

The Accessory Renal Arteries: A Comparative Study in Vertebrates with Its Clinical Implications

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ABSTRACT

Anomalous blood vessels are always interesting from a purely scientific point of view, especially since they so often shed light on obscure problems of phylogeny and ontogeny. The evolutionary history of kidney & renal artery is recapitulated during embryonic development. Most of the variations of human renal vessels can be explained on the basis of phylogeny as many conditions which are anomalous in human are normally present in some animals. The most common variation of renal artery is the presence of an accessory renal artery, occurring in approximately 30% of cases.

Aims: The present study was undertaken with the aim to study the accessory renal artery in human as well as in some other vertebrates and to make an attempt to explain them on ontogenetic & phylogenetic basis.

Materials and Methods: Material of this study comprised of 30 adult human cadavers (60 sides) and 30 animals of specified

vertebrate series. These were dissected to expose the kidneys and their arterial supply. The renal and accessory renal arteries were traced up to their origin from abdominal aorta.

Result and Discussion: In this study, in all experimental animals except mammals multiple renal arteries were found. In human beings the accessory renal arteries were found in 17(28.3%) kidneys. All of these were compared for understanding of the phylogeny and ontogeny of accessory renal arteries. Further an attempt has been made to discuss their clinical and surgical significance.

Conclusion: We as anatomist believe that knowledge and awareness of causes of these accessory renal arteries are necessary for better surgical management during urological procedures & angiographic interventions as well as to design newer technique for them.

Key Words: Renal artery, Accessory. Vertebrate, Variation, Phylogeny, Ontogeny

INTRODUCTION

With the advent of laparoscopic renal surgeries and donor nephrectomies, it becomes mandatory for the surgeons to understand the abnormality or variations in the renal vasculature [1], otherwise renal transplant may be jeopardized by the presence of aberrant or accessory vessels. Existence of the accessory arteries is accountable in cases of renal pathologies, radiological interventions, renal transplants, and other surgical approaches on them.

The renal arteries usually arise from the anterolateral or lateral aspect of the abdominal aorta just below the origin of the superior mesenteric artery [2]. Usually one renal artery supplies each kidney which enters through its hilum [3]. Variations in the pattern of renal arteries have been reported more frequently than other large vessels in the literature. The most common variation of renal artery is the presence of an accessory renal artery, which may enter through the hilum or through the surfaces of the kidney. Alternative nomenclatures have been used to describe the accessory renal artery as supernumerary, multiple, aberrant, additional etc. According to Graves (1956) [4], any artery arising from the aorta in addition to the main renal artery should be named 'accessory' and the renal arteries arising from sources other than the aorta should be called 'aberrant'.

Different studies have given different incidences of accessory renal arteries ranging from about 11% to 61% [5, 6]. Such high incidence certainly warrants proper understanding of this anomaly and its clinical implications. Almost all the studies of accessory renal artery

are conducted on humans whether living or cadavers but none have incorporated its comparative anatomy. The present study was undertaken with the aim to study the prevalence of accessory renal artery in humans as well as in some other vertebrates and to make an attempt to explain them on ontogenetic & phylogenetic basis. The study also throws light on the clinical applicability of the same.

The possible aetiology of this variation has been explained by embryological development from the lateral mesonephric branches of the dorsal aorta. Again, from the standpoint of comparative anatomy there are conditions which anticipate the variations. The anatomical knowledge of such may be important for academic, surgical as well as radiological procedures and the present study is a humble effort to highlight the same.

MATERIALS AND METHODS

Material of this study comprised of adult human cadavers and animals of specified vertebrate series. The well embalmed adult human cadavers of known sex were obtained from department of Anatomy. Experimental vertebrates were obtained from different departments of Govt. Medical College, Amritsar and from the slaughter house.

The human cadavers were serialized from 1-30 with suffix M for male & F for female. The abdominal cavity was opened by a cruciform incision passing through the whole thickness of anterior abdominal wall. Flaps were reflected and abdominal viscera

Name of species		No. of specimens
Man (Homo sapiens)	Primates	30
Rabbit (<i>Oryctolagus cuniculus</i>)	Mammals	6
Guinea pig (<i>Cavia percellus</i>)	Mammals	6
Domestic fowl (<i>Gallus domesticus</i>)	Aves	6
Wall lizard (<i>Hemidactylus flaviviridis</i>)	Reptilians	6
Frog (<i>Rana tigrina</i>)	Amphibians	6

were systemically removed according to Cunningham Manual of Practical Anatomy [7].

