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ORIGINAL RESEARCH

Study of variations in the origin of renal arteries by computed tomography

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Abstract
The aim of present study was to find the variations in the level of origin of renal arteries in relation to vertebrae and diameter by computed tomography. The scan films of abdomen of 300 patients were examined. The body of vertebra was divided into three parts, upper 1/3rd, middle 1/3rd and lower 1/3rd. The inter-vertebral disc was also considered. Each artery was divided into four types (Type I to Type IV) depending on the level of origin. Statistical analysis of data was done. The most common origin of Right Renal Artery was at L2 vertebra (2nd lumbar vertebra) in 61.33% of cases and L2 Type III was most common. The variations were observed in 38.67% of cases. The Left Renal Artery had shown most common origin at L2 vertebra in 61.67% of cases and L2 Type II was most frequent. The variations were observed in 38.33% of cases. The mean diameter of Right Renal Artery and Left Renal Artery was 6.04 mm and 5.90 mm respectively. The correlation of diameter of Right Renal Artery and Left Renal Artery was calculated with Pearson correlation coefficient which was significant with p-value <0.05. Accessory Renal Arteries were observed in 5.6% of cases. The diameter of main Renal Artery with Accessory Renal Artery was smaller than diameter of the main Renal Artery without Accessory Renal Artery. It was concluded that knowledge of variations in the Renal Arteries can be useful in renal transplantation and other surgical procedures of kidneys.
Key words: Accessory Renal Arteries**,** Diameter, Renal Arteries, Variations, Vertebrae

Introduction
The blood supply of each kidney is normally from single renal artery which arises from abdominal aorta at the level of intervertebral disc between L1-L2 vertebrae. Each artery enters the kidney at its hilum and divides into interlobar arteries in the renal sinus which are known as arcuate arteries. Arcuate arteries give rise to intralobular arteries [1]. Renal arteries are known for variations in their morphology. The knowledge of variations is important in renal transplantations and conservative renal surgeries [2]. Dogra and coworkers studied the variations in the renal arteries by 64 slice multidetector computed tomography on 100 patients of age between 18-80 years (86 males and 18 females). The most common origin of

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main renal artery in both the kidneys was at the level of intervertebral disc between L1-L2 lumbar vertebrae [3]. Palmieri in his study on the prevalence and distribution of renal arteries in 100 subjects by computed tomography angiography in Brazil, observed multiple renal arteries in 61.5% of cases. These were more frequent on the left side than on right side. The origin of renal arteries was more frequent between L1 and L2 vertebrae. Diameter was not affected by presence of multiple renal arteries [4].

Budhiraja and coworkers in a cadaveric study on 37 cadavers in Subharti Medical College, Meerut, India found the morphological variations of renal arteries. They used the term supernumerary renal arteries for accessory renal arteries. Supernumerary renal arteries were present in 62.2% of cases and single renal artery was present in 37.8 % of the cases. Authors stated that information of supernumerary renal arteries is important in the kidney transplantation as these may result in graft rejection [5]. In a retrospective study in Pondicherry, India, the authors examined Contrast Enhanced Computed Tomography scans of abdomen of the 200 patients. Renal arteries showed normal pattern in 79% of cases and variations were observed in 21% of cases [6].

TAO Xiano-feng and coworkers determined the prevalence of renal artery variations by Dual-Energy Computed Tomography (DECT) in 378 patients in radiology department of Tongi University, China. There were 197 males and 181 females between the age of 20-90 years. They divide the renal arteries into Type I and Type II. Type I: One main renal artery. Type II: Main renal artery with accessory renal arteries. Right renal artery variations were observed in 11.1% of cases and left renal artery variations were observed in 12.4% of cases. Bilateral renal artery variations were found in 4.5% of cases. Incidence of renal artery variations was 28% of population. In case of males, renal artery variations were seen in 32.0% of cases and in females in 23.8% of cases but this difference was not statistically significant. Types of variations between right and left side of kidneys did not show statistical differences [7].

