Magnetic Resonance Imaging Evaluation of Left Common Iliac Vein Compression in Patients With and Without Symptoms of Venous Disease

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Background: The goal of this study was to assess the degree of the left common iliac vein (LCIV) compression by the right common iliac artery (RCIA) on magnetic resonance imaging (MRI), and verify differences in compression measurements in end-inspiration, end-expiration, supine, and prone decubitus between patients with and without symptoms in the lower limbs.

Methods and Results: A total of 82 consecutive participants provided informed consent and underwent pelvic MRI for different clinical indications other than vascular-related disorders. The participants answered a questionnaire about venous disease in the lower limbs and history of previous deep vein thrombosis. This study measured the area and diameter of the LCIV at the site of the crossing with the RCIA and in the uncompressed caudal LCIV segment. Statistical analysis was performed to compare the degree of LCIV compression by the RCIA and verify differences in compression measurements. A total of 71 participants were included; 46.6% were in group A and did not experience signs and symptoms in lower limbs and 53.6% were in group B and answered at least one question with a positive answer. It was observed that there was a statistically significant difference between groups for end-expiration. No statistically significant differences were observed for all other measurements.

Conclusions: A substantial percentage of the asymptomatic and symptomatic population showed compression of the LCIV, suggesting there are no clear relationships between stenosis and non-specific symptomatology in the general population.

Key Words: Iliac compression; Magnetic resonance imaging; May-Thurner Syndrome; Vein

Anatomic compression of the left common iliac vein (LCIV) by the right common iliac artery (RCIA) against the fifth lumbar vertebra is usually referred to as May-Thurner Syndrome (MTS).^{1,2} Decreased lumen of the iliac vein may occur in 2 ways: by physical compression and by extensive intimal hypertrophy of the left common iliac vein from the chronic pulsatile force of the right common iliac artery.³ As collateral circulation development occurs over time, patients with LCIV compression may have no clinical symptoms; however, according to Virchow,⁴ LCIV may be associated with an increased incidence of left lower limb deep vein thrombosis (DVT).

Most patients are women in the second and fourth decades of life.⁵ Multiple pregnancies, the postpartum period, contraceptive pills, prolonged immobilization, and dehydration may be related to the pathogenesis of this syndrome.⁶ Although infrequent, MTS may cause significant hemodynamic consequences. In the acute phase, patients most often present with signs and symptoms of DVT, edema and swelling in the lower limbs, venous

claudication, redness or hyperpigmentation, pain, and secondary shift to chronic stasis.⁷

MRI is useful in the assessment of venous compression syndromes. However, several factors like the respiratory cycle and decubitus positioning can interfere with abdominal venous circulation and can have different degrees of influence in the compression of RCIA over LCIV. Therefore, the evaluation of patients with non-specific symptoms can be a challenge and may lead to overdiagnosis, resulting in unnecessary interventions. To the best of our knowledge, there are few imaging studies^{8,9} that compare venous calibers in asymptomatic and symptomatic groups, and none of them have a prospective design, and did not study other influencing factors in the measurements.

The aim of this study was to prospectively compare symptomatic and asymptomatic patients who might be suspected of having MTS, analyzing the degree of LCIV compression by the RCIA and verify differences in compression measurements in end-inspiration, end-expiration, supine, and prone decubitus.

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Methods

Ethical Approval

This study was approved by the Ethics Committee and the Review Board of Albert Einstein Hospital. Written informed consent was obtained from all participants.

Patient Selection and Study Design

We performed a prospective observational study conducted from June 2017 to July 2018. The inclusion criterion was

patients aged >18 years. Exclusion criteria were: (1) contraindications to gadolinium-based contrast injection; (2) pregnancy or suspected pregnancy; (3) MRI incompatible devices; (3) patients who had claustrophobia or were intolerant to examination; or (4) acquired images with technical limitations.

All initial 82 consecutive participants who underwent pelvic MRI for different clinical indications other than vascular-related disorders were invited to participate. Participants were asked to answer a comprehensive questionnaire based on signs and symptoms regarding venous disease in the lower limbs and history of previous DVT.^{10,11} We divided patients into 2 groups: group Asymptomatic, composed of the participants who did not mention any symptoms in the lower limbs, and group Symptomatic, composed of those who answered yes to at least one positive sign or symptom in the questionnaire for the left leg.

Questionnaire on Signs and Symptoms Regarding Venous Disease in Lower Limbs

The questionnaire comprises the evaluation of 8 symptoms and signs: edema, swelling, heaviness, pain, varicose veins, hyperpigmentation, venous leg ulcer and previous DVT.

