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American College of Radiology
ACR Appropriateness Criteria®
Nonthrombotic Iliac Vein Lesion

<u>Variant: 1</u> Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
US duplex Doppler lower extremity	Usually Appropriate	O
MRV abdomen and pelvis with IV contrast	Usually Appropriate	O
MRV abdomen and pelvis without and with IV contrast	Usually Appropriate	O
MRV abdomen and pelvis without IV contrast	Usually Appropriate	O
CTV abdomen and pelvis with bilateral lower extremity runoff with IV contrast	Usually Appropriate	☢☢☢☢
CTV abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢☢
MRI abdomen and pelvis with IV contrast	May Be Appropriate	O
MRI abdomen and pelvis without and with IV contrast	May Be Appropriate	O
CT abdomen and pelvis with IV contrast	May Be Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	May Be Appropriate	☢☢☢☢
US intravascular iliac veins	Usually Not Appropriate	O
US lower extremity	Usually Not Appropriate	O
US lower extremity with IV contrast	Usually Not Appropriate	O
Radiography abdomen	Usually Not Appropriate	☢☢
Catheter venography pelvis and lower extremity	Usually Not Appropriate	☢☢☢
MRA abdomen and pelvis with bilateral lower extremity runoff with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢
CTA abdomen and pelvis with bilateral lower extremity runoff with IV contrast	Usually Not Appropriate	☢☢☢☢
CTA abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢☢

<u>Variant: 2</u> Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
US duplex Doppler lower extremity	Usually Not Appropriate	O
US intravascular iliac veins	Usually Not Appropriate	O
US lower extremity	Usually Not Appropriate	O
US lower extremity with IV contrast	Usually Not Appropriate	O
Radiography abdomen	Usually Not Appropriate	☢☢
Catheter venography pelvis and lower extremity	Usually Not Appropriate	☢☢☢
MRA abdomen and pelvis with bilateral lower extremity runoff with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis with IV contrast	Usually Not Appropriate	O

MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
MRV abdomen and pelvis with IV contrast	Usually Not Appropriate	O
MRV abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRV abdomen and pelvis without IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CTA abdomen and pelvis with bilateral lower extremity runoff with IV contrast	Usually Not Appropriate	☢☢☢☢
CTA abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢☢
CTV abdomen and pelvis with bilateral lower extremity runoff with IV contrast	Usually Not Appropriate	☢☢☢☢
CTV abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant: 3 Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
US pelvis transabdominal	Usually Appropriate	O
MRV abdomen and pelvis with IV contrast	Usually Appropriate	O
MRV abdomen and pelvis without and with IV contrast	Usually Appropriate	O
MRV abdomen and pelvis without IV contrast	Usually Appropriate	O
CTV abdomen and pelvis with bilateral lower extremity runoff with IV contrast	Usually Appropriate	☢☢☢☢
CTV abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢☢
US duplex Doppler lower extremity	May Be Appropriate	O
MRI abdomen and pelvis with IV contrast	May Be Appropriate	O
MRI abdomen and pelvis without and with IV contrast	May Be Appropriate	O
CT abdomen and pelvis with IV contrast	May Be Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	May Be Appropriate	☢☢☢☢
US intravascular iliac veins	Usually Not Appropriate	O
US lower extremity	Usually Not Appropriate	O
US lower extremity with IV contrast	Usually Not Appropriate	O
Radiography abdomen	Usually Not Appropriate	☢☢
Catheter venography pelvis and lower extremity	Usually Not Appropriate	☢☢☢
MRA abdomen and pelvis with bilateral lower extremity runoff with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢
CTA abdomen and pelvis with bilateral lower extremity runoff with IV contrast	Usually Not Appropriate	☢☢☢☢
CTA abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢☢

