Clinical Imaging 85 (2022) 22–28

Contents lists available at ScienceDirect

Clinical Imaging

journal homepage: www.elsevier.com/locate/clinimag

Body Imaging

Aneurysm of the left ascending lumbar communicating vein: Its prevalence and possible association with nutcracker phenomenon

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ARTICLE INFO

Keywords:
Ascending lumbar communicating vein
Aneurysm
Aortomesenteric angle
Left renal vein
Computed tomography

ABSTRACT

Purpose: To evaluate abdominal computed tomography (CT) studies in respect of the prevalence of the left ascending lumbar communicating vein (ALCV) and ALCV aneurysm and to identify possible causes of aneurysm development in the ALCV.

Methods: Contrast-enhanced abdominal CT examinations were retrospectively investigated for the prevalence of the ALCV in the adult population. In patients with ALCV, the diameters of the following vessels were measured: ALCV, left renal vein (LRV) at two levels, compression ratio of the LRV (CR), left gonadal vein, right and left ascending lumbar veins (ALVs). The aortomesenteric angle was also measured for preaortic LRVs. ALCV aneurysm was noted during the assessment.

Results: Evaluation was made of 500 patients. ALCV was found in 240 patients (48%), more common in patients with retroaortic LRV and circumaortic LRV than in patients with preaortic LRV ($p = 0.003$). The mean diameter of the ALCV was 3.85 ± 2.06 mm. ALCV and the left gonadal vein merged to form a common vein draining into the LRV in 23 patients with preaortic LRV (9.6%). Of the patients with ALCV, 19 (8%) had aneurysm. The diameter of the left ALV and CR were significantly greater in patients with aneurysm than in patients without ($p = 0.001$ and 0.032, respectively). Patients with ALCV aneurysm had a significantly narrower aortomesenteric angle ($p = 0.004$).

Conclusion: The results of this study indicated that a narrower aortomesenteric angle and a greater CR might play a role in the development of ALCV aneurysm.

1. Introduction

Errors in the complex embryological development process of the inferior vena cava (IVC) and left renal vein (LRV), in which three pairs of the primitive veins (subcardinal, supracardinal, and postcardinal veins) form multiple anastomoses, result in venous anomalies such as retroaortic or circumaortic LRVs.[1–4] In addition, communications of the LRV with other veins, including ascending lumbar vein (ALV), hemiazygos, superior mesenteric vein, gastric veins, adrenal veins, and diaphragmatic veins, may also result from errors in the regression process of anastomoses.[5]

ALVs that connect the common iliac, iliolumbar, and lumbar veins ascend deep in the psoas major muscle and join with the subcostal veins to form azygos on the right and hemiazygos on the left side. Communication with the LRV via the left ascending lumbar communicating vein (ALCV) also commonly occurs. This variation has been described in a few phlebographic, cadaveric, and CT studies with various prevalences (34–75%).[5–8] The presence of the ALCV makes it difficult to mobilize the LRV during renal or retroperitoneal surgeries and may increase the risk of vascular complications.[9] Attention should also be drawn to this variant anatomy in spermatic or ovarian vein embolization and renal or adrenal venous sampling.[10–13] Furthermore, there are few case reports about the ALCV aneurysm, which may be confused with lymphadenopathy, especially in patients with a history of malignancy, and this may lead to complications during surgery.[14–18] Therefore, knowledge of the ALCV aneurysm is of the utmost importance so that it is not confused with other pathological conditions of the retroperitoneum on cross-sectional imaging.

Abbreviations: ALCV, Ascending lumbar communicating vein; ALV, Ascending lumbar vein; CR, Compression ratio; CT, Computed tomography; IVC, Inferior vena cava; LRV, Left renal vein; MIP, Maximum intensity projection; MPR, Multiplanar reconstructed.

