IVUS Use in Iliac Vein Compression

Executive Summary

Intravascular Ultrasound (IVUS) Use in Iliac Vein Compression

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IVUS Use in Iliac Vein Compression

Background

Compression of the pelvic vein structures has been known for many years under different names such as Iliac Vein Compression Syndrome (IVCS), May-Thurner Syndrome, and Cockett's Syndrome. This compression is synonymous with this perivenous fibrosis causing web and spurs inside the vessel seen most characteristically at the level of the left common iliac vein due to the pulsatile forces from the right common iliac artery on the underlying crossing vein which is compressed against the fifth lumbar vertebral body (Figure 1).[1]

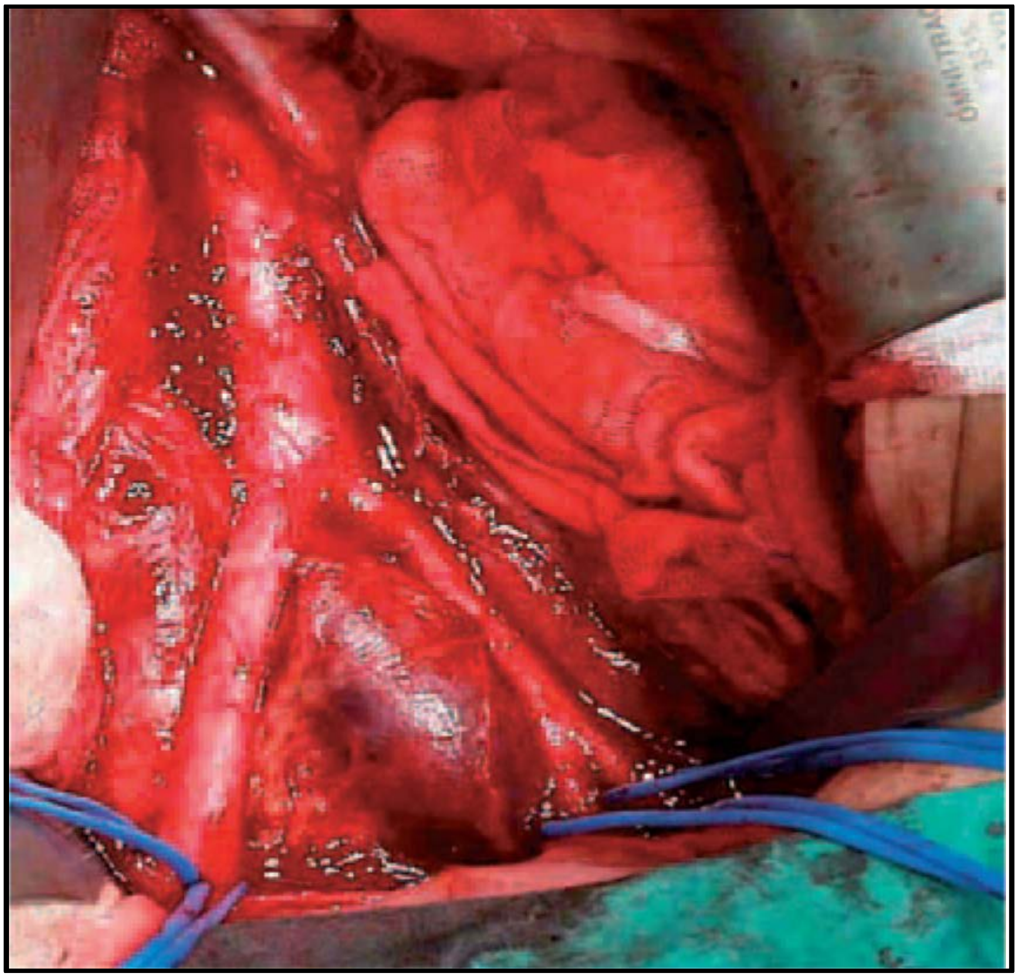

Figure 1.
Left iliac vein compression by the right common femoral artery, as seen during surgery[1]

IVUS Use in Iliac Vein Compression

One must maintain a high index of suspicion to recognize iliac vein compression. With the widespread use of contrast venography in patients who are undergoing percutaneous procedures, it is now possible to identify a culprit lesion in some patients.[5] However, venography has limitations that are described in this document. Intravascular Ultrasound (IVUS) of the major axial veins can provide a 360-degree, two-dimensional, gray scale image of lumen and vessel wall structures. IVUS can be a useful adjunct to venography when contemplating catheter-based interventions from the common femoral vein to the inferior vena cava.[16] Not only can location and size of these veins be assessed by IVUS from landmarks and venous branches, but other abnormalities may also be visualized. These include external compression, acute and chronic thrombus, fibrosis, mural thickening, spurs, and trabeculations. IVUS can provide real-time, cross-sectional imaging of the major axial veins when planning catheter-based procedures involving venous thromboembolism-related disorders.[16] IVUS is capable of imaging the blood–thrombus–lumen wall interfaces, and may help overcome certain limitations of venography.[7] (Figures 2-4)

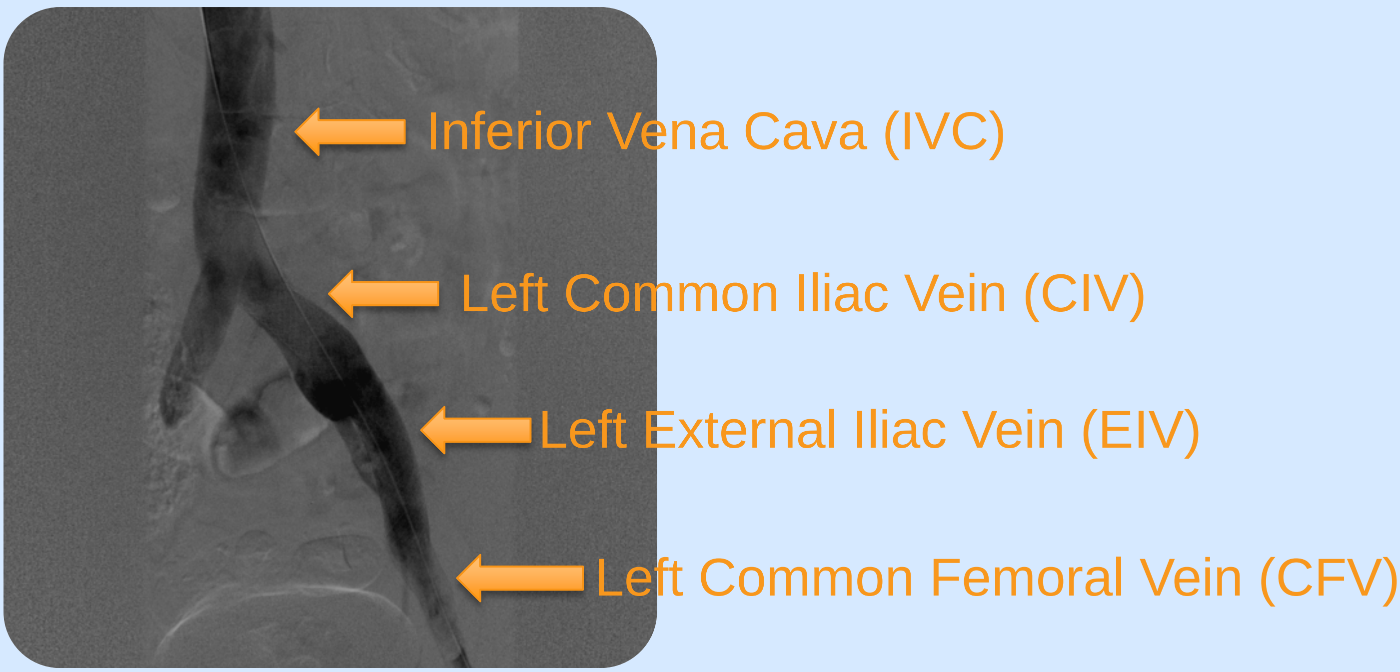

Figure 2. Non-Thrombotic Outflow Obstruction (Vein Compression) Venogram: Normal, Compliant and Large Caliber[17]

