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Original Article

Anatomic characteristics of the right internal spermatic vein based on imaging analysis: a retrospective study in southwest China

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Abstract: Objective: The specific anatomic characteristics of the right internal spermatic vein (ISV) are pivotal factors in embolism failure. However, the inherent angles and configurations of the right ISV remain incompletely explored. This study aimed to address this gap by conducting a thorough investigation into the specific anatomic characteristics of the right ISV using imaging analysis in southwest China. Methods: This retrospective study analyzed the imaging data of 1000 male patients who underwent multidetector spiral computed tomography (MCT). Anatomic characteristics of the right ISV, including position, type, distance, and angle, were also evaluated. Results: The most common anatomic type (87.8%) of the right ISV was direct drainage into the inferior vena cava, with 90% of the angles below 25.7°. There were 22 cases (2.2%) with parallel right spermatic veins. In the axial plane, the right ISV (86.4%) was located in the third and fourth quadrants. The diameter at the entrance of the right ISV ranged from 2.7-3.8 mm. When the right ISV drained into the inferior vena cava, 83% of cases were located within 40 mm distance below the ostium of the right renal vein, while during draining into the right renal vein, the average distance from the main vein was 6.3 mm. Conclusion: This study concluded that MCT can be used to evaluate the anatomical characteristics of the right ISV. The optimal interventional approach was through the jugular vein route to locate the ISV opening and improve the success rate of the embolization.

Keywords: Internal spermatic vein, varicocele, anatomy, angle, embolization

Introduction

Varicocele (VC) is a common vascular disorder primarily affecting young men, with an incidence ranging from 10%-15% [1]. VC is found in approximately 40% of male patients with infertility [2]. Most studies have focused on analyzing the anatomy of the left spermatic vein, because the higher incidence of left VC [3]. The anatomy of ISV on both sides is different. The left ISV usually joins the left renal vein at a right angle, while the right ISV typically joins the inferior vena cava at an acute angle with some anatomical variations. The right ISV is not easy to develop to varicocele, so few studies analyzed the rigoht ISV.

The purpose of surgical management of VC is to prevent venous reflux to the gonadal venous system. High spermatic vein ligation can improve semen quality, thus treating infertility caused by VC.

Since embolization is performed purely intravascular, it minimizes the risk of arterial and testicular injury compared to the surgical technique. It is cost-effective, with minimal complications and risk of postoperative hydrovial formation. However, VC embolization is constrained by the difficulty of dissection. In some cases, the procedure may need to be abandoned, often due to the inability to intubate the

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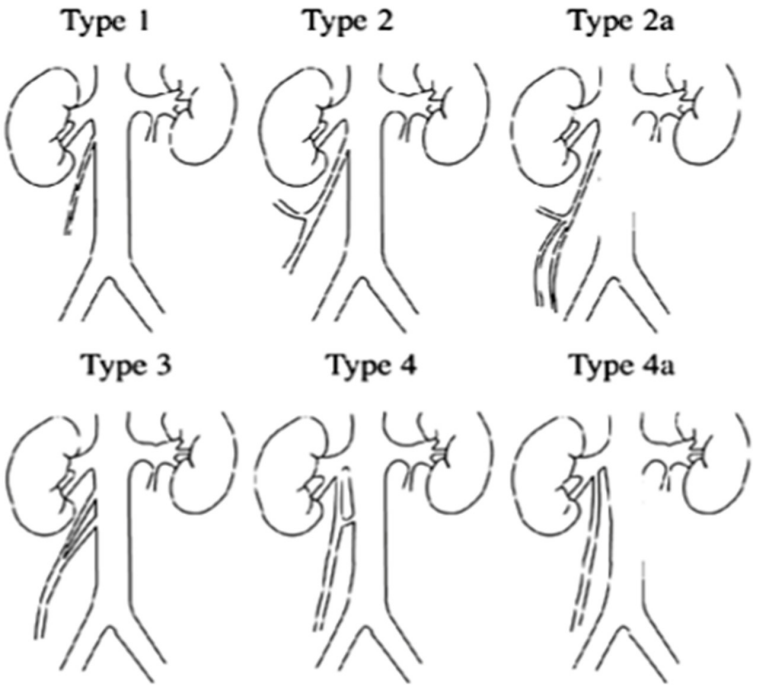

Figure 1. Six types of the anatomy of the right spermatic vein: cited from Yoel Siegel [7].

spermatic vein [4]. According to the study, the technical failure rate is 10%, and the right ISV is up to 25%-40% [5].

