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Left renal vein variations

K.S. Satyapal[1], J.M. Kalideen[2], A.A. Haffejee[3], B. Singh[4] and J.V. Robbs[5]

[1,2] Department of Anatomy, Faculty of Health Sciences, University of Durban-Westville, Private Bag X54001, Durban 4000, South Africa
[1,3,4,5] Department of Surgery, Faculty of Medicine, University of Natal, P.O. Box 17039, Congella, 4013, South Africa

Summary: The highly complex embryological development of the left renal vein compared to its right counterpart results in greater variations which are clinically significant. The study aimed to identify these variations and to document its incidence. Cadaveric study: 153 kidney pairs were harvested en bloc, dissected, 100 resin casts prepared and 53 plastinated; renal venography performed on further 58 adults and 20 foetal cadavers. Clinical study: (retrospective analysis): a) radiological study, 104 renal venograms; b) live related renal transplantation, 148 donor left kidneys; c) abdominal aortic aneurysm surgery, 525 patients. Total sample size: 1008. Renal collars observed in 0.3%; retro-aortic vein 0.5%; additional veins 0.4%; posterior primary tributary 23.2%, (16.7% Type IB; 6.5% Type IIB, cadaveric series, only). Our results differ significantly in incidence to that reported in the literature: renal collar 0.2-30%; retro-aortic vein 0.8-7.1%; additional renal vein 0.8-6%. Variations are clinically silent and remain unnoticed until discovered during venography, operation or autopsy. To a transplant surgeon, morphology acquires special significance, since variations influence technical feasibility of operation. Prior knowledge of circum-aortic vein is important when blood samples from suprarenal or renal veins are collected. Collar may provide developed collateral pathway immediately after surgery if renal interruption planned without awareness of its presence. Variations restrict availability of vein for mobilisation procedures. In aortic aneurysm repair, retro-aortic vein is important. During retroperitoneal surgery, the surgeon may visualise a pre-aortic vein but be unaware of an additional retroaortic component or a posterior primary tributary, and may avulse it while mobilising the kidney or clamping the aorta.

Correspondence to: KS Satyapal

Variations de la veine rénale gauche

Résumé : Du développement embryologique très complexe de la veine rénale gauche, comparé à son homologue droit, il résulte d'importantes variations, significatives du point de vue clinique. Le but de cette étude est d'identifier ces variations et de préciser leur fréquence. 1-Recherches cadavériques : (153 paires de reins ont été prélevées en bloc, disséquées) 100 moulages par résines et 53 plastinations. En outre, des phlébographies rénales postmortem ont été réalisées, 58 chez des adultes, 20 chez des fœtus. 2-Etudes cliniques (analyse rétrospective) : a) radiologiques : 104 veinogrammes rénaux, b) lors de transplantations rénales : 148 reins gauches de donneurs, c) au cours de la chirurgie de l'anévrysme de l'aorte thoracique : 525 patients. Soit, au total, 1008 reins. Le collier rénal a été observé dans 0,3 % de la série ; la v. rétro-aortique, 0,5 %, des vv. rénales supplémentaires : 0,4 % ; enfin, un collecteur rénal postérieur existait dans 23,2 % des séries cadavériques (16,7 % du type IB de notre classification et 6,5 % du type II B). Nos résultats diffèrent de façon significative par leur faible fréquence de celle relatée dans la littérature : collier rénal (0,2-30 %), veine rétro-aortique (0,8-7,1 %), veine rénale supplémentaire (0.8-6%). Les variations sont silencieuses cliniquement et demeurent méconnues jusqu'à leur découverte par phlébographie, opération ou autopsie. Pour le chirurgien transplanteur, la morphologie a une signification particulière puisque les variations déterminent la faisabilité technique ou non de l'opération. La connaissance préalable de la veine circum-aortique est importante lors du prélèvement d'échantillons sanguins des veines surrénaliennes ou rénales. Le collier rénal peut favoriser la formation d'un réseau collatéral dense immédiatement après l'opération, si l'interruption de la veine rénale est pratiquée sans connaissance de ce dispositif. Les variations restreignent l'utilisation de la veine dans les techniques de mobilisation. Lors de la cure d'un anévrysme aortique, l'existence d'une veine rétro-aortique est importante à connaitre. Lors d'une intervention rétro-péritonéale, le

chirurgien repère la veine pré-aortique, mais il méconnait une branche rétro-aortique supplémentaire, ou un tronc primaire postérieur qu'il peut léser en mobilisant le rein ou en clampant l'aorte.

