A Cadaver Study Evaluating Intraluminal Anomalies of the Left Common Iliac Vein

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A cadaver study evaluating intraluminal anomalies of the left common iliac vein

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Article Highlights

Type of Research: Multicenter prospective observational study

Key Findings: Left common iliac vein spurs were observed in 31.4% (n=16/51) of cadavers. Significantly more spurs were observed in those with an iliac vein confluence located at the L5/S1 spinal level (p=0.002). Body mass index and plaque within the overlying right common iliac artery displayed no significant relationship to spur presence.

Take Home Message: The level of the iliac vein confluence may be important in identifying patients at increased risk for venous disease, specifically iliac vein compression syndrome. Based on this data, body mass index and plaque burden within the right common iliac artery have no strong relationships with spur presence. Further investigation is needed to better understand factors that contribute to spur formation.

Table of Contents Summary

In this multicenter prospective observational study (n=51), significantly more left common iliac vein spurs were observed in cadavers with an iliac vein confluence located at the L5/S1 spinal level. The level of the venous confluence may be important in identifying patients at increased risk for venous disease, specifically iliac vein compression syndrome.
Abstract

Objective: Intraluminal anomalies within the left common iliac vein, characteristic of iliac vein compression syndrome, are thought to result from compression by and pulsation of the overlying right common iliac artery. This cadaver study was designed to expand on the existing literature by surveying and photographing these spurs in addition to exploring whether certain factors, inherent to the cadaver, are associated with spur presence.

Methods: Dissection to expose the aorta, inferior vena cava, and common iliac arteries and veins was performed in 51 cadavers. The spinal level at which the iliac vein confluence occurred was noted. The point at which the right common iliac artery crossed the left common iliac vein was examined for plaque presence. The overlying arterial structures were then transected to expose the venous system. The inferior vena cava was incised to facilitate observation into the mouth and full extent of the left common iliac vein. Spurs were photographed and documented. Statistical analysis was conducted to determine whether sex, body mass index, plaque presence, or level of the iliac vein confluence are associated with spur presence.

Results: Spurs within the left common iliac vein were observed in 16 of 51 cadavers (31.4%). All spurs were located at the point that the right common iliac artery crossed the left common iliac vein. Utilizing the classification system established by McMurrich, 67% (n=10) of spurs were marginal and triangular; 25% (n=4) were columnar. One (6%) marginal, linear spur and one (6%) partially obstructed spur with multiple synechiae were observed. Among this population, males were 73% less likely to have a spur (OR=0.269; p=0.041). No significant relationship was found between plaque presence and spur presence (OR=0.933; p=0.824) and no significant
differences were noted between body mass index and spur presence ($\chi^2=1.752$, $p=0.625$). Lastly, a significantly larger percent of spurs was found within cadavers with an iliac vein confluence located at the L5/S1 disc space ($\chi^2=9.650$; $p=0.002$).

**Conclusions:** Study findings show that spurs are more common when the confluence of the common iliac veins occurs at a lower spinal level. The level of the iliac vein confluence may be important in identifying patients at increased risk of venous disease. The findings also suggest that plaque within the right common iliac artery and BMI display no distinct relationship with spur presence. Further investigation is needed to understand exactly what factors lead to spur formation.

**Keywords:** Iliac vein compression syndrome, iliac vein, venous thrombosis

**Conflicts of Interest:** The authors have no conflicts to declare.

**Funding:** No funding was received for this study.
Introduction

Iliac vein compression syndrome, also known as May-Thurner syndrome, describes an anatomic variation in which the left common iliac vein is compressed between the overlying right common iliac artery and a lumbar vertebra, reducing venous caliber (Figures 1A and 1B). The L5 vertebra is commonly implicated; however, the structure inducing a posterior force on the vein varies with anatomy and may include the sacral promontory. Development of intravenous spurs (also referred to as ‘adhesions’ or ‘webs’), described as a fusion between the anterior and posterior venous walls, is also characteristic of iliac vein compression syndrome.1 The concomitant findings of vessel compression and intraluminal spur presence result in venous stenosis and outflow obstruction, increasing risk for thrombosis of the lower extremity. Importantly, the syndrome can occur bilaterally, or on either the left or right side. The condition affects males and females, and classically presents with acute pain, erythema, and edema secondary to deep vein thrombosis (DVT).2,3 Over years, patients may develop repeated DVTs and post-thrombotic syndrome, causing chronic symptoms.2,4

