Original Article

Anatomy

Congenital Variations of Renal Veins: Embryological Background And Clinical Implications.

ANUPMA GUPTA, RAMAN GUPTA, RIKKI SINGAL

ABSTRACT

Introduction : Venous variations, mainly resulting from the errors of the embryological development, are frequently observed.

Aims : This study reviews the embryogenesis of the renal vein and describes the variations in its anatomy. In addition, the clinical relevance of the variations is discussed.

Material and methods : Material of the study comprised of 30 well embalmed human cadavers of known sex obtained from department of Anatomy.

Result : In this study, out of 30 cases only 13(42%) cases showed standard pattern of renal veins and in rest of 17(58%) cases, variations in one or other forms were encountered. Four main anatomic variants of the renal veins namely the supernumerary veins, retro-aortic, circumaortic left renal vein & plexiform left renal vein were observed.

Discussion: These variants are explainable owing to the complexity of the ontogeny of the renal vein, with numerous anastomoses formed between the three primitive paired veins. Clinical significance of all variants is discussed.

Conclusion: Familiarity with these variations is essential for correct interpretation of cross-sectional images, to avoid erroneous diagnosis of retroperitoneal and mediastinal masses or adenopathy, and to alert the surgeon and angiographer of potential sources of complications pre-operatively.

Key Words: Renal vein, Retro-aortic, circumaortic, supernumerary, Congenital, variations.

INTRODUCTION

In an era of renal transplantation and changing trend in favor of conservative renal surgery, a meticulous knowledge of the anatomy and variational patterns of renal veins is mandatory for such retroperitoneal surgeries and venographic procedures. Variations in the origin, course & termination of renal veins, mainly resulting from the errors of the embryological development, are frequently observed. They have clinical implications in situations like lymphadenectomy where extensive dissection of the venous system is involved, renal transplant where venous systems are needed for reconstruction, renal cell cancer with venous extension, in staging of testicular tumours and placement of caval filters [1].

The renal veins lie anterior to renal artery and open into the inferior vena cava at the level of L2 vertebra. The right renal vein is a short vessel (2.5cm) and does not receive any tributary. The left renal vein is three times longer (7.5cm) than right and crosses anterior to aorta to open into left lateral aspect of inferior vena cava. It typically receives two tributaries. Left suprarenal vein and Left gonadal vein [2].

The development of the renal veins is a complex process with many possible alternative patterns of formation. This is particularly true on the left side because of the communication of the left renal vein with the adrenal, gonadal, phrenic and hemiazygos veins. The anatomical features of the left renal vein (its longer course and complex embryogenesis) add to its complexity and results in sizeable number of clinically significant variations [3]. A familiarity with such venous variations is the first step towards avoiding vascular injury during retroperitoneal procedures.

With these facts in mind, the present work has been designed to study the renal veins and their variations which in turn could provide a solution to innumerable problems encountered frequently during different urological procedures. Further an attempt has been made to throw light on ontogenesis of different variations and their clinical implications.

MATERIAL AND METHODS

This study comprises of 30 well embalmed human cadavers (60 renal veins) of known sex, obtained from department of Anatomy, Govt, Medical college Amritsar. These 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 was systemically removed according to Cunningham manual of practical Anatomy [4]. The renal veins were identified and traced from the hilum of kidney up to their termination in inferior vena cava. All of their tributaries were also traced up to their respective origins.

RESULTS

Out of 30 cadavers of present study a standard text book pattern of renal veins was observed only in 13(42%) cadavers. In the rest of 17(58%) cases, a wide range of variations were encountered. From developmental point of view, four major congenital variations of the renal vein namely the supernumerary renal veins, retro-aortic; circumaortic and plexiform renal vein were observed. [Table/Fig-1]

1. Supernumerary renal vein :

Supernumerary renal vein is defined as any additional vein arising from hilum of kidney and draining into Inferior vena

cava.

In the present study, supernumerary renal veins were seen on right side in 10 bodies [Table/Fig-2] and on the left side in one body. Out of 10 bodies, nine showed single right supernumerary renal vein while one showed double supernumerary veins which is a rare finding.

2. Retro-aortic left renal vein :

In 2 (6.6%) cadavers, the left renal vein was coursing entirely dorsal to aorta and draining into inferior vena cava. On its way, it received left supra-renal vein and left ovarian vein as usual [Table/Fig-3]

3. Circumaortic left renal vein :

In the present series, the circumaortic left renal veins were observed in 2 (6.6%) cases.

