CASE REPORT

RJME
Romanian Journal of Morphology & Embryology
http://www.rjme.ro/

Rare variant of renal vascularization with bilateral multiple pedicles and incomplete rotation – case report

DELIA ELENA ZĂHOI, DORINA SZTIKA, LUCIA STOICAN, ECATERINA DĂESCU

Department of Anatomy and Embryology, "Victor Babeş" University of Medicine and Pharmacy, Timişoara, Romania

Abstract

Renal blood vessels present great morphological variability. The routine dissection of a 68-year-old male cadaver revealed multiple bilateral vascular variations associated with the incomplete rotation of both kidneys. The left kidney was supplied by three renal arteries: one superior artery and one middle artery with hilum penetration, and one inferior artery with inferior polar penetration. All three arteries arose from the aorta: two from the anterior side at levels L1 and L3, and one – the inferior artery – from the posterior side of the aorta, as a common trunk with the middle sacral artery. The right kidney had two arteries, both arising from the aorta. The superior renal artery, arising at level L1, entered the renal parenchyma at the hilum; the inferior artery, arising at the point where the abdominal aorta branches in the two common iliac arteries, entered the parenchyma at the inferior pole. Each of the five arteries was accompanied by a vein. The (bilateral) superior renal veins and the middle left vein drained into the inferior vena cava. The two inferior renal veins joined to form a common trunk that drained into the left common iliac vein. Both kidneys presented incomplete rotation, each renal pelvis being situated anterior to the renal vessels, and the ureters descending on the anterior sides of the kidneys. The presence of several vascular pedicles may represent a contraindication in laparoscopic nephrectomy or cause severe bleeding if the pedicles are injured during endopyelotomy.

Keywords: kidneys, anatomic variation, renal arteries, renal veins, dissection.

Introduction

The renal arteries are the largest visceral collateral branches of the abdominal aorta. They arise from the lateral sides of the aorta, usually at L1–L2 intervertebral disc level [1]. At the renal pedicle level, the arteries run posterior to the renal veins and enter the renal hilum anterior to the pelvis. The arterial blood supply of the kidney has great variability, multiple renal arteries being the most common vascular variations.

The renal veins are formed by the confluence of two or three venous trunks at the renal sinus level. Usually, each kidney has a single vein that drains into the lateral side of the inferior vena cava, at an L2 level. The morphological variability of renal veins has not been as extensively studied yet, but variants' importance has increased with the number and variety of renal surgical and imaging procedures. Multiple renal veins occur less frequently than multiple renal arteries, however, there is a correlation between the presence of venous and arterial systems variations, especially among males [2].

The uniqueness of this case consists in the fact that multiple pedicles were present in both kidneys (two and three, respectively), a variant not previously described in the literature. This gives it not only academic importance, but practical significance as well, drawing attention to a complex morphological variant to be taken into account by clinicians.

Case presentation

The routine dissection of a 68-year-old male cadaver with no known renal pathology, performed in the Laboratory of Anatomy and Embryology revealed multiple renal vascular variations.

Both kidneys presented incomplete rotation, and the renal pelvis and ureter were in an anterior position. The left kidney had three vascular pedicles (arteries and veins). All three renal arteries arose from the abdominal aorta. The (main) superior renal artery arose from the anterior side of the aorta, at L1 level, initially followed a course posterior to the superior renal vein, then ran superior to the superior renal vein to enter the renal parenchyma at the upper end of the renal sinus. The middle renal artery also arose from the anterior side of the aorta, at L3 level, but followed an oblique ascending course, running posterior to the left gonadal vessels to enter the renal parenchyma at the lower end of the renal sinus, posterior to the renal pelvis. The inferior renal artery arose from the posterior side of the aorta, at level L4, as a common trunk with the median sacral artery; it descended in the angle between the two common iliac arteries, then ran obliquely upwards, crossing anterior to the left common iliac artery and passing posterior to the superior mesenteric artery, left gonadal vessels and left ureter. It then entered the parenchyma right at the inferior extremity of the kidney (inferior polar artery).