The animals procured for the study were sacrificed after deep anaesthesia with ether by open method. The body cavities were opened up and then animals were fixed by dipping in 10% formalin for 48 hours. The dissection was carried out to expose the kidneys & their arterial supply and observations were made.

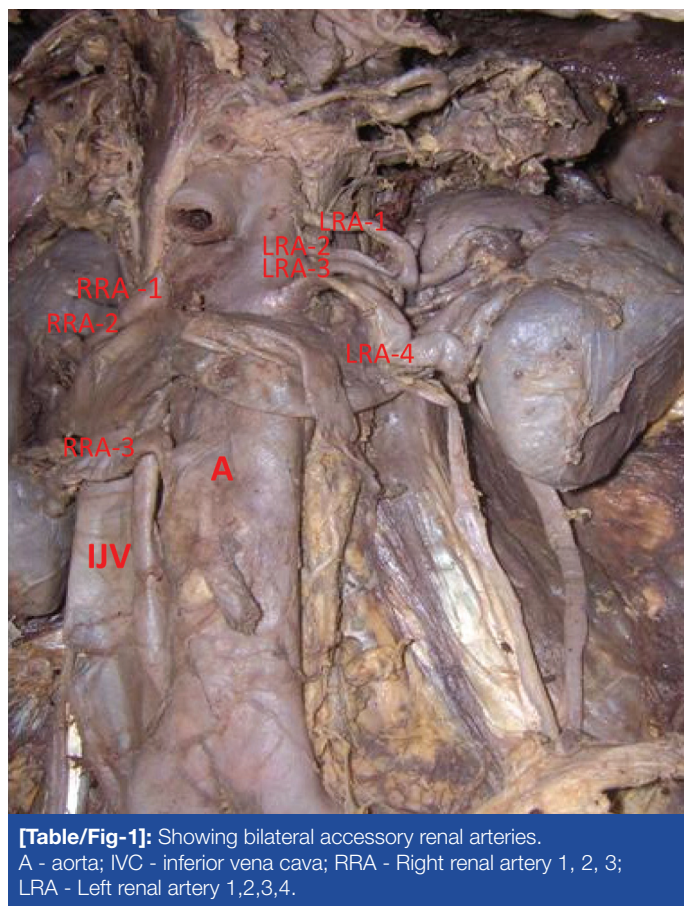
RESULTS

Human Beings

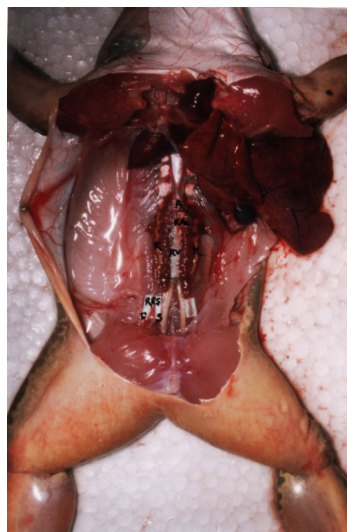
In the present study out of 60 kidneys (30 cadavers) accessory renal arteries were found in 17(28.3%). In one case, three accessory renal arteries were found on left side and two accessory renal arteries were present on right side, which is extremely rare anomaly [Table/Fig-1].

In Other Vertebrates

In the present study, in frog, lizard and domestic fowl, the kidney received multiple pairs of renal arteries from the aorta. In frog, dorsal aorta sends off 5-6 pairs of small renal arteries in a series, into both kidneys while in lizard, aorta sends off 3 or more pairs of renal arteries [Table/Fig-2&3].



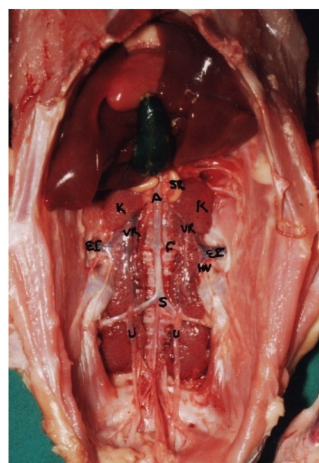
[Table/Fig-1]: Showing bilateral accessory renal arteries.
A - aorta; IVC - inferior vena cava; RRA - Right renal artery 1, 2, 3; LRA - Left renal artery 1,2,3,4.