IVUS Use in Iliac Vein Compression

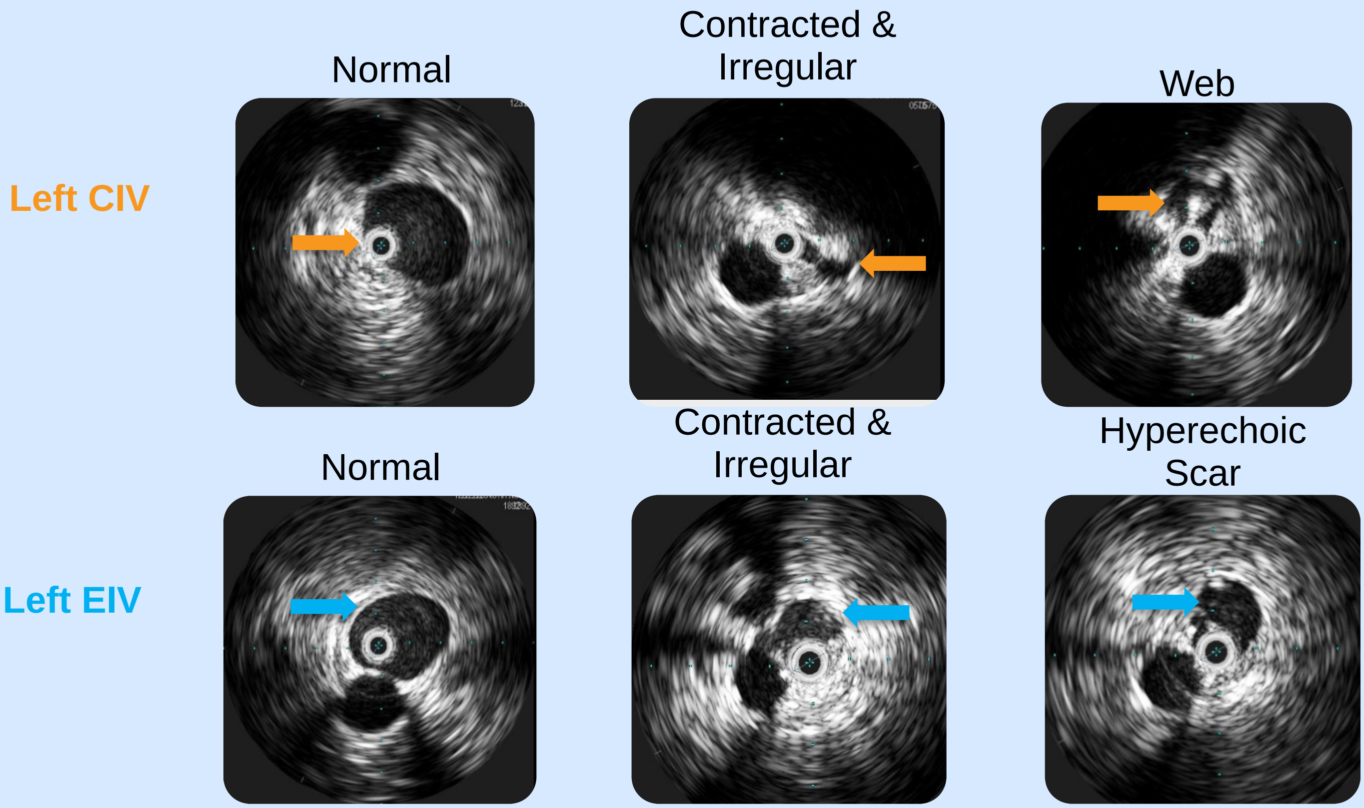

Figure 3. Non-Thrombotic Outflow Obstruction (Vein Compression) IVUS Images[17]

IVUS Use in Iliac Vein Compression

A

B

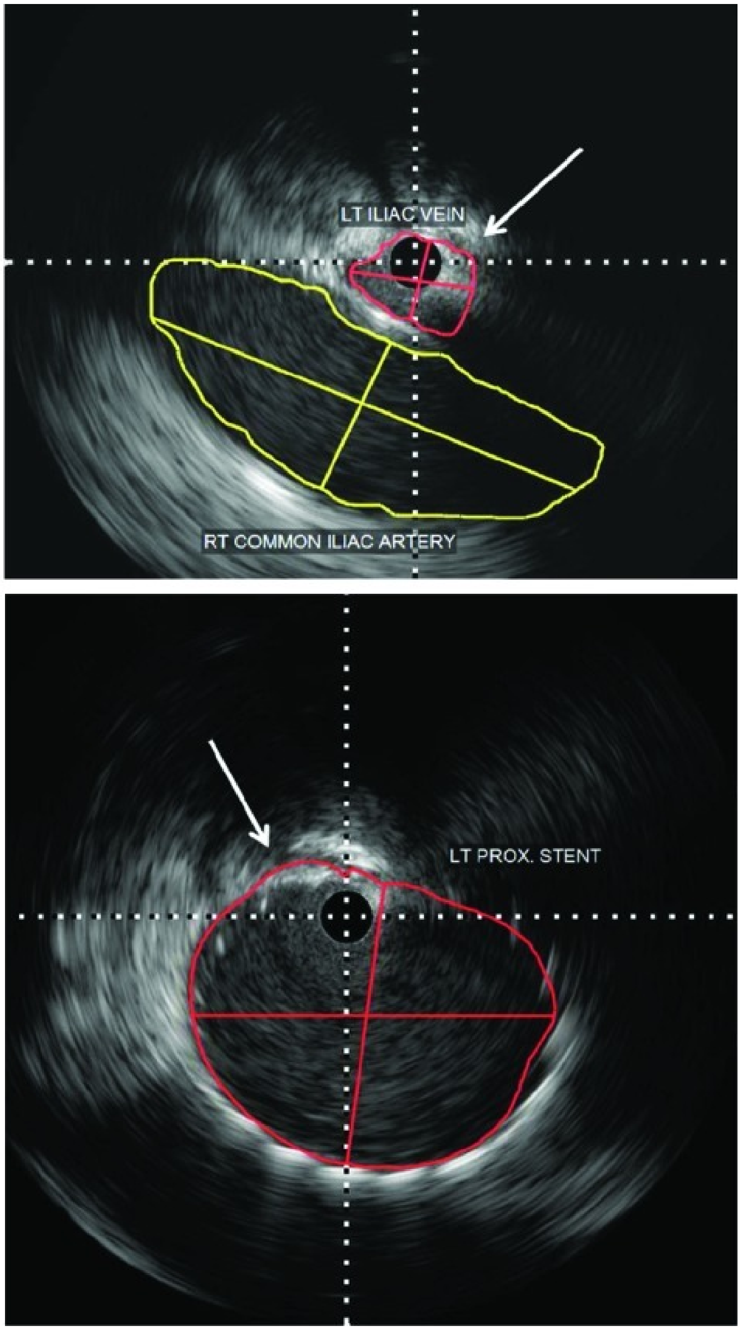

Figure 4. (A) IVUS of left common iliac vein being compressed between the right common iliac artery and sacrum (arrow). (B) Stenting of the left common iliac vein (arrow) with marked improvement in the diameter of the vein.[16]

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Objective

The purpose of this document is to summarize clinical evidence regarding the use of IVUS in the diagnosis, treatment, and evaluation of treatment of IVCS.

Search Strategy

Studies were identified by conducting a literature search to assess published evidence from the last 10 years. An analysis of all the available data considered, both favorable and unfavorable was conducted using the online search engine, PubMed (http://www.ncbi.nlm.nih.gov/pubmed/). The search engine identified all relevant clinical data available within published articles, using specific search criteria "intravascular ultrasound or IVUS, in combination with iliac vein compression, IVCS, May-Thurner or Cockett's Syndrome" through July 2014. The searches were supplemented by manual bibliography review of selected references. Eight (8) publications including 2 case reports were found to meet the search criteria and were summarized in this review. All publications were ranked using the Oxford Centre for Evidence Based Medicine method.[18] Published clinical trials and case series were included. Several additional relevant studies were identified based on IVUS use as a diagnostic or therapeutic tool for the evaluation of vessel wall morphology or for the assessment of adequate stent deployment.