The anatomy of iliac vein compression syndrome is found in approximately 30% of the population although many patients are asymptomatic.2,5 The diagnosis is reserved for those with symptoms.2,5 It is estimated that 2-5% of DVTs are attributed to iliac vein compression syndrome.2,6 However, considering the common and well-known risk factors for DVT (i.e., oral contraceptive use, prolonged immobility, cancer, coagulopathies), it is likely that iliac vein compression syndrome is overlooked and underdiagnosed.2 In fact, one study conducted by Mickley et al. (1989) detected spurs, via phlebography, in 49% of patients who presented with
acquired left-sided iliac vein thrombi. Similar findings by Vollmar et al. (1989) and Juhan et al. (1997) substantiated Mickley’s work.

Proper diagnosis requires visualization of the stenotic lesion. Non-invasive imaging is performed with duplex ultrasound, computed tomography (CT) venography, or magnetic resonance (MR) venography. When performed properly, CT and MR venograms have greater than 95% sensitivity and specificity in detecting iliac vein compression syndrome. For patients with an acute presentation requiring treatment, more invasive imaging is often required. Catheter contrast venography and intravascular ultrasound (IVUS) are the preferred modalities for diagnosing acute iliac vein compression syndrome. IVUS has a sensitivity and specificity exceeding 98% and is valuable in both diagnosis and intervention. Although IVUS is invasive, it is the most accurate in assessing cross-sectional venous anatomy and is capable of detecting stenotic lesions in up to 30% more patients than venography. Anticoagulation, venous angioplasty, and venous stenting are the mainstays of treatment, allowing for long-term patency and relief of symptoms.

History of Intravenous Spurs

Intravenous spurs were first documented in 1906 by anatomist, McMurrich. Examining the explanted iliac veins of 107 individuals, he noted spurs in 32.7% (n=35/107), 91.4% (n=32/35) of which were found in the left common iliac vein. McMurrich (1906) theorized that the greater frequency of left leg thrombosis, a phenomenon established by Virchow, was due to the preponderance of these left-sided spurs. Several decades later, it was proposed that spurs were acquired, rather than congenital, after researchers reported a significantly greater incidence among cadavers who had survived beyond the first decade of life. Furthermore, May and
Thurner (1957) reported an absence of spurs in the 88 fetuses and embryos they studied. When considering etiology, it was suggested that pressure exerted on the left common iliac vein by the right common iliac artery caused injury to the vein, resulting in fibrosis. This was corroborated by May and Thurner (1957), who suggested that spurs result from endothelial proliferation and adherence of the venous walls secondary to irritation of the endothelium, mechanical compression, and arterial pulsation by the overlying right common iliac artery.

Spur Histology

Spurs are made up of loose connective tissue and a proliferation of endothelial cells. A general absence of inflammatory pathology and presence of alpha smooth muscle actin indicate that a fibrotic processes drives spur formation. Absence of hemosiderin suggests that spur origin is not associated with thrombotic processes. However, more recently, spurs were found to have a variable composition with blood vessels present in some, but not all spurs. In addition, elastic structures contiguous with the inner elastic lamina were present in only some spurs. This variability in the histology suggests that venous compression is likely not the only etiology capable of driving spur formation. Instead, a multitude of mechanisms may be responsible for spur development, and in some cases, spurs may be congenital.

