Anatomical variations of renal venous vascularisation. a study of 71 three-dimensional kidney endocasts

Variations anatomiques de la vascularisation veineuse du rein. Etude de 71 moules rénaux

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RÉSUMÉ

Prérequis : Une meilleure compréhension de l'anatomie de la veine rénale et ses rapports avec les systèmes artériel et excréteur permet de prévenir les complications per opératoires de la chirurgie rénale.

Méthodes: Des moules tridimensionnels des vaisseaux et des systèmes collecteurs rénaux ont été obtenus à partir de cadavres frais, par injection d'une résine de polyester colorée différemment. Un total de 71 moules a étudié: 37 reins droits et 34 reins gauches.

Résultats: La veine rénale était unique dans 88% des cas et double dans 11% des cas. Elle était formée dans 52% des cas par 3 troncs. Les veines intrarénales étaient anastomosées ensemble pour former 2 niveaux d'arcades dans 28% des cas et 3 niveaux de 71% des cas. Le drainage veineux du pôle supérieur était assuré par deux plexus antérieur et postérieur dans 38% des cas, et par un seul plexus antérieur dans 61% des cas. Dans 22% des cas, le drainage veineux du pôle inférieur était assuré à la fois par un plexus antérieur et un autre postérieur, et dans 77% des cas, il y avait seulement un plexus antérieur. L'artère rénale était postérieure à la veine dans 66% des cas. Elle était antérieure à la veine dans 29% des cas, et située directement au-dessus d'elle dans 4% des cas. Dans 60% des cas, il existait un rapport étroit entre la face antérieure de la jonction pyélo-urétérale et la branche inférieure de la veine rénale.

Conclusion: La vascularisation veineuse du rein est variable et sa relation avec l'artère et le système excréteur peuvent être complexes.

Mots-clés
Rein ; veine ; anatomie

SUMMARY

Background: A better understanding of the anatomy of the renal vein and its relationship with the arterial and excretory systems can prevent intra operative complications.

Methods: Three-dimensional endocasts of intrarenal vessels and renal collecting systems were obtained from fresh cadavers, by injecting a polyester resin coloured with different pigments. A total of 71 endocasts were studied: 37 right kidneys and 34 left kidneys.

Results: Renal vein was unique in 88% of cases and double in 11% of cases. It was formed in 52% of cases by 3 trunks. Intrarenal veins anastomosed together to form 2 levels of arcades in 28% of cases and 3 levels in 71% of cases. The venous drainage of the upper pole was provided by two anterior and posterior plexus in 38% of cases, and by a single anterior plexus in 61% of cases. In 22% of cases, the venous drainage of the lower pole was provided by both an anterior and a posterior plexus, and in 77% of cases, there was only an anterior plexus. Renal artery was posterior to the vein in 66% of cases. It was anterior to the vein in 29% of cases, and located directly above it in 4% of cases. In 60% of cases, we noted a close relationship between the anterior surface of the ureteropelvic junction and the lower branch of the renal vein.

Conclusion: Venous vascularisation of the kidney appears to be variable and its relationship with the arterial and the excretory systems may be complex.

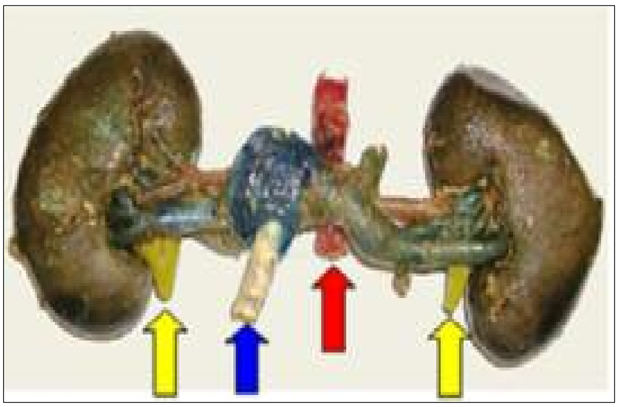
Key-words
Kidney ; vein ; anatomy

Renal vein is a vessel formed by the convergence and union of primary renal venous branches. It emerges from the kidney and ends in the inferior vena cava. An additional renal vein is a vessel that drains the kidney in the vena cava independently of the main renal vein [1, 2]. The anatomical study of the renal vein has prompted little interest because of the absence of major renal complications, particularly ischemic ones, after its ligation. However, an injury of a large vein can cause severe per or postoperative bleeding and its repair can lead to parenchymal ischemia by arterial wound or to a lesion of the upper urinary tract [1]. A better understanding of the anatomy of the renal vein and its anatomical relationship with the artery and the upper urinary tract can prevent these complications.
The aim of our work was to better understand the venous vascularisation of the kidney and its relationship with the other noble structures of the renal pedicle, by the study of 80 fresh cadaveric kidneys. This could have important practical implications in many procedures, particularly during living donor nephrectomy.