Introduction to Iliac Vein Compression Syndrome

In 1851, Virchow[2] first attributed the increased left-sided predilection of deep venous thrombosis was first attributed to left iliac vein compression by the crossing artery. In 1908, McMurrich[3] first reported the presence of web-like intrinsic intraluminal lesions in 33% of 107 unselected cadavers.[4] A more localized external compression by the adjacent arteries was demonstrated by May and Thurner (1957) and Cockett (1965)[1] and confirmed the surprisingly high prevalence of these non-thrombotic iliac lesions in the asymptomatic general population.[4] They published almost at the same time on this finding originally in combination with limb swelling, and it was also noted that the iliac compression could lead to deep vein thrombosis (DVT).[1] This condition is referred to as Iliac Vein Compression Syndrome (IVCS), Cockett's Syndrome, or May-Thurner syndrome.[5]

IVCS presents in three distinct clinical patterns. First, patients may present with sudden leg swelling and pain associated with iliofemoral DVT, with the anatomic defect discovered after the clot has been removed by thrombolysis or thrombectomy. This acute presentation is found most commonly in women in the third or fourth decades of life. Second, iliac vein compression may be discovered in patients with chronic leg complaints that are suggestive of chronic venous insufficiency (including stasis ulceration) without acute thrombosis. In these patients, a short-segment stenosis or occlusion of the proximal left common iliac vein is usually identified. Third, patients may present—months or years after a known episode of iliofemoral DVT—with extensive occlusion of the common and external iliac veins, in which instance venous drainage of the leg occurs mainly via collateral vessels that arise from the common femoral vein. Patients with mild degrees of iliac vein compression may manifest some leg swelling, varicosities, and valvular incompetence in both superficial and deep systems. Physicians are increasingly interrogating the iliac system in order to look for iliac vein compression in patients with advanced venous insufficiency, venous claudication, and pain out of proportion to varicosity. In 2007, however, there were insufficient clinical data to recommend this for routine clinical practice.[5]

The prevalence of IVCS is still not well characterized. In one study involving more than 1000 limbs treated for iliocaval obstruction, approximately 40% had non-thrombotic occlusion (defined by an absent history of DVT and no venographic or ultrasound findings indicating previous DVT).[6] Obstruction typically is due to compression, sometimes with intraluminal band or web formation, at the point where the right common iliac artery crosses the proximal left common iliac vein. Although this lesion is classically reported in the left iliac vein in young females, it is not uncommon in elderly patients and males, and may also involve the right limb. Compression involves both the common and external iliac veins in at least 15% of patients. Others have reported that intraluminal iliac vein lesions and external compression may be present in 14-30% and 88%, of the general population.[6] The incidence is probably higher in symptomatic patients. One may speculate that such lesions are clinically silent until other components of the venous circulation fail and the extremity decompensates and becomes symptomatic.[6]

Once symptomatic iliac vein compression is identified, lesions can usually be treated with percutaneous venoplasty and stenting. Endoluminal reconstruction of the compressed iliac vein by means of a stent is a less invasive solution than surgery.[5]

Discussion

IVUS Imaging in Iliac Vein Compression Syndrome

Intravascular ultrasound (IVUS) provides a real-time, cross-sectional imaging modality to assess lumen and vessel wall structures of major axial veins. IVUS complements imaging provided by traditional venography. Magnetic resonance (MR) venography and computed tomography (CT) venography can provide pre- and post-procedural imaging assessments, but do not provide imaging during the case. Traditional duplex ultrasound can provide adequate imaging of some axial veins of the extremities, but generally long penetration depths in the abdomen and pelvis and single-plane limitations cannot provide the same real-time luminal imaging that is often necessary for these endovascular procedures.[16]

Non-thrombotic iliac vein lesions (NIVLs), such as webs and spurs described by May and Thurner, are commonly found in the asymptomatic general population. However, the clinical syndrome, is thought to be a relatively rare contributor to chronic venous disease (CVD), responsible for only 1% to 5% of cases and predominantly affecting the left lower extremity of young women. The diagnosis is often established by venography in selected cases fitting the classic clinical profile. However, imaging data from Kibbe et al.[8] indicates that compression of the left iliac vein at the arterial crossover point may be present in 66% of the general population without any venous symptoms.[4]

The diagnostic sensitivity of venography for non-thrombotic iliac vein lesions is known to be poor.[4] Use of IVUS imaging yields a more diverse picture of the syndrome than previously appreciated.[4] Venography has many limitations such as contrast stasis within thrombus or obstructive anatomy that obscures underlying venous lesions, visualization is also diminished in obese patients. Without multiple views, 3-dimensional anatomy cannot be appreciated to diagnose extrinsic compression.[7] Similarly, a third to half of the cases can be missed if frontal projection venograms alone are relied upon for diagnosis. Diagnostic sensitivity may be increased by additional views, but this is a cumbersome process that increases radiation exposure (Figure 5).[4] Lastly, large volume contrast injections are used in the compliant venous system. IVUS, when used as an adjunct to venography, can provide imaging of the blood–thrombus–lumen wall interfaces and appears to overcome many of the limitations of venography used alone. Importantly, IVUS can image extrinsic compression and residual stenosis, which may be missed owing to contrast overlay in a uniplanar venogram.[7] IVUS has been described in the medical literature as a useful tool in the endovascular evaluation of IVCS.[10]

IVUS Use in Iliac Vein Compression

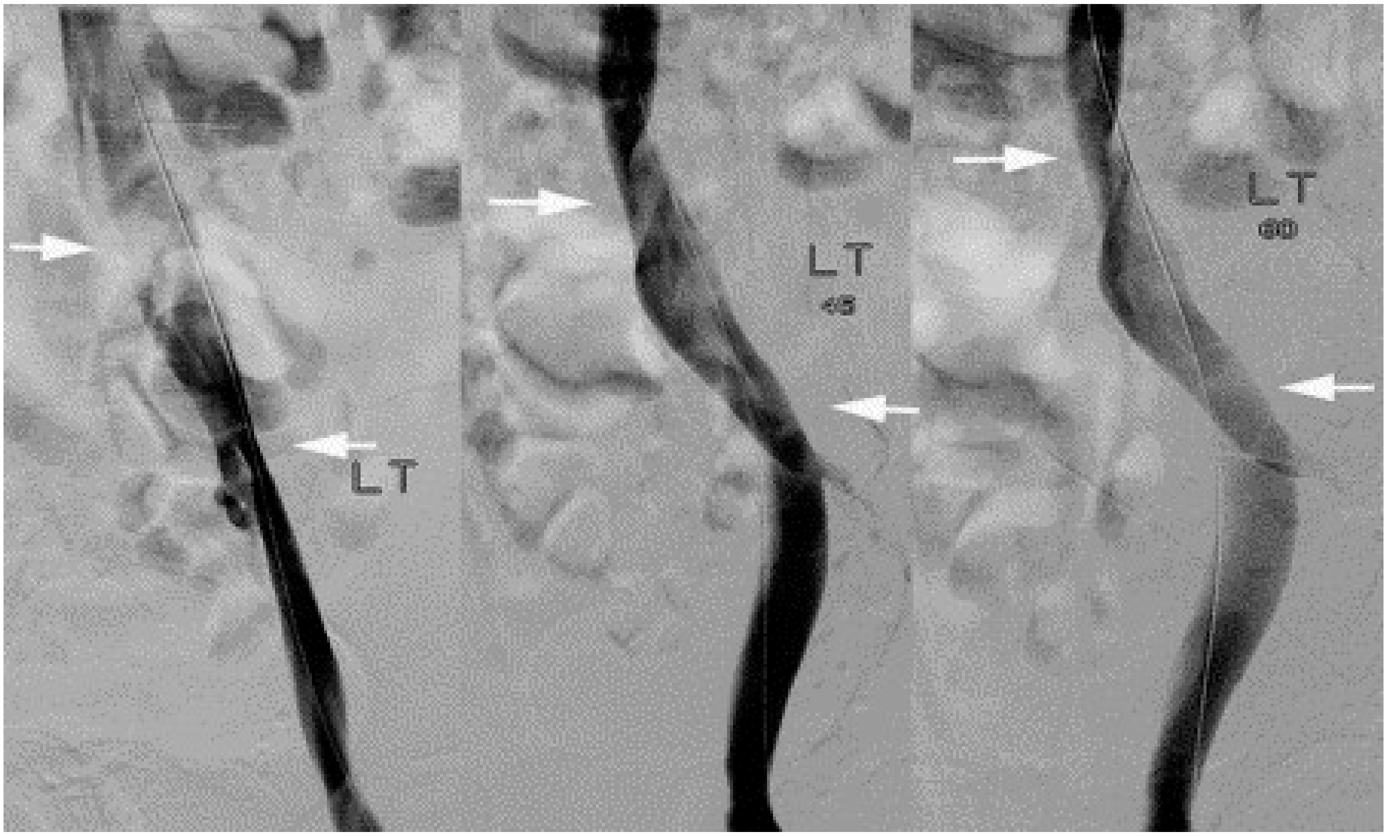

Figure 5. The proximal lesion is coronal and the distal lesion is often sagittal as the hypogastric artery crosses the vein from anterior to the posterior rather than transversely. Note the differential appearance and disappearance of the lesions as the tube is rotated from midline to lateral in the coronal plane: 0° (Left), 45° (Middle), and 60° (Right). The proximal lesion is spiral, often giving a corkscrew appearance.[4]

Traditional IVUS provides a two-dimensional gray scale image that allows varying discernment of the intimal, medial, and adventitial layers of a blood vessel. These layers are more readily apparent in muscular arteries such as the femoral artery. In large and medium size veins, these layers are less distinct due to the much thinner nature of the medial and adventitial layers. The intimal layer appears brightly echogenic, whereas the medial and adventitial layers produce fewer echoes and are less well demarcated (Figure 6).[16]