Key words: Left renal vein — Variations — Renal collar — Retroaortic — Posterior primary tributary

The highly complex embryological development of the left renal vein compared to its right counterpart results in greater variations. These are a) renal collar, b) retro-aortic v., c) additional renal v. and d) posterior primary tributary. When present, they hold important surgical and therapeutic implications. Their incidence also varies widely.

Material and methods

The study comprised two subsets, cadaveric dissections including phlebography and in-vivo clinical series to identify variations of the left renal v. This design acknowledges the limitations that the clinical series (both surgical and radiologic) may present in comparison to gross anatomical series.

The nomenclature of the renal variations are defined as follows:

A) Renal collar: a term first used by Huntington and McClure [20], is defined as "*the occurrence of a renal venous channel coursing both anteriorly and posteriorly to the abdominal aorta*" (Fig. 1).

B) Retro-aortic v.: single ectopic trunk in a relatively low position, with a trajectory that is oblique inferiorly and retro-aortic. Gérard [15] applied the term "anastomose veineuse renocave retro-aortique" to this vessel, which Seib [40] modified and called the retro-aortic renocaval arch (Fig. 2).

C) Additional renal v.: "*Any additional vessel that drains separately from the kidney and independently into the inferior vena cava should be considered as a normal variation and be named an additional renal v.*" [39]. This definition is based on a proposal by Satyapal [38], that "*a renal v. is one which is constituted from the convergence and union of a varying number of primary tributaries emerging from the kidney and which terminates separa-*

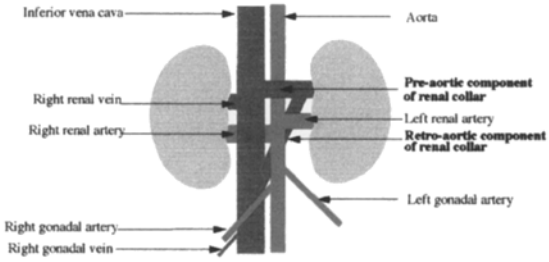

Fig. 1
Schematic drawing of renal collar

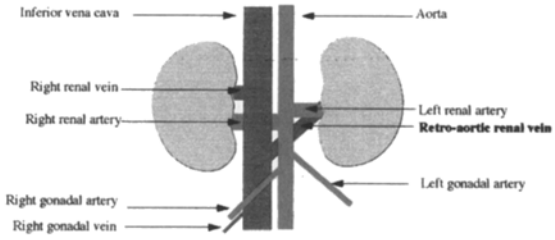

Fig. 2
Schematic drawing of retro-aortic v.

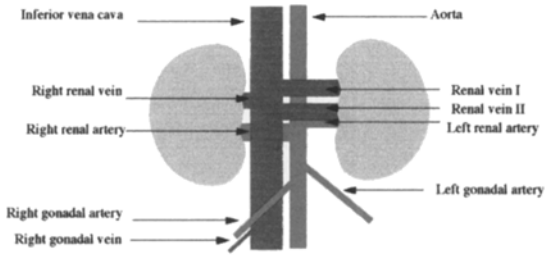

Fig. 3
Schematic drawing of additional renal v.

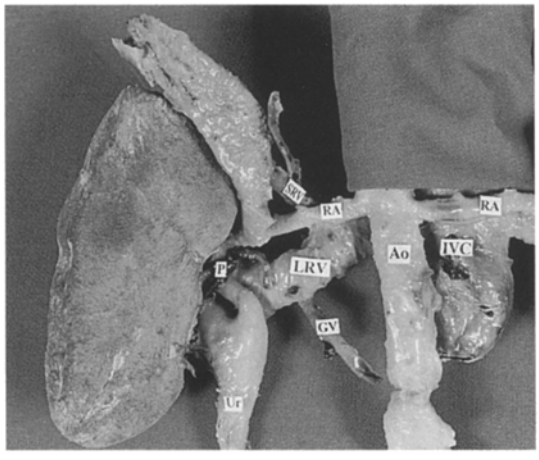

Fig. 4
Posterior view of plastinated left kidney demonstrating Type IB renal venous drainage. *LRV*: Left renal v., IVC: Inferior vena cava, GV: Gonadal v., SRV: Suprarenal v., P: Posterior primary tributary, Ao: Aorta, RA: Renal artery, Ur: Ureter

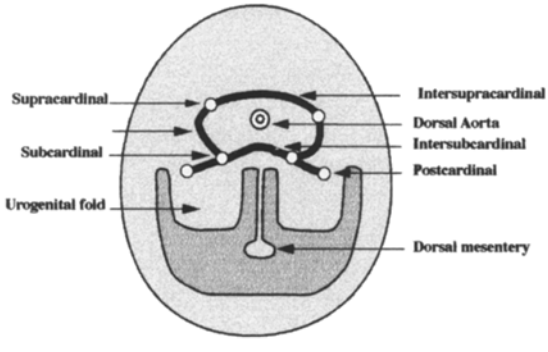

Fig. 5
Cross-section through embryo showing position of cardinal vv. and components of renal collar

