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CASE REPORT

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Circumaortic left renal vein (circumaortic renal collar) associated with the presence of vascular anomalies: a case series and review of literature

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Renal vessels exhibit a high degree of anatomical variations in terms of their number, level of origin, diameter and topographical relationships. In particular, it applies to the left renal vein which can take retroaortic or even circumaortic placement. Anatomical variations of the left renal vein may be of great clinical significance, particularly in the case of renal transplantation, retroperitoneal surgery as well as vascular or diagnostic procedures. Thus, the aim of this report was to present a complete anatomical description of two cases of the circumaortic left renal vein (CLRV; circumaortic renal collar) co-existing with the presence of various vascular anomalies. In the first case, the circumaortic renal collar was connected via a large anastomosis with the hemiazygos vein and was associated with the presence of the supernumerary left renal artery located below the main left renal artery. In the second case, the circumaortic renal collar was accompanied by the renal artery dividing close to its origin. Moreover, in the latter case, the fusiform aneurysm of the abdominal aorta was observed. In both cases, the CLRV began as a single and short trunk. On its further course, the initial segment of the CLRV was divided into two limbs — anterior (anterior left renal vein) and posterior (posterior left renal vein). Both anterior and posterior limb of the CLRV opened into the inferior vena cava. (Folia Morphol 2019; 78, 2: 437–443)

Key words: accessory renal vessels, anatomical variation, aneurysm, kidney, left renal vein, supernumerary renal arteries

INTRODUCTION

Normal anatomical relationships between renal vessels, abdominal aorta and inferior vena cava (IVC) were illustrated for the first time in 1564 in the Eustachi's treatise entitled *Opuscula anatomica*. Anatomical variants of the renal arteries and veins were also shown for the first time in the illustrations contained there [21]. Due to the development of advanced surgical and diagnostic procedures the issue of anatomical variations of renal vessels remains of utmost importance to practitioners. Typically, a single renal artery and vein is present on both the right and the left side. Each of the renal veins is located anterior to the appropriate renal artery and opens into the IVC [28]. However, there are numerous clinically relevant deviations from this arrangement [5].

Renal vessels demonstrate huge anatomical variability as regards to their number, level of origin, diameter and topographical relationships [2, 8–10, 17, 19, 25, 26, 30–36]. In particular, it applies to the

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left renal vein which can present retroaortic [1, 10, 12, 15] or even circumaortic placement [7, 11, 13, 20, 27]. Thus, the left renal vein may be a single vessel or double — with two limbs: one located anterior and the second posterior to the abdominal aorta [5, 19, 33].

Knowledge of the anatomical variations of renal vessels may be crucial during retroperitoneal surgery, renal transplants, as well as vascular or diagnostic procedures [3, 4, 7–11, 14, 16, 18, 19, 24, 30]. This applies in particular to the left kidney. Due to the fact that the left renal vein is about three times longer than the right one, the left kidney is the preferred side for live donor nephrectomy [28]. Thus, different variations of the left renal vein, including the circumaortic renal collars, should be recorded and analysed, especially in the context of their co-existence with vascular variations. So, the aim of this case report was to present a complete anatomical description of two cases of the circumaortic left renal vein (CLRV; circumaortic renal collar) associated with the presence of the atypical arrangement of renal arteries. In the first case, the circumaortic renal collar gave a large root to the hemiazygos vein and was accompanied by the presence of the accessory (supernumerary) left renal artery running below the main left renal artery. In the second case, the circumaortic renal collar was accompanied by renal artery dividing close to its origin. Moreover, in the latter case the fusiform aneurysm of the abdominal aorta was observed. Embryological background and clinical significance of the observed variation have also been discussed.

CASE REPORT

Case no. 1. The circumaortic renal collar accompanied by the presence of the supernumerary left renal artery

A 73-year-old female cadaver was subjected to dissection for teaching and research purposes. During the dissection of the posterior abdominal wall, the kidneys and renal vessels were exposed on both sides. Careful inspection of renal veins arrangements and tributaries revealed the presence of accessory (supernumerary) left renal vein which displayed retroaortic course. After a detailed inspection, the variation was classified as CLRV (circumaortic renal collar). The subsequent stages of the dissection were subordinated to a thorough examination of the observed vascular variations including measurements of the vessels diameters and also examination for the presence of possible venous valves. The measurements were performed *in situ* with a Digimatic digital calliper (Mitutoyo Company, Kawasaki-shi, Kanagawa, Japan).