MRI Protocol and Data Assessment

Pelvic MRI was performed in 1.5 Tesla scanners (Optima MR450 and MR450i; GE Medical Systems, Milwaukee, WI, EUA). Acquisition parameters for the dedicated sequences directed to the evaluation of the iliac vessels were:

- 1) Cine Gradient Eco SSFP (CINE GRE), 2 sagittal slices, FOV 32; thickness 6mm; TR 4.7ms, TE 1ms; matrix 200/200; NEX 1; 120 multi-phases. Acquired during end-inspiration and end-expiration.
- 2) 3D Gradient Eco T1- weighted (3D GRE), FOV 34, thickness 3.8mm; TR 4.6ms; TE 1.5ms; matrix 256/224; NEX 1. Acquired in supine and prone patient

Figure 1. Illustration showing site of crossing in the left iliac common vein with the right iliac common artery. Two planes were performed in the Cine Gradient Eco acquisitions to obtain sagittal images.

Figure 2. Multiplanar reconstruction technique applied to 3D Gradient Eco T1-weighted. White arrows showing the left common iliac vein at the site of crossing; black arrows showing the uncompressed caudal iliac vein segment. (A,B) Patient in the supine position; (C,D) patient in the prone position.

Figure 3. Sagittal magnetic resonance imaging (MRI) Cine Gradient Echo images. White arrows showing the left common iliac vein at the site of crossing; black arrows showing the uncompressed caudal iliac vein segment. (A,B) during end-inspiration; (C,D) during end-expiration.

positions after intravenous contrast administration.

These sequences were added to the institutional pelvic MRI protocol and enabled measurement of area and diameter of the LCIV at the site of the crossing with RCIA and in an uncompressed caudal iliac vein segment (i.e., standard normal parameter for each participant) (**Figure 1**). Degree of venous compression was calculated as the minimum diameter or area of LCIV at site of maximal compression divided by diameter or area of uncompressed caudal LCIV.

Data were collected using a picture archiving and communication system, PACS Workstation (Centricity, GE Health-care, Waukesha, WI, USA).

An experienced MR technologist performed the MR data analysis. A multiplanar reconstruction (MPR) technique was applied to 3D GRE acquisitions (**Figure 2**) to obtain sagittal images in supine and prone patient position and compare them with CINE GRE acquisitions (**Figure 3**). Data were analyzed in a blinded manner.

Here, we investigate the LCIV area and diameter stenosis between the site of crossing and caudal iliac vein segment in the supine, prone patient position and in end-inspiration and end-expiration.

Statistical Analysis

All analysis was performed using computer program R software version 3.1.2 (R Core Team, R Foundation for Statistical Computing, Vienna, Austria). Continuous variables are summarized as median and range, and categorical

variables are expressed as count and percentage. A Mann-Whitney U-test was used to compare stenosis rate and Fisher's exact test was used to compare differences in degree of compression between groups. All tests were tested with a statistical significance level of $P < 0.05$.

Results

From the initial number of patients enrolled, 11 were excluded. Therefore, the final casuistry was composed of 71 participants; 33 (46.6%) of them included in Group Asymptomatic and 38 (53.6%) in Group Symptomatic. The anthropometric characteristics and the signs and symptoms of the patients are presented in **Table 1**. We observed that the patients are mostly female, in the third or fourth decade of life and heaviness/pain are the most frequent symptoms in the symptomatic group.

The compression degrees are presented in **Table 2**. MRI measurements were absolutely identical in the 2 groups (end-inspiration and end-expiration). We note that 36.4% of both groups had a greater than 25% compression of the LCIV. In end-expiration, the values of >50% compression increase, while in supine decubitus, the degree of compression decreases and in prone decubitus, stenoses greater than 50% decrease even more, disappearing in the asymptomatic group and being present in only 3.4% in the symptomatic group.

The compression degrees diameters are presented in **Table 3**. For the two groups (end-inspiration and end-

Table 1. Patient Data and Questionnaire Answers		
	Asymptomatic (n=33)	Symptomatic (n=38)
Age (years, IQR)	41 [36.75; 46.25]	46 [36.50; 54.25]
Female n (%)	31 (93.9)	38 (100)
Symptoms in lower limbs n (%)		
Edema/swelling		14 (36.8)
Heaviness/pain		25 (65.8)
Varicose veins		19 (50)
Hyperpigmentation or venous leg ulcer		4 (10.5)
Previous deep vein thrombosis		2 (5.3)

n, number of samples; IQR, interquartile range.