Panel Members

Nicole A. Keefe, MD[a], Sandra Gad, MD[b], Minhaj S. Khaja, MD, MBA[c], Nima Kokabi, MD[d], Anant D. Bhave, MD[e], Umberto Campia, MD[f], Benjamin N. Contrella, MD[g], Saeed Elojeimy, MD, PhD[h], Edward Hulten, MD, MPH[i], Baljendra S. Kapoor, MD, MBA[j], Michael Malinowski, MD[k], Mark Meissner, MD[l], Rachel P. Rosovsky, MD[m], Fadi Shamoun, MD[n], Aditya M. Sharma, MBBS[o], Daniel P. Sheeran, MD[p], Bill S. Majdalany, MD[q]

Summary of Literature Review

Introduction/Background

Nonthrombotic iliac vein lesions (NIVLs), also referred to as a May-Thurner lesion/anatomy or Cockett syndrome, most frequently result from the left common iliac vein being compressed between the right common iliac artery and the spine. The associated compressive venous stenosis affects up to 70% of adult patients with 25% having a greater than 50% stenosis [1]. There are multiple additional anatomic variants based on patient anatomy, which can cause unilateral lower extremity venous compression [2]. NIVL is most commonly identified in the proximal common iliac vein (84% in a study by Kibbe et al and 37.4% in a study by Kheyson et al), followed by the middle external iliac vein (31.5%), and rarely, in the distal external iliac vein (2.6%) [1, 2]. Although much less common, this condition can also be seen on the right lower extremity, most frequently in the distal external iliac vein (7.62%) and has been reported in patients with a left-sided inferior vena cava (IVC) or a high aortic bifurcation [3].

Iliac vein compression is often clinically silent, but can be associated with significant symptoms in which case it is referred to as May-Thurner syndrome [4]. This nomenclature is no longer used, whereas the Symptoms-Varices-Pathophysiology classification system is now used, which allows more precise categorization of venous obstructive processes [5]. It is still unclear why some patients are asymptomatic, whereas others can develop severe, debilitating symptoms. Most frequently, this disorder can cause lower extremity edema, deep venous thrombosis, or chronic venous insufficiency. It is estimated that 53% to 87% of Clinical-Etiology-Anatomy-Pathophysiology class 4 to 6 patients have NIVL [6]. Sex-specific manifestations have been observed. In female patients, pelvic venous disease is primarily due to reflux through the internal iliac veins with varices formation; the gonadal vein serving as an outflow to this venous plexus [7]. Moreover, females often present with chronic pelvic pain (CPP), which can be precipitated by prolonged frequent standing, pregnancy, or hormonal contraception use. An equivalent symptom in males, albeit rarely, is varicoceles [8]. Since NIVL can be clinically silent, a thorough history and physical examination is needed to rule out alternative etiologies. For symptomatic patients, imaging evaluation is warranted to make a definitive diagnosis.

Special Imaging Considerations

The key component of imaging in the diagnosis of NIVL is identification of a compression within the pelvic vasculature. The addition of hemodynamic information and further evaluation of the vessel wall and luminal characteristics can aid in the evaluation. A variety of imaging studies have been assessed for both initial and follow-up evaluation of NIVL, including duplex ultrasound (US), catheter venography, and intravascular US (IVUS). It is important to note that will all imaging studies performed in the supine position, the degree and hemodynamic significance of any compressive lesions can be overestimated. Additionally, dehydration can result in an overestimation of the hemodynamic or clinical significance. Of the imaging modalities reviewed, duplex US has the advantage of being able to image the patient in the upright or decubitus positions allowing better characterization of compressive lesions [9].

Radiography allows for the evaluation of the structures within the abdomen and pelvis. Through the use of various shades of gray, different structures are more easily identified. However, standard noncalcified arterial and venous anatomy cannot be visualized on radiography.