IVUS Use in Iliac Vein Compression

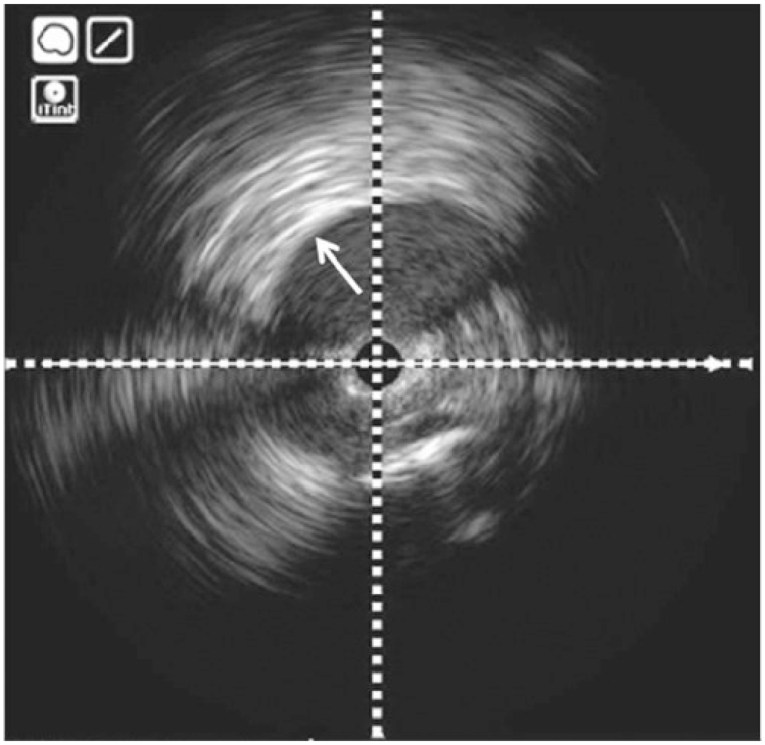

Figure 6. Intravascular ultrasound image of the common femoral vein. Note the more echogenic internal layer (arrow) compared to the medial/adventitial later. [16]

In a 2012 publication, McLafferty[16] discussed the role of IVUS in Venous Thromboembolism (VTE) wherein he states that IVUS imaging of veins can provide information about defects within the lumen, degree of stenosis, and structures immediately adjacent to the veins. Thrombus from DVT can have a varying spectrum of echogenicity depending on its age. Acute, non-occluding thrombus may not be visible on IVUS due to its high concentration of red blood cells, whereas chronic thrombus can be highly echogenic due to its more organized composition of fibrin. Luminal defects and/or external compression of a vein visualized by IVUS can be useful in determining the degree of stenosis. Unlike atherosclerotic lesions visualized by IVUS, whereby discrete changes in intimal and subintimal thickness allow for a traditional calculation of stenosis, calculation of stenoses in veins can be more challenging, thus accentuating the advantages of using IVUS in conjunction with venography. Venography may not show a discrete stenosis due to contrast flowing around and through these defects within the vein; IVUS, by comparison, can demonstrate abnormalities of the same vein when viewed in cross-section (Figure 7).[16]

IVUS Use in Iliac Vein Compression

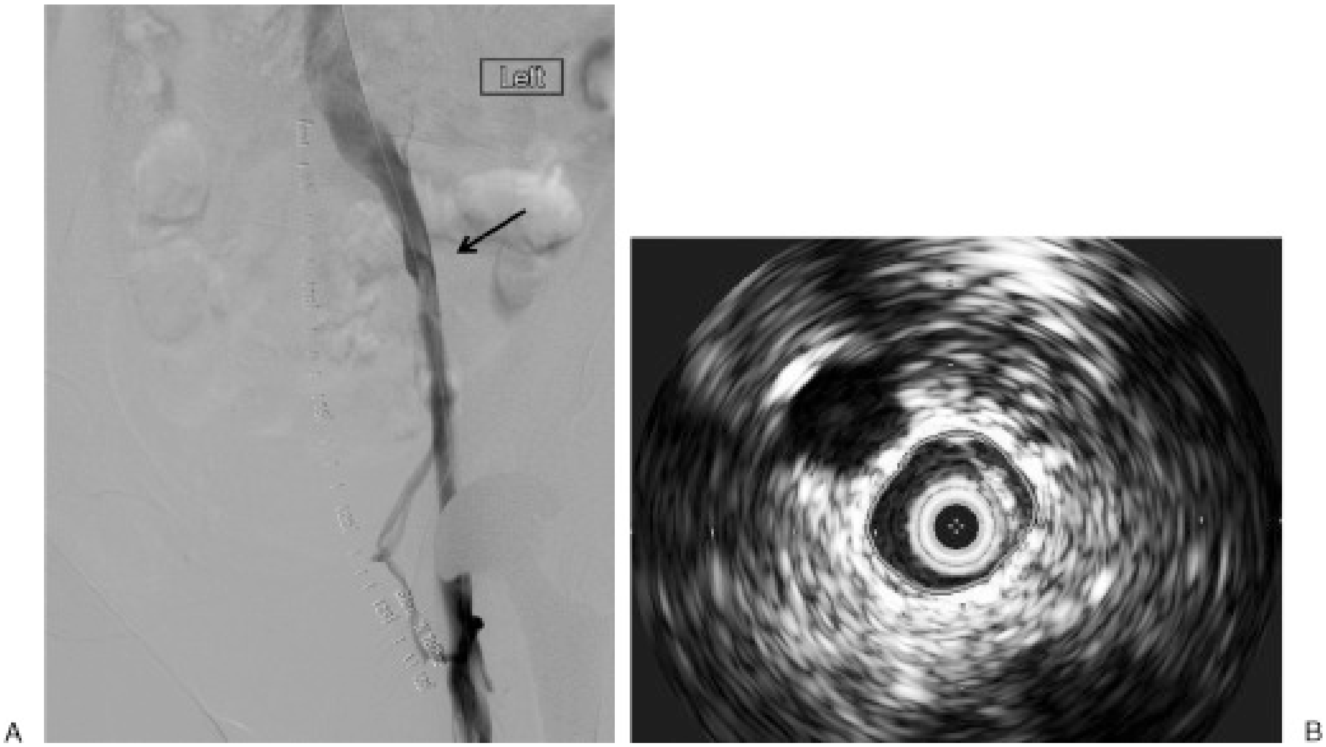

Figure 7. (A) Venography of the left common iliac vein (arrow). Note the lack of a discrete stenosis.
(B) Intravascular ultrasound image demonstrating a markedly narrowed iliac vein (outlined).[16]

External compression of a vein can be another area where IVUS provides information as to whether obstruction may be present. Due to low venous pressures, external compression may flatten the vein and make it appear ovoid. This type of “stenosis” or degree of obstruction may be more or less discernable or calculable on venography, depending on projection, due to contrast effacement (Figure 8).[16] Adjacent structures can also be visualized with IVUS which may provide important diagnostic information. The right renal artery, which lies directly dorsal to the inferior vena cava (IVC), can provide orientation regarding the location of the IVUS probe. Structures that compress the veins, such as tumors, arterial aneurysms, and ligaments, can also be visualized. May-Thurner syndrome, in which the right common iliac artery compresses the left common iliac vein against the sacral promontory, leading to DVT, can be imaged using IVUS.[16]

IVUS can also play a role in determining abnormalities causing obstruction in the major axial veins, particularly those extending from the common femoral vein to the IVC. Medical literature suggests that IVUS used in conjunction with venography identifies obstructive lesions more often than venography alone, which can fail to detect even severe obstruction.[16] Neglén et al.[9] compared transfemoral venography with and without IVUS in patients for whom chronic iliac vein obstruction was suspected and found the median stenosis on venography was 50%, compared with 80% by IVUS. Similarly, in this publication, the stenoses were significantly more severe when measured with IVUS compared with venography alone.[16]

McLafferty also points out limitations of IVUS. Several image artifacts are important to recognize during the use of IVUS. First, if using a system that requires a guidewire, image dropout of ~15 degrees will occur in the location of the wire. Dualchannel catheters have resolved this problem because the wire can be removed. Second, acoustic shadowing can occur from calcification, stent struts, and IVC filters, limiting the visibility of structures deep to these shadows. Third, mechanical (i.e., rotational) IVUS systems require careful flushing of saline into a small portion of the catheter housing the transducer. If air bubbles are present, a distorted image will appear. Fourth, if a mechanical IVUS catheter bends too much from being in a tortuous vessel, non-uniform rotational distortion artifact occurs because the transducer is not able to rotate properly. Reverberation or re-reflections can occur when the transducer itself reflects the returning reflected ultrasound beam, as evidenced by multiple circular echoes created equidistant from the catheter probe. Understanding and recognizing these limitations will allow more effective use of this user-dependent device for venous imaging.[16]