Chhetri and coauthors did a study on anatomical variations of renal arteries by computed tomography in a medical college at Bharatpur, Nepal. Computed tomography scans of 400 patients were examined. They observed that the arterial supply to both the kidneys was normal in 67.75 % of patients. In remaining 32.25% of the patients, variations were observed in either kidney or both the kidneys. Among these 72.09% of patients, had unilateral variations and 27.91% of patients had bilateral variations. The most common unilateral variation was one polar artery in 70.97% of cases. There was no statistically significant association observed between renal artery variation and gender. Renal artery variations were seen in one-third of cases. Unilateral variations were more common than bilateral variations [8].

Toro J and coworkers did a study in Universidad hospital, Colombia to find the prevalence of renal artery variations by 3D computed tomography angiography. Variations were found in 52% of patients and 77% of cases were with unilateral variations and 33% had bilateral variations. Among bilateral variations, right side variations were more frequent than left side and more common in males than females [9].

Material and methods

The present study was conducted at the department of Anatomy and department of Radiodiagnosis of Adesh Institute of Medical Sciences and Research, Bathinda. The Computed Tomography scan films of abdomen of 300 patients were examined who visited the department of Radiodiagnosis for other reasons. The duration of research period was two years and four months. The Computed Tomography machine used in this research, was 32-Slice Siemens Somatum Go Up with inbuilt Syngo software. To determine the level of origin of artery, the body of vertebra was divided into three parts: upper 1/3rd, middle 1/3rd and

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lower 1/3rd as shown in Figure 1. The intervertebral disc was also considered. Each artery was divided into four types (Type I to Type IV) depending on the level of origin.

1. **Type I:** The origin was at intervertebral disc.
2. **Type II:** The origin was at upper 1/3rd of body of vertebra.
3. **Type III:** The origin was at middle 1/3rd of body of vertebra.
4. **Type IV:** The origin was at lower 1/3rd of body of vertebra [Figure 2 a, 2 b, 2 c and 2 d].

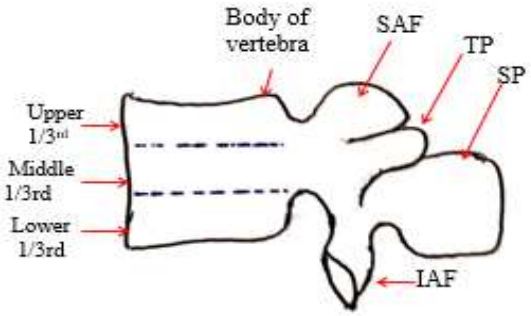

Figure 1. The division of vertebral body into upper 1/3rd , middle 1/3rd and lower 1/3rd. SAF – Superior Articular Facet, TP – Transverse Process, SP – Spinus Process and IAF – Inferior Articular Facet.