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https://doi.org/10.1016/j.clinimag.2022.02.022
Received 13 January 2022; Received in revised form 13 February 2022; Accepted 22 February 2022
Available online 25 February 2022

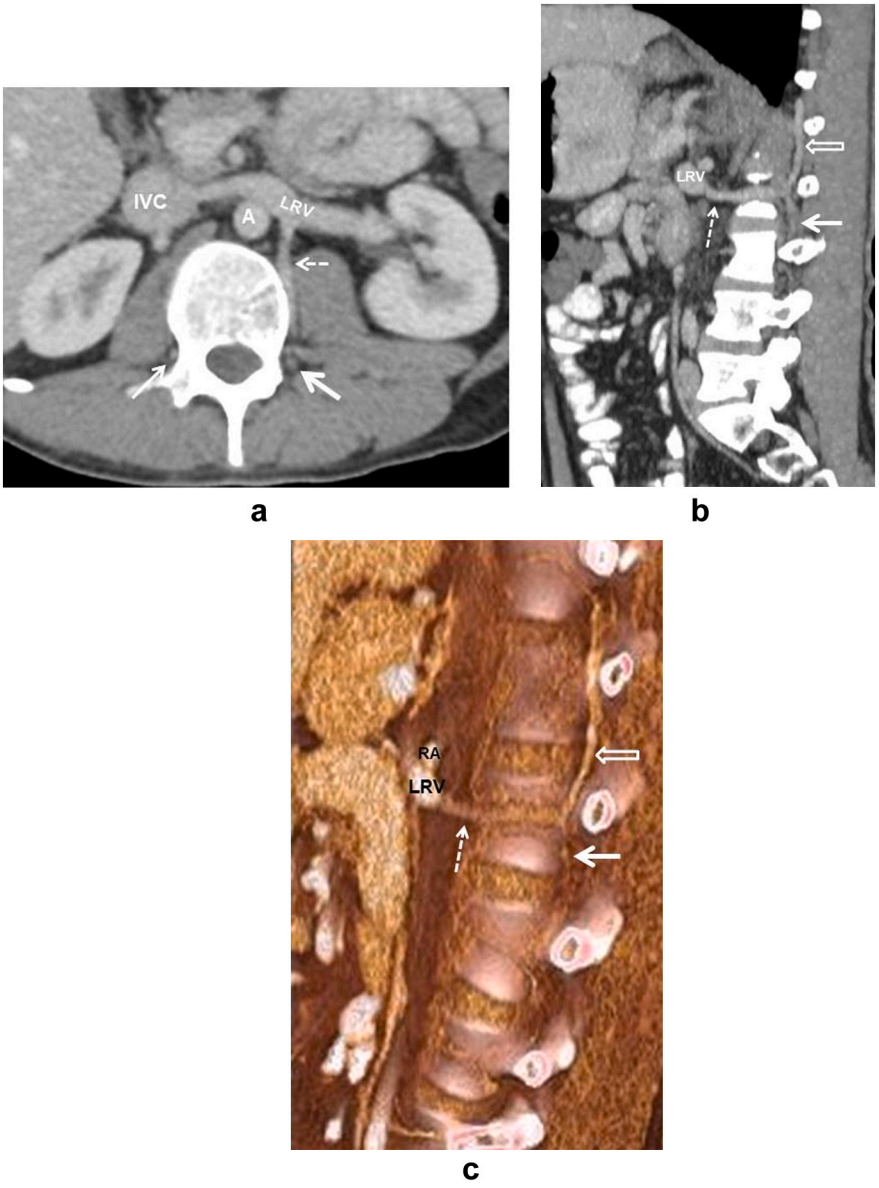

Fig. 1. Axial plane contrast-enhanced CT image at L2 vertebra level (a), sagittal plane reformatted CT image (b) and (c) sagittal plane volume rendering technique (VRT) image show normal anatomy of the ALCV (dashed arrows) in a 25-year-old male patient with preaortic LRV. A: Abdominal aorta IVC: Inferior vena cava LRV: Left renal vein RA: Left renal artery. Thick solid arrows: Left ALV. Thin solid arrow: Right ALV. Open arrow: Hemiazygos vein.

With recent developments in computed tomography (CT) technology, anatomical variations are now frequently encountered. Well-known variants are easy to recognize on CT; however, less well-known variants such as ALCV aneurysm, which is in the scope of this study, may cause diagnostic confusion in some specific conditions. To the best of our knowledge, there has been no previous study which has evaluated the possible causes of aneurysm development in the ALCV. The aim of this study was to evaluate abdominal CT studies for the prevalence of the ALCV and the ALCV aneurysm and to identify possible causes of aneurysm development in the ALCV.