Classical anatomic texts, based on autopsy studies and numerous venographic studies, have described various venous variants [6]; however, they did not provide the in vivo location and orientation of the ostia [7]. In this study, we referred to the results of Yoel Siegel [8], identifying six types of anatomy for the right internal spermatic vein (ISV) based on the findings (**Figure 1**).

However, venography is an invasive procedure typically performed during surgery, and it is not performed for clinical purposes. Currently, studies utilize multidetector spiral computed tomography (MCT) scans to assess the spermatic vein in systemic diseases or VC [9]. The MCT scans are non-invasive and provide rapid, clear, intuitive, three-dimensional, and accurate visualization of the anatomical relationships of the spermatic vein [10-12]. It enables precise measurement and analysis of observed indicators, including angles, diameters, and directions of the spermatic vein, thus potentially providing an accurate analysis of the classification and characteristics of the right spermatic vein, offering macroscopic three-dimensional images for interventional and surgical treatments, and allowing clinicians to choose appropriate surgical methods based on this imaging.

Interventional treatment for left VC is relatively successful, while treating right VC often fails due to the lack of understanding of the anatomy of right ISV [13]. Therefore, understanding the anatomical variations at the spermatic vein confluence is crucial for the success of interventional treatment. Further research on the anatomical characteristics of the right ISV will play an important role in the clinical treatment of VC.

Methods

Study participants

This retrospective study included a consecutive cohort of in-patients who underwent MCT. Imaging data were collected from 1000 male patients who had abdominal and pelvic MCT scans at Chengdu University of Traditional Chinese Medicine Hospital between April and October 2022. All the patients were from southwest China. Inclusion criteria were as follows: (1) Patients aged 21-60 years were selected, and all came from southwest China; (2) The abdominal and pelvic MCT scans included in the study could clearly display the morphology, course, and anatomical relationship of the right ISV with the surrounding blood vessels. Exclusion criteria were as follows: (1) Cases with unclear imaging on MCT; (2) Patients with severe heart, liver, or kidney diseases; (3) Patients with solid tumors. This study followed the principles outlined in the Declaration of Helsinki. This study was a retrospective analysis of already existing imaging data; therefore, no additional examinations were performed on patients. The gathering and publication of the

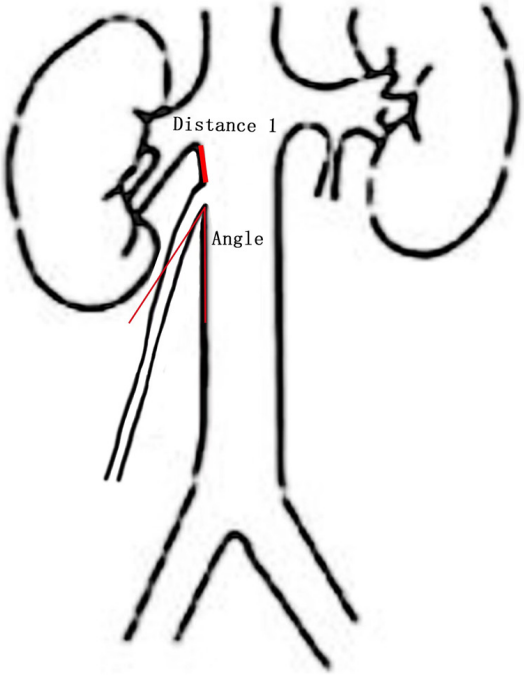

Figure 2. Angle of the IVC with the right internal spermatic vein (red line) and Distance from the entry point of the internal spermatic vein (Distance 1).

related data were approved by the Institutional Review Board.

MCT methods

This study utilized MCT scans performed at the same hospital using similar methods. The patients were supine, selected the abdomen routine, and set the thickness of the scanning layer, MCT with a resolution matrix of 512×512 and a slice thickness of 1.25 mm. The main focus is on the thin slices of the 1.25 mm axial plane and the reconstructed coronal plane. Multi-planar reconstruction was mainly based on thin-layer images, with angles in coronal, sagittal, or other suitable orientations for image reconstruction. This method addressed the limitations of solely analyzing images in the axial plane. Using MCT in this study exhibited the following advantages: 1) fast scanning (scanning of an organ within 1 s); 2) thin slice thickness; 3) high resolution, providing clear images for precise identification of venous pathological changes; 4) low radiation dose, safe for use in elderly and frail individuals for screening and health check-ups; 5) EndoSize software (version 3.1.25; Selerity, Rennes, France) was used for drawing and measuring angles.