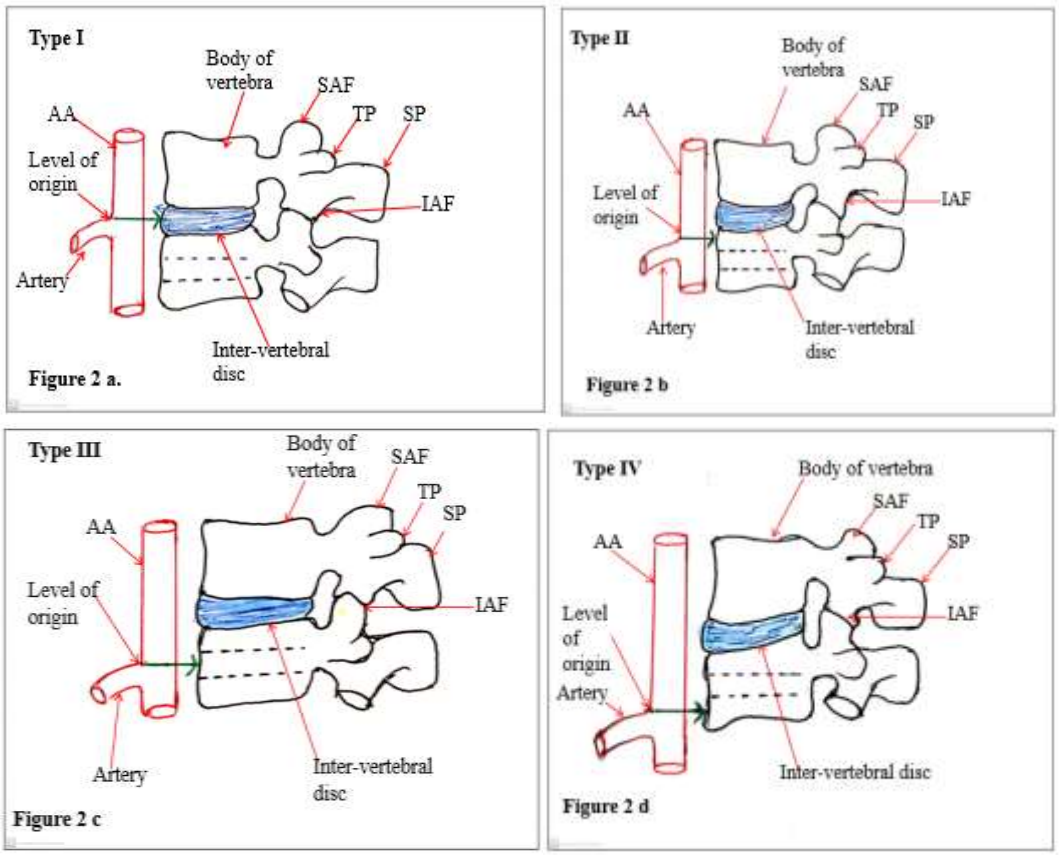

Figure 2 a, 2 b, 2 c and 2 d schematic diagrams showing the Type I, Type II, Type II and Type IV respectively. AA - Abdominal Aorta, Green arrow shows level of origin of

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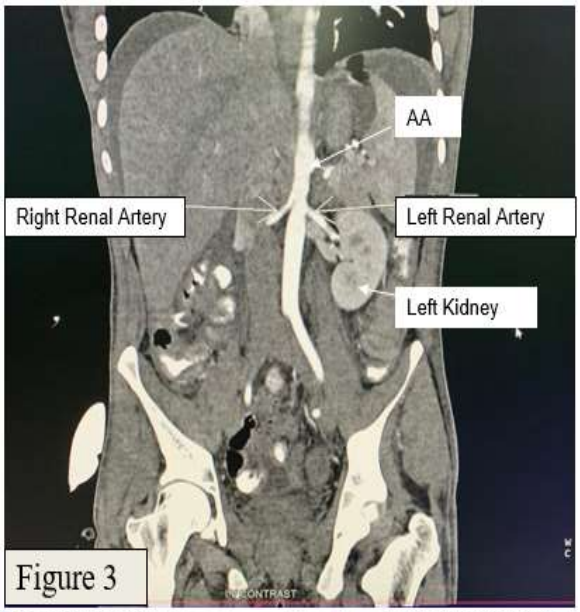
artery from AA, SAF - Superior Articular Facet, TP - Transverse process, SP - Spinus Process, IAF - Inferior Articular Facet.



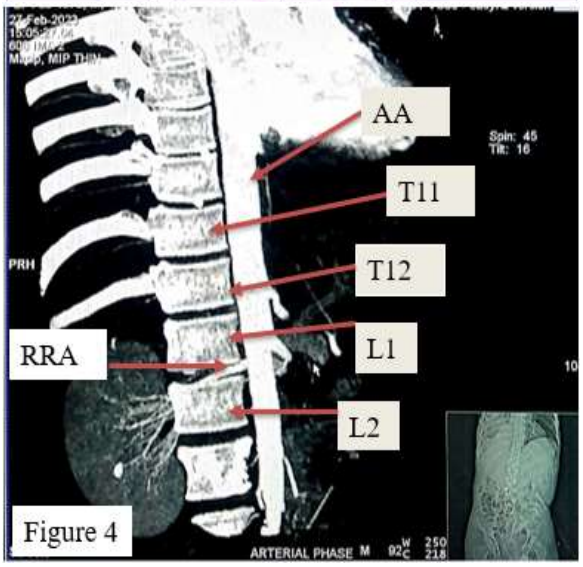


Figure 3. Computed Tomography scan of abdomen (Coronal Section) showing the origin of Right Renal Artery (RRA) and Left Renal Artery (LRA) from Abdominal Aorta (AA).