2. Materials and methods

2.1. Study population

This retrospective observational study was approved by the institutional review board with a waiver of informed consent. A retrospective investigation was made of the anatomy of the LRV and prevalence of the ALCV in the adult population who underwent contrast-enhanced abdominal CT examinations for various clinical conditions between January 2021 and July 2021. The abdominal CT examinations included in the study were those on which the ALVs could be clearly seen. Adult patients with renal anomalies and renal or retroperitoneal surgery and pediatric patients were excluded from this study. CT images showing suboptimal filling of ALVs and respiratory motion artifacts were also excluded. The reporting of this study conforms to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[19]

2.2. CT protocol

CT scans were performed on a 160-slice CT scanner (Aquilion Prime, Toshiba Medical, Tokyo, Japan). The scanning parameters were as follows: tube voltage 120 kV, collimation 160 × 0.5 mm, matrix 512 × 512, pitch 0.9, and gantry rotation time 0.5 ms. Images were reconstructed with a slice thickness of 2 mm with a slice interval of 2 mm. 100 ml of

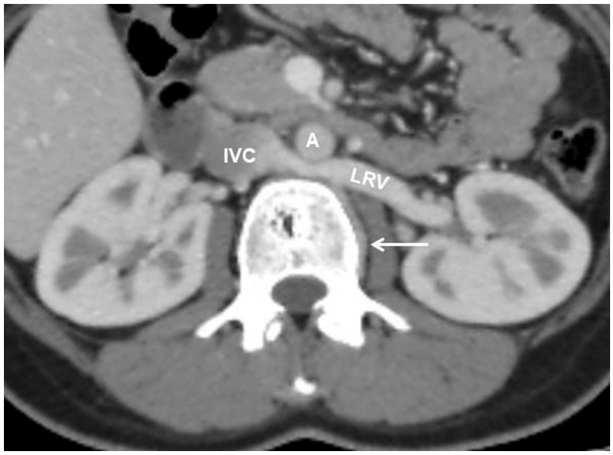

Fig. 2. Axial plane contrast-enhanced CT image at L3 vertebra level shows normal anatomy of the ALCV (arrow) in a 32-year-old female patient with retroaortic LRV. A: Abdominal aorta IVC: Inferior vena cava LRV: Left renal vein.

contrast agent (Xenetix 300/100 mg/ml, Guerbet, France) was administered intravenously at a flow rate of 3 ml/s followed by 40 ml saline flush at a flow rate of 3 ml/s. Scan delay was triggered with automatic bolus tracking (SUREstart, Toshiba Medical).

2.3. Imaging assessment

The anatomy of the LRV and the presence of ALCV were investigated on CT by a single radiologist with 5 years of abdominal radiology experience. CT images were initially evaluated in the axial plane, and then multiplanar reconstructed (MPR) images and maximum intensity projection (MIP) images were generated. In patients with ALCV, the diameters of the following vessels were measured in the axial plane: ALCV (within 2 cm from the renal vein inlet), LRV (at two levels; left margin of the abdominal aorta [level 1], between the abdominal aorta and superior mesenteric artery [level 2 for preaortic LRV], between the abdominal aorta and corpus of the lumbar vertebra [level 2 for retroartic LRV]), compression ratio of the LRV (CR) (level 1/level 2) (per its definition by Hangge et al.[20]), left gonadal vein (within 2 cm from the renal vein inlet), right and left ALVs (at the lower border of the L1 vertebra). The aortomesenteric angle was measured on the sagittal plane MIP CT image for preaortic LRVs. The diameter of the LRV was not measured for circumaortic LRVs. The diameter of the left gonadal vein was not measured in patients with double IVC due to IVC drainage of the left gonadal vein and in patients with double LRV where different LRVs drain the ALCV and the left gonadal vein. In cases with gonadal vein duplication, the total diameter of gonadal veins was calculated if they terminated separately in the LRV. ALCV aneurysm was also noted during the assessment. Although there is no exact definition for the ALCV aneurysm, focal enlargement of the ALCV more than 50% larger than the diameter of the non-dilated segment was considered an aneurysm. This definition is widely used elsewhere in the literature to diagnose arterial aneurysms.[21,22]

