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Analysis of renal hilum extraparenchymal structures in Brazilian adult human cadavers

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Summary

Anatomical knowledge of the exact topography of the renal hilar structures is of great importance when performing urological surgical procedures. Classically, the topographic distribution of hilar structures has been described in the antero-posterior direction as the renal vein-artery-pelvis complex. However, morphological studies have reported different dispositions. One hundred and thirteen renal hila from adult Brazilian human cadavers were dissected. The topographic analysis of hilar structures disposition was made at a distance of approximately 0.5 cm from the anterior border of the renal hilum, conserving the antero-posterior distribution. Only the renal artery, renal vein and renal pelvis were considered. The following antero-posterior distributions were observed: 94 (83%) presented the classic topographic organization: renal vein - renal artery - renal pelvis; 3 left kidneys (3%) presented the renal «vein-pelvis-artery» disposition; 3 kidneys (3%) presented the renal «artery-vein-pelvis» disposition; 1 left kidney (1%) presented the renal «artery-pelvis-vein» disposition; 12 kidneys (10%) presented an undefined organization of hilar structures. An atypical distribution of segmentary arteries related to renal hilar structures was found.

We believe this study may contribute to a better knowledge of the topographical organization of the renal hilum, which is a region frequently involved in surgical dissection during urological surgical procedures of the kidney.

Key words: Renal anatomy – Human dissection – Renal hilum – Renal artery – Renal vein

Introduction

Anatomical knowledge of the distribution of renal hilar structures topographic is of crucial importance for urological surgical procedures in which hilar vessel clamping is necessary, either temporally or definitively, such as in conventional and laparoscopic nephrectomy, anatrophic nephrolithotomy and renal transplantation, as well as in interventions in which a pyelic incision is needed for the removal of calculi, such as conventional and laparoscopic pyelolithotomy.

Classically, the topographic disposition of hilar structures is referred to in the antero-posterior sense as the «vein-artery-pelvis» complex (Testut and Jacob, 1947; Bouchet and Cuilleret, 1997; Williams et al., 2004;

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Moore and Dalley, 2005; Anderson et al., 2007). However, anatomical studies with different numbers of cases point to different dispositions.

Considering the classical anatomic studies (Testut and Jacob, 1947; Bouchet and Cuilleret, 1997; Williams et al., 2004), it is possible to define the renal arteries as large vessels that lie laterally to the descending abdominal aorta in an area delimited superiorly by the root of the superior mesenteric artery and inferiorly by the gonadal arteries, usually at the level of the intervertebral disks of the first and second lumbar vertebrae. They are typically described as being disposed anteriorly to the renal pelvis and posteriorly to the pancreatic head and duodenal second portion. Near the kidney, the renal artery shows a division in four or more terminal segmentary branches, which, besides being responsible for vascularization of the renal parenchyma, also nourish the adrenal gland and the initial portion of the ureters.

Still according to classical anatomical descriptions (Testut and Jacob, 1947; Bouchet and Cuilleret, 1997; Williams et al., 2004), the right renal artery heads towards the right renal hilum in an inferior oblique trajectory. Posteriorly to the inferior cava vein, this vessel passes over the great and minor psoas muscle and the lumbar vertebral bodies, with which it is in direct relation. After crossing the inferior posterior face of the cava vein, the artery follows to the kidney under the superior border of the right renal vein, where it divides in its terminal branches immediately before reaching the superior border of the renal pelvis.

The left renal artery, in turn, describes a shorter trajectory. It emerges at a point slightly superior to the contralateral renal artery, thus showing a more horizontal trajectory, that can be observed only when it is a few millimetres from the renal hilum, at a point where its terminal segmentary branches are observed. It usually lies posteriorly to the pancreatic body and the splenic vein, and may be crossed anteriorly by the inferior mesenteric vein (Testut and Jacob, 1947; Bouchet and Cuilleret, 1997; Williams et al., 2004).