In one of these, the retro-aortic limb was larger than pre-aortic limb, passed obliquely downward to drain into the inferior vena cava at the level of L3.It received two supra renal veins. The pre-aortic limb was smaller in size and coursed horizontally in front of aorta to drain into inferior vena cava at the level of its origin from hilum of kidney. It received one supra renal vein and a testicular vein [Table/Fig-4]

In the second case, the retro-aortic limb of the circumaortic left renal vein was a division of left renal vein and relatively of small diameter. It drained into inferior vena cava at the level of L3.The pre-aortic segment was larger in size and drained as usual. It also received both supra renal & gonadal veins.

4. Plexiform left renal vein :

It was a rare variation seen in two bodies where the left renal vein after its emergence from renal hilum divided and redivided to form a network and again reunited to form single renal vein. In this manner 2 hiatuses were formed and left gonadal artery, arising from left accessory renal artery was traversing through the lower hiatus [Table/Fig-5]

DISCUSSION

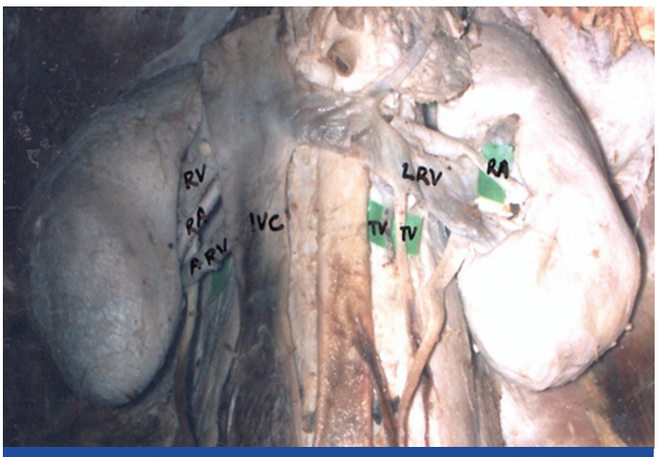
Variations of renal veins are usually clinically silent and remain unnoticed until discover during venography, operation or autopsy. To transplant surgeon, morphology acquires special significance, since variations influence technical feasibility of operation. Variations restrict availability of vein for mobilization procedures [5].

The occurrence of congenital variations of renal vein can be explained on the basis of its embryological development. The development of the renal veins is a part of the complex developmental process of inferior vena cava. The process starts from the forth week of conception and ends at about the eight week. There is vast network of three pair of parallel veins in communication. These are in the order of appearance; the posterior cardinal veins, the subcardinal veins and the supracardinal veins. The renal veins are formed by anastomoses of the subcardinal veins and supracardinal veins. Two renal veins form as ventral and dorsal; the dorsal vein usually degenerates, the ventral vein forms the renal vein [6].

This simplified version of the developmental events accounts for the major venous anomalies discussed below.

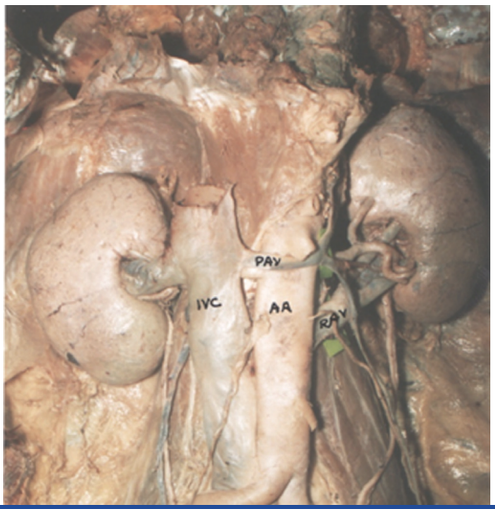
Sr.No	Type of variation	No of cadavers	Percentage
1.	Supernumerary vein	11(R:L::10:1)	36.3%
2.	Retro-aortic left renal vein	2	6.6%
3.	Circumaortic left renal vein-	2	6.6%
4.	Plexiform left renal vein	2	6.6%

[Table/Fig 1]: Different variational pattern of renal veins in present study

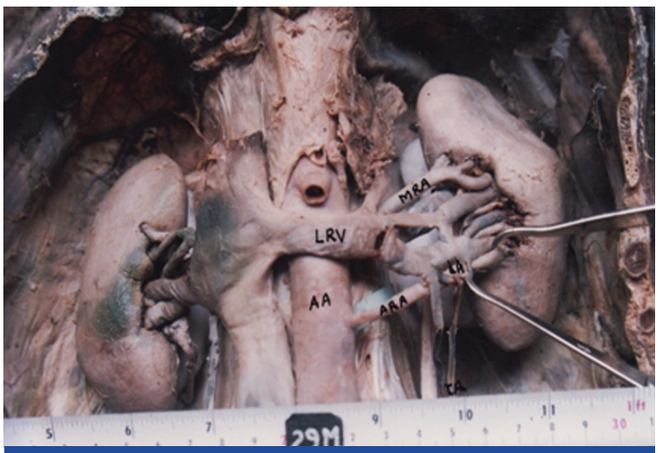


[Table/Fig-2]: Showing Accessory right renal vein (ARV), Inferior vena cava (IVC), Left renal vein (LRV), Testicular vein (TV).