Circumaortic left renal vein began as a single, short (29 mm) trunk originating from a few tributaries, 13 mm from the renal hilum (Fig. 1). This part of the left renal vein was in contact with the anterior surface of the psoas major muscle and occupied an antero-inferior position in relation to the main trunk of the left renal artery. On its further course, 42 mm from the renal hilum, the initial segment of CLRV was divided into two limbs — anterior (anterior left renal vein [aLRV]; Fig. 1A, B) and posterior (posterior left renal vein [pLRV]; Fig. 1B). Furthermore, the presence of the left accessory renal artery was observed below the main left renal artery (Fig. 1A). On its initial course the accessory artery ran posterior to the aLRV and at the distance of 27 mm from the renal hilum arched over the left renal vein and then coursed along its anterior aspect (Fig. 1A). The length (measured from the origin to the renal pelvis) of both renal arteries was respectively 57 mm for the main left renal artery and 66 mm for the accessory left renal artery. The diameters of both arteries were 6.14 mm for the main trunk and 3.32 mm for the accessory one.

Both limbs of CLRV (namely aLRV and pLRV) ran obliquely crossing, respectively, the anterior (aLRV) or posterior (pLRV) aspect of the abdominal aorta. Anterior limb of CLRV (i.e. aLRV) crossed the anterior surface of the abdominal aorta at the level of the inferior border of LIII vertebra, draining into IVC at the level of the intervertebral disc between LIII and LIV vertebrae. Posterior limb of CLRV (i.e. pLRV) crossed the LII vertebra and opened into the IVC at the level of the superior border of this vertebra. The length of aLRV was 51 mm. The diameter of aLRV was 10.45 mm before receiving the left suprarenal vein (of 4.32 mm diameter), and 11.23 after receiving the left suprarenal vein (Fig. 1). Moreover, the left ovarian vein (of 2.41 mm diameter) drained into the anterior surface of initial part of aLRV (Fig. 1). The length of pLRV was 56 mm. The large anastomosis (of 7.71 mm diameter) with the hemiazygos vein took origin from the upper surface of pLRV (14 mm from the origin of pLRV and 56 mm from the renal pelvis; Figs. 1, 2). The diameters of pLRV measured proximal and distal to the anastomosis with hemiazygos vein were 6.81 mm and 8.14 mm, respectively. No venous valves were found in both the CLRV and in the anastomosis between pLRV and the hemiazygos vein. The renal vessels on the right side were single and showed typical arrangement. The