Regarding the venous drainage of the kidney, it is considered that both renal veins are formed from the confluence of 2 to 4 venous stems that contribute to their formation and lie anteriorly to the homonymous renal artery, draining the ipsilateral renal parenchyma, the adrenal gland and the cranial portion of the ureter, with no internal valves (Testut and Jacob, 1947; Bouchet and Cuilleret, 1997; Williams et al., 2004; Moore and Dalley, 2005; Anderson et al., 2007).

The right renal vein measures approximately 3 cm in length and describes a horizontal trajectory from the kidney, ending in a 90º angle with the right lateral border of the inferior cava vein. In contrast, the left renal vein is longer, 7 cm in length, and pursues a slightly oblique and superior trajectory at the aortic anterior face, with which it forms a vascular pincer. Compared to the right renal vein, the left renal vein reaches the inferior cava vein at a slightly superior point and in a more antero-lateral location. Additionally, the left renal vein has the left adrenal vein (superiorly), the lumbar vein (posteriorly) and the left gonadal vein (inferiorly) as tributary veins. Typically the right renal vein does not receive any tributaries (Testut and Jacob, 1947; Bouchet and Cuilleret, 1997; Williams et al., 2004; Moore and Dalley, 2005; Anderson et al., 2007).

The renal pelvis is formed by the confluence of approximately three major renal calyces, commonly situated at the most external and posterior portion of the renal pedicle, showing a close relationship to the terminal segmentary vessels of the renal artery, as well as to the venous trunks that converge to the formation of the renal vein. Generally, the inferior narrowing of the pelvis forms the uretero-pelvic junction, which marks the origin of the ureter (Testut and Jacob, 1947; Bouchet and Cuilleret, 1997; Williams et al., 2004; Moore and Dalley, 2005; Anderson et al., 2007).

Currently, there are a reasonable number of studies addressing the anatomical analysis of renal hilar structures. Such studies have usually focused on the accessory (polar) arteries, on case reports of rare anatomical variations, and on the analysis of the distribution of the renal veins. However, there are still few anatomical studies concerning the evaluation of the topographic disposition of the main hilar structures, represented by the renal artery, vein and pelvis.

Our study aims to evaluate the anatomical disposition of the main renal hilar structures, consisting of the renal artery, vein and pelvis, in adult human cadavers, considering the antero-posterior distribution.

Materials and methods

A total of 113 renal adult Brazilian human cadaver hila (97 males, 15 females) were dissected from January to July 2008. The mean age of the cadavers was 55 (range 20 to 75 years). Among all specimens, 44 kidneys were dissected from the whole cadaver and 69 hila were dissected from avulse cadaver kidneys, which were available for study at the anatomic laboratory and had previously been separated from the cadaver body. All anatomical specimens were fixed in 5% formaldehyde solution and belonged to the anatomical laboratories of Estácio de Sá University.

Kidneys that displayed morphological alterations at either inspection (such as lobulations, hematomas, cysts, atrophic areas, tumors, pyeloureteral stenosis, anomalous pelvic dilatation and malformations) or palpation (urinary stones, nodules and cavities) were excluded. Likewise, those kidneys that exhibited vascular morphological alterations such as anomalous dilatations from varices and aneurisms were also excluded. None of the avulsed kidneys had small vessels and structures displaced or avulsed. None of the cadavers analysed had macroscopic alterations of the organs of the superior abdomen, or causa mortis related to any primary abdominal affection.

The kidney hilar structures were pinpointed with coloured pins for photographic recording with a high-resolution digital photographic camera (Sony® Cyber-shot® 7.2 Mega-pixels). The topographic disposition of the hilar structures was analysed at approximately 0.5 cm (0.2 inches) from the anterior lip of the renal hylum, antero-posterior sense, considering only the renal artery, renal vein and renal pelvis. Analysis of segmentary arteries and occasional anatomical variations was performed when such structures were present at the hilar region studied. The distribution and disposition of such structures inside the organ were not studied. Also, the renal poles were not evaluated for the presence of polar arteries.