Figure 4. Computed Tomography scan of abdomen (Sagittal section) showing the origin of Right Renal Artery from Abdominal Aorta (AA) at the level of intervertebral disc between L1-L2 lumbar vertebrae (Type I). T11- 11th thoracic vertebra and T12 - twelfth thoracic vertebra, L1 - 1st lumbar vertebra and L2 - 2nd lumbar vertebra.

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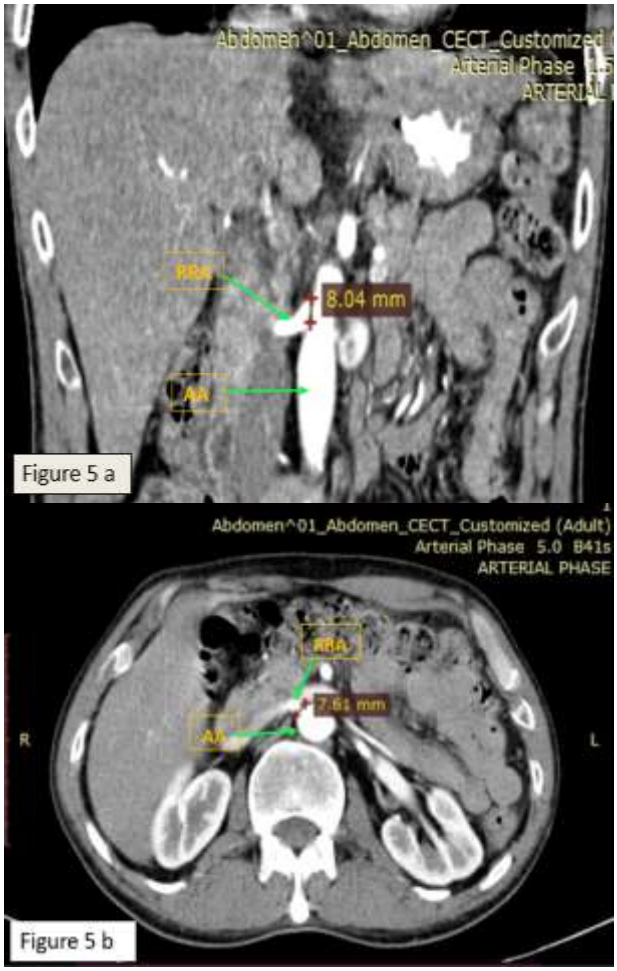

Figure 5 a. Computed Tomography scan of abdomen coronal section showing the measurement of Vertical Diameter of Right Renal Artery. VD = 8.04 mm
Figure 5 b. Computed Tomography scan of abdomen horizontal section showing the measurement of Horizontal Dimeter of Right Renal Artery HD = 7.61 mm. Mean of VD and HD = 7.82 mm was taken as final diameter.

Results:
1.Variations of Right Renal Artery:
In case of RRA, the most common level of origin was at L2 vertebra (61.33%) and variations were observed in 38.67% of cases. The most common type was L2 Type III (25.33%). The rarest type was L2-L3 Type I (1%) as shown in **Table 1.**
Table 1. Right Renal Artery vertebral levels and Types in percentage.

Right Renal Artery		**Type I n (%)**	**Type II n (%)**	**Type III n (%)**	**Type IV n (%)**	**Total n (%)**
RRA Vertebra	T12	0(0)	0(0)	0(0)	0(0)	0(0)
	T12-L1	0(0)	0(0)	0(0)	0(0)	0(0)
	L1	0(0)	11(3.67)	28(9.33)	23(7.67)	62(20.67)
	L1-L2	9(3)	0(0)	0(0)	0(0)	9(3)
	L2	**0(0)**	**74 (24.67)**	**76 (25.33)**	**34 (11.33)**	**184 (61.33)**
	L2-L3	3(1)	0(0)	0(0)	0(0)	3(1)

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	L3	0(0)	23(7.67)	7(2.33)	12(4)	42(14)
Total		12(4)	108(36)	111(37)	69(23)	300(100)

Types of Right Renal Artery observed were:

1. L1Type II, L1 Type III and L1 Type IV.
2. L1-L2Type I.
3. L2 Type II, L2 Type III and L2 Type IV.
4. L2-L3 Type I.
5. L3 Type II, L2 Type III and L3 Type IV.