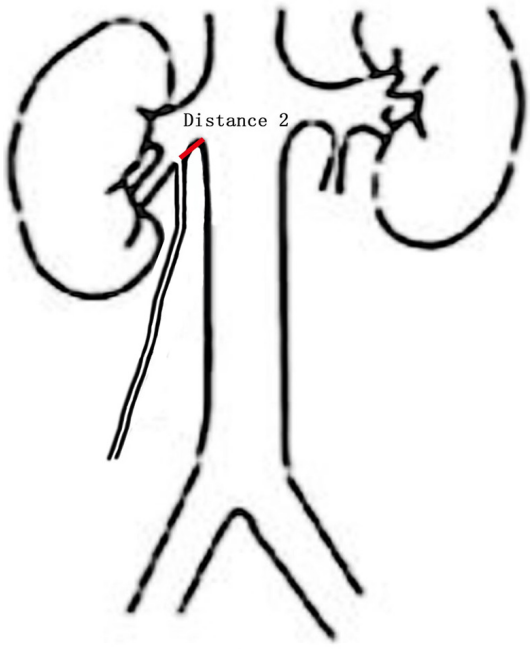

Figure 3. The right internal spermatic vein into the renal vein: Distance 2 (Red line).

Method for image measurement and observation indicators

Clear imaging data of the right ISV were selected from the MCT images. The primary focus was on thin axial slices (1.25 mm thick) and reconstructed coronal slices. First, the axial study was scrolled through to determine the position and course of the right spermatic vein. Only veins that could be tracked without interference with the contralateral gland were considered the true spermatic vein. Collateral veins referred to those veins that were connected to the already identified spermatic vein.

It was necessary to record the size type and position of the right ISV. The measurement data is illustrated in **Figures 2**, **3**. These particular measurement methods were chosen because they were considered the most useful spatial markers for exploring anatomical positions. The exploration process involved step-by-step measurements of relevant data, accurate to 0.1 mm. All measurements were performed thrice, and their average was used for statistical analysis. The measured data was input into an electronic spreadsheet to generate summary statistics. The main statistical data included: 1) the position, type, and number of the drainage veins of the right spermatic vein; 2) the

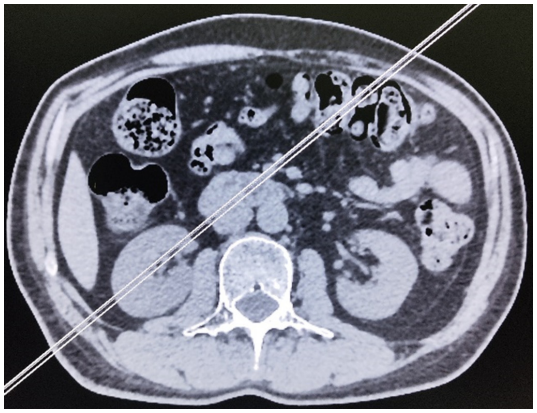

Figure 4. Axial multilayer spiral CT images.

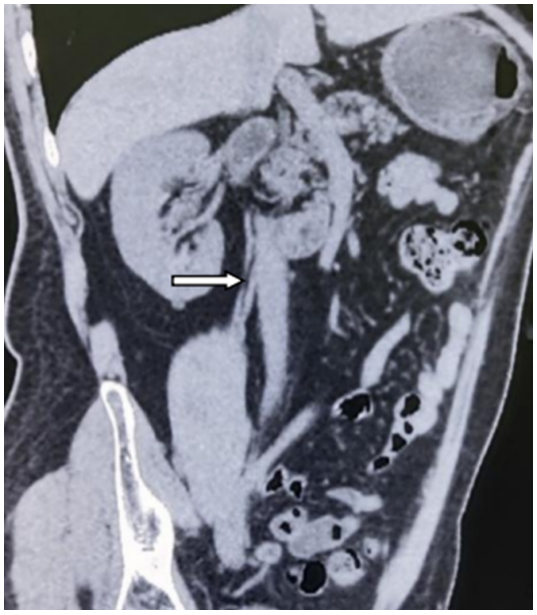

Figure 5. The reconstructed image of the coronal plane shows a parallel right internal spermatic vein (arrow).

angle measurement of the right ISV in the axial plane; 3) the diameter measurement of the right ISV in front of the drainage point; 4) the distance measurements (Distances 1 and 2) from the confluence of the right ISV to the main trunk of the draining vein; 5) the angle measurement between the right ISV and the inferior vena cava. The parameters of Distances 1 and 2 are illustrated in **Figures 2**, **3**.