Results

The data concerning the different distributions of the renal hilar structures are shown in Table 1. The following antero-posterior dispositions of the hilar structures were noted: «vein-artery-pelvis» (Fig. 1), «vein-pelvis-artery» (Fig. 2), «artery-vein-pelvis» (Fig. 3) and «artery-pelvis-vein» (Fig. 4).

Among the specimens in which the renal «vein-artery-pelvis» disposition was present, the segmentary arteries were related to these structures, as shown in Table 2. The following relationships of the segmentary arteries with the renal vein, artery and pelvis were observed: one to three segmentary arteries crossing the renal vein anteriorly from its superior border (Fig. 5); one segmentary artery anteriorly along the renal vein at its superior border, and another segmentary artery along its inferior border (Fig. 6); one segmentary artery along the inferior border of the renal vein crossing its anterior face (Fig. 7). We also observed a renal vein bifurcation in the extraparenchymal region in 4 specimens (4%) (Fig. 8) and one right-kidney specimen from a male cadaver (1% of total cases) that had the gonadal vein as a tributary of the ipsilateral renal vein.

Among the 113 kidneys dissected, 12 specimens had an undefined pattern of hilar anatomical disposition (Fig. 9). The data concerning the anatomical arrangements of this group are shown in Table 3.

Discussion

Morphological studies of the renal hilar structures have traditionally covered them individually, not taking into consideration the relationships between the other elements of the extra-renal hilar region. In this context, we found two studies whose analysis focused on the distribution of the renal artery at the hilar region (Sampaio and Passos, 1992; Khamanarong et al., 2004), including a significant number of dissected anatomical specimens represented by 267 kidneys and 266 kidneys from adult cadavers. Similar analyses evaluating exclusively the hilar arterial distribution have also been performed in early-aged cadavers, such as foetuses (Cicekcibasi et al., 2005) and children (Palmeira, 1985). Similarly, studies that have assessed only the renal vein at the extraparenchymal region are also available. For instance, Baptista-Silva et al. (1997) described the main presentations of the renal vein in 342 kidneys from living donors for renal transplantation.

When the structures of the renal pelvis are not analysed in isolation, in studies that have addressed the anatomical relationships between the artery, vein and pelvis set, the evaluation has generally been performed in the intra-renal region (Sampaio and Aragão, 1990a,b; Sampaio, 1992) or using case reports involving a single cadaver (Das and Paul, 2006). In 2007, for instance, Sampaio reported a very interesting study concerning such relationships inside the kidney, highlighting the importance of having a good knowledge about them for the purposes of surgical puncture of the kidney, in his book dedicated to renal anatomy for urologists.

In our study, we performed a topographic assessment of the main elements of the extra-renal hilar region, considering their importance for open and laparoscopic urological interventions. Here, the evaluation of the polar regions, a site of possible anatomical variations, mainly represented by the presence of polar arteries, was not considered since there are numerous studies on the anatomical variations of the renal vasculature, and it is well-known that such anatomical variations occur in 25% to 40% of kidneys, mainly featuring supernumerary renal arteries, usually at the left side (Anderson et al., 2007). However, during the dissection of our cases, when supernumerary arteries related to the main hilar structures were observed their presence was recorded.

Table 1. Anatomical distribution of renal hilar structures in the antero-posterior sense.

Number of specimens	Percentage	Side	Segmentary artery disposition
94	83%	44 right kidneys 50 left kidneys	Renal vein-artery-pelvis
12	10%	3 right kidneys 9 left kidneys	Undefined pattern of hilar anatomical disposition
03	3%	3 left kidneys	Renal vein-pelvis-artery
03	3%	2 right kidneys	
		1 left kidney	Renal artery-vein-pelvis
01	1%	1 left kidney	Renal artery-pelvis-vein

