Right Kidney (RK) showing six segmental branches (arrows) of the right Renal Artery (RA). The Renal Vein (RV) is cut and reflected. IVC: Inferior Vena Cava, U: Ureter.

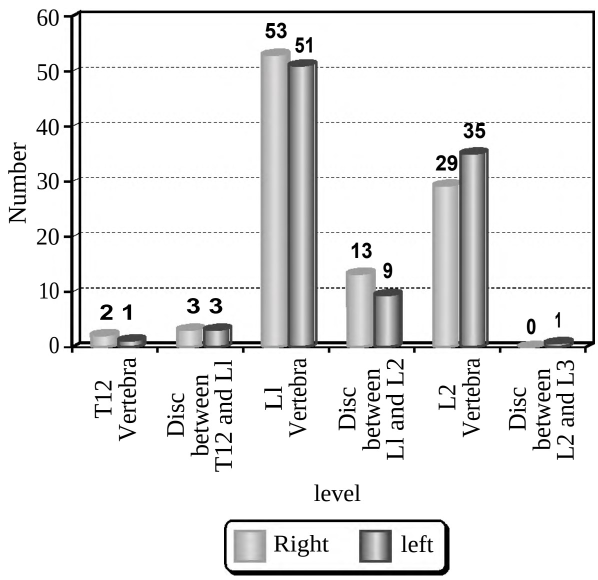

Fig. (8): Bar chart showing the level of origin of the right and left main renal arteries according to vertebral bodies.

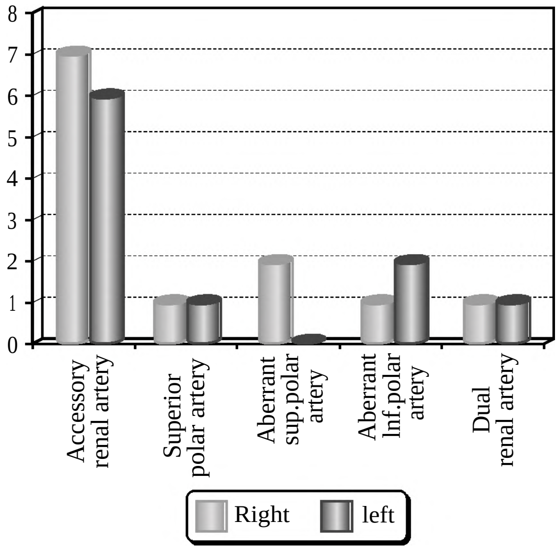

Fig. (9): Bar chart showing the frequency of branches other than the main renal arteries in both sides.

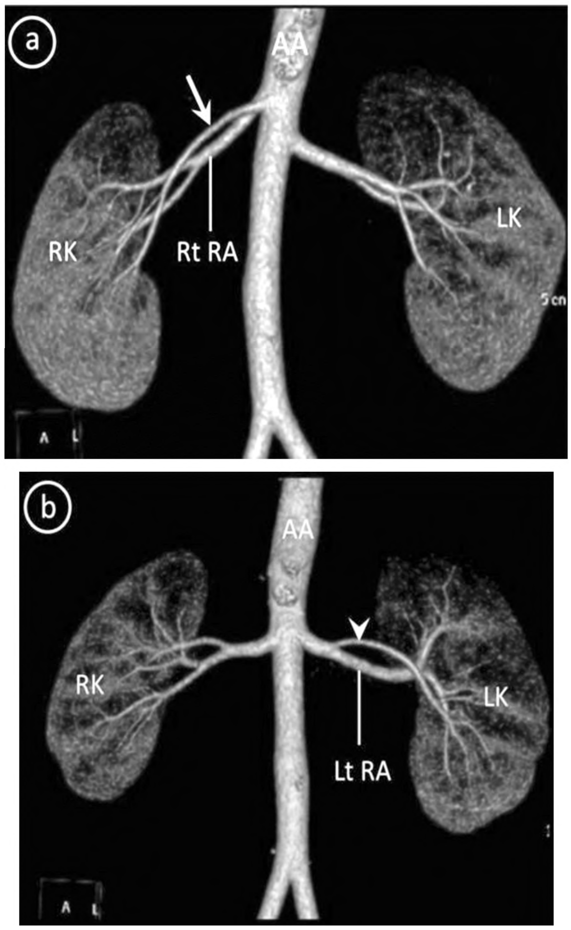

Fig. (10): Coronal volume rendering images of two male patients showing accessory renal arteries of different origin. (A): Right accessory renal artery (arrow) arises directly from Abdominal Aorta (AA). (B): Left accessory renal artery (arrow head) arises from the left main renal artery (Lt RA). Both arteries enter the kidney through the hilum. RK: Right Kidney, LK: Left Kidney, Rt RA: Right Renal Artery.