2.4. Statistical analysis

Data analysis was performed using IBM SPSS Statistics 23.0 (Armonk, NY, USA). Descriptive analyses were based on frequencies and means of the variables. Numerical variables were evaluated for normality of data distribution using the Kolmogorov–Smirnov and Shapiro-Wilk tests. The Chi-Square test was used to compare the prevalence of the ALCV according to the different LRV anatomy. Post hoc analysis (Bonferroni correction) was performed after the Chi-Square test if significance was detected among groups. ALCV diameters of the different LRV groups were compared using the Kruskal-Wallis test. The one-sample *t*-test was used to compare the difference in size between the left and right ALVs in patients with ALCV. Parameters were compared between ALCVs with and without aneurysm using the Mann-Whitney *U* test. Spearman correlation analysis was performed to assess the relationship between the diameter of the ALCV and ALCV aneurysm and other variables. A value of $p < 0.05$ indicated statistical significance.

3. Results

Overall, the study included 500 patients (250 females, 250 males) with a mean age of 44 years (range, 18–92 years). ALCV, observed either at L2 or L3 vertebra level, was found in 240 patients (48%). The mean diameter of the ALCV was 3.85 ± 2.06 mm with a range of 2 to 13 mm.

Preaortic LRV was identified in 423 patients (84.6%), retroaortic LRV in 30 patients (6%), circumaortic LRV in 37 patients (7.4%), double LRV in 4 patients (0.8%), and double IVC in 6 patients (1.2%). ALCV was found in 189 patients with preaortic LRV (45%), in 20 patients with retroaortic LRV (66.7%), in 27 patients with circumaortic LRV (73%), in 2 patients with double LRV (50%), and in 2 patients with double IVC (33.3%) (Figs. 1-3) (Table 1). The prevalence of the ALCV was significantly different between the various LRV anatomies ($p = 0.003$). Post hoc analysis showed that ALCV was more common in patients with retroaortic LRV and circumaortic LRV than in patients with preaortic LRV. ALCV was found to be related to the dorsal limb of the LRV in patients with circumaortic LRV (Fig. 3). The diameter of the ALCV

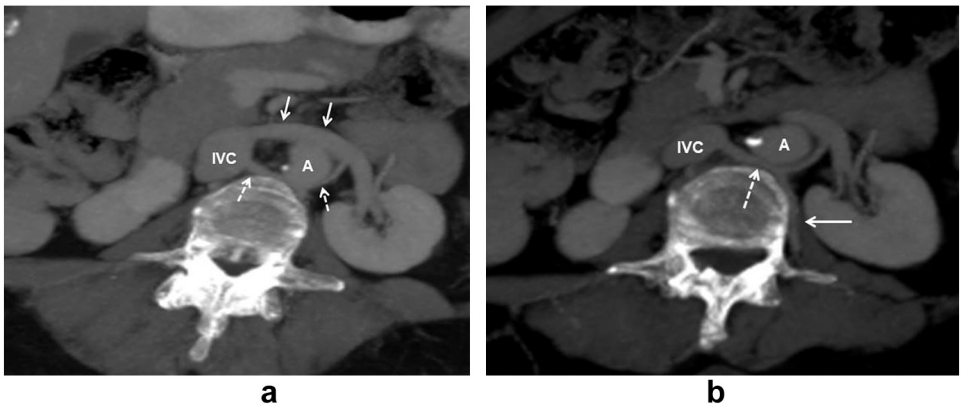

Fig. 3. Normal anatomy of the ALCV in a 68-year-old female patient with circumaortic LRV. (a) Axial plane contrast-enhanced MIP CT image shows ventral (solid arrows) and dorsal limbs (dashed arrows) of the circumaortic LRV. (b) Note the ALCV (solid arrow) related to the dorsal limb of the circumaortic LRV (dashed arrow). A: Abdominal aorta IVC: Inferior vena cava.

Table 1
Characteristics of the study population ($n = 500$).

Characteristic		p[a]
Age years (mean, [range])	44 [18–92]	
Sex (F:M)	250:250	
Anatomy of the LRV, n (%)		
Preaortic LRV	423 (84.6%)	
Retroaortic LRV	30 (6%)	
Circumaortic LRV	37 (7.4%)	
Double LRV	4 (0.8%)	
Double IVC	6 (1.2%)	
Prevalence of the ALCV, n (%)	240 (48%)	0.003
Preaortic LRV	189 (44.7%)	
Retroaortic LRV	20 (66.7%)	
Circumaortic LRV	27 (73%)	
Double LRV	2 (50%)	
Double IVC	2 (33.3%)	
Prevalence of the ALCV, n (%)		0.531
Male	124 (49.6%)	
Female	116 (46.4%)	
ALCV aneurysm	19 (8%)	

ALCV: Ascending lumbar communicating vein.
LRV: Left renal vein.
IVC: Inferior vena cava.
[a] Chi-square test.