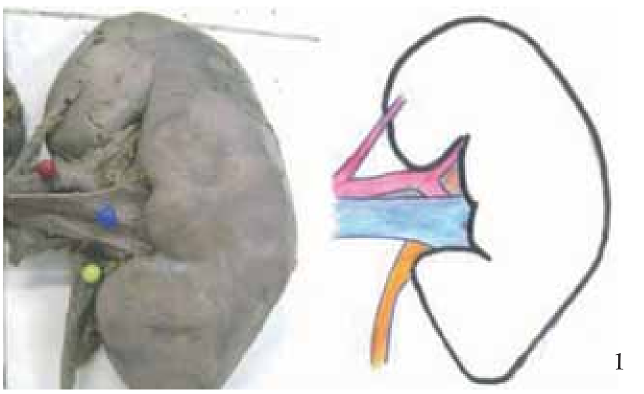

Fig. 1. The «vein-artery-pelvis»-type hilar anatomical disposition, found in 83% of dissected kidneys, in which the renal vein is represented in blue, the renal artery in red and the renal pelvis in yellow.

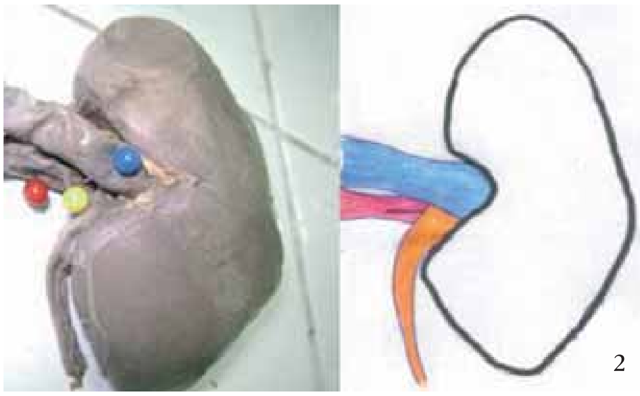

Fig. 2. The «vein-pelvis-artery»-type hilar anatomical disposition, found in 3% of dissected kidneys, in which the renal vein is represented in blue, the renal artery in red and the renal pelvis in yellow.

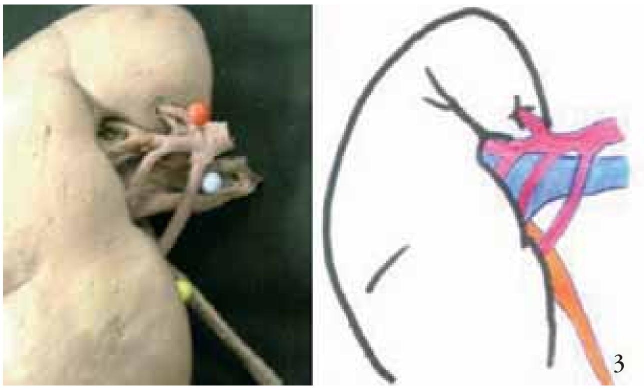

Fig. 3. The «artery-vein-pelvis»-type hilar anatomic disposition, found in 3% of dissected kidneys, in which the renal vein is represented in blue, the renal artery in red and the renal pelvis in yellow.

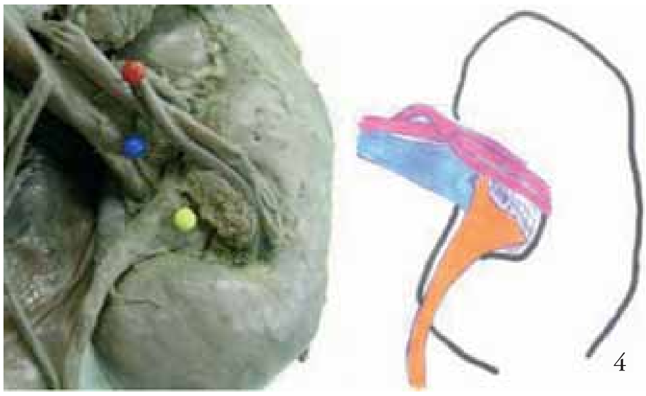

Fig. 4. The «artery-pelvis-vein»-type hilar anatomic disposition, found in 1% of dissected kidneys, in which the renal vein is represented in blue, the renal artery in red and the renal pelvis in yellow.