IVUS Use in Diagnosing Iliac Vein Compression

Between 1996 to 2004, Raju and Neglen studied 4026 new patients with chronic venous disease (CVD); all CEAP clinical classes were evaluated. Venography, IVUS examination, and possible concurrent stent placement were considered in patients who had severe symptoms interfering with work or daily living and had failed conservative therapy. Significant proximal venous outflow obstruction was found by IVUS examination in 938 limbs (879 patients), which were treated by stent placement.[4]

NIVLs and post-thrombotic syndrome (PTS) lesions have distinctive features when imaged with IVUS. PTS lesions are segmental, involving at least one entire segment (e.g., common iliac vein) and often adjacent segments as well (e.g., external iliac and common femoral veins), because the thrombus typically propagates to the next large tributary. PTS lesions are irregular, multiple, and diffuse with wall fibrosis and lumen stenosis in the entire vein segment; trabeculae may be present. In contrast, NIVLs are subsegmental and focal (<2 cm), they occur at or near arterial crossover points near the upper or lower ends of the vein segment, and wall thickness and lumen size of the rest of the vein segment are normal. The etiology of obstruction was classified as NIVL in 493 limbs (53%), as PTS in 377 limbs (40%), and as mixed in 68 limbs (7%) by distinctive IVUS appearance supplemented by ancillary clinical data, such as prior deep venous thrombosis, and venographic and duplex features. The non-thrombotic to thrombotic disease ratio was 5:4.[4]

In 2006, Raju and Neglen[4] published results from a cohort of the 493 limbs with NIVLs treated by stent placement alone that were functioning well during the observation period. All patients requiring additional procedures for treatment of reflux or with significant in-stent restenosis (>20% stenosis) were excluded from analysis as the aim was to compare the outcome of successfully corrected NIVLs in the two targeted subsets unadulterated by concurrent procedures or impaired stent patency. The remaining 332 limbs in 319 patients were divided into two subsets: (1) NIVL limbs with concurrent superficial or deep reflux, or both, that were stented with the reflux component left untreated during the observation period (n = 151); and (2) limbs with NIVL alone, without associated reflux, that were also stented (n = 181).[4] The authors describe the much broader disease profile that has emerged with the use IVUS for diagnosis, finding the incidence of non-thrombotic iliac vein type lesions to be very high in symptomatic CVD cases. The median age was 54 years (range, 18 to 90 years). The female-male ratio was 4:1 and the left-right ratio was 3:1. NIVL lesions in the iliac vein occurred at the iliac artery crossing (proximal lesion) and also at the hypogastric artery crossing (distal lesion). In this study, venography was only 66% sensitive, with 34% of venograms appearing “normal”; IVUS had a diagnostic sensitivity of >90%. The cumulative results observed at 2.5 years after stent placement in the NIVL subsets with reflux and without reflux, respectively, were complete relief of pain 82% and 77%, complete relief of swelling 47% and 53%, complete stasis ulcer healing 67% and 76%, and overall clinical relief outcome 75% and 79%. These results are similar between the two subsets even though distal reflux remained uncorrected in the NIVL plus reflux subset.[4]

With IVUS, a newer clinical profile of NIVL has emerged: the disease is dominant but not exclusive to left lower limbs of young women. Clearly, no patient should be excluded from consideration of the syndrome based on age, sex, bilaterality, or involvement of the right side. Leg swelling in older patients is often dismissed as due to cardiac causes, hormonal imbalance, or fluid retention without adequate venous investigation.[4] Outcome data after successful stent correction of the lesions in two specific subsets suggests that NIVLs may play a permissive role in the development of CVD.[4]

In a 2007 review of secondary chronic venous disorders, Meissner et al.[6] explains the limitations of diagnostic tests such as ascending contrast venography, and the absence of a uniform definition of hemodynamically significant venous stenosis. Tests suggesting obstruction indicate the need for further investigation, and a negative test does not exclude the presence of a lesion. Absence of a "gold standard" is a major obstacle in evaluating the importance of chronic outflow obstruction, selecting limbs for treatment, and evaluating outcome. At present, the diagnosis of outflow obstruction largely depends on anatomic rather than hemodynamic criteria. Ascending or antegrade transfemoral venography (optimally performed with oblique projections) is the standard method of imaging the venous outflow tract and may disclose the site of obstruction and the presence of collaterals. However, IVUS plus venography has been reported in clinical studies to be better than venography alone in estimating the morphological degree and extent of iliac vein stenosis and visualizing details of intraluminal lesions.[6]

The appropriate diagnosis of venous obstruction requires a high degree of suspicion and a low threshold for extending investigation beyond duplex ultrasound evaluation of the lower extremity. Especially targeted patients are those with clinical features (especially pain) out of proportion to detectable pathology, patients lacking another explanation for their symptoms, and patients with previous deep venous thrombosis.[6]

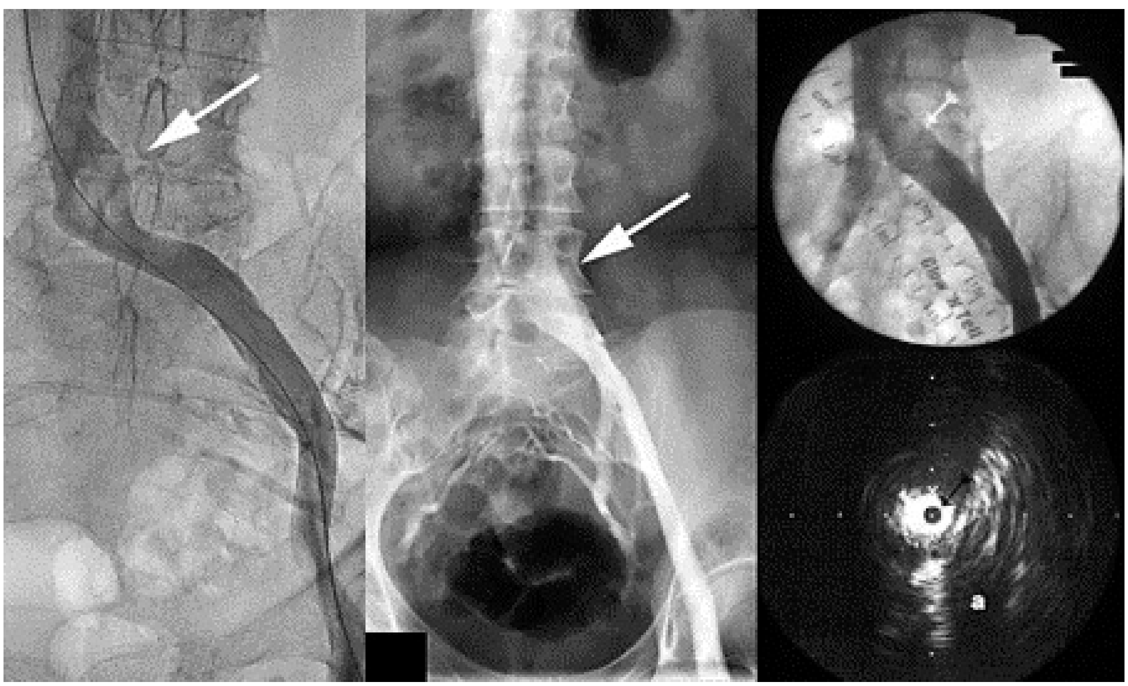

Figure 8. Variable venographic appearance of non-thrombotic iliac vein lesions (NIVLs). **Left,** "Classic" appearance with contrast translucency appearing as a filling defect *(arrow)*. **Middle,** Broadening (pancaking) of the vein with collaterals *(arrow)*. **Right,** the venogram appears entirely normal in about a third of cases. Note the absence of collaterals. However, an IVUS scan showed a tight lesion *(inset)* with the lumen not larger than the 6F IVUS catheter *(arrow)*; "a" denotes adjacent artery. The *arrow* in the venogram points to the general area where the IVUS found the NIVL.[4]

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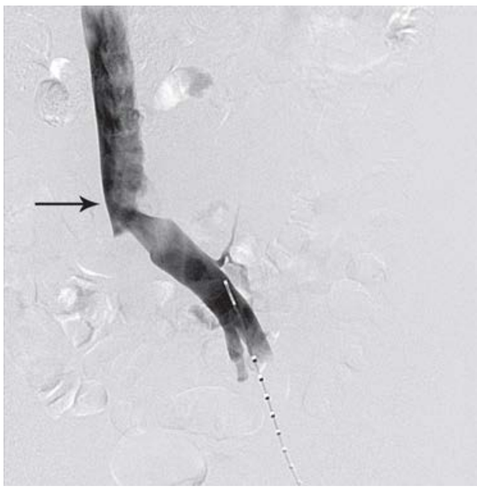
IVUS Use in Iliac Vein Compression