MATERIAL AND METHODS

We studied 80 three-dimensional endocasts of intrarenal vessels and renal collecting systems obtained from fresh cadavers of both sexes (the cause of death was not related to the urinary tract).
A polyester resin was injected into the vessels and into the collecting system. We used a yellow pigment to colour the resin for the ureteral injection, a red one for the arterial injection and a blue one for the venous injection (Fig.1).

Figure 1: Injection of polyester resin using a yellow pigment for the ureter, a red one for arteries and a blue one for veins



A styrene monomer as diluent and a methyl ethyl ketone peroxide as catalyst were added to the resin. After injection, the kidneys were immersed in sulphuric acid for 48 hours, then in commercial hydrochloric acid for 48 hours, until total corrosion of the organic matter. The endocast was thus obtained (Fig.2).
Given the fragility of the resin and our inexperience at the beginning of the study, some endocasts were uninterpretable. Finally, a total of 71 endocasts were studied: 28 kidneys joined to the aorta and to the vena cava and 43 separate kidneys, with 37 right kidneys and 34 left kidneys.

Figure 2 : Final endocast obtained after total corrosion of the organic matter

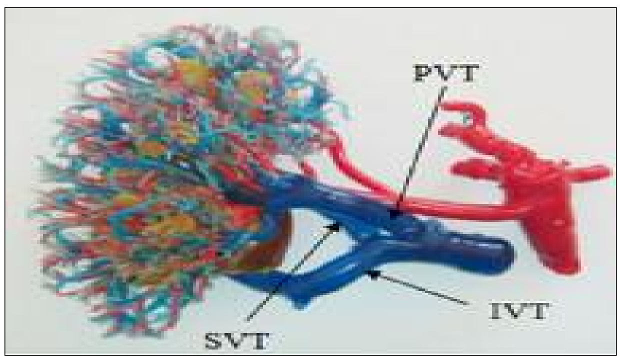
RESULTS

Renal vein was unique in 63 kidneys (88% of cases). There was a double vein in 8 kidneys (11% of cases), 5 right kidneys and 3 left kidneys. In one case, we found a retro aortic left renal vein (Fig.3).

Figure 3 : Retro aortic left renal vein

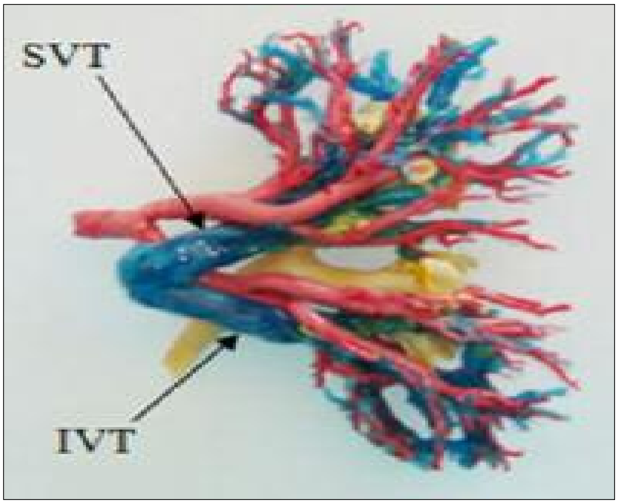
Renal vein was formed by several main trunks. The most common number of trunks was 3, noted in 37 endocasts (52% of cases). Two trunks were observed in 28 kidneys (39% of cases), and 4 trunks in 6 kidneys (8% of cases). The most common modes of reunion were:
* 3 trunks: superior (SVT), inferior (IVT) and posterior (PVT) in 19 cases (fig.4)

Figure 4 : Posterior view of a left kidney : renal vein formed by the reunion of 3 trunks (superior, inferior and posterior trunks)



* 2 trunks: SVT and IVT in 28 cases (Fig.5).
Renal veins drained into the inferior vena cava at its anterolateral wall, at the same level in 28% of cases, at a higher level for the right vein in 57% of cases and for the left vein in 14% of cases.

Figure 5 : Anterior view of a left kidney : renal vein formed by the reunion of 2 trunks, a superior and an inferior one



Intrarenal veins followed the same path as the arteries. They anastomosed together to form true arcades extending from the base of the renal pyramids to the renal sinus region. These arcades were concave inward. We noted the presence of 2 levels of arcades in the periphery and at the base of the pyramids in 28% of cases and 3 levels in the periphery, at the base of the pyramids and near the sinus in 71% of cases (Fig.6). There were also large longitudinal branches to connect the main venous trunks forming anastomoses between the anterior and posterior plans (Fig.7).