Although spur formation may be driven by different mechanisms, intimal hypertrophy and hyperplasia secondary to irritation by the overlying artery remains the predominant theory. The current cadaver study was pursued to further explore this principle. The objectives were to: (1) evaluate the prevalence of spurs, (2) categorize spurs by morphology, (3) provide photographic evidence of spurs, the existence of which is sparse, to help clinicians better understand lesion
morphology, and (4) explore whether certain factors (sex, body mass index (BMI), presence of plaque in the overlying right common iliac artery, and level of the iliac vein confluence) are associated with spur presence.

Methods
Fifty-one formalin-embalmed cadavers were utilized (Institutional Biosafety Committee #1961318). Consent was obtained through donor participation in the medical schools’ gift body programs. Institutional Review Board approval was not required. Cadaver sex, age at death, and BMI at death were recorded. With the cadavers positioned supine, the abdomen and pelvis were dissected to expose the abdominal aorta, inferior vena cava, and bilateral common iliac arteries and veins. Pins were placed in the L4/L5 and L5/S1 disc spaces to help with identification of the spinal level (L4, L4/L5 disc space, L5, L5/S1 disc space, S1) at which the iliac vein confluence occurred. Next, the point at which the right common iliac artery crossed the left common iliac vein was evaluated and recorded. This point along the artery was palpated to examine for plaque presence before transecting both common iliac arteries to expose the underlying veins. Following arterial transection, the lumen of the right common iliac artery was visually examined to confirm plaque presence. Plaque presence or absence was recorded.

Using a syringe and needle, wetting solution (Downey, ethanol, ethylene glycol, 2- phenoxyethanol) was injected into the left common iliac vein to encourage dissolution of congealed blood within the lumen. Of note, the authors do not believe that this caused any trauma to existing spurs, but it is important to be aware that this is a possibility. Following the methodology described by Mitsuoka et al. (2014), an incision was made along the right margin
of the inferior vena cava and right common iliac vein (Figure 2).\textsuperscript{11} A second incision was made perpendicular to the first, along the longitudinal axis of the left common iliac vein, creating flaps to view the mouth and eventually the full extent of the left common iliac vein.\textsuperscript{11} Throughout this process, the vein lumen was repeatedly examined to ensure that the planned venotomy would not disrupt any existing spurs. Residual blood and thrombotic material were evacuated from the vein to allow for clear visualization. The full length of the left common iliac vein, extending from the origin of the left internal iliac vein to the inferior vena cava, was examined for spur presence. Intraluminal spurs were documented, categorized based on descriptions in Table I, and photographed. Any structure located at the inferior junction of the right and left common iliac veins was considered a valve, and not included in this analysis.\textsuperscript{10}

Data collection was organized using Microsoft Excel (Microsoft Corp, Redmond WA). Statistical Package for Social Sciences (SPSS version 23, IBM, Armonk, NY) was utilized for all statistical analyses. Logistic regression was employed to assess for association between spur presence and sex, and spur presence and plaque presence. Chi-squared testing was employed to assess for differences between spur presence and BMI category (<20, 20-24.99, 25-29.99, ≥30), and spur presence and location of the iliac vein confluence along the spinal column (L4, L4/L5 disc space, L5, L5/S1 disc space, S1).

\textbf{Results}

Fifty-three percent (n=27/51) of the study population was male and 47% (n=24/51) was female. Mean age at death was 74.1 years old (range: 36-90+); however, a precise age was not available for all cadavers (i.e., “90+”). Mean BMI at death was 24.3 (range: 13.9-34.9). Medical histories
of the cadavers were incomplete, so it is unknown whether any donors suffered from iliac vein compression syndrome or any other venous conditions. Spurs were observed in the left common iliac vein in 31.4% (n=16/51) of cadavers. All spurs were located at the point that the right common iliac artery crossed and exerted pressure on the left common iliac vein. The right common iliac artery consistently crossed the vein at the junction of the left common iliac vein and the inferior vena cava.