Table 2. Comparison of Compression Degree Area Between Groups			
	Asymptomatic	Symptomatic	P value
LCIV area in end-inspiration - (%) (n=55)			>0.999
≤25%	14 (63.6)	21 (63.6)	
25.1–50%	6 (27.3)	9 (27.3)	
≥50%	2 (9.1)	3 (9.1)	
LCIV area in end-expiration - (n=55)			0.854
≤25%	13 (59.1)	21 (63.6)	
25.1–50%	5 (22.7)	8 (24.2)	
≥50%	4 (18.2)	4 (12.1)	
LCIV area in supine decubitus - (n=50)			0.583
≤25%	18 (85.7)	21 (72.4)	
25.1–50%	2 (9.5)	6 (20.7)	
≥50%	1 (4.8)	2 (6.9)	
LCIV area in prone decubitus - (n=49)			0.824
≤25%	16 (80.0)	24 (82.8)	
25.1–50%	4 (20.0)	4 (13.8)	
≥50%	0 (0.0)	1 (3.4)	

n, number of samples; percentage in each group. LCIV, left common iliac vein.

Table 3. Comparison of Compression Degree Diameter Between Groups			
	Asymptomatic	Symptomatic	P value
LCIV diameter in end-inspiration - (%) (n=55)			0.93
≤25%	12 (54.5)	20 (60.6)	
25.1–50%	5 (22.7)	7 (21.2)	
≥50%	5 (22.7)	6 (18.2)	
LCIV diameter in end-expiration - (n=55)			0.328
≤25%	11 (50.0)	22 (66.7)	
25.1–50%	7 (31.8)	5 (15.2)	
≥50%	4 (18.2)	6 (18.2)	
LCIV diameter in supine decubitus - (n=50)			0.603
≤25%	11 (52.4)	11 (37.9)	
25.1–50%	8 (38.1)	15 (51.7)	
≥50%	2 (9.5)	3 (10.3)	
LCIV diameter in prone decubitus - (n=49)			0.828
≤25%	12 (60.0)	16 (55.2)	
25.1–50%	6 (30.0)	11 (37.9)	
≥50%	2 (10.0)	2 (6.9)	

n, number of samples; percentage in each group. LCIV, left common iliac vein.

Table 4. LCIV Diameter and Area Measurements in the Site of Crossing, Comparison Tests Between Groups

Variables	Asymptomatic	Symptomatic	P value
Area in end-inspiration (mm ²)	104.55 [77.70; 150.52]	124.60 [84.70; 156.00]	0.6
Diameter in end-inspiration (mm)	5.35 [4.34; 7.20]	5.88 [3.85; 7.66]	0.797
Area in end-expiration (mm ²)	70.15 [50.07; 89.85]	96.80 [63.90; 131.90]	0.074
Diameter in end-expiration (mm)	2.85 [2.50; 3.63]	4.10 [2.91; 6.50]	0.008*
Area in supine decubitus (mm ²)	150.30 [126.70; 194.00]	156.70 [130.00; 175.40]	0.709
Diameter in supine decubitus (mm)	6.84 [5.84; 7.79]	6.20 [5.73; 8.23]	0.798
Area in prone decubitus (mm ²)	170.65 [123.72; 195.58]	169.40 [145.70; 221.00]	0.768
Diameter in prone decubitus (mm)	7.33 [5.74; 8.49]	7.00 [5.65; 8.26]	>0.999

*The only one significant P-value. Data are presented as median [interquartile range]. LCIV, left common iliac vein.

expiration), measurements were similar (54.5% vs. 60.6%). In end-expiration, the values of >25% compression diameter increase in asymptomatic patients (50% vs. 33.3%), the same as in the supine decubitus.

The LCIV diameter and area measurements in the site of crossing are presented in **Table 4**. We observed a statistically significant difference between groups in end-expiration, measuring when the LCIV at the diameter of the site crossing was measured ($P=0.008$) and a marginal statistically significant difference in area ($P=0.074$), which were 2.85 mm and 70.15 mm² in Group Asymptomatic and 4.10 mm and 96.80 mm² in Group Symptomatic, respectively.

Discussion

Here, we investigate the prevalence of LCIV degree compression by the RCIA and verified differences in compression measurements in end-inspiration, end-expiration, supine, and prone decubitus between groups.

Prevalence of LCIV Degree Compression

We found 38.1% of asymptomatic patients (Group A) with compression between 25.1 and 50% and 9.5% of patients with more than 50% of compression. These data are in line with results found by de Cheng et al,⁹ who reported 37.8% of participants with $\geq 25\%$ compression and 9.8% with $\geq 50\%$ compression in one study, with 500 asymptomatic patients for vascular factors submitted to CT. In contrast, our results do not completely match those by Kibbe et al,⁸ who evaluated 50 asymptomatic patients with end-inspiratory acquisition with CT and found LCIV compression >25% in 66% of patients and $\geq 50\%$ in 24% of the evaluated individuals.