2. Variations of Left Renal Artery

In the case of LRA, the most common origin was at the level of L2 vertebra in 61.67% of cases and variations were found in 38.33% of cases. The most common type was L2 Type II (42%). The rarest type was T12 Type II (0.33%) as shown in **Table 2.**

Table 2. Left Renal Artery vertebral level of origin and Types in percentage

Left Renal Artery		**Type I n (%)**	**Type II n (%)**	**Type III n (%)**	**Type IV n (%)**	**Total n (%)**
LRA vertebra	T11-T12	0(0)	0(0)	0(0)	0(0)	0(0)
	T12	0(0)	1(0.33)	0(0)	0(0)	1(0.33)
	T12-L1	0(0)	0(0)	0(0)	0(0)	0(0)
	L1	0 (0)	40 (13.33)	15 (5)	16 (5.33)	71 (23.67)
	L1-L2	8(2.67)	0(0)	0(0)	0(0)	8(2.67)
	L2	**0 (0)**	**126 (42)**	**44 (14.67)**	**15 (5)**	**185 (61.67)**
	L2-L3	3(1)	0(0)	0(0)	0(0)	3(1)
	L3	0(0)	23(7.67)	6(2)	3(1)	32(10.67)
Total		11 (3.67)	190 (63.33)	65 (21.67)	34 (11.33)	300 (100)

Types of Left Renal Artery observed were:

1. T12 Type II
2. L1Type II, L1 Type III and L1Type IV.
3. L1-L2 Type I
4. L2 Type II, L2-Type III and L2 Type IV.
5. L2-L3Type I.
6. L3 Type II, L3 Type III and L3 Type IV.

Variations in the diameter of Right Renal Artery and Left Renal Artery:

The mean diameter of Right Renal Artery and Left Renal Artery was 6.04± 0.59 mm and 5.90±0.58 mm respectively as shown in **Table 3.**

Table 3. Mean diameter and SD of Right Renal Artery and Left Renal Artery. Total cases=300

Name of artery	**Mean (mm) ± SD**	**Range (Min – Max) mm**
Right Renal Artery	6.04 ± 0.59	4.50 – 7.30
Left Renal Artery	5.90 ± 0.58	4.05 – 7.20

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Diameter of Right Renal Artery had shown significant correlation with diameter of Left Renal Artery as r-value=0.878 with p-value <0.05 as shown in the **Table 4.**

Table 4. Correlation of diameter of Right Renal Artery and Left Renal Artery

Name of Artery	Pearson correlation (r-value)		p-value
	RRA	LRA	
Right Renal Artery	-	0.878	<0.05
Left Renal Artery	0.878	-	<0.05

Comparison of diameter of Right Renal Artery and Left Renal Artery in gender:

To determine the correlation of diameters of RRA and LRA in males and females, t-test was applied. It was significant with p-value <0.05 as shown in **Table 5.**

Table 5. Comparison of diameter of RRA and LRA in males and females. Total cases=300

Name of artery	Gender	Mean ± SD	Minimum diameter in mm	Maximum diameter in mm	p-value
RRA	Male	6.38±0.54	4.75	7.30	<0.05
	Female	5.58±0.23	4.50	5.90	
LRA	Male	6.21±0.56	4.20	7.20	<0.05
	Female	5.49±0.25	4.05	5.75	

Comparison of diameter of Right Renal Artery in males and females with age groups:

In case of RRA, in males, the maximum and minimum mean diameters were shown by age group 61-70 years and group 21-30 years respectively. In females the maximum and minimum mean diameter was shown by group 51-60 years and 21-30 years respectively as shown in the **Table 6.**

Table 6. Comparison of diameter of Right Renal Artery in Males and Females with age groups.