Table 2
Correlation results between variables and diameter of the ALCV and ALCV aneurysm.

Parameters	Diameter of the ALCV		ALCV aneurysm	
	r-value[a]	p-value[b]	r-value[a]	p-value[b]
Aortomesenteric angle	−0.271	**<0.001**	−0.209	**0.004**
Diameter of the left gonadal vein	0.175	**0.007**	0.05	0.454
Diameter of the LRV at level 1	0.114	0.098	0.03	0.662
Diameter of the LRV at the level 2	−0.007	0.917	−0.104	0.133
Compression ratio of the LRV (level 1/level 2)	0.091	0.189	0.149	**0.031**
Diameter of the left ALV	0.566	**<0.001**	0.221	**0.001**

ALV: Ascending lumbar vein.
LRV: Left renal vein.
[a] Correlation coefficient.
[b] Spearman correlation test. $p < 0.05$ is significant (bold).

showed no significant difference between the various LRV anatomies ($p = 0.094$). No significant difference was detected between the ALCV prevalence and sex ($p = 0.531$) (Table 1). The diameter of the left ALV (2.83 ± 1.05 mm) was significantly greater than the diameter of the right ALV (2.47 ± 0.81 mm) in patients with ALCV ($p < 0.001$).

In the results of the correlation analyses between the diameter of the ALCV and other parameters, a significant positive correlation was determined between the diameter of the ALCV and diameters of the left gonadal vein and left ALV ($p = 0.007$ and $p < 0.001$, respectively), and a significant negative correlation was detected between the diameter of the ALCV and the aortomesenteric angle ($p < 0.001$) (Table 2).

Of the patients with ALCV, 19 patients (8%) had aneurysm near the LRV inlet (Figs. 4, 5). The diameter of the left ALV and CR were significantly greater in patients with ALCV aneurysm than in patients without (3.45 mm vs 2.63 mm and 1.9 vs 1.54, respectively) ($p = 0.001$ and 0.032, respectively). Patients with ALCV aneurysm had a significantly narrower aortomesenteric angle (40° vs 53°, $p = 0.004$). The diameter of the left ALV and CR showed a significant positive correlation with ALCV aneurysm ($p = 0.001$ and 0.031, respectively), and a significant negative correlation was detected between ALCV aneurysm and the aortomesenteric angle ($p = 0.004$) (Table 2).

In the overall assessment of the patients with ALCV, two patients were determined with tumoral thrombus of the IVC (with renal cell carcinoma of the right kidney) and three patients with portal

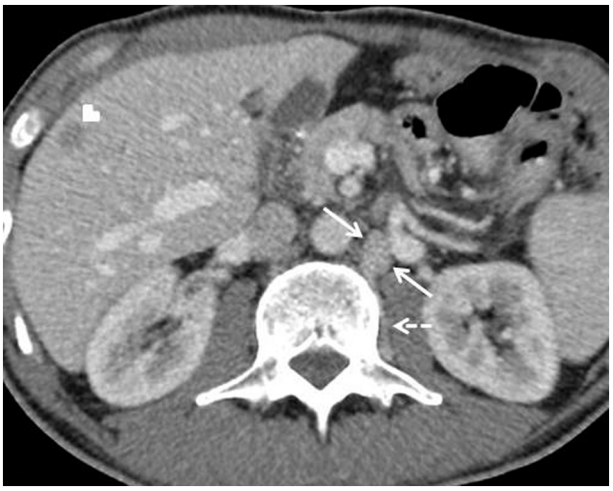

Fig. 4. ALCV aneurysm mimicking lymphadenopathy. A 39-year-old male patient with known gastric cancer underwent a contrast-enhanced abdominal CT scan for metastasis evaluation. Axial plane CT image shows aneurysm (solid arrows) in the ALCV (dashed arrow) near the LRV inlet. Also note is made of a hypodense metastasis in the right liver lobe (arrowhead).

hypertension and splenorenal shunt. In these patients, the diameter of the ALCV (range 5.3–8 mm) was greater than in the majority of patients, but aneurysm was not detected (aortomesenteric angles ranged between 67° and 83°) (Fig. 6).