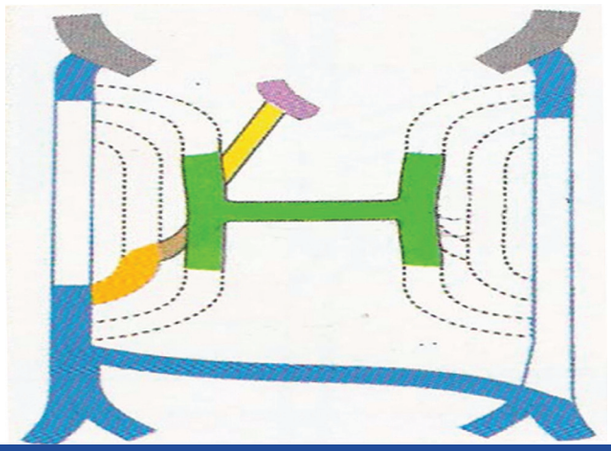
[Table/Fig-3]: Showing Retro-aortic left renal vein-RAV; IVC-Inferior vena cava; AA-Abdominal aorta; OV-Ovarian vein and SV-Supra renal vein.



[Table/Fig-4]: Circumaortic left renal vein (IVC-Inferior vena cava; RAV-Retro-aortic renal vein; PAV-Pre-aortic renal vein; AA-Abdominal aorta)



[Table/Fig-5]: Plexiform left renal vein, Left renal vein (LRV), Testicular artery (TA) arising from accessory renal artery - (ARA) and traversing through the lower hiatus in left renal vein. Main renal artery-MRA; Abdominal aorta-AA



[Table/Fig-6]: Normal development of renal veins. HCC: right hepatocardiac channel; 1: posterior cardinal veins; 2: subcardinal veins; 3: supracardinal veins; 4: intersubcardinal anastomosis;5: supracardinal–subcardinal anastomosis; 6: anastomosis between subcardinal vein and HCC. (Adapted and reprinted, with permission, from reference 17.)

Supernumerary renal vein : Different authors have given a varied incidence of supernumerary renal veins on two sides but all of them agree without reserve that these are seen more frequently on right side than left [Table/Fig 7].

The observation made in the present study was same whereby supernumerary renal vein was seen in 10 (33%) bodies on the right side and in 1 (3.3%) body on left side.

Ontogeny : Quoting the work of Mankhause and Khalique [10], [12] explained a higher incidence of supernumerary renal vein on the right side than on the left side by embryological development of the abdominal venous structures. Around 8th week, the bilaterally symmetrical cardinal venous system converts into unilateral right-sided Inferior vena cava. At this time, two renal veins are present on each side, one on ventral plane and another dorsal it. With further development, there is confluence of the two tributaries producing a single vessel. The persistence of these two veins results in the additional renal vein of right side. The shifting of venous arrangement to the right and complex embryogenesis of left renal vein, discourage the retention of any additional left-sided renal veins. Hence Supernumerary renal veins are much more common on the right side than the left side.

Clinical implications : Multiplicity of renal veins, being particularly susceptible to trauma, constitutes a perpetual threat during various surgical and interventional procedures, in the retroperitoneal region of the abdomen [3].

2. Retro-aortic left renal vein :

It was seen in 2(6.6%) bodies of the present study. The table-3 depicts percentage range of retro-aortic left renal vein as seen by earlier workers. It has been reported from 0.5% to 17% in different studies. Our incidence of 6.6% fills well within this range however the frequency of retro-aortic renal vein shows social, ethnic and racial differences.

Ontogeny : In this present case, the development of retro-aortic left renal vein may be explained ontogenetically by persistence of posterior limb of renal collar & disappearance of its anterior limb.

Clinical implications : Singla et al [17] reviewed the earlier literatures and suggested retro aortic left renal vein may be compressed between the aorta and the lumbar spine leading to left renal venous hypertension which is known as Posterior Nutcracker Syndrome which is manifested by left flank and abdominal pain with or without hematuria. Compression of retro-aortic left renal vein can cause left renal to gonadal vein reflux resulting in lower limb varices and varicocele which may produce difficulties in spermatogenesis and may lead to infertility. Retro-aortic left renal vein has been also associated with Pelvic Congestion Syndrome in females which is characterized by lower abdominal pain, dysmenorrhoea, dyspareunia, vulval, gluteal or thigh varices and emotional disturbances. It may be obstructed by pressure from retroperitoneal growths leading to congestion of kidney. If prolonged, it may give rise to a form of Chronic Interstitial Nephritis.