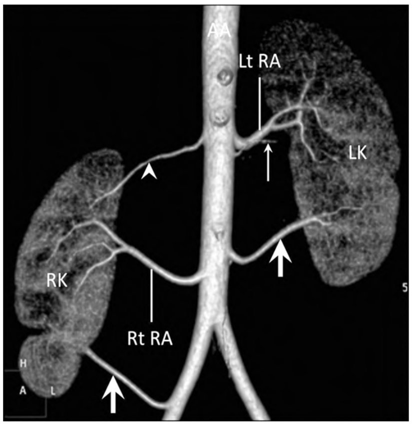

Fig. (11): Coronal volume rendering image of a male patient showing the right (Rt RA) and left (Lt RA) renal arteries at different levels. Left accessory renal artery (thin arrow) enters the hilim of the Left Kidney (LK). Right aberrant superior artery (arrow head) enters the upper pole of the Right Kidney (RK). Right and left aberrant inferior polar arteries (thick arrows) enter the lower pole of both kidneys. AA: Abdominal Aorta.

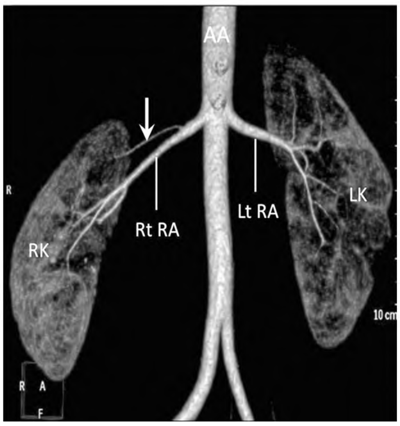

Fig. (12): Coronal volume rendering images of male patient showing superior polar artery (arrow) arises from the right main Renal Artery (Rt RA) and enters the Right Kidney (RK) from the superior pole. AA: Abdominal Aorta, LK: Left Kidney, Lt RA: Left Renal Artery.

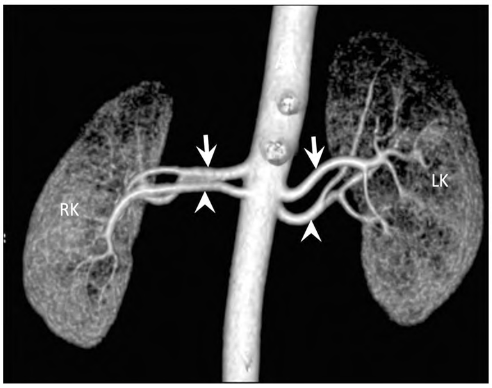

Fig. (13): Coronal volume rendering image of a male patient showing double renal arteries on both sides. On the right side, the upper right renal artery (arrow) divides near the hilum (hilar), while the lower right renal artery (arrow head) divides inside the kidney (intraparenchymal). On the left side, the upper left renal artery (arrow) divides inside the kidney (intraparenchymal), while the lower left renal artery (arrow head) divides near the hilum (hilar). AA: Abdominal Aorta, RK: Right Kidney, LK: left Kidney.

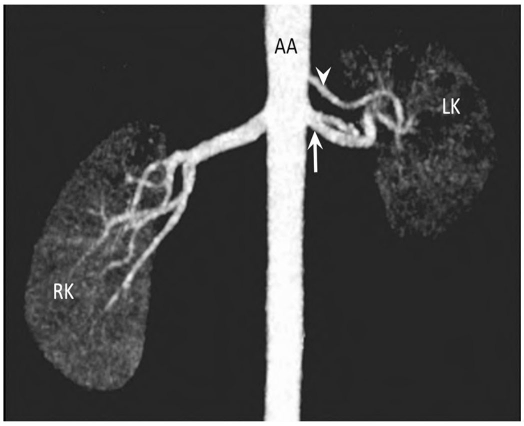

Fig. (14): Coronal maximum intensity projection image of a male patient showing early division of the left renal artery (arrow). Left accessory renal artery (arrow head) is illustrated. AA: Abdominal Aorta, RK: Right Kidney, LK: Left Kidney.

Discussion

Variations in renal vasculature are crucial due to the increase in interventional radiological procedures, urological and vascular operations and renal transplantation [12]. In the present study, the renal vasculature was studied in both cadavers and radiological images. Cadaveric dissection is important as it enables detection of small branches, accurate relations to surroundings and different branching patterns of the RA [13]. The vascular imaging is essential before surgery; however, it misses small branches less than two mm in diameter and precise relations to the surroundings [5].