Age groups	Male	Female
	Mean±SD	**Mean±SD**
21- 30 years	**5.73±0.13**	**5.32±0.33**
31-40 years	6.10±0.46	5.51±0.16
41-50 years	6.17±0.32	5.72±0.08
51-60 years	6.60±0.27	**5.78±0.09**
61-70 years	**7.01±0.29**	5.57±0.16
71-80 years	6.74±0.35	5.53±0.05
81-90 years	6.72±0.06	5.47±0.03

Comparison of diameter of Left Renal Artery in Males and Females with age groups:

In males, the maximum mean diameter and minimum mean diameter was shown by group 61-70 years and group 21-30 years respectively. In females, the maximum and minimum mean diameters were shown by group 51- 60 years and group 21- 30 years respectively as shown in the **Table 7.**

Table 7. Comparison of diameter of Left Renal Artery in Males and Females with age groups.

Age groups	Male	Female
	Mean±SD	**Mean±SD**
21- 30 years	**5.60±0.37**	**5.25±0.33**

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31-40 years	5.97±0.43	5.37±0.24
41-50 years	6.10±0.33	5.54±0.21
51-60 years	6.19±0.30	**5.63±0.17**
61-70 years	**6.81±0.37**	5.58±0.17
71-80 years	6.62±0.56	5.55±0.04
81-90 years	6.72±0.05	5.60±0.01

Accessory Renal Arteries

In the present study, the bilateral and unilateral Accessory Renal Arteries (Acc RA) were observed in 17(5.66 %) cases out of 300 cases. The bilateral Accessory Renal Arteries were observed in 11 cases (1.33%) out of 17 cases of Accessory Renal Arteries. The unilateral Accessory Left renal arteries were found in 6 cases. The unilateral Accessory Right Renal Arteries were not found in this study as shown in the **Table 8.** The bilateral Accessory Renal Arteries were more in number in males (2.33%) as compared to females (1.33%) and unilateral Accessory Left Renal Arteries (Acc LRA) were also more in males (1.33%) as compared to females (0.66%) as shown in **Table 8.**

Table 8. Distribution of Cases according to Bilateral and Unilateral Accessory Renal arteries in gender.

Bilateral Acc RA	**Male n (%)**	**Female n (%)**	**Total n (%)**
	7 (2.33)	4 (1.33)	11(3.66)
Unilateral Acc LRA	4 (1.33)	2 (0.66)	6 (2)
Unilateral Acc RRA	0	0	0
Total	11(3.66)	6 (2)	17 (5.66)

DISCUSSION

Renal arteries are known for variations in their morphology. The knowledge of variations is important in renal transplantations and conservative renal surgeries [2]. Renal artery transplantation becomes necessary in the patients who have end stage renal failure and treatment with drugs does not give beneficial results [10].

Renal artery variations may be related to their origin, number and distribution [11]. Abuelnaur and coworkers did a meta-analysis on prevalence of variations in origin and number of renal arteries. They included 14 studies based on vertebral level of origin. They concluded that the most common level of origin of main renal artery was at the level of L1 lumbar vertebra, with prevalence 20.37%. The least common level of origin was at the T12 vertebra in 0.38% of cases [12].

In the present study, the most common level of origin of Right Renal Artery was at L2 vertebra in 61.33% of cases, second most common origin was at the level of L1 vertebra in 20.67% of cases. The least common origin was at the level of intervertebral disc between L2-L3 lumbar vertebrae **(Table 1).** Variations were observed in 38.67% of cases. In the case of Left Renal Artery, the most common level of origin was at the L2 vertebra in 61.67% of cases, second most common origin was at the level of L1 vertebra in 23.67% of cases. The least common origin was at the level of T12 vertebra in 0.33% of cases. Variations were shown in 38.33% of cases **(Table 2).**

Table 9. Comparison of percentage of variations of present study with previous studies:

Authors	**Percentage of variations**	
	Right Renal Artery (RRA)	**Left Renal Artery (LRA)**
Mokhasi's study (2011)	20%	18%

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Santhil's study (2018)	40%	38%
Fataftha's study (2018)	59%	59.5%
Present study (2022)	38.67%	38.33%

In the present study, the prevalence of variations in the level of origin of Right and Left Renal Arteries was 40% and 38% respectively, which was close to Santhil's study [13]. Whereas Mokhasi's study had shown less prevalence of variations in the origin of Right Renal Artery and Left Renal Artery in 20 % and 18 % of cases respectively as compared to present study [14]. Fataftha's study had shown very high percentage of variations in Right Renal Artery and Left Renal Artery which was 59% and 59.5% respectively [15].