Additionally, several case studies have been published describing IVUS use in the setting of iliac vein compression. Canales and Krajcer,[10] in 2010 published a case report of a 36-year-old man with Sjögren's syndrome and a 3-year history of left pelvic pain and an inability to sit for prolonged periods of time. Angiography revealed a filling defect at the proximal left common iliac vein (Figure 9A) consistent with May-Thurner syndrome. IVUS (Visions® PV8.2F catheter, Volcano Corporation; San Diego, Calif.) revealed severe venous compression with reduced cross-sectional area (Figure 9B). Stenting was performed (Figure 10A), and post-stenting IVUS revealed good wall apposition and improved cross-sectional area (Figure 10B).[10]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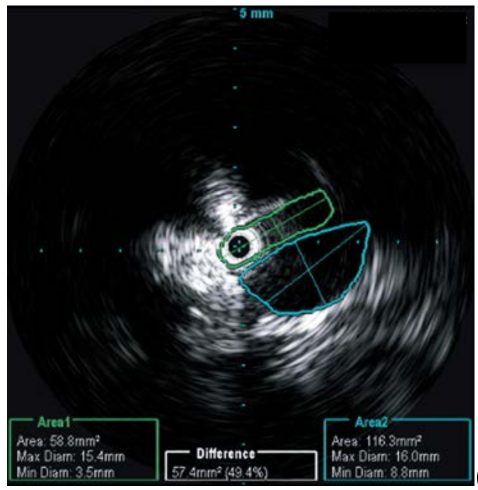
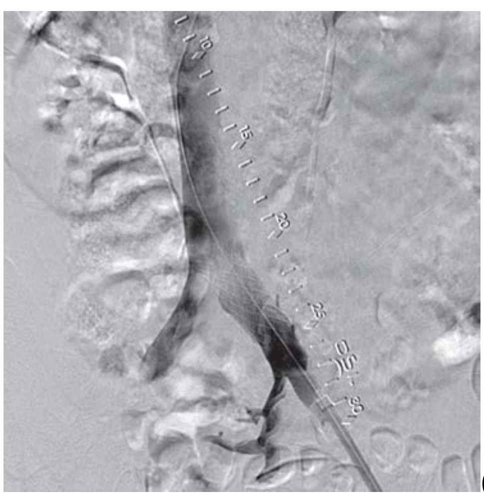


(B)

Figure 9A. Venous angiogram of the inferior vena reveals external compression of the left common iliac vein (arrow)[10]
Figure 9B. IVUS reveals cava May-Thurner syndrome. green = left common iliac vein; blue = left common iliac artery[10]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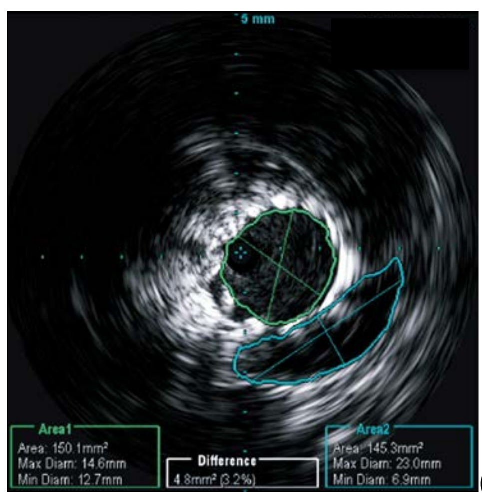


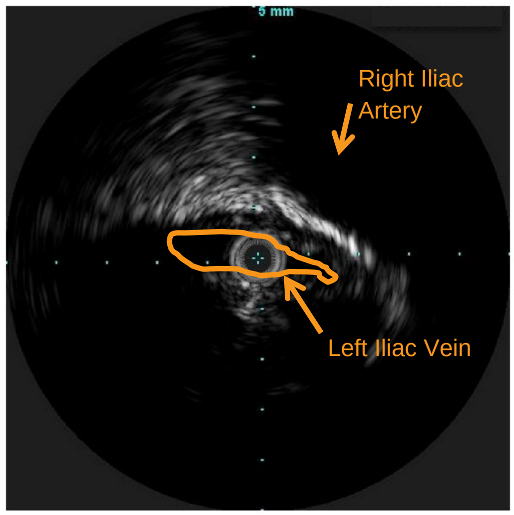
(B)

Figure 10A. Venous angiogram shows the result of stenting the left common iliac vein.[10]
Figure 10B. Intravascular ultrasonography shows the left common iliac vein after endovascular stenting.
green = left common iliac vein; blue = left common iliac artery[10]

IVUS Use in Iliac Vein Compression

Vaidya et al.[11] in 2012, reported a unique case in which presentation of renal vein thrombosis occurred four months after kidney transplant with a predisposing anatomy consistent with iliac vein compression syndrome, which was diagnosed with the aid of IVUS in conjunction with venography, and successfully treated with local thrombolytics. (Figure 11)[11]

(A)



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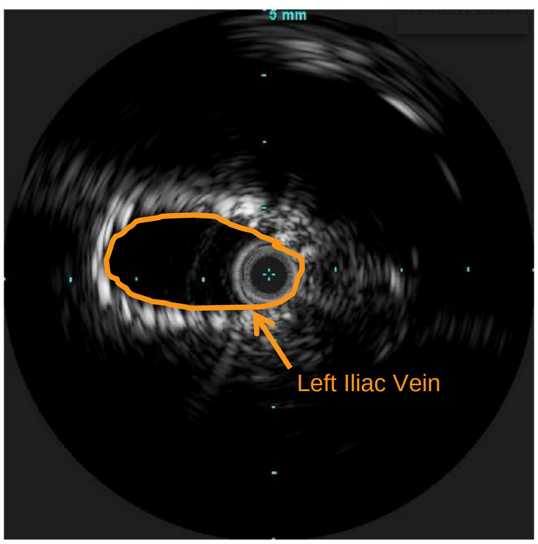
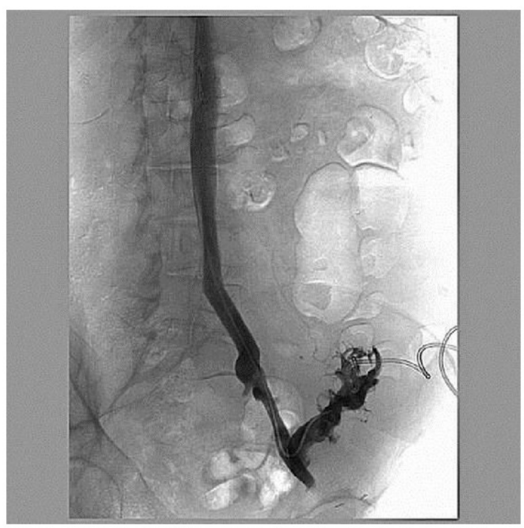


(C)



(D)

Figure 11.[11]
(A) Initial diagnostic venography at presentation prior to thrombolysis; left iliac vein.
(B) IVUS in the left iliac vein (anterior at top of image) demonstrating compression from the adjacent right iliac artery (2 o'clock position) before stenting.
(C) Post-stent placement IVUS in the left iliac improvement in lumen size.
(D) Follow-up venogram demonstrating widely patent iliac vein, stent, and transplant allograft vein.[11]

IVUS Use in Iliac Vein Compression

IVUS Use in Guiding Venous Stenting

IVUS has not only aided in the diagnosis, but has also helped guide the therapeutic aspects of intravascular interventions by providing information related to vessel size and morphology. Endovascular treatment of iliac vein compression has emerged within the last decade as a cornerstone of therapy. Although endovascular balloon angioplasty alone has been attempted in iliac vein compression, endovascular stenting is the preferred therapy, due to continued arterial compression of the iliac vein. Small, nonrandomized studies of endovascular stenting for this condition have shown good initial patency rates and durable symptomatic relief on long-term follow-up. As a result of high technical success rates and the clear relief of symptoms, endovascular stenting is now the preferred initial therapy. In a small study of 16 patients who had May-Thurner syndrome,[4] Forauer et al.[11] (2002) found that IVUS-guided endovascular repair influenced decisions on additional therapy in 50% of the patients.[10]

