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Left renal vein abnormalities detected during routine abdominal computed tomography imaging: clinico-radiological significance

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Background: *Preoperative knowledge of the presence of major venous anomalies facilitates the safe performance of aortic surgery. The purpose of the study was to estimate the incidence, as detected by abdominal computed tomography (CT), of major left renal vein anomalies related to the abdominal aorta in an adult population.*

Material and methods: *Seven hundred and fifty abdominal CT examinations were reviewed retrospectively for the presence of left renal vein anomalies. Eleven CT scans were excluded from the study because of technical or patient-related factors. The course of the left renal vein was assessed on the CT slices to detect any anomalies.*

Results: *Left renal vein anomaly was detected in 23 (3.1%) of 739 cases. Seventeen (2.3%) of them were a retro-aortic, and six (0.8%) of them were a circumaortic left renal vein.*

Conclusions: *It is important to detect left renal vein anomalies before retroperitoneal surgery or interventional procedures. These anomalies can be identified in routine abdominal CT examinations with a careful inspection.* (Folia Morphol 2012; 71, 3: 168–172)

Key words: anatomical variations, computed tomography, renal vein, vascular abnormalities

INTRODUCTION

Venous structures may show variations due to their complex embryological development. Understanding these variations is critical in planning operative interventions involving such anatomic regions. Moreover, inadequate knowledge of such variations may result in misinterpretation of these images as abdominal and retroperitoneal lymphadenomegalies [9, 14].

The inferior vena cava (IVC) forms as a complex structure within 6 to 10 weeks of gestation. In the case of an inappropriate developmental stage, major anatomical variations such as duplication, transpositioning, retroaortic, or circumaortic left renal vein (LRV) may occur, either as single or as multiple abnormalities [9]. The rate of developmental abnormalities of the vena cava is 0.4–3.5% [2, 4, 14].

Cavography and venography are accurate but invasive techniques for the imaging of IVC and superior vena cava. Ultrasonography, a non-invasive technique, and particularly coloured Doppler ultrasonography, is a useful diagnostic modality. Coloured Doppler ultrasonography plays a major role in determining the direction of vascular blood flow, measuring the waveform and index by spectral ana-lysis and evaluating the vascular nature. However, spiral and multidetector computed tomography (CT) — angiographic studies and magnetic resonance imaging (MRI) — angiography techniques

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have brought new insight into the examination of vascular structures [3]. It is important for surgeons to have extensive preoperative knowledge of the renal vascular anatomy for selecting the proper kidney and for surgical planning when performing laparoscopic donor nephrectomy. Depiction of the vascular variants on the preoperative imaging facilitates the dissection of these vessels and helps avoid vascular injuries [2–4].

The aim of this article is to present the CT scanning findings of 23 cases with LRV variations, incidentally determined in the CT unit of our department, with a review of the literature.

MATERIAL AND METHODS

Patients

A total of 750 abdominal CT images examined in the CT unit of our department between March 2007 and May 2008 were evaluated retrospectively for possible accompanying IVC and renal vein abnormalities. Eleven CT images in which the renal vein could not be evaluated due to technical or patient-related factors (such as nephrectomy) were excluded. Of the 739 cases included in the study with contrast-mediated abdominal CT images, 425 were males and 314 were females; the mean age of the cases was 49.8 (range, 23–76) years.

Imaging data

All CT procedures were performed using two different CT devices (Picker-PQS, Cleveland, OH, USA and Philips, Brilliance MDCT 16, Amsterdam, Holland) according to the standard abdominal protocol. Parameters used according to the characteristics of the examination were as follows: collimation 5–10 mm, reconstruction index 5–10 mm, pitch 1–1.5, 140–200 mAs, 120–140 kV. According to the routine abdominal examination protocol, cases were administered 3–5 mL/s of intravenous non-ionic contrast substance (Iohexol, 300 mg/mL; Omnipaque™, Amersham, Cork, Ireland) and oral opaque substance for opacification of the intestines (a mixture of 1000 mL water and 50 mL contrast material). The portal phase images used to assess abdominal venous structures were acquired 60 s after a 120–150 mL intravenous bolus of non-ionic contrast material. All cases were reconstructed in the sagittal and coronal planes, in addition to the conventional axial reconstruction at a workstation (Extended Brilliance workspace, Philips Medical systems). The course of the LRV was followed with sequential CT sections, starting from the kidney, up to its entrance into the IVC, and abnormalities were classified according to the vein's type of crossing the aorta. In this context, while an LRV passing anterior to the aorta and entering the IVC was considered the normal pre-aortic route, one that crossed the aorta posteriorly and entered the IVC was defined as a retro-aortic renal vein abnormality. A vein complex that crossed the aorta both anteriorly and posteriorly forming a ring and entering the IVC at different levels was defined as a circumaortic renal vein abnormality. In addition, IVC and kidneys were also evaluated in terms of possible abnormalities.