Table 2. Anatomical distribution of segmentary arteries related to the renal vein, artery and pelvis.

Number of specimens	Percentage	Side	Hilar anatomical disposition
34	30%	13 right kidneys 21 left kidneys	One to three segmentary arteries crossing the renal vein anteriorly from its superior border
04	4%	3 right kidneys 1 left kidney	One segmentary artery anteriorly along the renal vein at its superior border and another segmentary artery along its inferior border
04	4%	2 right kidneys 2 left kidneys	One segmentary artery along the inferior border of the renal vein crossing its anterior face

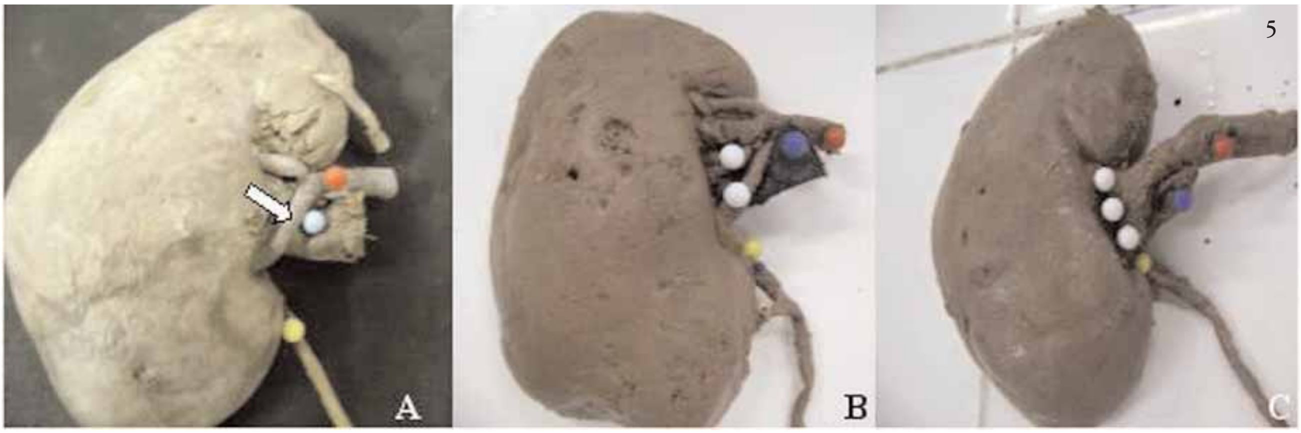

Fig. 5. The «vein-artery-pelvis»-type hilar anatomical disposition, in which one (**5A** - white arrow), two (**5B** - white pins) or three (**5C** - white pins) segmentary artery(ies) cross(es) the anterior border of the renal vein, from its superior margin (renal vein - blue pin; renal artery - red pin; renal pelvis - yellow pin).

Fig. 6. The «vein-artery-pelvis-vein»-type hilar anatomical disposition, in which one segmentary artery crosses the anterior border of the renal vein, from its superior margin, and the other one from its inferior border (segmentary arteries - pink pin; renal vein - blue pin; renal artery - red pin; renal pelvis - yellow pin).

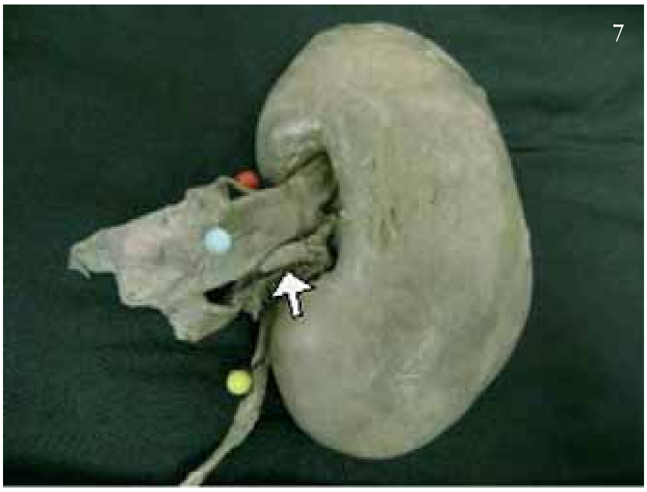

Fig. 7. The «vein-artery-pelvis»-type hilar anatomical disposition, in which one segmentary artery (white arrow) crosses the anterior border of the renal vein, from its inferior margin (renal vein - blue pin; renal artery - red pin; renal pelvis - yellow pin).