Spur Morphology

Spurs were noted to be relatively flimsy and flexible, rather than stiff. Utilizing McMurrich’s classification system (Table I), 67% (n=10/16) of spurs were marginal and triangular (Figures 3A and 3A’), 25% (n=4/16) were columnar (Figures 3B and 3B’), and 6% (n=1/16) were marginal and linear (Figures 3C and 3C’). One cadaver (6%) had a severely stenotic (4 mm) left common iliac vein mouth with spurs present on both the medial and lateral aspects of the vein and several synechiae bridging across the remaining lumen (Figures 3D and 3D’), classified as partial obliteration. While spur size was not explicitly measured, spurs were observed to make up less than 50% of the venous diameter in all but one case. In all cases, the vein was observed to be patent and smooth proximal and distal to the location of the spur. Venous valves, occurring at the inferior aspect of the junction of the left and right common iliac veins, were observed in 19 of 51 cadavers (Figures 4A and 4B). Although macroscopic valve morphology is similar to that of spurs, these structures were considered to be distinct from spurs.
**Spur Prevalence vs. Donor Sex**

Spurs were observed in 19% of males (n=5/27) and 46% of females (n=11/24). Sixty-nine percent of all spurs were observed in female cadavers. Among this population, males were 73% less likely to have a spur (OR=0.269; p=0.041).

**Spur Prevalence vs. Donor BMI**

Among all cadavers with BMI data available, 18% (n=9/49) had a BMI less than 20, 35% (n=17/49) had a BMI ranging from 20 to 24.99, 35% (n=17/49) had a BMI ranging from 25 to 29.99, and 12% (n=6/49) had a BMI greater than or equal to 30 (Supplemental Table I). No significant difference was observed in the prevalence of spurs among the BMI categories (χ²=1.752, p=0.625). BMI data was not available for two cadavers, who were excluded from this analysis.

**Spur Prevalence vs. Plaque Burden in Right Common Iliac Artery**

Plaque within the right common iliac artery, at the point at which it crossed the left common iliac vein, was observed in 65% (n=33/51) of cadavers. Plaque in the overlying artery was present in 63% (n=10/16) of the cadavers with spurs. No significant relationship was found between presence of plaque in the artery and spur prevalence (OR=0.933; p=0.824).

**Spur Prevalence vs. Location of Iliac Vein Confluence**

The iliac vein confluence is defined as the location where the left and right common iliac veins meet. The confluence was located at the L4 spinal level in 2% (n=1/51), the L5 spinal level in 53% (n=27/51), the L5/S1 disc space in 43% (n=22/51), and the S1 spinal level in 2% (n=1/51).
Spurs were only observed in cadavers with an iliac vein confluence located at the L5 or L5/S1 level. Twenty-five percent (n=4/16) of spurs were observed among cadavers with a confluence located at the L5 level, while 75% (n=12/16) of spurs were observed among cadavers with a confluence at the L5/S1 disc space. A statistically significant percent of spurs was found within cadavers with an iliac vein confluence located at the L5/S1 level ($x^2=9.650; p=0.002$).

**Discussion**

The prevalence of iliac vein spurs in this donor population is comparable to prior publications (Table II), and consistent with disease estimates of 20-30%.2,6 The observed prevalence reflects the proportion of the donor population with iliac vein compression syndrome anatomy, not the proportion with symptomatic disease. Consistent spur location at the point of venous compression corroborates Ehrich et al.’s (1943) findings and further supports the theory that spurs develop secondary to venous compression and irritation.9,10

**Spur Morphology**

The morphology of spurs observed is consistent with the descriptions provided by McMurrich.1 However, the observation of a severely stenotic left common iliac vein due to the presence of medial and lateral spurs with several concomitant synechiae (Figure 3D) was not adequately described by McMurrich. While he described a spur with similar stenotic morphology: “a strong adhesion [spur] projected from the lateral border of the vein medially, and another occurring at the medial border, so that the interval between the free edges of the adhesions [spurs] was only about 1 mm,” McMurrich did not note the presence of synechiae.1 However, May and Thurner
later described a spur of similar morphology with the presence of synechiae, termed “partial obstruction.” While their description matches our observation, the spur depiction included in their manuscript does not adequately portray the synechiae observed in this study (Figure 3D).