In 23 (9.6%) patients (12 males, 11 females) with preaortic LRV and ALCV, it was observed that the ALCV and the left gonadal vein merged and issued into the LRV with a common vein (Fig. 7).

On the CTs of the patients with ALCV, the left gonadal vein terminated in the LRV in 89.2% ($n = 214$) with a solitary ending and in 10.8% with a double ending (25 testicular veins and one ovarian vein).

4. Discussion

The complex embryological development of the IVC and renal veins, which starts in the 6th week of gestation and continues to the 8th week, involves the development, anastomosis, and regression of three pairs of cardinal veins (subcardinal, supracardinal, and postcardinal veins). During the development process of the LRV, a dorsal arch (developed from anastomosis between the supracardinal and subcardinal veins) and a ventral arch (developed from intersubcardinal anastomosis) form the aortic collar. The dorsal arch usually regresses, and the ventral arch forms the main renal vein. Errors in the resolution of anastomoses result in anomalies of the LRV and some communications between the LRV and other vessels.[1–4] Communication from the LRV and the left ALV commonly occurs at a prevalence ranging from 34% to 75%.[5–8] The results of this study showed the prevalence of ALCV to be 48%, and the prevalence of ALCV aneurysm to be 8%. Such anatomical variations have clinical importance in retroperitoneal surgeries, spermatic or ovarian vein embolization, renal or adrenal venous sampling, and surgeries that need extensive dissection of the venous system (i.e., lymphadenectomy and renal transplantation).[9–13] In addition, ALCV aneurysm may cause diagnostic confusion on cross-sectional imaging.[14–18]

In a phlebographic study of the LRV by Ahlberg et al.[5] and a cadaveric study of the renal vascular pedicle by Pick et al.,[6] the prevalence of ALCV was reported as 75% and 69%, respectively. The disparity between phlebographic and anatomical studies and the current study may be due to the limited spatial resolution of CT compared to other techniques. Furthermore, contrast filling of the ALCV with selective renal venography is easier than with CT due to the high contrast pressure within the LRV in the venography procedure. However, one exceptional