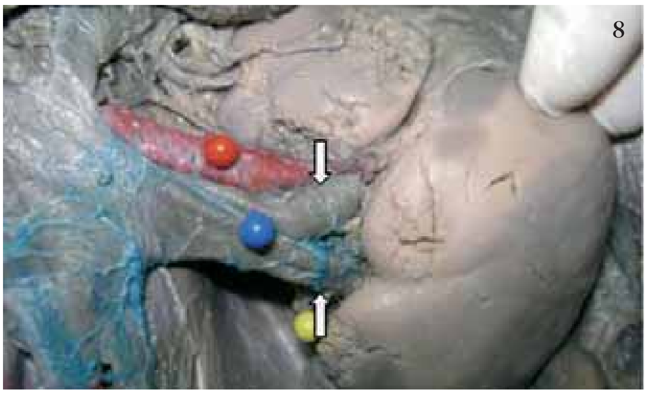

Fig. 8. The «vein-artery-pelvis»-type hilar anatomical disposition, in which a bifurcated renal vein (white arrows) - (renal vein - blue pin; renal artery - red pin; renal pelvis - yellow pin) can be observed

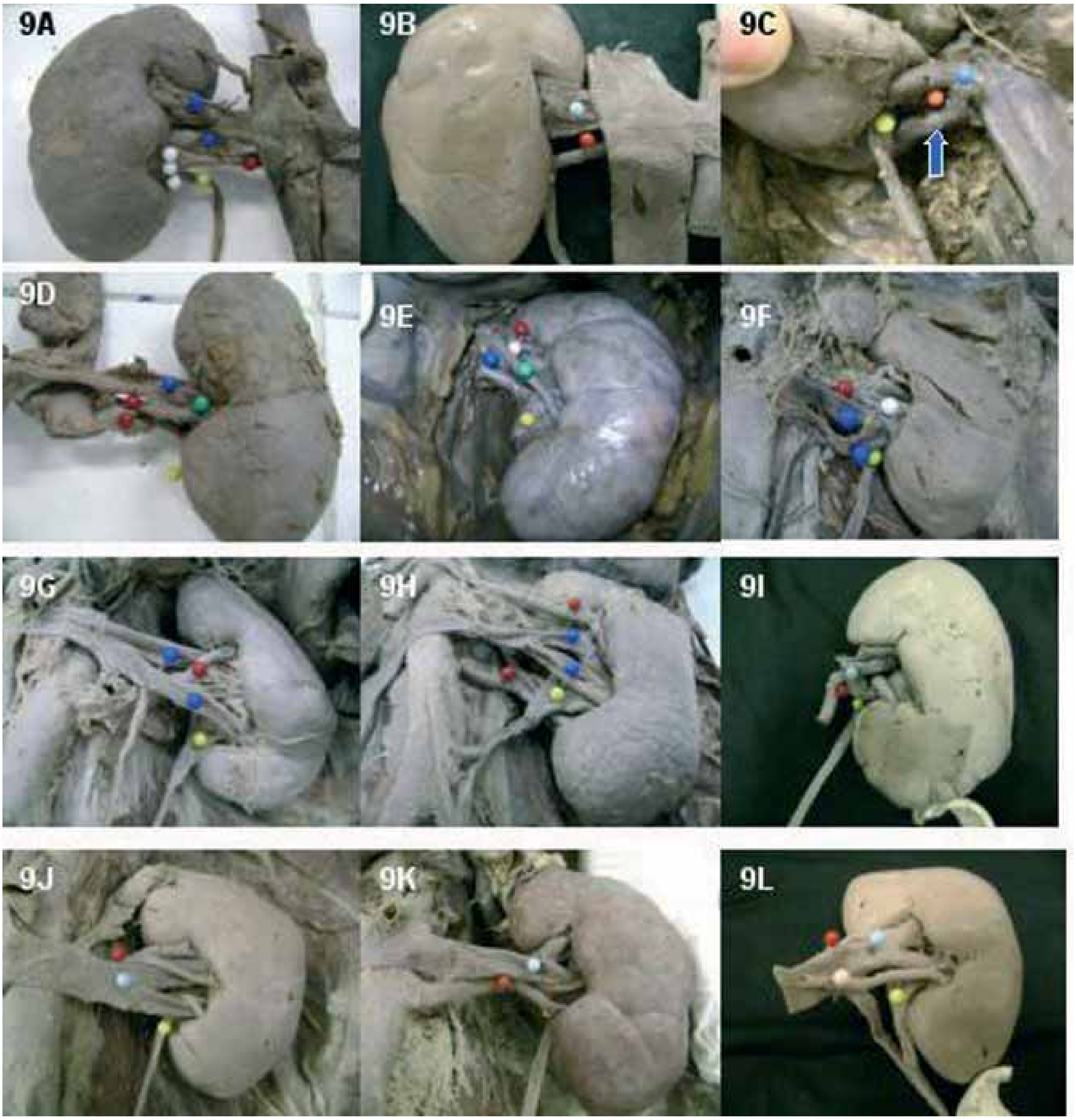

Fig. 9. Undefined patterns of hilar anatomical disposition observed in twelve dissected specimens.

Some studies have described alterations in the hilar vascular pattern associated with anomalies or anatomical variations of other organs and structures (Ozan, 1998). In none of our specimens were alterations of the large vessels or adjacent organs observed. Likewise, we failed to observe vascular alterations in the kidneys from the same cadaver, as reported by Bulic et al. (1996), who described a double right renal artery and a triple left one in a single cadaver. We believe the explanation for such a difference from our findings lies in the fact that many of our specimens were obtained from avulse anatomical specimens, already dissected from the cadavers before our study.

Once we had evaluated the studies addressing the anatomical variations of gonadal vessels, we noted that these were few and far in between. In this sense, Ozan et al. (1995) described more cranially situated vascular origins of variant gonadal arteries in a male and a female cadaver. In the same context, during routine anatomical dissection Bergman et al. (1992) identified a male cadaver with two

Table 3. Anatomical arrangements in specimens with an undefined pattern distribution of hilar structures.

Number of specimens	Percentage	Antero-posterior distribution