This spur was remarkable in that it likely caused significant disturbance of blood flow, more so than any of the other spurs observed. This spur was found in a 66-year-old female with a BMI of 20.6 and a known history of breast cancer. A more thorough medical history would be crucial in understanding the clinical effects of such a significant finding. Importantly, this spur may represent a recanalized vein secondary to chronic thrombosis. However, without histological evaluation for the presence of hemosiderin, it is impossible to know. Supplemental Table III compares relative frequency of spur morphology among the current study to the work completed by McMurrich, and May and Thurner.

This study was not designed to assess degree of venous stenosis. The methodology followed here did not allow for simultaneous observation of the effect of compression and spur presence on lumen caliber, as the overlying right common iliac artery was transected prior to evaluating for spur presence. However, it should be noted that greater than or equal to 50% stenosis is used as the threshold for defining a clinically relevant lesion when using IVUS. In this study, all but one spur comprised less than 50% of the vein diameter on observation. While there is no way to retrospectively estimate the concomitant effect of vein compression on lumen caliber in the cadavers observed, spur presence alone did not represent clinically significant disease in most cases.
**Relationship Between Spur Development and BMI**

Obesity is a well-known risk factor contributing to the development of chronic venous disease and has been shown to be associated with increased Clinical, Etiological, Anatomical, Pathological (CEAP) scores, representing more severe disease.\(^{13}\) It has also been suggested that those with higher BMI have increased vein diameter, increased venous pressures, and worse venous filling indices, which likely contribute to increased rates of venous disease in the obese population.\(^{14}\) In addition to the established association between high BMI and venous disease, obesity is also known to increase intra-abdominal pressure, which can be transmitted to the pelvic compartment and may exacerbate iliac vein compression.\(^{15}\) Assuming that chronic pressure exerted on the left common iliac vein drives spur formation, one could theorize that a higher BMI increases the likelihood of spur development. Although the current results suggest that BMI does not have a significant impact on spur development, a relationship between these two factors may still exist. Importantly, only 12% of the cadavers were noted to have a BMI diagnostic of obesity (BMI $\geq 30$). Therefore, further investigation with a larger population of obese patients is needed to understand the presence or absence of a relationship. Furthermore, one must also consider when spurs develop. While data on this is sparse, Ehrich et al.’s (1943) findings suggest that spurs develop during the first decade of life.\(^{10}\) If that is the case, end-of-life BMI is indeed an inappropriate proxy for estimation of intra-abdominal pressure during spur formation.

**Spur Prevalence vs. Donor Sex**

Spur preponderance in females reported here is consistent with prior research and known epidemiological trends.\(^{2,3}\) Female sex is a well-known risk factor for development of iliac vein
compression syndrome, especially among those who are peripartum or using oral contraception.\textsuperscript{2}

In fact, the typical clinical presentation is that of a 20- to 40-year-old female with unilateral left leg swelling lasting more than four weeks.\textsuperscript{2}

**Relationship Between Spur Development and Plaque Presence**

Assuming that irritation by the overlying artery drives spur formation, it is possible that plaque presence within the artery, specifically at the point of venous compression, could exert additional pressure on the vein and lead to a greater risk of spur development. However, our findings do not support this theory. Similar to the discussion of cadaver BMI, it is important to consider the temporal relationship between spur formation and plaque development. It is possible that plaque is absent or only minimally present at the time of spur development. Again, this is consistent with Ehrich et al.’s (1943) findings that spurs form early in life, likely before sizable plaques capable of significant compression develop.\textsuperscript{10} Alternatively, plaques may be able to exert a somewhat protective role against spur development. It is possible that plaque within the overlying artery insulates the underlying vein from the chronic, irritative effects of arterial pulsation. Lastly, plaque burden was coded as a dichotomous variable (present or not present) in this study; however, it may be more appropriate to quantify the degree of plaque burden (i.e., mild, moderate, heavy) and subsequently assess the relationship with spur presence. It may also be worthwhile to consider whether plaque histology (i.e., inflammatory changes) affects spur formation.
Relationship Between Spur Development and Location of Iliac Vein Confluence