Statistical analyses

Statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS) software (version 26.0) and R (version 4.2.3). The collected data were compiled into a database file, and logical checks for data consistency were performed to ensure data accuracy before analysis. All data in this study do not follow a normal distribution (**Figures 7**-**10**) and are represented as M (p25, p75).

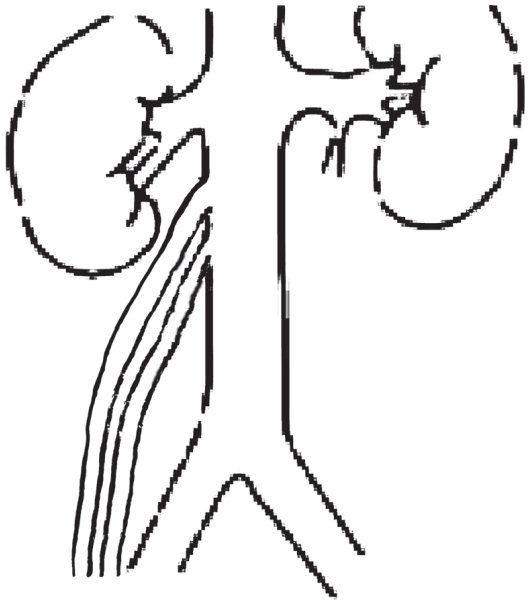

Figure 6. The parallel right internal spermatic vein (type 5).

Results

The demographic characteristics of patients

1189 male patients who underwent MCT scans were initially screened. CT scans of 1000 patients showed a clear three-dimensional course of the right ISV and its branching vessels, making them suitable for statistical evaluation. After applying exclusion criteria, 189 cases were excluded because their right ISV could not be clearly traced in the MCT scans. Reasons for exclusion included previous pelvic surgery, kidney surgery, trauma, or unclear visualization of the right spermatic vein.

Classification number of the right spermatic vein

In this study, the right ISV was classified into six types: Type 1, Type 2, Type 2a, Type 3, Type 4, and Type 4a. 978 cases (97.8%) showed a single right spermatic vein draining either into the

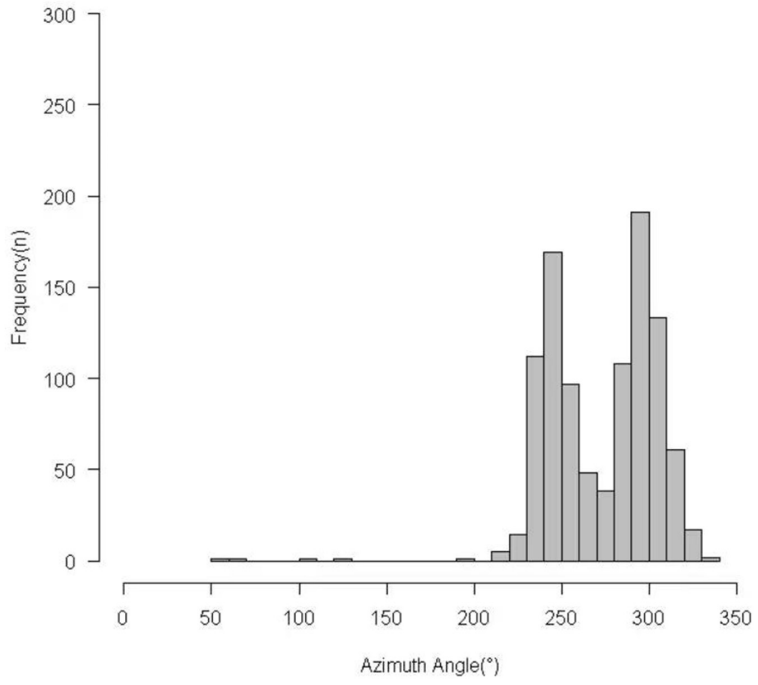

Figure 7. Frequency distribution histogram of azimuth angle.