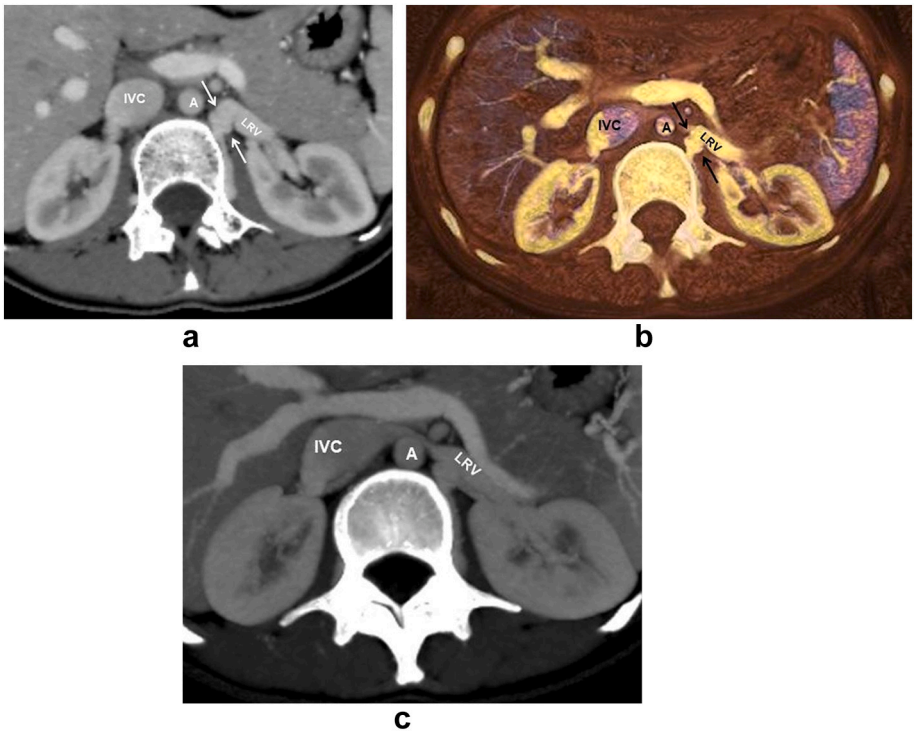

Fig. 5. ALCV aneurysm in nutcracker phenomenon. A 27-year-old female patient presenting at the Emergency Department with right lower quadrant pain underwent a contrast-enhanced abdominal CT scan. (a) Axial plane CT and (b) VRT images show ALCV aneurysm (arrows). (c) Axial plane MIP CT image demonstrates compression of the LRV between the abdominal aorta and superior mesenteric artery compatible with nutcracker phenomenon (aortomesenteric angle = 13°, CR = 4). A: Abdominal aorta IVC: Inferior vena cava LRV: Left renal vein.

Fig. 6. Retrograde drainage of the LRV via ALCV in a 58-year-old male patient with histopathologically proven clear cell RCC of the right kidney and tumoral thrombus of the IVC. Axial plane contrast-enhanced CT image shows a large heterogeneous mass in the right kidney (dashed arrows) and tumoral thrombus of the IVC. The ALCV (solid arrow) is tortuous without aneurysm. IVC: Inferior vena cava LRV: Left renal vein.

phlebographic study by Lien et al. found the ALCV prevalence to be 34%.[7] Yao et al. retrospectively assessed 100 abdominal CT examinations and reported ALCV prevalence of 34%.[8] In that study, the diameter of the ALCV was 6.7 ± 1.9 mm, which was greater than in the current study (3.85 ± 2.06 mm). However, Yao et al. evaluated images with a slice thickness of 7 mm and therefore it may not have been possible to detect small diameter ALCVs. In addition, some CT studies in that study were completed before the ALCV was sufficiently enhanced, which may have prevented detection of some ALCVs. In the current study, a slice thickness of 2 mm was used and images were excluded if the ALVs could not be seen clearly, and a higher prevalence of ALCV was determined than in the Yao et al.'s study.[8] It was also seen that the ALCV was more common in retroaortic and circumaortic LRVs than in preaortic LRVs ($p = 0.003$), which has not been previously addressed in the literature.

ALCV aneurysm may mimic paraaortic lymphadenopathy, renal artery aneurysm, and paragangliomas, especially on non-enhanced abdominal CTs and contrast-enhanced abdominal CTs where the ALCV is not sufficiently opacified. The enhancement pattern of aneurysm, which follows the enhancement pattern of other venous structures, and its contiguity on consecutive slices is usually sufficient to differentiate it from other pathological conditions.[18] In the current study, 8% of ALCVs had aneurysm. Patients with ALCV aneurysm had a narrower aortomesenteric angle and greater CR than patients without aneurysm ($p = 0.004$ and 0.032, respectively). The correlation results revealed a significant negative correlation between ALCV aneurysm and the aortomesenteric angle ($p = 0.004$) and a significant positive correlation with the CR ($p = 0.0031$). There have been few case reports in literature about the ALCV aneurysm.[14–18] Although some hypotheses have been proposed for aneurysm development in the ALCV, to the best of our knowledge, there has been no study evaluating the possible causes of aneurysm development in the ALCV. Yao et al. observed that the gap between the proximal portion of the superior mesenteric artery and the aorta was narrower in patients with a visible communicating vein than in patients without it, but no significant difference was found.[8] Lien et al. retrospectively evaluated their phlebographic series of the LRV and found ALCV aneurysm in 9 of 34 patients (25%) and filling the left ALV only in the cranial direction in 6 of these 9 patients.[7] It was concluded that caudal non-filling might be due to the interruption of ALV trunks, which might play a role in aneurysm development. The findings of the current study support that a narrower aortomesenteric angle causing high pressure in the LRV may play a role in aneurysm development in the ALCV. This finding might also imply that the ALCV has a role in the nutcracker phenomenon characterized by compression of the LRV between the abdominal aorta and superior mesenteric artery or corpus of the lumbar vertebra. No aneurysm was detected in the ALCV of 5 patients with tumoral thrombus of the IVC or splenorenal shunt, which caused acquired high pressure in the LRV. The wider aortomesenteric angle in these patients may have prevented the development of aneurysm.