The ACR Appropriateness Criteria topics use the definition in the ACR-AIUM-SPR-SRU Practice Parameter for the Performance of Peripheral Venous Ultrasound Examination [10]. This document specifies the technique needed for both compressive US and Doppler evaluation for the evaluation of NIVL.
US includes a range of imaging studies that may be used to evaluate the venous vasculature including; with and without duplex, with and without intravenous (IV) contrast, and IVUS. Conventional US is a noninvasive, nonionizing study using high-frequency sound waves to create images of the body's internal structures. The addition of Doppler evaluation allows the operator to discern movement of materials, most importantly blood, within the body. Although color Doppler shows the speed and direction of blood, power Doppler is more sensitive and can detect flow when it may be minimal. Spectral Doppler further characterizes flow in distance traveled per unit of time. For venous structures, the phasicity of flow seen with respiratory variability, Valsalva maneuver, or compression allows for further description. For example, reversal of flow can indicate an upstream obstruction. Notably, in the evaluation for NIVL, reversal of flow may be seen in the deep venous system in the legs or within the internal iliac veins [11-13].

Color duplex US is a noninvasive imaging modality that uses microbubbles injected intravenously to characterize blood flow dynamics in real time, allowing for better quantification of luminal diameter and cross-sectional area of the vessel. Color duplex US has not been studied extensively for the evaluation of NIVL.
IVUS is another ultrasonographic modality, which places the US transducer on the end of an intravascular catheter to allow visualization of a blood vessel from the inside. This type of US aids in characterizing lesion morphology and lesion length, as well as identifying endoluminal webs, thrombus, and fibrous tissue. Furthermore, IVUS may aid in stent sizing and placement. Specifically, IVUS overcomes many of the limitations of venography in that it uses sound waves to produce a 2-D luminogram of a 3-D structure.

CT is a cross-sectional imaging modality that offers excellent spatial resolution and fast image acquisition times. However, without contrast administration, evaluation of the venous structures is severely limited. Evaluation of the veins may be performed through CT venography (CTV), a technique that uses contrast administration with delayed imaging acquisition to allow contrast to flow within the venous structures. CTV has been demonstrated to be a valuable study for the evaluation of NIVL [14-17]. However, a disadvantage of CTV is the potential nephrotoxicity that can develop from the administration of contrast material. Conventional CT of the abdomen and pelvis with IV contrast in the portal venous phase may also provide preliminary evaluation of the venous structures; however, the timing is suboptimal for full evaluation. CT angiography (CTA) uses thin-section CT acquisition that is timed to coincide with peak arterial enhancement. By definition, this is not designed to look at the venous structures, and as such, has limited usefulness for the evaluation of NIVL.
MRI is advantageous over CT due to the superior soft tissue characterization and relatively low

nephrotoxicity. Disadvantages include the long acquisition time, claustrophobia for some patients, decreased spatial resolution, and limitation with various implantable devices. MR venography (MRV) represents the optimal MR imaging for the evaluation of the venous vasculature. Although rare, because MRV includes administration of a gadolinium-based contrast agent, it has been linked to nephrogenic systemic fibrosis. Newer MRI techniques have been developed recently, which allow for noncontrast evaluation of the veins [11-13].

Catheter venography was once considered the reference standard for evaluation of NIVL but has since been supplanted by IVUS. It is still an important imaging modality for characterization of vasculature, flow dynamics, and visualization of collateral vessels. However, because it is an invasive procedure, venography is not typically recommended as a first-line imaging evaluation for NIVL. Moreover, IVUS has been proven to be superior to venography in multiple studies due to its superior lesion characterization [18-20].

Initial Imaging Definition

Initial imaging is defined as imaging at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the initial imaging evaluation when:

- There are procedures that are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care)

OR

- There are complementary procedures (ie, more than one procedure is ordered as a set or simultaneously wherein each procedure provides unique clinical information to effectively manage the patient's care).

Discussion of Procedures by Variant

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.