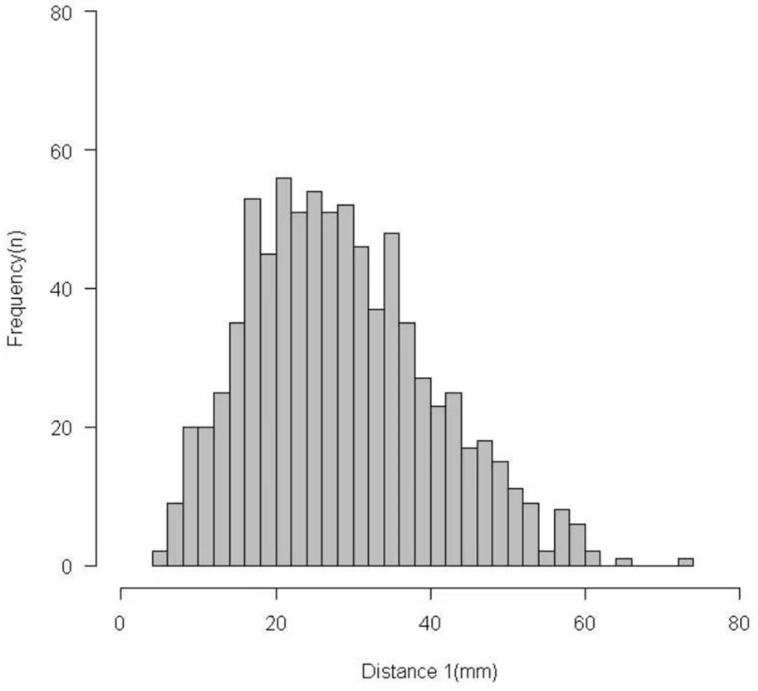

Figure 8. Frequency distribution histogram of distance 1.

inferior vena cava or the right renal vein. **Figure 4** illustrates the axial CT image of the right spermatic vein. Additionally, 22 cases exhibited repeated and parallel right spermatic veins (**Figure 5**), defined as Type 5 (**Figure 6**), with drainage into the inferior vena cava, constituting 2.2% of all cases.

In this study, the right ISV was classified into seven types (**Figure 6**). The most common type was Type 1, with direct drainage into the inferior vena cava, constituting 778 cases (77.8%). The second most common type was Type 4a, with drainage into the right renal vein, constituting 109 cases (10.9%). The least common type was Type 2a, with only 5 cases (0.5%). There were 44 cases of Type 3 and 13 cases of Type 4. The specific distribution is indicated in **Table 1**.

The azimuth angle of the right ISV at the confluence and drainage site

The measurement results showed a skewed distribution. The minimum value was 59.6°, the maximum value was 336°, the mean value was 273.6°, and the median value was 281.5° (Range = 246.8°-298.2°). The measurement results were divided into four quadrants: 0°-90° for the first quadrant, 90°-180° for the second quadrant, 180°-270° for the third quadrant, and 270°-360° for the fourth quadrant. Consequently, the majority (56.9%) of the right ISV orientations in the axial plane were in the fourth quadrant, followed by the third quadrant (42.9%). The azimuth angles are presented in **Table 2**, and the frequency distribution is depicted in **Figure 7**.

Diameter of the right spermatic vein

For the right ISV, when diverted into the inferior vena cava or right renal vein, the minimum