In 2007, Mussa et al.[5] published a review of current literature of iliac vein stenting and described imaging for iliac vein obstruction. They reported that visualization of the iliac veins in the pelvis can be difficult due to overlying pelvic organs and bowel gas. In addition, Doppler waveforms in the common femoral veins can display normal spontaneous flow and respiratory variation due to large collateral vessels around the site of proximal obstruction. Hurst and associates[13] reported false-negative scans in 5 of 18 patients with iliac vein obstruction. In the setting of unilateral lower-extremity pain and edema, especially after a normal lower-extremity venous duplex scan, direct imaging of the pelvic veins should be considered. Magnetic resonance venography has proved helpful as an alternative to conventional contrast venography. Others have used computed tomographic angiography as an alternative to reveal iliac vein stenosis due to compression.[5]

Again, the authors discussed the lack of a gold standard for the selection of patients who need treatment for iliac outflow obstruction. Venographic evidence of collateral vessels certainly strengthens the case for intervention, but significant lesions can be present without collateralization. IVUS investigation in conjunction with venography should be considered, especially for patients in whom there is clinical suspicion of outflow obstruction with symptoms of pain and swelling and a history of DVT. Trabeculation and axial collateral vessels may be seen on the IVUS image, and measurements of venous diameter for device sizing may also be obtained. IVUS is capable of displaying post-dilation flaps or venous wall irregularities and can be used to assess stent apposition to the venous wall.[5] Frequently, venographic collaterals are absent even in high-grade obstructions. Very little is known about venous collateral development; it probably requires a higher degree of stenosis than is necessary to generate symptoms of pain and swelling. Clinical studies suggest that IVUS has a diagnostic sensitivity of >90%, and may also be a useful adjunct to venography in guiding endovascular interventions.[4]

Venous outflow obstruction may play a role in patients with chronic venous stasis symptoms who fail to improve despite conventional modalities of treatment that focus on the reflux component of the disease with little attention to the possibility of an obstructive component. The introduction of minimally invasive venous stenting using venography and IVUS guidance may provide the ability to treat the "obstructive" component of the disease.[14]

In 2012, Alhalbouni et al.[14] undertook a retrospective review of 56 limbs in 53 patients with chronic venous stasis symptoms. Initial transcutaneous Doppler ultrasonographic evaluation of the inferior vena cava, iliac, femoral, greater saphenous, and perforator veins was performed looking for any evidence of deep venous thrombosis, superficial venous thrombosis, perforator veins, and reflux (location and degree). Afterword, the patients were managed for a period of 3 months. If ulcer healing was not noted, iliac-femoral venography and IVUS were undertaken. A significant stenosis was defined as a 50% reduction in vein cross-sectional area as measured by IVUS. Stenotic lesions were managed with stenting followed by balloon angioplasty. Patients were followed up for ulcer healing or improvement of stasis symptoms.[14] They concluded that half of their patients with open ulcers had stenotic lesions. The ulcers healed in 58% of the stented limbs. The results of this study indicate that outflow obstruction may play a significant role in patients with chronic venous stasis symptoms, especially for those patients with open ulcers who failed to respond to other treatment modalities.[14]

In a 2014, Bækgaard et al.[1] published review of criteria for additive stenting during catheter-directed thrombolysis (CDT) where they discussed the potential value of IVUS. In ‘‘Clinical Practice Guidelines for acute deep venous thrombosis of the Society for Vascular Surgery and the American Venous Forum’’ from 2012 it is recommended that stenting be used for the treatment of chronic iliocaval compressive or obstructive lesions, which are uncovered by any of the thrombus removal strategy.[15] The authors go on to state that IVUS is an adjunctive imaging modality that may be able to identify the extension of the intra-luminal and mural lesions, which can be missed on a single-plane venography alone. A clinical study reported that single-plane venography significantly underestimated the degree of stenosis by 30%, and that IVUS provided more morphologic information about the vessel lumen.[9] IVUS may have other potential advantages such as imaging of the landing zone for the distal part of the stent, and assessing the extent of lumen restoration.[1] The authors conclude that no criteria exists to perform additive stenting during CDT for iliofemoral DVT. Even IVUS, as an aid for visualizing intraluminal lesions and control after stent insertion, has failed to show a significant improvement in patency. Series on CDT for iliofemoral DVT show a great variation in the number of stent procedures from below 20% to more than 60%. The authors believe that iliac compression, which is very common in this level of DVT, should be stented in at least 60% of such patients. They suggest that IVUS may be considered for cases in which the interventionalist is in doubt whether or not to stent.[1]

IVUS Use in Post-Procedure Endovascular Assessment

Adequate post-procedure imaging allows identification and treatment of residual clot burden and underlying venous pathology, and helps to increase the likelihood of short- and long-term success of these interventions. Most interventionists rely on standard imaging techniques with fluoroscopy and venography. IVUS has also been used as an adjunctive imaging strategy. However, data comparing the ability of these imaging techniques to visualize residual thrombus burden and correctly diagnose concomitant venous luminal lesions is lacking.[7]

As part of a study published in 2010, Murphy et al. compared IVUS scans and venograms for their ability to identify residual lesions or clot in need of treatment.[7] Between 2004 and 2009, 33 patients (18 women; mean age 47 years) with iliofemoral DVT underwent pharmacomechanical thrombectomy (PMT) using the AngioJet® (n=18) or Trellis™ (n=15) devices with 10 mg of tenecteplase. IVUS and venography were performed over the iliofemoral segments before and after treatment.[7]

All measurements with venography and IVUS were performed by 2 independent observers blinded to the treatment method. Vessel and lumen diameters were obtained at 3 points along the 20-cm iliofemoral vein segment (proximal, mid-section, and distal). The same diameters of the major and minor axes were made on the anteroposterior and lateral venograms at 3 corresponding points (proximal, mid-section, and distal). Volumes of the recanalized segments were calculated and compared to volumes of the original venous segments to assess clot lysis with each percutaneous mechanical thrombectomy (PMT) device. IVUS scans and venograms were also compared for their ability to identify residual lesions or clot in need of treatment.[7]

On standard completion venography, 16 (48%) patients were believed to have underlying venous stenosis or May-Thurner anatomy requiring further intervention. However, in this study, IVUS was able to delineate significant residual thrombus, stenosis, or May-Thurner anatomy (Figure 12) requiring ancillary interventions in all 33 (100%) patients ($p<0.05$). Importantly, in 12 (36%) patients, IVUS identified residual thrombus not recognized on venography.[7]