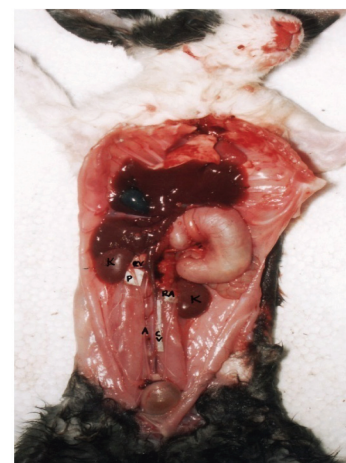
[Table/Fig-2]: Frog
K: Kidney; A: Aorta;
RV: Renal vein



[Table/Fig-3]: Lizard
A: Dorsal aorta; K: Kidney;
PV: Portal vein.



[Table/Fig-4]: Domestic fowl
K: Kidney; R: Renal artery;
A: Aorta; S: Sciatic; AF: Femoral
artery; U: Ureter; SR: Suprarenal.



[Table/Fig-5]: Rabbit
K: Kidney; RA: Renal Artery;
A: Aorta; RV: Renal vein;
CV: Caudal vena cava.

In domestic fowl the kidneys were supplied by three pair of arteries but arrangement was different as the cranial pair was arising directly from the aorta and middle & caudal pairs from the left and right ischiatic arteries [Table/Fig-4].

However in mammals, only cranial pair of arteries from aorta was present. In guinea pig renal arteries gave rise to caudal phrenic, caudal abdominal and suprarenal arteries as well as tiny twigs to the ureter. In rabbits each renal artery sent a branch to suprarenal gland [Table/Fig-5].

DISCUSSION

[Table/Fig-6] compares the %age incidence of accessory renal arteries as observed by earlier workers in human beings. It shows a great disparity ranging 11% to 61% which may be owing to the social, ethnic and racial differences. It is more common in Africans (37%) and Caucasians (35%) when compared with other populations, and less common in Hindus (17%) [8]. Our results are more in line with Merklin & Michel (1958) and Bregman et al (2000).

Opinions of earlier authors differ on the side of accessory renal arteries; some authors have reported a high frequency on the left side [14, 16] while other [3, 5] reported it to be more frequent on

Author	Percentage of Total ARA
Macallister	43.00
Rupert (1915)	61.00
Eisendrath (1920)	45.00
Anson and Kruth (1955)	20.00
Merklin & Michel (1958)	30.00
Bregman et al (2000)	30.00
Nayak (2008)	20.00
Saldarriaga et al (2008)	24.90
Zaoyapan et al (2009)	42.00
Budhiraja et al (2010)	11.66
Present study (2011)	28.33

[Table/Fig-6]: Prevalence of Accessory Renal Artery

right side. In the present study, these were more frequent on right side (11 cases) as compared to left side (6 cases).

The high prevalence of accessory renal arteries confirms the statement of Anson & Kruth (1955) [11] that variation is the rule in renal vessel, not the exception. Presence of accessory renal arteries can be explained on the basis of phylogeny and the complex ontogeny.

Phylogeny

Development of the vertebrate urogenital system reviews the apparent evolutionary history of this system. Without knowledge of comparative anatomy, the development of urogenital system of higher vertebrate is puzzling [17].

Many conditions which are anomalous in human are normally present in some lower animals. In this study, in all experimental animals except mammals multiple renal arteries were found originating from aorta. Thus the occurrence of multiple renal arteries in human may be explained from point of view of phylogeny [6]. In other words, it may be the persistence of these phylogenetic traits.

Ontogeny

Ontogenic basis of accessory renal artery has been convincingly explained by Keibel & Mall (1912) [18]. As the kidneys ascend from the pelvis during the ontogeny, they receive their blood supply from the vascular structures close to them. Initially renal arteries are the branches of common iliac arteries. Later, while the kidneys ascend they receive new branches from the aorta, and the inferior branches disappear. In the ninth week of the intrauterine life the kidneys come in contact with the suprarenal glands and the ascent ceases. The kidneys receive their most cranial branches from the aorta. These are the permanent renal arteries. Failure of degeneration of initial branches leads to formation of accessory renal artery.

Clinical Implications

Accessory renal arteries originate from the abdominal aorta either above or below the main renal artery and reach the hilum. It is important to be aware that accessory renal arteries are end arteries; therefore, if an accessory artery is ligated or damaged, the part of kidney supplied by it is likely to become ischemic [3].

The unrecognized presence of accessory renal arteries is a hazard in surgery. Apart from the danger of damage to them during surgical procedure, the arteries have an additional interest. Lower

polar arteries which typically pass in front of ureter are associated with a relatively higher incidence of hydronephrosis resulting from obstruction of ureter in the uretopelvic region [19].