Considering the inspiratory diameter measurements in Group Symptomatic, we found that 20 (60.6%) of the participants presented with compression $\leq 25\%$, 7 (21.2%) between 25.1% and 50%, and 6 (18.2%) with compression greater than 50% ($P=0.930$). Expiration measurements ($P=0.328$) were similarly expressed, 22 (66.7%) participants showed a compression $\leq 25\%$, 5 (15.2%) between 25.1% and 50%, and 6 (18.2%) had a degree of stenosis above 50%. Our data are partially divergent from Nazzari et al,¹² who studied 300 consecutive patients by using CT scans of patients with risk factors or signs and symptoms for venous diseases in lower limbs and reported the presence of 193 (64.3%) participants with $\geq 50\%$ compression.

There was no statistically significant difference between degrees of compression measurements (inspiration, expiration, dorsal, and ventral decubitus) and the surveyed groups. The only difference was observed in forced expiration

($P=0.008$). The diameter in asymptomatic patients were smaller than symptomatic patients (2.85 mm vs. 4.10 mm), the opposite of what was expected. We demonstrated that the degree of stenosis is not related to symptoms. Comparing groups, we observed there was little variation in prevalence between degree of compression when considering inspiration and expiration phases. With these data, a relevant percentage of Group Asymptomatic (45.4%) presented with some degree of compression >25.1% when measuring inspiratory diameter, which may suggest that the symptoms in the lower limbs referred by Group Symptomatic in the form may not be exclusively related to LCIV compression but rather to other factors, such as a history of surgery in the lower limb, prolonged immobilization, trauma, cancer treatment or others, conditions that require investigation, and future correlations.

Compression Measurements and Differences Between Groups

Mean compression among the studied population was quite divergent in the literature. In our study, mean compression (diameter) of VICE in inspiration of Group Symptomatic was estimated to be 13.58% vs. 20.47% in Group Asymptomatic. In studies with the asymptomatic population, we found data ranging from 16% to 36%,^{8,9} and in the symptomatic population for vascular complaints, the means vary from 14% to 37%.^{13,14} Other studies involving patients with confirmed diagnosis of chronic MTS demonstrate a 40% to 76% variation in LCIV compression.^{15,16} We bring special attention to the study by McDermott et al¹⁷ who compared MR angiography with CT and reported a mean difference of 23.1% among the methods performed. Such findings were attributed to divergence in factors that may influence venous filling such as cardiac output, degree of hydration and Valsalva, thereby showing that there is no precise definition that relates degree of compression to increased risk for DVT.

According to our results, almost all area and diameter and compression degree measurements presented no statistical significance. Therefore, we can infer that there is no evidence to support a difference between compression measurements between groups. Thus, MRI can satisfactorily show morphology and patency of LCIV, RCIA, and adjacent structures, but isolated quantitative evaluation is not sufficient to discriminate between groups, corroborating previously published studies.^{8,17-21}

To the best of our knowledge, this is the first prospective MRI study evaluating prevalence of LCIV compression in a population grouped by symptoms. In addition, no study to date has surveyed LCIV behavior during expiration

maneuver and in ventral decubitus.

The results allow us to suggest that LCIV stenosis measurements by diameter or area with MRI should not be used as the only and exclusive parameter for MTS diagnosis, as significant vein compression may exist without intervention.

Study Limitations

Female individuals were predominant in this study because they are the patient population who usually undergo pelvic MRI (screening for endometriosis, ovarian cyst, and other gynecological pathologies). However, Kaltenmeier et al,¹⁶ in a systematic review, showed there was no significant difference between men and women regarding risk of developing DVT from LCIV compression, which allows us to suggest that there was no influence of female predominance on our results.

Area and diameter measurements, although standardized, are reader-dependent and may vary according to each observer, a fact to be considered when we observed interclass correlation coefficient that showed poor agreement for some measures in dorsal and ventral decubitus. This finding may be influenced by MPR, which introduces bias when choosing the representative image to analyze. Nonetheless, the methodology employed that was conducted in radiological report analysis can be generalized to clinical practice.

Classification of the groups by questionnaire¹⁰ screening can be an insufficient evaluation of presence or absence of signs and symptoms related to LCIV compression. However, a methodology based on the collection of random and subjective retrospective data from patient records, which was performed in the studies of Kibbe et al¹⁸ and McDermott et al,¹⁷ was used for stratification of the groups in this study.

Conclusions

In general, considering compression degrees of the LCIV in both groups, we did not find a statistically significant difference between the asymptomatic and symptomatic population. However, we found a slight difference in the end-expiration diameter measurements between groups, a finding that requires further investigation (in addition to patients' clinical history, hematological investigation, and symptomatology) to define its significance.

Disclosures

The authors declare that they have no conflicts of interest.

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