Dogra and coworkers did a multidetector computed tomography study on 100 patients (86 males and 14 females, age group 18-80 years) in a primary health center in north India. Most common level of origin of main renal artery was between L1 to L2 vertebrae in 99% of cases and this level of origin was close to present study [3].

Animaw's cadaveric study in a medical school at Ethopia on 30 cadavers (25 males and 5 females) had shown the most common level of origin of Right Renal Artery at the disc between L1-L2 vertebrae in 57.7% of cases and in case Left Renal Artery, the most common origin was at L1 vertebra in 53.6% of cases [11].

Accessory Right Renal (Acc RRA) and Accessory Left Renal Arteries (Acc LRA):

During embryonic development, the mesonephros, metanephros, adrenals and gonads are supplied by paired mesonephric arteries which are branches of dorsal aorta [16]. The caudal branches usually disappear and single artery persists which supplies the kidney of its side. When more than one of lateral mesonephric arteries persists, multiple renal arteries are formed [4].

The multiple renal arteries supply the blood to kidney, are named as accessory or aberrant renal arteries. They are estimated to be found in 30% of cases. Several studies have reported the racial differences in the anatomy of main renal artery and Accessory Renal Arteries [11]. In the present study Accessory Renal Arteries on left side were more in number (5.66%) as compared to right side (3.6%). Accessory Renal Artery variations may range from 13.3% to 36.1% as reported from previous studies [17]. Greece population reported 27.4% cases of Accessory Renal Arteries [18]. The presence of Accessory Renal Arteries is most common variation in the blood supply of kidneys. These may take origin from abdominal aorta, from main renal artery or from some branches of abdominal aorta. They are important in renal and abdominal aorta surgeries [19].

The presence of Accessory Renal Arteries may be associated with genetic background, oxygenation and hemodynamic changes. Accurate knowledge of Renal Arteries and Accessory Renal Arteries is important in the renal artery stenosis, renal transplantation procedures, treatment of renovascular hypertension. Any pathology present in the upper or lower pole of kidney would need special care in the case of Accessory Renal Arteries supplying these parts [16].

Diameter of Renal Arteries

Diameter of renal arteries have great importance in kidney transplantation procedures. In the present study mean diameter of Right Renal Artery had shown significant correlation with mean diameter of Left Renal Arteries having p-value <0.05. The mean diameter of renal arteries in males was significantly higher than mean diameter of renal arteries in females with p-value <0.05. The mean diameter had shown increase with advancing age. In the both Right Renal Arteries and Left Renal Arteries, mean diameter increases from age 21-70 years in males and then decreased from 71-90 years in males and in females, the mean diameter increased from 21- 50 years and then decreased from 61-90 years. It can be explained on the

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basis that increase may be due to pressure effects of blood with advancing age and decrease may be due to hypoplastic effects of vessel wall with advancing age. It was observed that the mean diameter of main Renal Artery was less in the presence of accessory renal arteries.

Conclusion

From the present study, it can be stated the renal arteries show variations in their level of origin, number and diameter that can be helpful to the surgeons during operative procedures on kidneys. The complications during treatment and after treatment can be avoided.