IVUS Use in Iliac Vein Compression

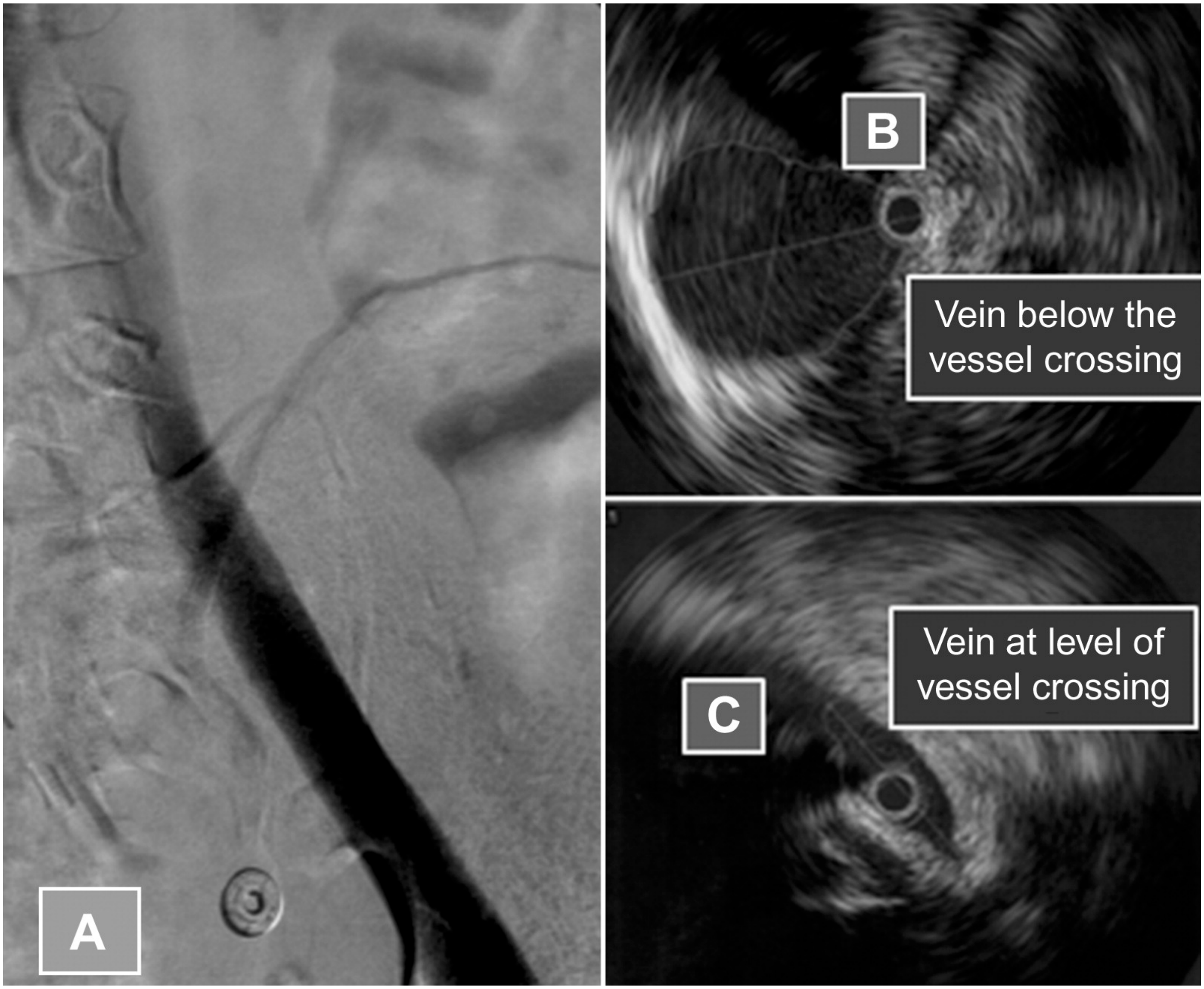


Figure 12. Comparison of completion IVUS and venography for the detection of underlying venous pathology following PMT. Venography may appear normal (**A**) despite the presence of pervasive venous lesions, such as May-Thurner anatomy, visualized here with IVUS (**B**, **C**). Failure to recognize and treat these underlying venous lesions may reduce the benefits of intervention and increase the patient's risk of DVT recurrence.[7]

VOLCANO
PRECISION GUIDED THERAPY

IVUS Use in Iliac Vein Compression

Murphy et al. concluded, that in this study, IVUS was superior to venography for detection of residual thrombus and underlying venous pathology after pharmacomechanical thrombectomy. The mean volume of the recanalized segment was 2255±66 mm^3 by IVUS, representing 80% lysis of the clot compared to what was perceived as >90% lysis with venography ($p<0.05$). IVUS was able to delineate significant residual thrombus, stenosis, or May-Thurner anatomy requiring ancillary interventions in 100% of patients versus 48% (16/33) on the venograms ($p<0.01$). Quantitative assessments of the diameters of the involved venous segments from the venograms and IVUS were consistent between and among observers. In this study, while greater clot lysis was seen with the AngioJet® system, both the AngioJet® and Trellis™ devices resulted in excellent clinical clot lysis.[7]

The data reveal a statistical trend for venography to overestimate thrombus removal. While all completion venograms demonstrated >90% thrombus removal, IVUS showed a mean 20% residual thrombus for all patients after the initial treatment. In more than half the patients, underlying venous pathology not visualized on venography was detected by IVUS, which suggests that the limitations of completion venography may contribute to inadequate thrombolysis, limit the diagnosis of venous strictures/external compression, and hinder the interventionist's ability to direct more aggressive treatment at target areas.[7]

In this study, IVUS was also used to compare the degree of clot lysis between the Trellis™-8 catheter and the AngioJet® system, two of the most commonly employed devices for PMT interventions. The authors speculate that, in the future, IVUS may be used to further define and quantify the venous thrombolysis classification scheme.[7]

The ability of IVUS to identify underlying venous pathology not identified on completion venography, however, is clinically significant. It has been well documented that success of PMT interventions for iliofemoral DVT is largely dependent on the identification and treatment of underlying venous lesions that predispose patients to DVT recurrence. The authors state that, for this reason, using IVUS to supplement venography may lead to better long-term technical outcomes.[7]

IVUS Use in Iliac Vein Compression

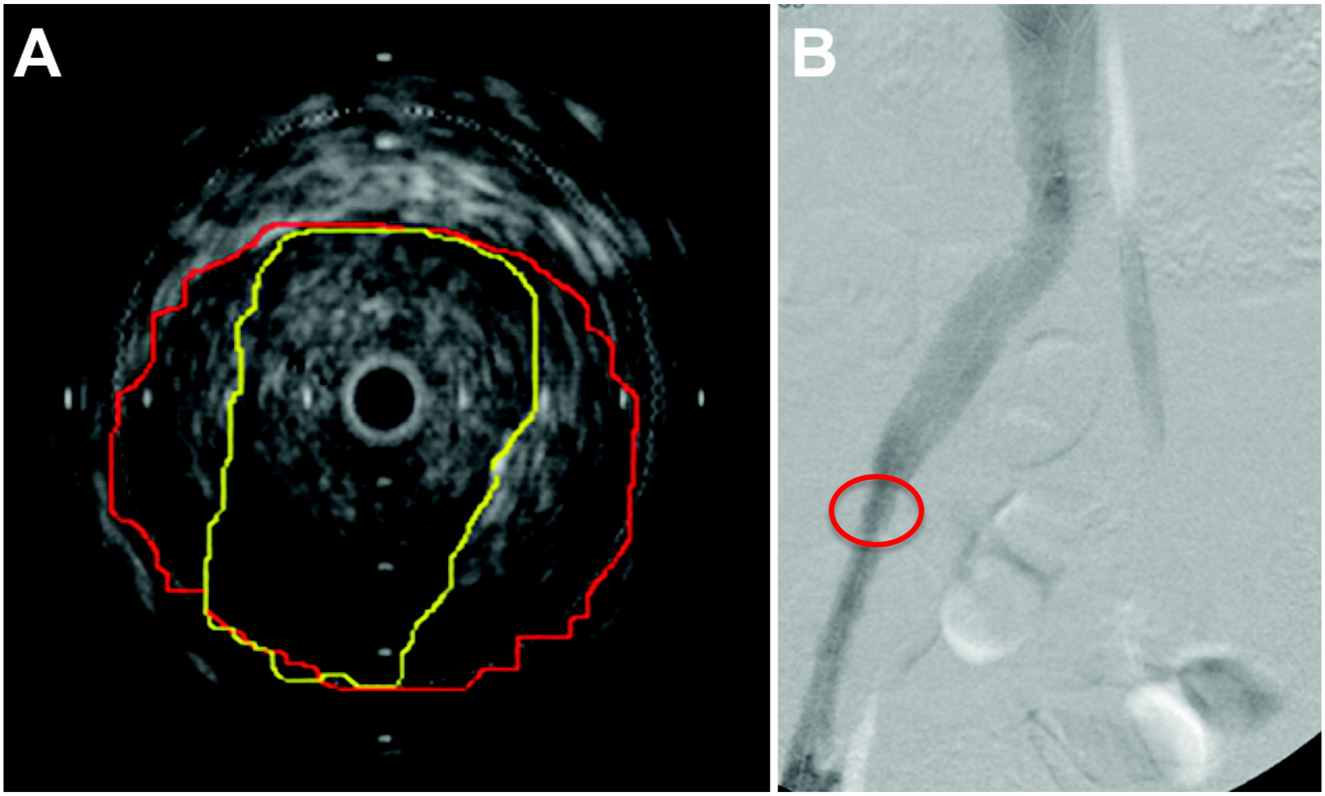


Figure 13. Comparison of IVUS (**A**) and venography (**B**) for the detection of residual thrombus following PMT. IVUS image assessment of the right common iliac vein reveals residual thrombus along the yellow dashed line as compared to the venous walls outlined in red. There is nearly 40% residual thrombus along the lateral walls. However, the concurrent venogram suggested grade III thrombolysis.[7]

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IVUS Use in Iliac Vein Compression

Conclusion

There is a growing body of clinical research published on the use of IVUS in iliac vein compression syndrome (IVCS). Additional prospective studies are indicated; however, current literature supports the use of IVUS as diagnostic tool, a guide to therapy, and a way to assess completeness of therapy in the endovascular treatment of IVCS. This is reflected in the 2011 SVS and AVF Clinical Practice Guidelines[19] which includes the following statement regarding IVUS:

> "*Intravascular ultrasonography (IVUS) has been used successfully to evaluate iliac vein compression or obstruction and to monitor patients after venous stenting. For patients with varicose veins, IVUS should be used selectively in those with suspected or confirmed iliac vein obstruction. IVUS is important in assessing the morphology of the vessel wall, identifying lesions such as trabeculations, frozen valves, mural thickness, and external compression that are not seen with conventional contrast venography, and it provides measurements in assessing the degree of stenosis. In addition, IVUS confirms the position of the stent in the venous segment and the resolution of the stenosis.*"

IVUS Use in Iliac Vein Compression

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