Statistical analysis

Statistical analysis was performed using the Statistical Package for Social Sciences Version 12.0 for Windows (SPSS Inc., Chicago, IL, USA). The χ^2 test was used to compare frequencies of LRV in men and women. P values less than 0.05 were considered statistically significant.

RESULTS

Of the 739 cases included in the study, 23 (14 males, 9 females) had LRV abnormalities with an inci dence of 3.1%. The overall incidence of renal vein abnormalities did not differ with regard to sex. Retroaortic left renal vein (RLRV) was present in the abdominal CT scans of 17 (11 males, 6 females) cases (Figs. 1A, B). Circumaortic left renal vein (CLRV) abnormality was detected in six (4 males, 2 females) cases. The CLRV was clearly detected in all patients using multiplanar images and 3D volume rendering images (Figs. 2A, B). In addition, CT examination revealed a posterior "nutcracker" phenomenon in a patient with a CLRV. The LRV was considered normal pre-aortic in 716 abdominal CT images (Fig. 3). The incidence of RLRV was 2.3%, that of CLRV was 0.8%, and that of normal pre-aortic LRV was 96.9%. There was no significant difference between genders with regard to specific abnormalities. No accompanying IVC (duplication or transpositioning) or renal abnormality was detected in cases with LRV abnormality. Circumaortic and retroaortic LRV variants were identified in 9 (2.8%) of the 314 women and in 14 (3.3%) of the 425 men. This difference was not statistically significant ($p > 0.05$). Table 1 summarises the distributions related to the cases.

DISCUSSION

The LRV has a longer and more complex embryological developmental process compared to the right renal vein. Posterior cardinal, subcardinal and supracardinal venous channel pairs play an important role in the developmental process of the IVC (6^{th}–10^{th} intrauterine weeks). Anastomotic links are

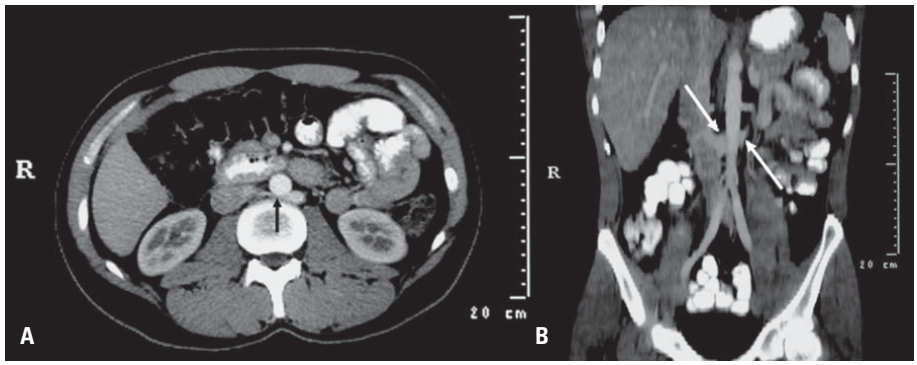

Figure 1. Patient with retroaortic left renal vein; **A.** Axial contrast-enhanced computed tomography and (**B**) coronal reconstruction shows retroaortic left renal vein (white arrows) courses posterior to aorta.