Spinal anatomy plays a role in the development of iliac vein compression syndrome, as spinal abnormalities are said to be a risk factor for disease development.² The greater preponderance of spurs among individuals with an iliac vein confluence located at the L5/S1 spinal level may suggest that this anatomy is more conducive to spur formation. This anatomy may exert more pressure on the venous structures, leading to a greater risk of spur formation. Additional research may explore whether any anatomic features, specific to the L5/S1 level, are responsible for spur formation. Furthermore, this finding is clinically actionable. Individuals with a confluence occurring at the L5/S1 disc space, which can be detected by CT scan, may be at greater risk for developing spurs and may be better candidates for more invasive imaging modalities (i.e., IVUS). This may also serve as a useful clue when determining disease etiology in a patient presenting with DVT or post thrombotic syndrome.

Future Research

Advanced investigation is needed to understand the proportion of patients with anatomy characteristic of iliac vein compression syndrome (venous compression and concomitant spur presence) who develop symptomatic disease. This type of evaluation likely necessitates an extensive imaging study, utilizing both CT venography and IVUS, among a diverse population of symptomatic and asymptomatic individuals. However, it may also be possible to investigate this in a cadaveric population by assessing presence and frequency of venous collaterals around the area of stenosis, as presence of collaterals is known to be associated with a more severe stenosis.⁸ It will also be important to further explore the timing of spur development. This may help elucidate other factors that contribute to the disease etiology. Ultimately, this study’s findings
should be correlated with patients in vivo. As suggested by Saleem and Raju (2021), it may be worthwhile to screen patients with CT venography and subsequently use IVUS, the gold standard for diagnosis, to closely evaluate obstructive iliac-caval lesions.\textsuperscript{8,14,16} Lastly, given that unique spur morphology was observed in a cadaver with known history of breast cancer, it should be investigated whether hypercoagulable disease states increase the risk of spur formation.

Limitations

It is unknown who, if any, among this cadaver population suffered from symptomatic iliac vein compression syndrome. As a result, it is impossible to know the significance or the clinical outcomes of any spurs observed. Additionally, anatomy in a cadaver, especially after embalming, may be different from in vivo anatomy. It is, therefore, important to recognize that the observations described (i.e., location of compression, location of spur etc.) may not exactly resemble in vivo anatomical relationships. Evaluation of spurs in this study was limited to observation and did not involve histologic evaluation. As such, the structures categorized as spurs may represent fibrosis secondary to chronic compression, characteristic of iliac vein compression syndrome, or post-thrombotic stricture, which is thought to be distinct.

When considering additional limitations, end-of-life BMI may not be an accurate representation of an individual’s average lifetime BMI, and therefore may not appropriately reflect the degree of intra-abdominal pressure the vein was subjected to at the time of spur formation. Further investigation is needed to better elucidate the timeline of spur development and whether increased intra-abdominal or pelvic pressure, secondary to large body habitus, may be a contributing factor. Lastly, this study only examined left-sided iliac vein compression syndrome
and did not evaluate any intraluminal findings within the right common iliac vein or other venous structures. Therefore, the findings described here cannot be generalized to right-sided disease. Furthermore, additional segments of the venous system should be studied to examine whether spurs are observed elsewhere and whether extrinsic compression can be appreciated in those locations. This would better elucidate the relationship between spur presence and the effect of external compressive forces.