The surgical significance of such variants lies principally in the fact that the availability of the long left renal vein for mobilization procedures gets restricted thereby nullifying the advantages which normally occur from the greater length of

WORKERS	RIGHT SIDE	LEFT SIDE
Rupert (1915)	25.4%	8%
Anson et al(1936)	11%	3%
Pick and Anson(1940)	27.8%	1%
Mankhouse (1986)	7.2%	None
Bregman (2000)	18%	9%
Dhar P and Ajmani ML(2004)	12%	3%
Present study (2011)	33%	3.3%

[Table/Fig-7]: Prevalence of supernumerary renal veins.

WORKERS	RETROAORTIC LRV	CIRCUMAORTIC LRV
Pick and Anson(1940)	16.8%	3.4%
Anson (1966)	-	2%
Chuang et al (1974)	2-3%	6-17%
Reed et al (1982)	1.8%	4.4%
Trigaux et al (1998)	3.7%	6.8%
Bergman(2000)	1.5-8.7%	2%
Dhar and Ajmani(2004)	7.8%	4.5%
Tatar et al (2008)	0.5%-6.8%	0.3%-3,7%
Present study (2011)	6.6%	6.6%

[Table/Fig-8]: Prevalence of retro-aortic &circumaortic left renal veins.

the left renal vein. Also, the presence of the left retro-aortic renal vein bears clinical significance because of its susceptibility to injury during retroperitoneal surgery [14].

3. Circumaortic left renal vein :

In the present series, the circumaortic left renal vein was observed in 2 (6.6%) cases. [Table/Fig-8] also depicts incidence of circumaortic left renal veins as observed by earlier authors. Accordingly it ranges from 0.3% to 6.8%.

Ontogeny : A circumaortic left renal may be explained ontogenetically by persistence of both pre- & post- aortic segment of renal collar. Out of the two renal veins; the superior vein passes in front of the aorta at the usual level, the inferior vein runs downward and medially behind the aorta draining into the inferior vena cava [6].

Clinical implications : Although the circumaortic renal collar is usually asymptomatic, the knowledge of this variation is useful, mainly before abdominal aortic aneurysm surgery and renal transplantation. The risk of venous injury is higher in patient with a circumaortic left renal vein because the large anterior component of renal collar can easily mislead the surgeon to think that the development of renal vein is normal and injury to retro-aortic component may lead to hemorrhage and death during retroperitoneal surgery [9].

4. Plexiform left renal vein :

It was seen in 2(6.6%) bodies. Published information regarding the frequency and anatomic relationships of such Plexiform left renal vein is scarce so we can't compare the results.

Ontogeny [18]: Simplified the intersubcardinal anastomosis in form of single channels passing anterior and posterior to aorta but [6] states that actually these are in the form of network of veins. So ontogeny of plexiform left renal vein may be easily explained by persistence of these networks of veins. It leads to formation of hiatuses through which gonadal vessels may pass and cause clinical symptoms.

Clinical implications : The hiatuses as formed in the present cases may transmit prevertebral venous plexus en route to inferior vena cava. Occasionally internal spermatic vein or testicular vessels passes through hiatuses and may be clamped during surgery in this region

CONCLUSION

To conclude, a detailed knowledge about major congenital anomalies of the renal veins is vital for vascular surgeon and urologist as it provides safety guidelines for endovascular procedures. Sound knowledge and understanding of these variations is also essential to make distinctive diagnosis of retroperitoneal lymph node pathologies, masses and renal vascular pathologies and to impede complications at the time of surgery.

ACKOWLEDGEMENT

Authors are grateful to their respected teachers and staff of the department for helping them in this study

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AUTHOR(S):

1. Dr. Anupma gupta
2. Raman gupta
3. Rikki singal

PARTICULARS OF CONTRIBUTORS:

1. Corresponding Author
2. Department of Surgery – Adesh Institute of Medical Science and Research, Bathinda, Punjab
3. Department of Surgery- Maharishi Markendeshwar Institute of Medical Sciences and Research, Mullana, Ambala, Haryana, India.

NAME, ADDRESS, TELEPHONE, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Anupma Gupta
Associate professor.
Department of Anatomy - Adesh Institute of Medical Science and Research, Bathinda, Punjab, India.
Email : anupmag@ymail.com

DECLARATION ON COMPETING INTERESTS:

No competing Interests.

Date of Submission: **Aug 21, 2011**
Date of per review: **Sep 18, 2011**
Date of acceptance: **Sep 19, 2011**
Date of Publishing: **Nov 11, 2011**