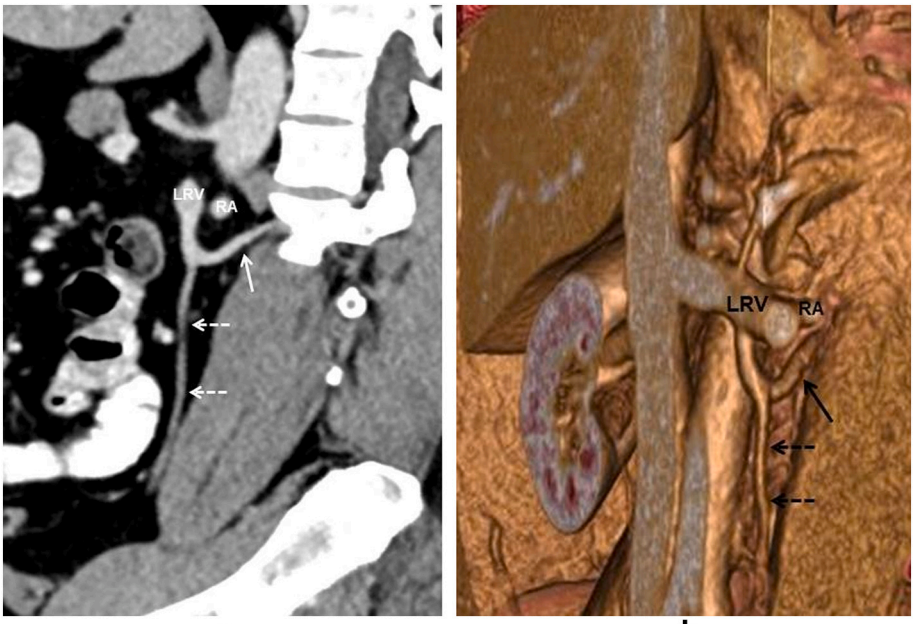

Fig. 7. Sagittal plane contrast-enhanced curved MPR CT image (a) and coronal oblique VRT image (b) show merging of the ALCV (solid arrow) and left testicular vein (dashed arrows) in a 36-year-old male patient. LRV: Left renal vein RA: Left renal artery.

In 23 of the current study patients with preaortic LRV, it was observed that the ALCV and the left gonadal vein merged and issued into the LRV with a common vein. To the best of our knowledge, this variation has not been previously reported in the literature. Although Lien et al. demonstrated the filling of ALV following injection into the left testicular vein in 12 of 100 patients, they did not mention the merging into a common vein of the corresponding veins.[7] This variation is particularly important in patients who undergo spermatic or ovarian vein embolization, as this communication can cause the embolization of non-target vessels, in particular with liquid embolic agents.[10–12] This collateral pathway may also cause persistent and recurrent varicocele or pelvic congestion after surgery or endovascular treatment.[13]

This study had several limitations. Due to the retrospective nature of the study, the relationship between the ALCV aneurysm and nutcracker syndrome could not be assessed as urine analyses were not available. Nevertheless, as the first study to observe possible causes of aneurysm development in the ALCV, these results may support that retrograde flow through the ALCV in the nutcracker phenomenon can cause aneurysm development. Further studies are needed to assess this relationship. In addition, it was not possible to detect some gonadal vein duplications due to the limited spatial resolution of CT compared to venography, which might have affected correlation analyses' results.

5. Conclusion

This study showed a high prevalence of ALCV (48%), and that ALCV is more common in retroaortic and circumaortic LRVs. Aneurysm was found in 8% of the patients with ALCV. The results of our study indicated that a narrower aortomesenteric angle and greater CR might play a role in aneurysm development of the ALCV. A new variation was also observed of merging of the left gonadal vein and the ALCV in 9.6% of the patients with preaortic LRV. It can be recommended that this variation is taken into consideration in gonadal vein embolization.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Consent to participate/consent for publication

Approval from the Institutional Review Board was obtained and in keeping with the policies for a retrospective review, informed consent was not required.

Availability of data and material

Can be provided if required.

CRediT authorship contribution statement

Sevtap Arslan: Conceptualization; Investigation; Methodology; Formal analysis; Writing original draft.

Yasin Sarıkaya: Supervision; Validation; Writing-reviewing and editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

None.

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