01	Right	Renal "artery-vein-pelvis», with a bifurcated renal vein and three segmentary arteries disposed at the anterior face of the inferior hilar venous division (figure 9A)
01	Right	Renal "vein-double artery-pelvis" (figure 9B)
01	Right	Renal "Vein-artery-pelvis-vein" (figure 9C)
01	Left	Renal "vein- double artery-pelvis", with the superior renal arteriorly crossing the renal vein from its inferior border (figure 9D)
01	Left	Renal "pelvis-vein-artery", where one accessory renal artery crosses such complex anteriorly, originating directly from the abdominal aorta and associated with a segmentary renal artery that crosses the anterior face of the renal vein from its superior border (figure 9E)
01	Left	Renal "double vein-artery-pelvis", with one segmentary renal artery crossing the anterior face of the superior renal vein from the vein's superior border (figure 9F)
01	Left	Renal "vein-artery-vein-pelvis" (figure 9G)
01	Left	Renal "artery-double vein–pelvis-artery", where the superior renal artery is located at the most superior region of the renal hilum (figure 9H)
01	Left	Renal "vein-artery-pelvis" with a bifurcated renal vein and segmentary arteries at the superior and inferior borders of the superior venous division (figure 9I)
01	Left	Renal "vein-artery-pelvis" with a bifurcated renal vein and a segmentary artery crossing anteriorly de superior venous divison from its superior border (figure 9J)
01	Left	Renal "vein-artery-pelvis" with a bifurcated renal vein and segmentary artery crossing the anterior face of the inferior venous division, from its inferior border (figure 9K)
01	Left	Renal "vein-artery-pelvis" with a bifurcated renal vein and a segmentary artery directly originating from the abdominal aorta, crossing the hilar complex anteriorly (figure 9L)