The (main) left superior renal vein arose superior to the renal pelvis and inferior to the superior renal artery, through the confluence of two collecting trunks. After receiving the inferior suprarenal vein and the left gonadal vein, it drained into the inferior vena cava. The smaller middle renal vein had an initial horizontal course superior to the artery. It then ran obliquely upwards and drained into the left gonadal vein, below the point of drainage into the left superior renal vein. The (polar) inferior renal artery had two satellite veins superior and inferior to it. These descended obliquely downwards, posterior to the

left ureter and left gonadal veins, up to the lateral end of the left common iliac artery. At this point, the two veins joined to form the inferior left renal vein. This descended anterior of the left common iliac artery and joined the inferior right renal vein, forming a trunk before draining into the left common iliac vein (Figure 1).

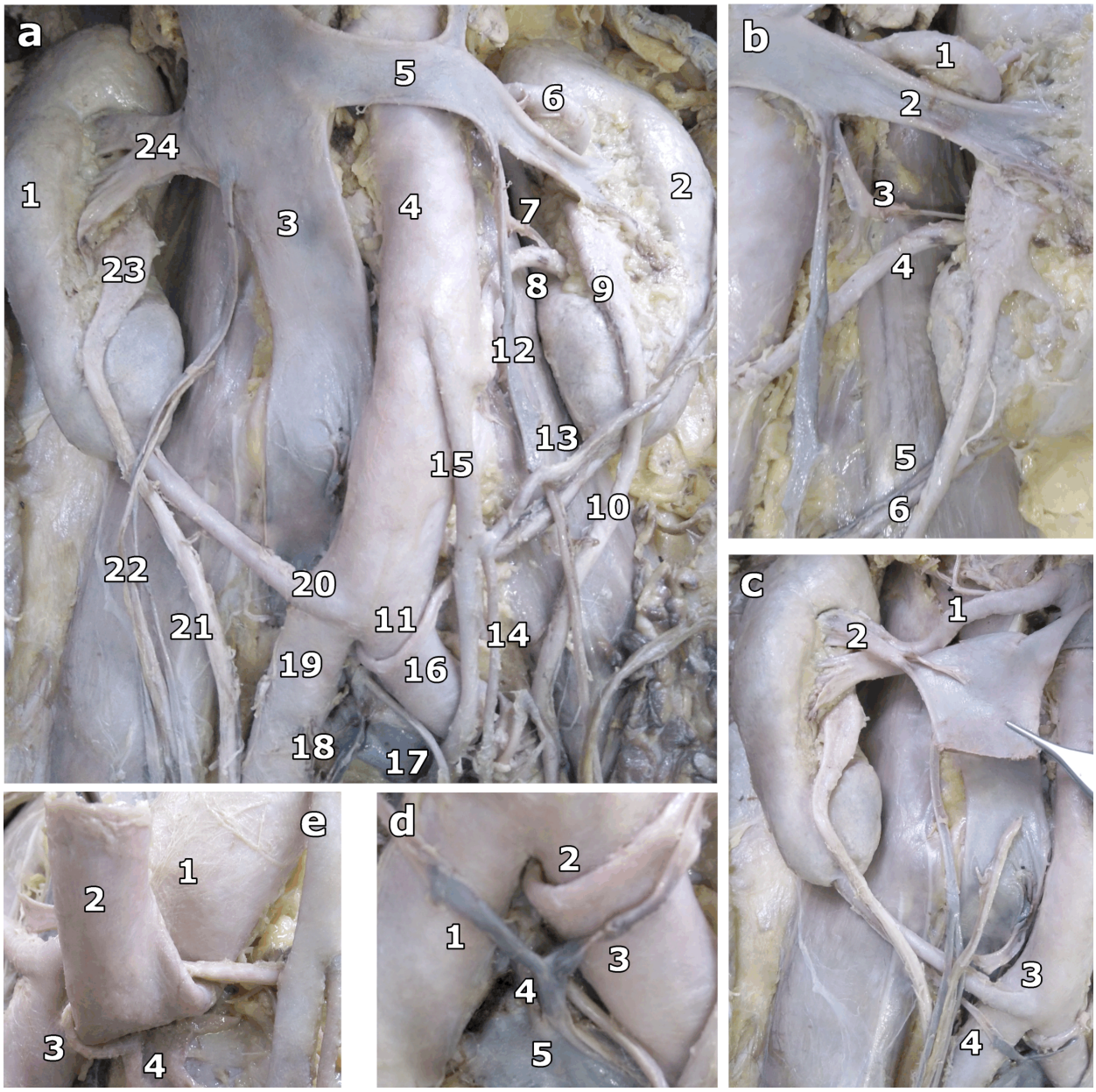

Figure 1 – ***(a) Kidney and great vessels. Anterior view. 1: Right kidney; 2: Left kidney; 3: Inferior vena cava; 4: Abdominal aorta; 5: Left superior renal vein; 6: Left superior renal artery; 7: Left middle renal vein; 8: Left middle renal artery; 9: Left renal pelvis; 10: Left ureter; 11: Left inferior renal artery; 12: Left testicular vein; 13: Left colic artery; 14: Sigmoid artery; 15: Inferior mesenteric artery; 16: Left common iliac artery; 17: Left inferior renal vein cut; 18: Right inferior renal vein cut; 19: Right common iliac artery; 20: Right inferior renal artery; 21: Right ureter; 22: Right testicular vessels; 23: Right renal pelvis; 24: Right superior renal vein. (b) Left kidney vascularization – detail. Anterior view. 1: Superior renal artery; 2: Superior renal vein; 3: Middle renal vein; 4: Middle renal artery; 5: Inferior renal vein; 6: Inferior renal artery. (c) Right kidney vascularization – detail. Anterior view. 1: Superior renal artery; 2: Superior renal vein; 3: Inferior renal artery; 4: Inferior renal vein. (d) Inferior right and left renal veins confluence and opening into the left common iliac vein – detail. Anterior view. 1: Right inferior renal vein; 2: Left inferior renal artery; 3: Left inferior renal vein; 4: Common venous trunk; 5: Left common iliac vein. (e) Left inferior renal artery origin – detail. Anterior view. 1: Abdominal aorta; 2: Left common iliac artery cut; 3: Left inferior renal artery; 4: Median sacral artery.***