Although it is very rare, fibro muscular dysplasia in an accessory renal artery can be responsible for renovascular hypertension. Selective renal angiography should be performed as the "gold standard" test when renovascular intervention is considered. Every accessory renal artery is related to segmental arteries, so the risk of bleeding during urological surgery or renal transplantation, segmental ischemia and postoperative hypertension increases [20]. Lastly, the demand for kidney donation has rapidly increased, so it is essential to be aware of the possibility of donors with multiple renal arteries. Even though being considered as relative contradiction, allograft with multiple renal arteries can be implanted with short and long term results comparable to those with single renal arteries by using surgical technique that best fits a particular situation.

CONCLUSION

To conclude the evolutionary history of kidney & renal artery is recapitulated during Ontogenic development. Most of the variations of human renal vessels can be explained on the basis of phylogeny.

We as anatomist believe that knowledge and awareness of causes of these anomalies of the renal arteries are necessary for sufficient surgical management during renal transplantation, repair of abdominal aorta aneurysm, urological procedures and angiographic interventions and to design newer technique for the same.

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BIBLIOGRAPHY

- [1] Ramesh Rao T, Rachna. Aberrant renal arteries and its clinical significance: a case report. *IJAV* 2011; 4: 37-39.
- [2] William PL, Bannister LH, Berry MM, Collins P, Dyson M, Dussek JE et al. cardiovascular system. In *Grays Anatomy* 38th Ed. Churchill Livingstone Edinburgh 1995:1547.
- [3] Nayak S. Presence of accessory renal artery and kinking of aorta due to the abnormal origin of renal arteries. *The Internet Journal of Biological Anthropology*. 2008; Volume 1 Number 2.
- [4] Graves FT. The aberrant renal artery. *J Anat* 1956; 90: 553-58.
- [5] Budhiraja V, Rastogi R, Asthana AK. Renal artery variations: embryological basis and surgical correlation. *Romanian journal of morphology and embryology* 2010; 51(3): 533-36.
- [6] Rupert RR. Further study of irregular kidney vessels as found in one hundred eighteen cadavers. *Surg Gynae Obst* 1915; 21:471-80.
- [7] Romanes GJ, Cunningham s manual of practical anatomy. In: *The abdomen*; 15th Edition, vol 2, Oxford University Press, New York, Tokyo.142-53.
- [8] Özkan U, Oğuzkurt L, Tercan F, Koç Z, Koca N. Renal artery origins and variations: angiography evaluation of 855 consecutive patients. *Diagn Interv Radiol* 2006; 12: 183-86.
- [9] Macallister A. Multiple renal arteries. *J Anat and Physiol*; 17.
- [10] Eisendrath DN. The relation of variations in the renal vessels to phylotomy and nephrectomy. *Am J Surg*;71: 723-43.
- [11] Anson BJ and Kurth LE. Common variations in the renal blood supply. *Surg Gynae Obst* 1955;100: 157-62.
- [12] Merklin RJ, Michel NA. The variant renal and suprarenal blood supply with data on the inferior phrenic, ureteral and gonadal arteries' *Int Coll Surg* 1958; 29: 41-76.
- [13] Bergman RA, Afifi AK, Miyauchi R. Virtual hospital: Illustrated encyclopedia of abdominal aorta2000;<http://www.virtualhospital.com>
- [14] Saldarriaga B, Perez AF, Ballesteros LE. A direct anatomical study of additional renal arteries in a Colombian mestizo population. *Folia Morphol* 2008; 67(2):129-34.

- [15] Ayyappan R, Pelin C, Kürkçüoğlu A. A retrospective study on multiple renal arteries in Turkish population. *Anatomy* 2009; 3: 35-39.
- [16] Satyapal KS, Haffjee AA, Singh B, Ramsaroop L, Rabbs JV, Kalideen JM, et al. Additional renal arteries incidence and morphometry. *Surg Radiol Anat*, 2000; 23(1): 33-38.
- [17] Montagna W. Comparative anatomy. In Excretory System. John Wiley and Sons Inc. London, Chapman and Hall Limited; 253-68.
- [18] Keibel F, Mall FP. Manual of human embryology, Vol.2, J.B. Lippincott, Philadelphia. 1912; 820-25.
- [19] Anson BJ. The cardiovascular system- arteries and veins. In Morris Human anatomy, 12th Edition. The Blakiston Division McGraw Hill book Company, New York. 1966; 741.
- [20] Sampaio FJ, Passos MA. Renal arteries: Anatomic study for surgical and radiologic practice. *Surg Radiol Anat*. 1992; 14: 113-17.

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