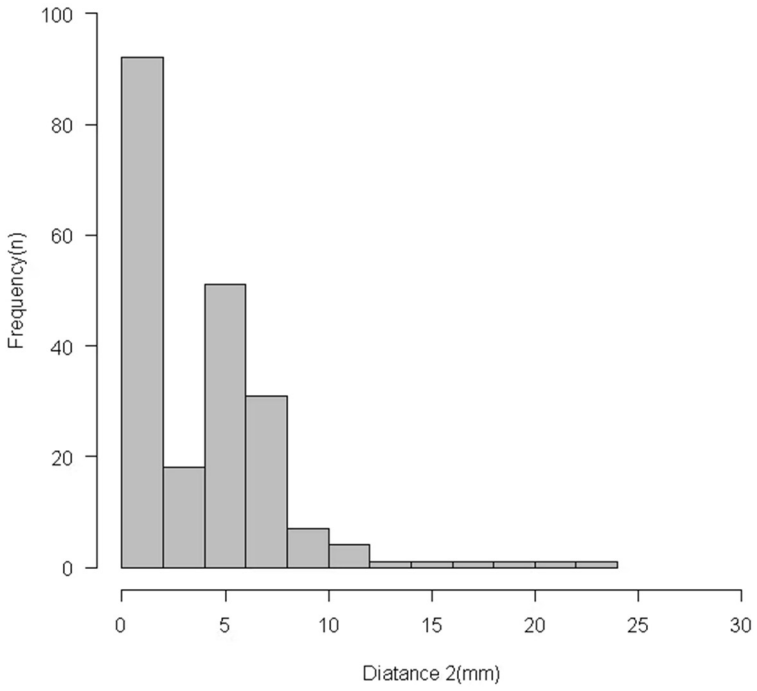

Figure 9. Frequency distribution histogram of distance 2.

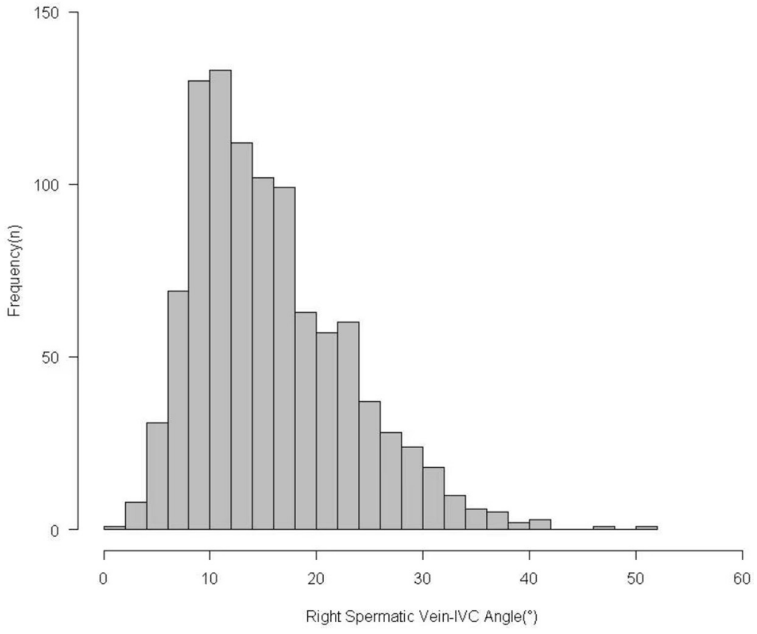

Figure 10. Distribution of the angle of the right spermatic vein.

diameter was 1.5 mm, the maximum diameter was 6 mm, the mean was 3.3 mm, and the median was 3.2 (2.7-3.8 mm). Diameters are listed in **Table 2**.

The distance from the right ISV to the draining vein

According to the types of the right ISV, 87 cases (10.8%) of Type 1 directly drained into the junction of the right renal vein and the inferior vena cava; therefore, the Distance 1 was 0. In the remaining 791 cases (including Type 5), the average Distance 1 was 28.5 mm, mainly between 19.6 and 36 mm, with 83% of the right ISV located within 40 mm below the renal vein port. The frequency distribution of Distance 1 is displayed in **Figure 8**. For 117 cases of Type 4 and 4a draining into the right renal vein, the mean Distance 2 was 6.3 mm, mainly between 4.4-6.9 mm. The frequency distribution of Distance 2 is illustrated in **Figure 9**. The parameters of Distances 1 and 2 are presented in **Table 2**.

Angle between the right ISV and the inferior vena cava

The right ISV mainly drained into the inferior vena cava, forming mostly an acute angle with it. While Type 4 and 4a drained into the right renal vein, the vertical inferior vena cava vein as a reference, its angle was mostly acute, generally between 10° and 20°, with an average of 15.8°. A 90% of drainage angle was below 25.7°, as shown in **Table 2**. The distribution of the right ISV angle is depicted in **Figure 10**.