The right kidney had two renal arteries. The superior renal artery originated from the lateral side of the aorta, at L3 level, and followed a slightly ascending course, passing posterior to the inferior vena cava and the right superior renal vein to enter the upper renal sinus. The inferior renal artery arose from the anterior side of the aorta, at L4 level (superior to the origin of the right common iliac artery). It ran obliquely upwards and to the right, passing posterior to the gonadal vessels and the right ureter. It entered the parenchyma at the lower end of the right kidney (inferior polar artery).

The (main) right superior renal vein was formed

anterior to the superior renal artery and superior to the renal pelvis, by the confluence of two venous trunks, and drained into the inferior vena cava. The inferior renal vein followed a descending course inferior to the inferior renal artery and posterior to the ureter and the right gonadal vessels. It crossed anterior to the right common iliac artery and after it joined the left inferior renal vein, drained into the left common iliac vein.

Discussions

Renal artery variations in number, origin, course and branching are frequent and thoroughly studied. Nevertheless, there are rare variations and even variations that have not been described so far. The most frequent renal artery variations are of number. The incidence of multiple renal arteries varies with gender, race and study method [computed tomography (CT)/dissection] [3, 4]. As for their location, they are unilateral in about 30% of cases and bilateral 10% [5]. Most multiple renal artery cases involve two arteries, with three being present in only 2.5% of cases, and four or more in less than 1%. Some of the highest numbers were reported by Hirai *et al.* in 2013 [6] – nine arteries.

In our case, all five arteries originated from the aorta: the superior arteries and the left middle artery at a L1–L3 level, and the inferior polar arteries at L4. The left inferior renal artery arose from the posterior side of the abdominal aorta, as a common trunk with the median sacral artery. The right inferior renal artery arose from the anterior side of the aorta, at the point where it branched into the two common iliac arteries. In this regard, the case fits with the norms found in previous studies on larger samples, which found that 72.2% [7] and 76.7% [8] of multiple renal arteries have a direct aortic origin. Bergman *et al.* (1998) [9] mention the possibility of renal arteries arising from the abdominal aorta's branching point or the middle sacral artery, however, we have not found any other such cases reported.