right testicular arteries, originating from the ipsilateral renal artery and the polar renal artery. Considering only the anatomical variations of the gonadal veins, it may be seen that these may have a venous ending in the subcostal, colonic and renal veins, thus differing from the classical anatomical description (Wishahi, 1991; Tubbs et al., 2005; Favorito et al., 2007). A very elegant study conducted by Favorito et al. (2007) in which the authors analysed male human cadavers (100 adults and 24 fetus) revealed the presence of a right gonadal vein ending at the ipsilateral renal vein in only one adult cadaver (1%) and in only one foetal cadaver (4.2%). Other anatomical studies using adult human cadavers have reported similar results, in which the right gonadal vein ended at the homolateral renal vein in 0.7% to 2.3% of cases, out of a total number of cadaver specimens ranging from 42 to 150 (Asala et al., 2001; Das and Vasudeva, 2005). The anatomical variation of the gonadal vessels found in our analysis was represented by the right gonadal vein end at the ipsilateral renal vein; this was observed in a single cadaver (male) specimen (0.9%), in agreement with previous findings from studies addressing this issue.

Considering the distribution of the extraparenchymal renal vein, we observed that 3 specimens (2.6%) had more than one renal vein and 8 (7%) had a bifurcated renal vein. In 1995, Satyapal, analysing 306 kidneys from adult human cadavers (262 male and 44 female), proposed a classification for the renal vein disposition at the pre-hilar region, in which the bifurcated renal vein corresponds to «type IA» (Satyapal, 1995). This type of venous arrangement was found in 39% of his specimens; i.e. more than in the present study (7%). In that South African study, the presence of more than one renal vein in the hilar region (classified as type III) was reported in 13% of cases, represented by specimens with a bifurcated renal vein and an accessory renal vein. In 2.6% of our specimens, we observed a different disposition, composed of 2 independent renal veins with distinct topographic dispositions. The study, performed in 1995, did not take into account the anatomical relationships and the topographical distribution of the main components of the renal hilum in the extraparenchymal region. It might therefore be possible to propose a second classification for the venous arrangement, considering such elements.

Variations in the number of renal arteries found in the hilar region are sometimes associated with renal malformations in the embryo (Bayramoglu et al., 2006). In our study we found that in most specimens the number of renal arteries found at the renal hilum was constant: 1 renal artery. We observed only 2 specimens (1.8%) with a duplication of arteries in the extraparenchymal hilar region. When we compared our findings with those of studies performed in cadavers without malformations (generally comprising case reports from a single cadaver based on routine anatomical dissection in University laboratories (Rao et al., 2006; Nayak, 2008), we observed that our own data were in agreement with these. Some studies have reported the presence of multiple renal arteries in up to 25% of dissected specimens (Kaneko et al., 2008); However, such studies considered the polar arteries (accessory renal arteries) as main renal arteries, so this may have been a misleading factor for the interpretation of the true number of renal arteries (Ross et al., 1961; Harrison et al., 1978; Kaneko et al., 2008). As previously mentioned, we stress that in our evaluation we only considered those arteries found at the extraparenchymal renal region for analysis, since we understand that the other arterial vessels should be classified as accessory renal arteries.

From the findings reported here it may be concluded that the most commonly observed topographic organization of renal hilar extraparenchymal structures in adult human cadavers corresponds to the descriptions of the classical anatomical evaluations of the region. Anatomical variations in the disposition of these main hilar structures -although only found in a minority of the specimens analysed- were present, suggesting that urologists should become familiarized with this kind of anatomical analysis, thereby increasing safety in surgical interventions on the kidney.

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