Conclusions

The prevalence of spurs documented in this study is consistent with existing literature. The results herein suggest that spurs are more common when the confluence of the common iliac veins occurs at a lower spinal, specifically at the L5/S1 disc space. The level of the iliac vein confluence may be an important finding in identifying patients with a higher probability of venous disease. Analysis of the data collected also suggests that BMI and plaque burden within the overlying right common artery do not correlate with spur formation; however, these relationships should be explored further. Further investigation is needed to understand when spurs form and exactly what factors contribute to spur development.

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<table>
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<tr>
<th>Spur Type</th>
<th>Description</th>
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<tr>
<td>Columnar$^1$</td>
<td>Bisects the vein for a short period; often creates a medial lumen that is</td>
</tr>
<tr>
<td></td>
<td>greater in caliber than the lateral lumen$^1$</td>
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<tr>
<td>Marginal and triangular$^1$</td>
<td>Triangular spur at the lateral aspect of the vein, with apex pointing</td>
</tr>
<tr>
<td></td>
<td>toward the center of the lumen$^1$</td>
</tr>
<tr>
<td>Marginal and linear$^1$</td>
<td>Occurs longitudinally along lateral border of vein and may be overlooked;</td>
</tr>
<tr>
<td></td>
<td>produces minor diminution of venous caliber$^1$</td>
</tr>
<tr>
<td>Medial$^1$</td>
<td>Occurs along medial border of vein, protruding upward and outward to</td>
</tr>
<tr>
<td></td>
<td>create a 90° angle with the left common iliac vein$^1$</td>
</tr>
<tr>
<td>Perforated$^1$</td>
<td>Vein is doubled for a short period$^1$</td>
</tr>
<tr>
<td>Partial obliteration$^9$</td>
<td>Majority of lumen is obstructed (“quilted” appearance) with remaining</td>
</tr>
<tr>
<td></td>
<td>opening divided by “slender bridges”$^9$</td>
</tr>
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**Table I.** Spur classification system established by McMurrich (1906), and further added to by May and Thurner (1957).
Table II. Comparison of spur prevalence.

LCIV: Left common iliac vein.

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<td></td>
<td>29.9% (321/07)</td>
<td>23.8% (95/399)</td>
<td>22% (95/430)</td>
<td>14% (14/100)</td>
<td>21.4% (6/28)</td>
<td>31.4% (16/51)</td>
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</table>

Table II. Comparison of spur prevalence.
**Figure 1.** An anatomical depiction of iliac vein compression syndrome. (A) Compression of the left common iliac vein as it travels underneath the right common iliac artery. (B) Sagittal view of left iliac vein compression between the right common iliac artery and lumbar vertebrae.

**Figure 2.** Perpendicular venous incisions were made to visualize the mouth and lumen of the left common iliac vein.

**Figure 3.** Types of spurs observed. Spur is denoted by a blue asterisk(s). (A) Marginal and triangular spur, seen at the lateral junction of the LCIV and IVC. (A’) Pictorial reference to enhance understanding of anatomic orientation in Figure 3A. (B) Columnar spur; pin is traveling through the secondary lumen created by the spur. (B’) Pictorial reference to enhance understanding of anatomic orientation in Figure 3B. (C) Marginal and linear spur stretches several centimeters along the lateral wall of the LCIV. (C’) Pictorial reference to enhance understanding of anatomic orientation in Figure 3C. (D) Partially obstructed spur with abnormal tissue bands at both the lateral and medial aspects of the LCIV with multiple synechiae stretching across the mouth of the LCIV. The picture is oriented such that the mouth of the LCIV is visualized from the IVC. (D’) Pictorial reference to enhance understanding of anatomic orientation in Figure 3D.

IVC: inferior vena cava; LCIV: left common iliac vein; RCIV: right common iliac vein.
**Figure 4.** Depiction of venous valve. (A) Venous valve (at tip of double arrows) located at the inferior aspect of the junction of the left and right common iliac veins. (B) Pictorial reference to enhance understanding of anatomic orientation in Figure 4A. Valve is denoted by a blue asterisk.

IVC: Inferior vena cava; LCIV: Left common iliac vein; RCIV: Right common iliac vein.