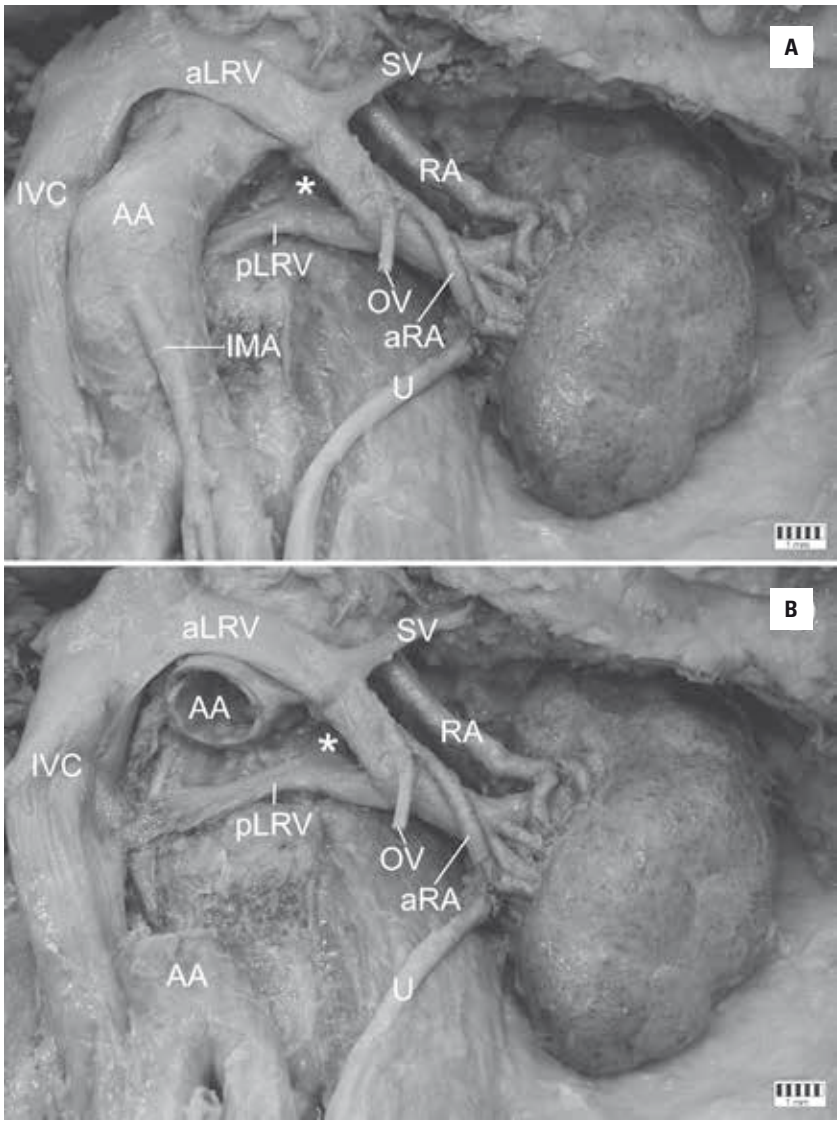

Figure 1. Case no. 1. The circumaortic renal collar anastomosing with the hemiazygos vein and associated with the presence of the accessory left renal artery; **A.** Anterior view showing general topographical relationships within the dissected area. The left kidney has been exposed; **B.** Anterior view after partial removal of the abdominal aorta showing the location and course of the posterior limb (posterior left renal vein) of the circumaortic renal collar; aLRV — anterior left renal vein; aRA — accessory (supernumerary) left renal artery; AA — abdominal aorta; IMA — inferior mesenteric artery; IVC — inferior vena cava; OV — left ovarian vein; pLRV — posterior left renal vein; RA — left renal artery; SV — left suprarenal vein; U — ureter; *anastomosis between the posterior left renal vein and the hemiazygos vein.

diameter (measured at the midpoint of length) of the right renal artery was 7.18 mm and the diameter of the right renal vein was 9.91 mm.

Case no. 2. The circumaortic renal collar accompanied by the left renal artery dividing close to its origin

The second case of the persistent circumaortic renal collar was observed during dissection of the block of abdominal organs harvested from the male body donor of unknown age. Also in this case the CLRV began as a short, single trunk (17 mm) originating from a few tributaries, 9 mm from the renal hilum. This part of the left renal vein was crossed (22 mm from the renal hilum) by one of the anterior branches (4.06 mm of diameter) of the left renal artery (Fig. 3). On its further course, 26 mm from the renal hilum, the initial segment of CLRV was divided into the aLRV and pLRV. The length measured from the origin of the left renal artery to the renal pelvis was 55 mm, while the place of division of the left renal artery into anterior and posterior branches was located 22 mm from its origin. The diameter of the main trunk of the left renal artery was 7.62 mm.