Table 1. Incidence of renal collar

Reference	Sample size	Renal collar (%)
Zumstein (1896)	220	8.2
Jeanbrau (1910)	24	4.2
Hovelacque (1914)	20	30.0
Gérard (1920)	225	7.5
Seib (1934)	176	9.1
Fagarasanu (1938a)	not recorded	8.5
Pick & Anson (1940)	215	16.8
Anson & Cauldwell (1947)	425	17.0
Davis, et al (1958)	100	6.0
Reis & Esenther (1959)	not recorded	2.4
Anson & Daseler (1961)	100	1
Davis & Lundberg (1968)	270	1.5
Ortmann (1968)	79	11.4
Brener, et al (1974)	not recorded	2 cases
Chuang, et al (1974b)	3 case reports	1 case
Royster, et al (1974)	387	0.5
Gillot (1978)	322	5.6
Beckmann & Abrams (1979)	127	7.9
Kramer & Grine (1980)	193	5.7
Nishimura, et al (1986)	31	3.2
Hoeltl (1990)	5089	0.2
Satyapal, et al (1997)	1008	0.3
Range	0.2-30%	
Median	5.7%	

Table 2. Incidence of retro-aortic vein

Reference	Sample size	Retro-aortic v. (%)
Froriep (1895)	28	7.1
Zumstein (1896)	220	1.8
Eisendrath (1920)	218	4.1
Seib (1934)	176	1.7
Fagarasanu (1938a)	not recorded	7.0
Pick & Anson (1940)	215	3.4
Davis, et al (1958)	100	2.0
Anson & Daseler (1961)	100	1
Davis & Lundberg (1968)	270	1.8
Thomas (1970)	20	10
Brener, et al (1974)	not recorded	20 cases
Chuang, et al (1974b)	3 case reports	2 cases
Royster, et al (1974)	387	1.3
Gillot (1978)	322	2.5
Beckmann & Abrams (1979)	76	0.0
Royal & Callen (1979)	4 case reports	2 cases
Nishimura (1986)	31	0.0
Hoeltl (1990)	5089	0.8
Turgut, et al (1996)	1 case report	1 case
Satyapal, et al (1997)	1008	0.5
Range	0.8-7.1%	
Median	1.8%	

Table 3. Incidence of additional left renal v.

Reference	Sample Number	Additional left Renal v. (%)
Rupert (1915)	118	1.0
Anson, et al (1936)	200	3.0
Pick & Anson (1940)	194	1.0
Weinstein, et al (1940)	203	6.0
Merklin & Michels (1958)	185	3.1
Reis & Esenther (1959)	500	0.8
Ross, et al (1961)	34	3.0
Beckmann & Abrams (1980)	56	1.0
Pollak, et al (1986)	400	2.0
Satyapal, et al (1995b)	153	2.6
Satyapal, et al (1997)	1008	0.4
Range	0.8%-6%	
Median	2.3%	

tely into the inferior vena cava" and is classified as Type III (Fig. 3).

D) Primary tributaries: these tributaries that emerge from the kidney are classified into 3 types using the drainage pattern of the primary renal v. tributaries and the renal v. proper as a basis on both the left and right sides [38] (Fig. 4). Type IA consisted of two primary tributaries only an upper and lower, while Type IB had in addition, a posterior primary tributary. Type IIA displayed more than two primary tributaries; eg. upper, middle and lower, while Type IIB had in addition a posterior primary tributary. Type III consisted of any of the above classification patterns as well as displaying an additional renal v. Types IB and IIB are particularly important surgically.

The subsets of the study are: A) Cadaveric study: 153 pairs of morphologically normal kidneys were harvested en bloc and dissected. Of these, 53 pairs were injected with differently coloured latex to demonstrate the venous, arterial and pelvicalyceal systems and subsequently plastinated using a modification of a technique of von Hagens [44]. The remaining 100 pairs were injected with similarly coloured polyester crystic resin and casts were prepared according to the method of Tompsett [42]. Renal venography (*in situ*) was performed on 58 adults and 20 foetuses. B) Clinical study: A retrospective study comprising: a) radiologic study performed between 1974 and 1994 yielded 104 renal venograms; b) live related renal transplantation operations performed between 1990 and June 1997 yielded 148 donor left kidneys and c) patients undergoing abdominal aortic aneurysm surgery between 1987 and 1997 yielded 525 cases, were analysed. The total sample size was 1008.

The study aimed to identify variations of the left renal v. and to document its incidence in the South African population.