The large number of variations in renal vascular morphology or kidney position can be explained by the kidneys' complex embryological development. Most studies hold that multiple renal arteries are the result of persistent mesonephric arteries – the "ladder theory" [10]. However, in 2015, Hinata *et al.* [11] formulated a new theory. According to them, in the 7th week of development, mesonephric arteries disappear, and thus cannot become final renal arteries. In the same week, a new pair of symmetrical arteries appears near the upper end of the metanephros.

The theory seems to have been confirmed in 2018 by Fukuoka *et al.* [12], in a study on kidney ascent. They claimed that nephrogenesis begins only when the metanephros reaches its final position. The metanephros is not functional during its ascent, contradicting theories that the ascending kidney is supplied with blood from the aorta at increasingly higher levels, the last branch being the definitive renal artery. The abdominal aorta seems to preserve its potential for budding even after the mesonephric arteries have been eliminated, which could be the cause of multiple renal arteries.

Renal vein anomalies are less frequent and are caused by the regression or abnormal development of the embryonic venous system. There is a close correlation between the embryonic development of the renal veins and the development of the inferior vena cava.

The intrahepatic inferior vena cava develops between the 4th–8th weeks from three pairs of veins: posterior cardinal, subcardinal and supracardinal. Anastomoses occur between them through numerous transverse channels. The renal segment of the inferior vena cava is formed from the anastomoses of the supra- and subcardinal veins, which create a circular venous system around the aorta (renal collars). The posterior renal collar, formed by the supracardinal veins, degenerates progressively. The anterior renal collar, formed by the subcardinal veins is integrated into the lateral wall of the inferior vena cava on the right, while on the left it becomes the definitive renal vein [13].

Bilateral multiple renal veins cases are very rare (0.6% – [14]). In our case, we observed three veins on the left side and two on the right, counter to most studies, which found higher numbers of vessels, tend to be on the right.

Another particularity of our case is the completely separated vascularization of the bilateral inferior renal segments. During angiographies, such arteries arising from the aorta can be mistaken for other branches (capsular arteries), and their accidental ligation or embolization may cause the infarction of the corresponding renal parenchyma [15].

Additionally, in our case, both kidneys presented incomplete rotation, the renal pelvis being situated anterior to the renal vessels, and the ureter descending on the anterior side of the lower end of the kidney. In some cases, the ureter or the ureteropelvic junction (UPJ) may be obstructed through compression between the inferior renal parenchyma and the inferior polar vessels [16, 17]. Crossing vessels are one of the most common causes of UPJ obstruction (29–46%), with only 5–10% of crossing vessels passing posterior to the UPJ [18]. During their ascent, fetal kidneys undergo a 90° rotation around their longitudinal axis before reaching their final position at the end of the 8th week of intrauterine life [19]. The perturbation of this process may produce unilateral or bilateral kidney position or rotation anomalies. Incomplete rotation of the kidney, or simple renal ectopia, is generally asymptomatic and tends to only be discovered by happenstance during imagistic investigations or dissections [20].

The incidence of cases with multiple associated renal variants – arterial, venous, as well as ureteropelvic or position is very rare (0.13%) [21].

The incidence of laparoscopic nephrectomy in donors has increased considerably in the past years. The left kidney is preferred for harvesting, due to its longer renal vein. Consequently, the preoperative evaluation of the renal venous system is as important as the evaluation of the arterial one [22].

Conclusions

Detailed familiarity with the renal vascular anatomical variations is important for renal trauma investigation and treatment, renal transplant, renal artery embolization and conservative or radical renal surgery.

Conflict of interests

The authors declare that they have no conflict of interests.

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Corresponding author

Delia Elena Zăhoi, Professor, MD, PhD, Department of Anatomy and Embryology, "Victor Babeş" University of Medicine and Pharmacy, 2 Eftimie Murgu Square, 300041 Timişoara, Timiş County, Romania; Phone +40256–204 400, e-mail: dzahoi@umft.ro

Received: July 20, 2019

Accepted: November 25, 2019