Figure 6 : Posterior view of a right kidney : 3 levels of venous arcades in the periphery, at the base of the pyramids and near the sinus

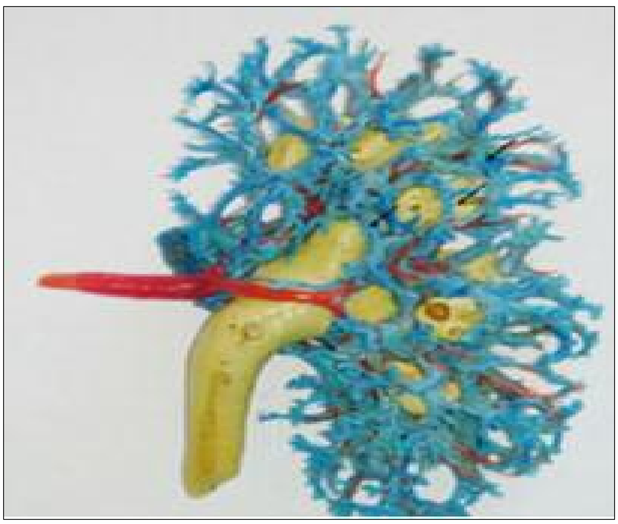


Figure 7 : Posterior view of a right kidney : large longitudinal venous branches connecting the anterior and the posterior venous plans

In 27 endocasts (38% of cases), the venous drainage of the upper pole was provided by two plexus: an anterior plexus and a posterior one. In 44 kidneys (61% of cases), we noted the presence of only an anterior plexus. We have not noted in any case the presence of a single posterior plexus.
In 16 endocasts (22% of cases), the venous drainage of the lower pole was provided by both an anterior and a posterior plexus. In 55 kidneys (77% of cases), the venous drainage of the lower pole was only provided by an anterior plexus. A single posterior plexus for the lower pole was not noted in any endocast.
Renal artery was posterior to the vein in 47 endocasts (66% of cases), corresponding to 26 right kidneys and 21 left kidneys. The artery was posterior and ran alongside the top edge of the vein in 19 kidneys (26% of cases). The artery was anterior to the vein in 21 kidneys (29% of cases), 10 left kidneys and 11 right ones. It was anterior, skirting the top edge of the vein, in 11 kidneys (52% of cases). The artery was located directly above the vein in 3 endocasts (4% of cases).
In 43 endocasts (60% of cases), we noted a close relationship between the anterior surface of the ureteropelvic junction and the lower branch of the renal vein. In 9 endocasts (12% of cases), the junction was sandwiched by 2 inferior venous branches, an anterior and a posterior one. In 2 cases, the lower branch of the renal vein was in relation to the posterior surface of the ureteropelvic junction. In 17 kidneys (23% of cases), the anterior surface of the junction was not in contact with vessels. In all cases, the two inner and outer edges of the ureteropelvic junction were not in touch with vessels (fig. 8).
In all cases, the bottoms of calyces had not any relationship with vascular structures (fig. 9). We also noted a decrease in vascular density from the upper pole to the lower pole. The bottoms of calyces are best viewed at the lower pole than in other parts of the kidney.

Figure 8 : Posterior view of a left kidney : The inner and outer edges of the ureteropelvic junction are free of any vascular contact

Figure 9 : Lateral view : The bottoms of calyces are free of any vascular contact

DISCUSSION

Renal vein is generally unique. A single vein was found in 88% of cases in the series of Arvis et al (1995) [3]. In our series, only one renal vein was present in 88% of cases. A double renal vein was noted in the literature, with a frequency ranging from 2% to 28% [1, 2, 3, 4, 5]. In our series, it was noted in 11% of kidneys. Some authors reported the presence of three main renal veins [2, 4].