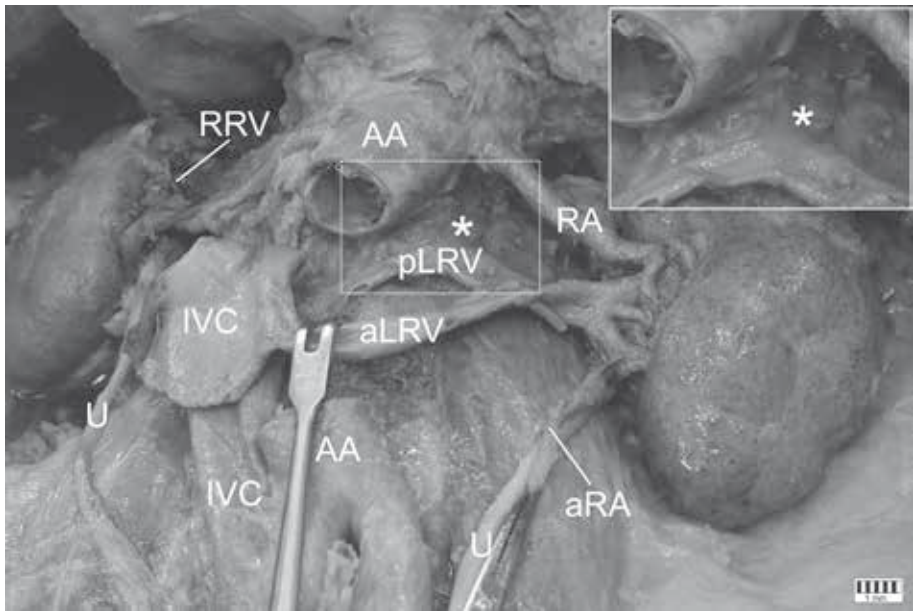

Figure 2. Case no. 1. The circumaortic renal collar anastomosing with the hemiazygos vein. Anterior view after partial removal of the abdominal aorta showing the anastomosis between the posterior left renal vein and the hemiazygos vein (inferior vena cava has been cut and reflected together with the anterior left renal vein). Magnification of the anastomosis (region marked by dotted rectangle) has been shown in the right upper corner; AA — abdominal aorta; aLRV — anterior left renal vein; aRA — accessory left renal artery (cut and reflected); IVC — inferior vena cava; pLRV — posterior left renal vein; RA — left renal artery; RRV — right renal vein; U — left ureter; *anastomosis between the posterior left renal vein and the hemiazygos vein.

Both aLRV and pLRV ran obliquely crossing the anterior or posterior aspect of the abdominal aorta, respectively (Fig. 3). The length of aLRV was 61 mm, its diameter was 9.6 mm before receiving the left suprarenal vein (of 5.8 mm diameter), and 10.68 mm after receiving the left suprarenal vein. The length of pLRV was 63 mm. The small anastomosis (of 3.32 mm diameter) with the hemiazygos vein took origin from the upper surface of pLRV (19 mm from the origin of pLRV and 45 mm from the renal pelvis; Fig. 3). The diameters of pLRV measured proximal and distal to the anastomosis with hemiazygos vein were 7.13 mm and 7.66 mm, respectively. Moreover, the left gonadal vein (of 4.55 mm diameter) drained into the anterior surface of initial part of pLRV (Fig. 3). No venous valves were found both in the CLRV and in the anastomosis between pLRV and the hemiazygos vein. The renal vessels on the right side were single. The diameter (measured at the midpoint of length) of the right renal artery was 8.28 mm and the diameter of the right renal vein was 12.59 mm. However, similarly to the left side, the right renal vein was also crossed by the anterior branch of the right renal artery (of 4.34 mm diameter). Thus, on both sides of the examined specimen, the anomalous arrangement of hilar structures was observed (in which the anterior branch of the renal artery occupied the most anterior position within the renal hilum). Additionally, the presence of the fusiform aneurysm of the abdominal aorta located between the level of the pLRV and inferior mesenteric artery was revealed during the dissection.

DISCUSSION

The initial venous channels undergo several stages of remodelling early in embryonic development [23, 28]. As the embryo increases in size, the postcardinal veins, draining the body walls, are supplemented by longitudinal vascular channels transforming into: subcardinal, supracardinal, azygos line, subcentral and precostal veins [28]. These venous channels anastomose with both posterior cardinal system and with each other. The drainage of developing mesonephros is provided mainly by the subcardinal veins. Subcardinal veins are connected by the pre-aortic anastomotic plexus [28]. At the latter stages of development, the plexus is involved in the formation of the left renal vein, located anterior to the abdominal aorta. A series of complex changes leads to that end. Before the renal vessels develop in their final form, a circumaortic renal venous ring, known as 'renal collar', exists around the aorta. The renal collar is formed by: communications between subcardinal veins (anastomotic