Results

The following variations were observed:

A) Renal collar : 0.3% (*in vivo* radiological series, 2; renal transplantation series, 1) (Fig. 1).

B) Retro-aortic v.: 0.5% (abdominal aortic aneurysm series, 3; renal transplantation series, 2) (Fig. 2).

C) Additional veins: 0.4% (cadaveric series, 4) (Fig. 3).

D) Primary tributaries: posterior primary tributary 23.2%, (16.7% (51) Type IB; 6.5% (20) Type IIB) (cadaveric series only) (Fig. 4).

Of the variations observed in the clinical study, (8 patients, 3 with renal collars and 5 with retro-aortic vv.) these were appreciated only intraoperatively and did not impact upon the outcome of the procedure.

Discussion

Embryology

The kidney develops in a highly complex plexiform vascular environment (Fig. 5). The circum-aortic renal venous collar is composed from a ventral inter-subcardinal anastomosis and by a small part of the right and left sub-posterior cardinal anastomosis [25]. On either side, the right and left sub-supracardinal anastomosis forms the ring, while dorsally it is complete by the inter-supracardinal anastomosis. Usually the ventral portion of the circum-aortic plexus persists as the normal left renal v. If the dorsal portion of the plexus persists, then the left renal v. is posterior to the aorta (retro-aortic renal v.). If both the dorsal and the ventral portions persist, there will be a circum-aortic venous collar in the adult [27].

The recorded incidence of left renal v. variations varies widely (Tables 1-3). Our results differ significantly in incidence to that reported in the literature: A) Renal collar: 0.3% vs median 5.7% with range of 0.2-30% (Table 1); B) Retro-aortic v.: 0.5% vs median 1.8% with range of 0.8-7.1% (Table 2); C) Additional renal vv.: 0.4% vs median 2.3% with range of 0.8-6% (Table 3).

It is also apparent from our results that the anatomical dissections were able to easily reveal particularly the posterior primary tributary whilst radiological analysis did not, no doubt due to the difficulty of distinguishing anterior from posterior branches from an antero-posterior view only. Furthermore, the very nature of the *in vivo* operative procedures, limited by incision and mobilisation tends to preclude visualisation of some of these variations particularly the posterior primary tributary. Recent advances in surgical technique such as minimal access surgery to the retroperitoneum for procedures such as lumbar sympathectomy, adrenectomy and nephrectomy will probably warrant a greater appreciation of the posterior veins. Using a minimal access approach that affords optimal magnification and illumination a greater visualisation of this previously neglected anatomy is effected. Traditional retroperitoneal surgical approaches do not lend itself easily to appreciate some of the variations alluded to.

Variations are clinically silent and remain unnoticed until discovered during operation or autopsy. To the transplant surgeon, morphology of the renal vessels acquires a special significance, since variations and anomalies may greatly influence the technical feasibility of the operation. Prior knowledge of a circum-aortic venous ring is important when blood samples from the suprarenal or renal vv. are collected. When performing venous sampling procedures of the suprarenal v. (e.g. for hormonal assays), in the presence of a circum-aortic venous ring, the pre-aortic segment should be selected since the suprarenal v. always drains into this segment. If a solitary retro-aortic v. is present, the adrenal v. may drain either into the prehilar portion of this renal v., or into the IVC directly [13]. A circum-aortic venous ring may provide a fully developed collateral pathway immediately after surgery if caval interruption is planned without awareness of its presence [24, 30]. Therefore, a careful search for this anatomic anomaly must be made by renal venography before operation. Should a circum-aortic venous ring be found, the caval interruption ought to be performed at a level below the orifice of the retro-aortic renal v. in the lower lumbar region [12, 17]. An additional surgical significance of the occurrence of these congenital variations is that they restrict the availability of the left renal v. for mobilisation procedures (e.g. splenorenal shunts) and nullify the advantages which normally accrue from their greater length (e.g. left renal transplant) [8]. In repair of an abdominal aortic aneurysm where the aorta is mobilised, the retroaortic v. becomes especially important. During retroperitoneal surgery, the surgeon may visualise a pre-aortic v. but may be unaware of an additional retroaortic component or posterior primary tributary and may tear it while mobilising the kidney or clamping the aorta [45, 27]. Furthermore, as previously indicated, these variations require appreciation especially since some centres currently employ the more recent innovation of performing nephrectomy using the laparoscopically assisted technique [22].

Conclusion

The incidence of left renal v. variations observed in this study is discussed and compared with that obtained in the literature. The wide discrepancy of the incidence of these variations warrants further epidemiological analysis. It is necessary to emphasise that the presence of these renal v. variations in particular must be acknowledged since they have significant clinical importance.

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