Discussion

After analyzing 1000 cases, this study revealed that most (80.0%) of the right ISV directly drained into the inferior vena cava. The next most common type was Type 4a, with 109 cases (10.9%) draining into the right renal vein. The observed branch-

Table 1. Summary of types of right spermatic vein

Type	1	2	2a	3	4	4a	5	Total
Number	778	29	5	44	13	109	22	1000
Percentage	77.8%	2.9%	0.5%	4.4%	1.3%	10.9%	2.2%	100%

Table 2. Anatomical features of the right spermatic vein

	Minimum	Maximum	Mean	Median	Quartiles		
					25	50	75
Azimuth (°)	59.6	336	273.6	281.5	246.8	281.5	298.2
Angle (°)	1.0	51.4	15.8	14.3	20.2	14.3	25.2
Diameter (mm)	1.5	6	3.3	3.2	2.7	3.2	3.8
Distance 1 (mm)	5.2	72.6	28.5	27.1	19.6	27.1	36
Distance 2 (mm)	2.1	23.0	6.3	5.5	4.4	5.5	6.9

ing at the end of the right ISV could be attributed to the right gonadal vein branching during development [8].

This study determined the location and three-dimensional orientation of the spermatic vein opening. In the axial plane, most (56.9%) of the right ISV openings were situated in the fourth quadrant, followed by the third quadrant (42.9%). The 86.4% of the orientations fell between 240° and 360°. Barber *et al.* [10] also reviewed 106 cases of abdominal pain using multidetector CT and observed that the gonadal vein openings in the axial plane were in the fourth quadrant in 97% and 85% of cases, respectively, mainly ranging from 240°-360° and 270°-360°. In the right-sided cases, 92 out of 100 cases exhibited direct insertion into the inferior vena cava, with 83% located within 25 mm below the renal vein ostium. When searching for the right renal spermatic vein, the right anterior lateral quadrant should be the initial focus.

Regarding the distance measurements in this study, the angle between the right ISV and the inferior vena cava was generally acute, with an average of 15.8°, and 90% of the drainage angles were below 25.7°. Using the gathered data, simple anatomical rules that could serve as a basis for locating the spermatic vein were established. Based on the angle of confluence, the optimal interventional embolization approach was through the jugular vein route.

This study aimed to evaluate the normal anatomy and variations of the right ISV using MCT. The right ISV demonstrated complex variations, including duplications and an anomalous number of veins, which are common abnormalities in the spermatic vein. A previous study identified duplication of the right ISV in 4% of cases [14], while another study found duplication in 15% of cases [15]. Taylan Kara [16] examined 101 male patients who underwent abdominal CT scans for various clinical indications and found that 99 cases (98%) had a single right spermatic vein, while 2 cases (2%) had duplicated right spermatic veins (103 veins). Our study found that 22 cases exhibited parallel right spermatic veins. The parallel images were classified as Type 5, with drainage into the inferior vena cava, constituting 2.2% of all cases.

To achieve personalized medicine, understanding variations is essential before any medical procedure. The gold standard examination method for visualizing the spermatic vein is direct venography [16-18]. This study classified the right ISV based on the analysis by Yoel Siegel [8]. They evaluated venography images of 150 patients with VC treated with sclerotherapy and identified six anatomical types of the right ISV based on drainage locations and patterns of tributary veins. Classifying anatomical variations identified by venography helps angiographers gain insight into the nature and presence of collaterals, which is essential for treating the right VC. Our study found 22 cases with parallel right spermatic veins (Type 5), which may be easily overlooked by interventional operators. Therefore, we defined them as Type 5 to remind the operator easily.

Although venography facilitates direct vascular imaging, this method is invasive, has radiation,

and is commonly used in patients with intravascular spermatic vein occlusion in VC cases. In today's technologically advanced society, the high demand for medical equipment has led to the development of faster CT hardware and software equipment, facilitating rapid CT scans while clearly depicting the anatomy of various blood vessels and adjacent relationships. The MCT plays a crucial role in the three-dimensional reconstruction of various vessels, making it highly valuable for researching vascular lesions.

The MCT examination is a non-invasive technology that can rapidly, clearly, and intuitively provide three-dimensional visualization and accurately depict the anatomical relationship of blood vessels. It can accurately measure and analyze the vein angle, diameter, and direction. Moreover, it can accurately analyze the right vein classification and the characteristics of various classifications. It can be helpful in planning the next steps of interventional and surgical treatments. It provides clinicians with macroscopic stereoscopic images to guide appropriate surgical plans.