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References

1. Gulas E, Wysiadecki G, Szymański J, Majos A, Stefańczyk L, Topol M, Polguj M. Morphological and clinical aspects of the occurrence of accessory (multiple) renal arteries. Archives of Medical Science. 2018 Mar 1;14(2):442-53.
2. Aristotle S, Felicia C. Anatomical study of variations in the blood supply of kidneys. Journal of Clinical and Diagnostic Research. 2013 Aug;7(8):1555.
3. Dogra A, Chauhan RS, Sharma S, Partap A, Diwan Y, Chawla K, Negi K, Rana S, Diwan D. Variations of renal arteries on 64 slice Multidetector Computed Tomography. Journal of the Anatomical Society of India. 2017 Jun 1;66(1):20-5.
4. Palmieri BJ, Petroianu A, Silva LC, Andrade LM, Alberti LR. Study of arterial pattern of 200 renal pedicle through angiotomography. Revista do ColégioBrasileiro de Cirurgiões. 2011; 38:116-21.
5. Budhiraja V, Rastogi R, Anjankar V, Babu CS, Goel P. Supernumerary renal arteries and their embryological and clinical correlation: a cadaveric study from north India. International Scholarly Research Notices. 2013; 2013:1-4.
6. Purushothama Raju N. Variants of Coeliac Trunk, Hepatic Artery and Renal Arteries in Puducherry Population Yash Kumar Achantani, Purushothama Raju N, Ramesh Kumar. International Journal of Anatomy, Radiology and Surgery.2018 Jan, Vol-7(1): 38-43.
7. Tao XF, Zhu JQ, Wu YW, Tang GY, Shi YZ, Zhang L, Lin Y. Dual-energy computed tomography angiography for evaluating the renal vascular variants. Chinese medical journal. 2013 Feb 20;126(04):650-4.
8. Chhetri PK, Basnet P, Adhikari A. Anatomical Variations of Renal Artery in Patients Undergoing Computed Tomography of Abdomen: A Hospital-based Cross-sectional Study. Journal of Lumbini Medical College. 2021 Aug 29;9(2):7-pages.
9. Toro JS, Prada G, Takeuchi SY, Pachecho R, Baena G, Granados AM. Anatomic variations of the renal arteries from a local study population using 3D computed tomography angiography reconstruction images from a reference hospital in Cali, Colombia. Artery Research. 2016 Jun 1; 14:22-6.
10. Sungura RE. The CT angiography pattern of renal arterial anatomy among Africans and its implication on renal transplantation. (Dissertation, University of Nairobi, 2012).
11. Animaw Z, Worku A, Muche A. Renal artery origins, destinations and variations: Cadaveric study in Ethiopian population. International Journal of Anatomical Variations. 2018;11(1).
12. Abuelnour MA, Faiz YM, Abubaker ET. A systematic review of the prevalence of anatomical variations of the renal artery. La Prensa Medica Argentina. 2020;6(6):1-6.
13. Senthil Kumar J. A study of the extent, branching pattern and applied aspects of abdominal aorta (Doctoral dissertation, Stanley Medical College, Chennai).2018

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 02, 2023

14. Mokhasi V, Rajini T, Shashirekha M. The abdominal aorta and its branches: anatomical variations and clinical implications. Folia morphologica. 2011;70(4):282-6.
15. Fataftah J, Amarin JZ, Suradi HH, Hadidi MT, Shatarat AT, Al Manasra AR, Shahin S, Badran DH. Variation in the vertebral levels of the origins of the abdominal aorta branches: a retrospective imaging study. Anatomy & Cell Biology. 2020 Sep 30;53(3):279-83.
16. Hlaing KP, Das S, Sulaiman IM, Abd-Latiff A, Abd-Ghafar N, Suhaimi FH, Othman F. Accessory renal vessels at the upper and lower pole of the kidney: a cadaveric study with clinical implications. Bratisl Lek Listy. 2010 Jan 1;111(5):308-10.
17. Johnson PB, Cawich SO, Shah SD, Aiken W, McGregor RG, Brown H, Gardner MT. Accessory renal arteries in a Caribbean population: a computed tomography-based study. Springerplus. 2013 Dec; 2:1-5.
18. Papaloucas C, Fiska A, Pistevou-Gombaki K, Kouloulias VE, Brountzos EN, Argyriou P, Demetriou T. Angiographic evaluation of renal artery variation amongst Greeks. Aristotle University Medical Journal. 2007;34(2):43-7.
19. Prevljak S, Prelevic E, Mesic S, Abud OA, Kristic S, Vegar-Zubovic S. Frequency of accessory renal arteries diagnosed by computerized tomography. Acta Informatica Medica. 2017 Sep;25(3):175.