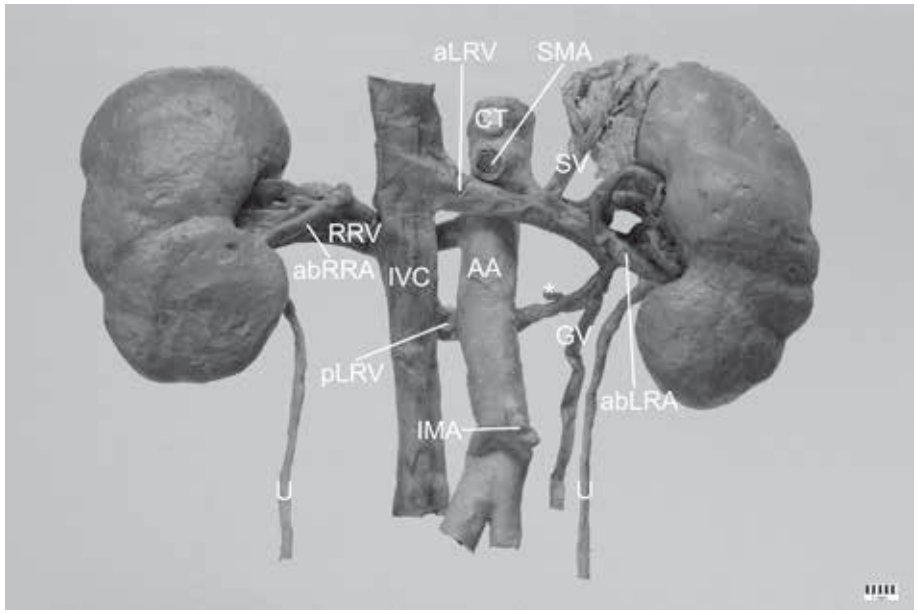

Figure 3. Case no. 2. The circumaortic renal collar accompanied by the left renal artery dividing close to its origin. Anterior view of the isolated specimen. In this case, the circumaortic renal collar coexisted with the left renal artery dividing close to its origin. On both sides of the specimen, the anomalous arrangement of hilar structures was observed, in which the anterior branch of the renal artery occupied the most anterior position within the renal hilum; AA — abdominal aorta; abLRA — anterior branch of the left renal artery; abRRA — anterior branch of the right renal artery; aLRV — anterior left renal vein; CT — celiac trunk; GV — left gonadal vein; IMA — inferior mesenteric artery; IVC — inferior vena cava; pLRV — posterior left renal vein; SMA — superior mesenteric artery; SV — left suprarenal vein; U — ureter; *anastomosis between the posterior left renal vein and the hemiazygos vein.

plexus mentioned above), communications between supracardinal veins, and supracardinal-subcardinal anastomoses [20, 28]. During normal formation of the left renal vein, the dorsal part of the circumaortic renal venous ring degenerates and the ventral vessel becomes the renal vein. However, occasionally, the post-aortic part of the renal collar may persist. Due to such complex developmental relationships and conditions, the number, orifices, and main tributaries of the renal veins may exhibit numerous variations. Also, the arterial blood supply of both the kidneys and adrenal glands is extremely variable during the foetal period, which may give rise to several anatomical variations observed in the postnatal period and in adults [22].

Anatomical variations of renal veins differ in terms of the prevalence depending on the side. Multiple renal veins are frequent on the right side (frequency to 28%), whereas they are less frequent on the left side (frequency from 1% to 9%) [33]. The left renal vein may be doubled. In this case, one limb of the left renal veins runs anterior and the other runs posterior to the abdominal aorta before opening into the IVC [5]. This condition may be referred to as persistence of the renal collar. The approximate prevalence of this variation differs among various authors and is estimated at 0.3% to 6.3% [25, 26, 29, 32]. According to *Bergman's Comprehensive Encyclopaedia of Human Anatomic Variation*, CLRV is observed in 1.02% of cases [33]. However, Bergman et al. [5] in their earlier work reported a wider range of frequency of the circumaortic renal venous collar — from 1.5% up to 8.7%. The circumaortic renal collar occurs with a similar frequency in both sexes (48.1% in male and 51.9% female subjects with persistent renal collar) [33]. Also, no significant correlation between gender and variations of the left renal vein was observed in the study of Boyaci et al. [6]. A study with a multidetector computed tomography performed in an adult population by Zhu et al. [36] confirmed, that the frequency of right renal vein variations was significantly higher than the frequency of left renal vein variations. Furthermore, in this study no statistically significant correlation was found between variations of the renal vein and gender. Based on the morphology of the renal veins, Zhu et al. [36] classified variations of the left renal vein into five types. The CLRV was classified as the type I, and its frequency was estimated at 2.1%, (31 out of 1452 patients who underwent multidetector computed tomography angiography) [36].