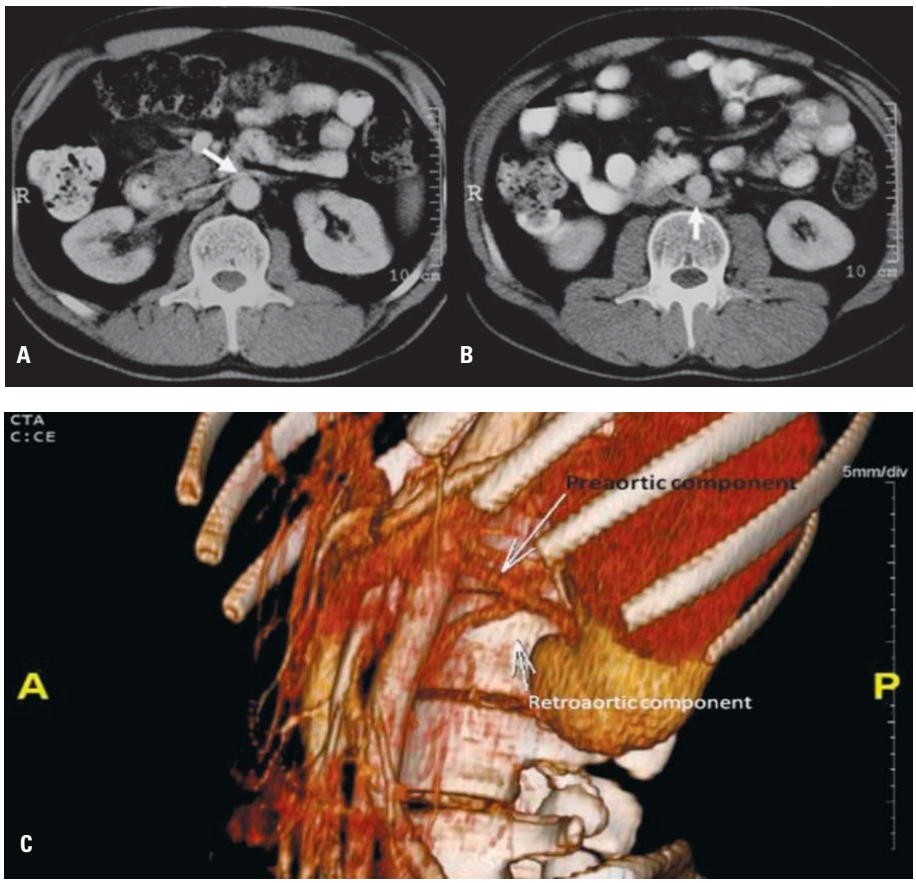

Figure 2. Patient with retroaortic left renal vein. Axial contrast-enhanced computed tomography scans show the preaortic (**A**, white arrow) and retroaortic (**B**, white arrow) components of circumaortic left renal vein. **C.** Three-dimensional volume-rendered computed tomography angiographic image demonstrate the circumaortic left renal vein (white arrows).

present between the venous channels. These links form a circumaortic venous circle through which the aorta passes, between sub-supracardinal channels and intersubcardinal anastomoses. While the bilateral symmetric cardinal system transforms into the unilateral right-sided IVC, the right sub-supracardinal anastomosis forms the right renal vein. The left part of the circumaortic venous circle has two components — ventral and dorsal — in this transformation. While the dorsal arm atrophies during the normal developmental process, the ventral arm continues to develop and forms the normal LRV with a pre-aortic course. In cases when the ventral part atrophies and the dorsal arm continues to develop, a retro-aortic renal vein abnormality emerges. The retro-aortic renal vein follows a downward oblique

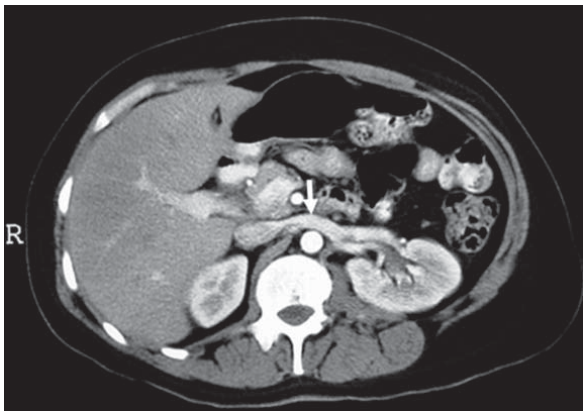

Figure 3. Axial contrast-enhanced computed tomography scan shows normal preaortic left renal vein (white arrow).

Table 1. Distributions of left renal vein (LRV) variations in the 739 patients

LRV variants	All patients (n = 739)	All variations (n = 23)
Circumaortic LRV	6 (0.81%)	6 (26.1%)
Retroaortic LRV	17 (2.3%)	17 (73.9%)

route and enters the IVC. From time to time, none of these arms atrophies and they form a CLRV abnormality through which the aorta passes. The vein usually drains into the IVC in renal vein abnormalities. However, the LRV is reported to drain into the left common iliac vein, in addition to the IVC [1–4]. We did not observe such an abnormality in our study.

Congenital venous abnormalities in the retroperitoneal space are relatively infrequent but are of clinical importance to general, vascular, and transplant surgeons, urologists, and interventional radiologists [1–4, 6].

Abnormalities in the course of the LRV may be detected with radiological methods such as contrasted CT scanning, angiography, Doppler ultrasonography, and MRI. Inferior vena cavography and renal venography are direct but invasive techniques in the evaluation of anatomical structures. While Doppler ultrasonography may be used in determining the retro-aortic renal vein, this technique may be inadequate in obese patients. Techniques such as MRI and MR angiography are used with success in the evaluation of the renal vein [1, 3, 6]. However, CT seems to be more advantageous with regard to factors such as duration, cost, and patient compliance. Contrast-enhanced CT scanning may accurately determine the normal pre-aortic LRV and its abnormalities. Considering the advances in CT technology, such as spiral and multidetector angiography, CT seems to be a more practical method in determining renal vein abnormalities effectively and immediately. In particular, CT angiography, a less invasive technique than standard angiography, is a generally accepted method in the evaluation of renal vessels [6, 10, 13]. CT angiography is a technique that is safe, fast, minimally invasive, and relatively inexpensive, and it presents excellent agreement with both catheter angiography and surgery in predicting the variations of the renal vessels. It can also provide preoperative information about other renal vascular diseases, such as aneurysm, arteriovenous malformation, or stenosis [7].