This was not observed in our series. Some studies showed that accessory renal arteries arose more frequently on the left side [4, 6, 7]. Unlike arteries, it was shown that additional veins arose more commonly on the right side [1, 2]. In our study, double veins were more common on the right than on the left side (62% Vs 38% of cases). It was showed that the diameter of an additional vein or the sum of the diameters of two additional veins were equal to the diameter of the main renal vein [2, 4]. In terms of embryology, the anatomy of renal veins is defined by the embryology of inferior vena cava, and is independent of the embryology of renal arteries. When the kidney reaches its final position, the final venous branches are in place with two renal veins, an anterior and a posterior one. On the right side, these two branches will then unite giving birth to a single renal vein. The persistence of two veins after this stage results in a main renal vein with additional veins in adults. Anomalies of the left renal vein are more frequent because it is longer than the right vein and its embryogenesis is more complex due to interposition of the aorta. The two definitive branches place themselves on either side of the aorta, on its front and back surfaces. In most cases, the posterior branch obliterates and the anterior one becomes the final renal vein. If the anterior branch obliterates, it is the posterior branch that forms a retro aortic renal vein. The persistence of the posterior vein, in addition to the anterior one, results in a periaortic renal vein and explains the presence of additional veins on the left side passing behind the aorta. In these cases, some anastomoses between the renal vein and the azygos and lumbar veins can cause major bleeding complications. Thus, care must be taken during dissection of the posterior surface of the aorta because it is an area rich in veins. Moreover, the retro aortic position of the renal vein makes it exposed to extrinsic compression by pancreatic or hepatic tumors or retroperitoneal nodal metastases [7]. Some authors found that if the posterior retro aortic renal vein exists alone, the adrenal vein can drain either in the pre-hilar portion of the renal vein or directly into the vena cava, either alone or after union with the gonadal vein. It is the same for the gonadal vein [5, 7].

In a series of living donors, Lin et al (2004) found these variations of the renal vein (retro aortic or periaortic vein) in 10.6% of cases [8]. The presence of these variants does not contraindicate nephrectomy for kidney donation by laparoscopy or open surgery.

The average length of the right renal vein is 32 mm (20-45 mm). That of the left renal vein is 84 mm (60-110 mm) [9]. The left renal vein is longer than the right one, allowing an easier dissection. However, some anatomical elements restrict the mobility of the left renal vein, ie its close relationship with the superior mesenteric artery, the ligament of Treitz, the hemiazygos vein and the lumbar veins, and the presence of periaortic or retro aortic renal veins [1].

The origin of the renal vein is, in most cases, located outside of the sinus, on the front of the renal pelvis. The number of afferent branches forming the renal vein ranges from 2 to 5 with a variable meeting mode. The meeting of 3 branches was the most frequently described in the literature [10]. This was also observed in our series (52% of cases). It was showed by Arvis et al (1995) that the formation of the renal vein was done either by a symmetric confluence suggesting a dichotomy in 72% of cases, or by an asymmetric confluence found in 28% of cases [3].

Some studies showed that the venous drainage of the upper pole was provided, in 84.6% of cases, by two plexus: an anterior and a posterior one. These two plexus surrounded the upper calyceal group and gave rise to anteroposterior bridging veins. In 15.4% of cases, only an anterior plexus was noted [10, 11]. Our results were different as, in 60% of our endocasts, drainage was done by the anterior plexus only. In the literature and in our series, was never noted the presence of only a posterior plexus.

Kinnunen et al (1985) [12] and Sampaio et al (1992) [13] demonstrated that the venous drainage of the lower pole was provided in 50% of cases by 2 anterior and posterior plexus. In 50% of cases, there was only an anterior plexus. In our series, the presence of a single anterior venous plexus ensuring the drainage of the lower pole was more common (77% of cases).

At its origin, the renal artery is always posterior to the venous plan and usually located above the renal vein. Valentine et al (1990) [14] found that, in 95% of cases, the origin of the renal artery was located in an area ranging from 23 mm above the upper edge of the renal vein to 17 mm below it. In our series, the artery was located above the vein in 46% of cases and was not below it in any case.

Anson et al (1961) [9] found that the arrangement vein-artery-renal pelvis was the most frequent. Our results were similar, since we noted that the artery was in front of the vein in 29% of cases and backwards in 66% of cases.

Ozan et al (1998) [15] reported a rare anomaly resulting from an abnormal development of the vena cava: a bifurcation of the vena cava next to the lower pole of the right kidney. The right hemi branch drained the right renal vein and the hepatic veins, and emptied into the right atrium. The left hemi branch drained the left renal vein and some intercostal veins, and emptied into the superior vena cava. Azygos veins were absent. The right renal artery ran between the two hemi branches in front of the left one and behind the right one.

Sampaio et al (1990) [10] found that, in 40% of cases, there was a close relationship between the anterior surface of the ureteropelvic junction and the lower branch of the renal vein. This was noted in 60% of cases in our series.

CONCLUSIONS

Venous vascularisation of the kidney is far from being stereotyped. Many variations can be seen from one side to another and within the same side. Inconstant relations of the renal vein with arterial and excretory systems can be a source of intraoperative complications.

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