Persistent renal collar may occur in numerous variations, especially when communications with neighbouring veins are taken into consideration [7, 11, 13, 20, 25-29, 32]. In the case described by Panagar et al. [20] the left preaortic renal vein receives left suprarenal and left ovarian veins as tributaries, while the left posterior renal vein ran obliquely downwards to open into IVC after being joined by lumbar veins. Thus, drainage of lumbar vein may be anomalous in the cases of persistent renal collar. In such cases the lumbar vein may open into retroaortic renal vein [20, 34]. Terayama et al. [30] described another case of double left renal vein, in which, in addition to the primary left renal vein, the presence of a pLRV draining to the left ascending lumbar vein without communicating with the IVC and other renal veins was observed. Our case no. 1 differs from those previously described, as the posterior renal vein was directly connected with the initial part of the hemiazygos vein via a strong anastomosis (root). Thejodhar et al. [31], in turn, reported the co-existence of circumaortic renal collar, accessory renal artery and an anomalous arrangement of hilar structures on the left side in the same cadaver. The atypical hilar arrangement presented in Thejodhar et al.'s case [31] reminds our descriptions, except that in our case no. 2 renal arteries were single on both sides and were divided close to their origin, especially on the left side. In addition, in our case no. 2, the unusual hilar arrangement occurred both on the right and the left side. Thus, the persistent renal collar may be accompanied by atypical topographical relationships between renal vessels, as well as by the possibility of co-occurrence of arterial variations. According to Bergman et al. [5] the renal veins show less variation than the renal arteries. The frequency of double renal artery is estimated at 10% of cases [5]. Wherein, so-called accessory (or supernumerary) renal arteries arising below the usual trunk (similar to those described in our case no. 1) are less frequent than those arising above [5, 8]. For the kidney transplantation team, it is crucial to consider significant variations in the atypical hilar arrangement during the time of organ harvest [3, 24]. This fact was reflected in the study of Bachul et al. [3] who described "crossing anatomic barriers" during the transplantation of a kidney with five arteries, duplication of the pyelocalyceal system, and a double ureter. Sabouri et al. [24] in turn reported retro-aortic inverted left renal vein in a renal donor.

The openings of pre-aortic and retro-aortic left renal veins in the renal collar are usually located at different levels, which is similar to our observations. According to Trigaux et al. [32] the mean distance between the openings of the retroaortic and preaortic left renal veins into the IVC was 39.0 ± 17.4 mm. The aLRV may also be absent. In such cases, the single retroaortic left renal vein replaces the typical left renal vein [19, 29]. Anjamrooz et al. [1] described another case of the left renal vein bifurcating into two branches passing behind the aorta. Before its division, the left renal vein received the left suprarenal and testicular veins.

Occasionally, the renal collar is also detected in patients with different disorders during diagnostic procedures. Garg et al. [7], basing on computed tomography angiography, described the presence of incidental finding of CLRV with "gross aneurysmal dilatation of both pre- and retro-aortic part of the renal vein". These anomalies were found in a patient with delayed presentation of post-traumatic aortic pseudoaneurysm and its fistulous communication with the right renal vein after a gunshot injury. Lee et al. [13] described a case of double left renal veins in the form of a venous collar in a 15-year-old girl who presented with intermittent haematuria. Nishibe et al. [18] described the combination of abdominal aortic aneurysms and congenital anomalies of the IVC and its tributaries such as double IVC, left-sided IVC, circumaortic renal collar and retroaortic renal vein. In our case no. 2, the fusiform aneurysm of the abdominal aorta was found beginning at the level of the pLRV, which could potentially cause the difficulties in the operating field.

In the group of patients with persistent renal collar the risk of venous injury and subsequent bleeding increases, since typically the retroaortic component of the left renal vein does not occur [7, 20, 24–26, 29]. Furthermore, the situation may be complicated by the presence of additional anastomoses reaching the pLRV. According to Bergman et al. [5] the root of the hemiazygos vein originating from the left renal vein is observed in 88% of the cases. However, the authors of this report, making a detailed analysis of the literature, did not find the description of the circumaortic renal collar giving a very strong root to the hemiazygos vein, like in our case no 1. In both cases described in our study the anastomosis with the hemiazygos vein was present. Thus, awareness of the variations in the blood supply of kidneys is mandatory [2].

CONCLUSIONS

The persistent renal collar may be accompanied by atypical topographical relationships, atypical connec-

tions to the adjacent veins as well as the possibility of co-occurrence of arterial variations. Anatomical variations of renal vessels, due to their diversity and high prevalence, should be taken into account both in planning and conducting diagnostic and surgical medical procedures.

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