In the current study, early division of the main RA was observed in the dissected cadavers as well as MDCTA images. This finding was in accordance with the data provided by Arora et al., [12] and Munnusamy el at., [11] in Indian population. Early division of the main RA in patients with multiple renal arteries should be considered by the surgeons in order to safely ligate the main RA in the living donor or perform anastomosis without stricture in recipient area. The main RA in such cases is named "precocious bifurcation" [14]. Early ramification of the renal artery could be also mistaken with the presence of additional renal arteries in diagnostic imaging, resulting in surgical complications during renal transplantations [12]. There is no clear explanation about the exact cause of early division of the RA [15].

In the present work, fork (duplicate and triplicate) and ladder branching patterns were detected in cadavers. These unusual branching patterns of the RA have been also reported by Shoja et al., [16] in Iran and Aristotle et al., [4] in India. Budhiraja et al., [1] found an additional branching pattern (net branching pattern), where the RA divided into segmental branches that arranged in away showing gaps between them like a net. This type of pattern wasn't seen in the present study.

In the current study, one cadaver showed RA with six segmental branches. Ogeng'o et al., [10] also observed cases with more than five segmental branches in Kenyan population; some of these branches entered the kidney through the poles.

In the radiological images of the present study, 52% of renal arteries were seen arising from the aorta at the level of L 1 vertebra. This finding was not consistent with Mokhasi et al., [17] who reported that the RA was detected at the level of L 1 vertebra in most of cases in cadaveric study carried out on Indian population (82% on the right and 80 & on the left).

In the current study, 1.5% of arteries were seen at the level of T 12 and 3% at the level of T 12-L 1 intervertebral disc. Natsis et al., [5] reported 2.9% of arteries at the level of T 12; however, they didn't observe renal arteries at the level of T12-L1 intervertebral disc in Greek Population. We also observed one artery at the level of L2-L3 intervertebral disc, which was in accordance with Özkan et al., [18] in Turkish population. These authors also reported renal arteries at the level of L3 vertebra unlike the present work. Variations of the level of origin of the RA are important in renal transplantation. Different levels of origin of RA are considered as a technical limitation in kidney transplantation as the leveling is important in selecting the appropriate kidney (left or right) for laparoscopic procedures [19].

In the present study, the mean length of the RA was significantly greater on the right side as compared to the left side. This has been explained by the position of the aorta to the left of the median plane. These results agreed with Palmieri et al., [20] in Brazilian population and Venkataramulu et al., [21] in Indian population.

In the current study, the mean caliber was greater on the left side as compared to the right side and this difference was statistically significant. In contrast, Tarzamni et al., [22] in Iran and Palmieri et al., [20] in Brazil didn't find statistically significant difference in the caliber between both sides. Knowing the diameter of the renal arteries and its variations is of clinical importance as the anastomosis in arteries with a diameter less than three mm is difficult and there is a great risk of thrombosis [23].

In this work, the diameter of the main RA in absence of additional arteries was less than the diameter in the presence of additional arteries; however, the difference was statistically not significant. This was in agreement with the findings of Palmieri et al., [20] in Brazilian population. In contrast, Aytac et al., [13], Tyagi et al., [24] and Venkataramulu et al., [21] found that the diameter of the main RA with additional artery was significantly less than those without additional arteries in Indian population. Venkataramulu et al., [21] reported that when the diameter of the renal artery is found less than 4.5mm, the presence of additional artery is suspected. When the diameter is found more than 5.7mm, most probably there is no additional artery.

In the present study, the mean distance from the origin of the RA to SMA was significantly greater on the left side than the right side. The results were in agreement with the data collected by Saldarriaga et al., [25] who found the distance of the right main RA to the SMA was 1.02±0.6cm and that of the left main RA was 1.12 ±0.57cm in Colombian population. In contrast, D'Souza et al., [26] and Mazzaccaro et al., [27] reported that these data were statistically not significant in Indian and Italian populations respectively.

Radiological images of the current work showed additional renal arteries in 1 1% of the cases, which was similar to the data provided by Natsis et al., [5] in Greek population (11.2%) and Ogeng'o et al., [10] in Kenyan population (14%). The finding in the present study was less than the results reported by Satyapal et al., [28] (27.7%) in Indian population and Palmieri et al., [20] in Brazilian population (61.5%), however, it was more than the data provided by Haling et al., [29] in Malaysian population (4%). This difference could be explained due to the different society, ethnicity and race. Additional arteries are clinically significant because they affect several surgical procedures, so it is necessary to know the incidence of additional arteries in each population [30].

Regarding additional renal arteries in this study, one superior polar artery was observed in a cadaver. In radiological images, two superior polar arteries (1%) from the main RA and two aberrant superior polar arteries (1%) from the abdominal aorta were detected. Superior polar and aberrant superior polar arteries have been observed by Budhiraja et al., [1], who carries out a cadaveric study in India. Bordi et al., [31] in Romania and Vatsala et al., [32] in India reported the presence of superior polar arteries in percentages of 9.2% and 12.5% respectively.