This study has the following limitations: Patient height and weight were not recorded during the study. According to the literature study, the left VC was affected by the body mass index (BMI). Conversely, on the right side, it has to be determined whether the diameter and angle of the right spermatic vein are affected by BMI. This study is a retrospective analysis involving randomly selected adults with clear MCT data on the spermatic vein, posing some limitations to the representativeness of the sample.

In conclusion, MCT can be used to evaluate the anatomic characteristics of the right ISV. Based on the angle of the right ISV join the inferior vena cava, the optimal interventional approach was through the jugular vein route to locate the ISV opening and improve the success rate of embolization.

Disclosure of conflict of interest

None.

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References

[1] Sasson DC and Kashanian JA. Varicoceles. JAMA 2020; 323: 2210.

[2] Casey JT and Misseri R. Adolescent varicoceles and infertility. Endocrinol Metab Clin North Am 2015; 44: 835-842.

[3] Iaccarino V and Venetucci P. Interventional radiology of male varicocele: current status. Cardiovasc Intervent Radiol 2012; 35: 1263-1280.

[4] Cayan S, Shavakhabov S and Kadioğlu A. Treatment of palpable varicocele in infertile men: a meta-analysis to define the best technique. J Androl 2009; 30: 33-40.

[5] Jacobson DL and Johnson EK. Varicoceles in the pediatric and adolescent population: threat to future fertility? Fertil Steril 2017; 108: 370-377.

[6] Perdikakis E, Fezoulidis I, Tzortzis V and Rountas C. Varicocele embolization: anatomical variations of the left internal spermatic vein and endovascular treatment with different types of coils. Diagn Interv Imaging 2018; 99: 599-607.

[7] Robinson SP, Hampton LJ and Koo HP. Treatment strategy for the adolescent varicocele. Urol Clin North Am 2010; 37: 269-278.

[8] Siegel Y, Gat Y, Bacher GN and Gornish M. A proposed anatomic typing of the right internal spermatic vein: importance for percutaneous sclerotherapy of varicocele. Cardiovasc Intervent Radiol 2006; 29: 192-197.

[9] Kolettis PN, Sabanegh ES, Nalesnik JG, D'Amico AM, Box LC and Burns JR. Pregnancy outcomes after vasectomy reversal for female partners 35 years old or older. J Urol 2003; 169: 2250-2252.

[10] Nallikuzhy TJ, Rajasekhar SSSN, Malik S, Tamgire DW, Johnson P and Aravindhan K. Variations of the testicular artery and vein: a meta-analysis with proposed classification. Clin Anat 2018; 31: 854-869.

[11] Vanlangenhove P, Dhondt E, Van Maele G, Van Waesberghe S, Delanghe E and Defreyne L. Internal spermatic vein insufficiency in varicoceles: a different entity in adults and adolescents? AJR Am J Roentgenol 2015; 205: 667-675.

[12] Altunoluk B, Soylemez H, Efe E and Malkoc O. Duration of preoperative scrotal pain may predict the success of microsurgical varicocelectomy. Int Braz J Urol 2010; 36: 55-59.

[13] Rais-Bahrami S, Montag S, George AK, Rastinehad AR, Palmer LS and Siegel DN. Angiographic findings of primary versus salvage varicoceles treated with selective gonadal vein embolization: an explanation for surgical treatment failure. J Endourol 2012; 26: 556-560.
[14] Chan P. Management options of varicoceles. Indian J Urol 2011; 27: 65-73.
[15] Xue HG, Yang CY, Asakawa M, Tanuma K and Ozawa H. Duplication of the inferior vena cava associated with other variations. Anat Sci Int 2007; 82: 121-125.
[16] Kara T, Younes M, Erol B and Karcaaltincaba M. Evaluation of testicular vein anatomy with multidetector computed tomography. Surg Radiol Anat 2012; 34: 341-345.
[17] Cassidy D, Jarvi K, Grober E and Lo K. Varicocele surgery or embolization: which is better? Can Urol Assoc J 2012; 6: 266-268.
[18] Storm DW, Hogan MJ and Jayanthi VR. Initial experience with percutaneous selective embolization: a truly minimally invasive treatment of the adolescent varicocele with no risk of hydrocele development. J Pediatr Urol 2010; 6: 567-571.