LRV abnormalities are usually detected incidentally. Although such abnormalities are generally asymptomatic, there are papers reporting cases presenting with intermittent haematuria and blunt side pain with no pathology other than renal vein abnormality [1, 7, 13].

The rate of LRV abnormalities varies in different studies. Reed et al. [11] reported the frequency of RLRV abnormality as 1.8% and CLRV abnormality as 4.4% with CT scanning in 433 cases. In another study including 1014 cases by Trigaux et al. [15], RLRV was detected in 3.7% and CLRV abnormality in 6.3% of cases with CT scanning. In a study by Oyar et al. [8], the rate of RLRV abnormality was 0.4% and CLRV abnormality was 1.2% in 250 abdominal CT images. The frequencies of retro-aortic and circumaortic renal vein abnormalities in autopsy series were 1.5–3.4% and 1.8–16.8%, respectively [8]. Satyapal et al. [12] examined 1008 cases in their combined series of cadaver and clinical cases and reported RLRV abnormality in 0.5% and CLRV abnormality in 0.3% of cases. The reported incidence of venous anomalies of the renovascular pedicle and the IVC was much lower in a CT-based study compared with autopsy results, which indicates the difficulty of imaging. In this study, the frequency of RLRV was 0.5% (29/4520 CT studies) and furthermore quite divergent for transposition of IVC (0.04%), duplication of IVC (0.02%), and circumaortic renal collar (0.08%) [1]. In another study by Yesildag et al. [17], the rate of RLRV abnormality was 0.9% and CLRV abnormality was 2.3% in 1003 abdominal CT images. Our rates of 2.3% and 0.8% of retro-aortic and circumaortic renal vein abnormalities, respectively, are within the ranges reported in other studies. The normal pre-aortic course of the renal vein may be easily detected during routine abdominal CT scanning. If such a course cannot be detected, the case should be evaluated in terms of variations and findings should be reported. Report-

ing of renal vein abnormalities is valuable in surgery because a lack of knowledge on the existence of an abnormality may result in complications leading to haemorrhage, nephrectomy, or even death [12, 17]. In renal transplant donors, the left side is preferred due to the length of the LRV. Thus, knowing whether the LRV has a normal pre-aortic course is important. This information is also important in cases of renin sampling from the renal vein. Moreover, care should be taken to differentiate the abnormality from a retroperitoneal lymph node in patients with testicular and renal neoplasms [16]. In addition, RLRV anomaly can cause a relatively uncommon condition, which leads to LRV hypertension syndrome, otherwise called as "posterior Nutcracker phenomenon". The syndrome is mani-fested by left flank and abdominal pain with or without unilateral haematuria. Another common presentation is as "Pelvic Congestion syndrome" in females, characterised by symptoms of dysmenorrhoea, dyspareunia, lower abdominal pain, vulval, gluteal, or thigh varices, and emotional disturbances. Likewise, compression of the LRV can cause left renal to gonadal vein reflex resulting in lower limb varices and varicoceles in males [5].

Surgically, these anomalies can affect decisions about choosing prospective renal transplant donors, choosing the site for IVC ligation for thromboembolic disease, repairing aortic aneurysms, and performing other retroperitoneal surgery. Prior to the routine use of CT before abdominal surgery, most venous anomalies were diagnosed at operation. In many of these cases, injuries often precede their recognition. Since CT scans are routinely performed today on patients scheduled for abdominal surgery, an accurate preoperative diagnosis can usually be made [13, 15, 17]. The surgeon should systematically consider each venous anomaly as part of the review of the CT scan prior to surgery. Angiographically, awareness of this anomaly is important in performing adrenal venography, renal vein sampling, and spermatic vein embolisation and in avoiding the false interpretation that a mass lesion is causing the inferior displacement of the RLRV [13].

CONCLUSIONS

In conclusion, we can say that despite the condition being subject to variation, detection and reporting of congenital abnormalities of the LRV are important for radiologists and surgeons to differentiate them from retroperitoneal lymph nodes or masses, and to prevent complications that may occur during retroperitoneal vascular or surgical interventions. LRV abnormalities may be easily recognised by careful examination during routine abdominal CT scanning.

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