Only three aberrant inferior polar arteries (1.5%), which entered the kidney through the parenchyma of the lower pole was found in this work, which agreed with Saldarriage et al., [25] (1.8%), but it was less than results reported by Vatsala et al., [32] (12.5%). Two double renal arteries (1%) were seen in one case in the current study, which agreed the data provided by Rusu [33] in Romanian population. However, Vatsala et al., [32] reported that 50% of cases had double renal arteries in a study carried out in India.

The presence of additional renal arteries was attributed embryologically to the existence of a capillary network called rete arteriosum urogenitale that gives rise to all definitive renal arteries. The segmental lateral splanchnic arteries arise from the aorta and from the proximal portion of this network [34]. These arteries disappear during development, but they may persist as additional renal arteries. Other explanations are genetic background, oxygenation and hemodynamic changes [29].

Additional renal arteries complicate the renal transplantation and may cause post-operative bleeding, renovasculare hypertension and rejection of the transplanted kidney [34]. There is no intrarenal anastomosis between the multiple segmental renal arteries as they are end arteries. Therefore, the urologist should preserve each additional RA to save the renal segments by anastomosing both the main and additional artery during transplantation [5].

In the present work, the most commonly seen branching pattern in MDCTA images was the hilar (82%), followed by prehilar (11.5%) then intaparynchymal branching pattern (6.5%). The observation of the hilar pattern as the most common branching pattern was also reported by Agarwal et al., [3] in Indian population. This finding disagreed with the study conducted by Palmieri et al., [20] who mentioned that the prehilar branching pattern was the most common pattern in Brazilian population. The incidence of the prehilar branching pattern was more on left side (21 %) as compared to the right side (2%). These observations supported the findings of Raman et al., [35] in USA and Ogeng'o et al., [10] in Brazil. Prehilar branching pattern is important as it is similar to the additional renal arteries. Both conditions make laparoscopic nephrectomy more difficult because surgeons need RA with two centimeters neck free of branches during surgery [25].

Conclusion:

- Variations of the RA are common in Egyptian population. The most important variations are the presence of additional arteries and different branching patterns.
- Variations in renal vasculature in relation to population and side should be taken in consideration during radiological, vascular and urological interventions.
- The data obtained from the current work will encourage further studies concerning evidence-based teaching resources of anatomical variations in RA in the Egyptian population.

Limitations:

Dissected cadavers were used for descriptive purpose only due to limited numbers of specimens.

Author contributions:

Al Moatasem-Bellah M. Al-Sherif : Project development, critical revision of manuscript.

Ahmed S. Awad: Data collection, interpretation of findings.

Doaa M. Shuaib: Manuscript writing, photograph taking, drowning of diagrams, editing and critical revision of manuscript.

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Compliance with ethical standards:

Conflict of interest: The authors declare no conflict of interest.

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الأختلافات فى الشريان الكلوى عند المصريين: دراسة بإستخدام الجثث والتصوير الوعائى

يهدف هذا البحث إلى دراسة تشريح الشريان الكلوى وإختلافاته التشريحية عند المصريين بإستخدام الجثث والتصوير المقطعى المتعدد للأوعية الدموية.

أجريت هذه الدراسة على ٧ كلى تم الحصول عليها من جثث محنطة بقسم التشريح وعلم الأجنة بكلية الطب جامعة القاهرة. كما شملت الدراسة ١٠٠ أشعة (٢٠٠ شريان كلوى) تم الحصول عليها من قسم الأشعة بكلية الطب، مستشفى قصر العينى.

لقد لوحظت إختلافات بالشريان الكلوى أثناء تشريح عينات الكلى مثل وجود شريان قطبى علوى بالإضافة إلى الأنقسام المبكر للشريان الكلوى الرئيسى. كما لوحظ أنماط مختلفة للتفرع وفقاً لشكل الفروع مثل النمط الشوكى (ثنائى وثلاثى) والنمط السلمى.

أثناء دراسة الأشعات، لوحظ تباين فى مستوى منشأ الشريان الكلوى الرئيسى ومتوسط طول الشريان الكلوى. شوهدت أيضاً شرايين إضافية (شرايين كلوية زائدة، شرايين قطبية علوية، شرايين قطبية سفلية وشرايين كلوية مزدوجة). كذلك وجد أنماط مختلفة لتفرع الشريان الكلوى الرئيسى مثل أنقسام الشريان الكلوى عند مدخل الكلى، ما قبل مدخل الكلى وداخل الكلى.

يمكن إستنتاج أن الأختلافات التشريحية فى الشريان الكلوى شائعة عند المصريين ولذلك ينبغى الأخذ فى الأعتبار هذه الأختلافات فيما يتعلق بالسكان والجانب خلال التدخلات الإشعاعية وعمليات المسالك البولية.