There are several reasons for a patient to develop unilateral lower extremity edema. When a venous etiology is suspected, it can be either in the superficial or the deep venous system. It is crucial to differentiate between these two in order to recommend the appropriate treatment. For deep venous etiologies such as deep vein thrombosis, the reason for swelling must be identified to initiate the appropriate therapy in a timely manner in order to mitigate potential complications such as postthrombotic syndrome.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
A. Catheter venography pelvis and lower extremity

Currently, there is no literature that supports the use of catheter venography in the initial imaging evaluation for NIVL. With the availability and adoption of noninvasive techniques to evaluate NIVL, this invasive option is a less reasonable choice.

Historically, catheter venography was used for confirmatory intraprocedural diagnosis. More recently, catheter venography has been evaluated in comparison to IVUS [31]. Studies demonstrated that venography had poor sensitivity of 45% and an NPV of 49% in the detection of venous stenosis >70% when compared to IVUS. This is favored to be secondary to the noncircular lumen geometry of the stenosis, which is inadequately evaluated by single-plane venography. Pancaking is described as an increase in the vessel diameter relative to the normal proximal or distal segments noted on venography. When seen in combination with collateral vessels, this identified a left common iliac vein lesion with 97% sensitivity [19].

In addition to lacking in the identification of NIVL, catheter venography may also over identify nonsignificant variants. For example, in a study of 30 healthy asymptomatic subjects (median age 21), catheter venography found two or more venographic signs of NIVL in 80% of the patients [34]. Signs on venography of NIVL included >50% diameter narrowing of the left common iliac vein, deformity or translucency of the lumen by the overlying artery, and presence of collateral veins. These findings demonstrated a significant imbalance between clinical signs and imaging findings of young patients with central venous obstruction, which may potentially lead to overtreatment based on venography. This type of potential misrepresentation is further substantiated by a study by Kibbe et al [1], which demonstrated NIVL as a potential normal variant.

In comparison to catheter venography, 3-D rotational venography has a higher detection rate of pelvic collateral veins (P = .03), contralateral iliac vein filling (P = .002), and external iliac vein indentation (P = .001), which all correlate with a higher sensitivity for the detection of NIVL. Although 3-D rotation venography and standard DSA identify similar stenosis, 3-D rotational venography provides richer diagnostic information while also reducing procedure time (P < .01) and contrast usage [35]. Although 3-D rotational venography is relatively new in its implementation, it may serve as a reliable and safe adjuvant to standard venography for vessel evaluation.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
B. CT abdomen and pelvis with IV contrast

Currently, there is no relevant literature supporting the use of the conventional CT abdomen and pelvis in the initial imaging evaluation for NIVL. CT abdomen and pelvis with IV contrast in the standard portal venous phase may highlight a NIVL; however, CTV will allow for a better evaluation given the optimal contrast bolus timing for the evaluation of venous structures. The advantage of CT abdomen and pelvis is that it can identify alternative sources of compression such as tumors or masses that may mimic the signs and symptoms of NIVL.

In a study by Pei et al [26] computational fluid dynamic evaluation was performed using a 3-D modeling of the IVC and iliac veins. This was developed to evaluate hemodynamic metrics on static CT imaging. The velocity within the stenotic segment of the vessel was noted to increase with severity of compression (R = 0.9, P < .001). Furthermore, the pressure differential between the cranial and caudal extent of the stenosis correlated strongly with the clinical classification of degree of severity (R = 0.94, P < .001). This successfully quantified flow disturbances caused by NIVL closely reflecting the severity of the stenosis.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
C. CT abdomen and pelvis without and with IV contrast

CT abdomen and pelvis without and with IV contrast will provide similar details as a CT abdomen and pelvis with IV contrast. The addition of the CT abdomen and pelvis without IV contrast is inferior for evaluation of the vasculature, although it can add additional diagnostic value, particularly in cases where there may be underlying contrast or calcifications within the system.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
D. CT abdomen and pelvis without IV contrast

There is no relevant literature supporting the use of conventional CT abdomen and pelvis without IV contrast in the initial imaging evaluation for NIVL. The lack of IV contrast limits the evaluation of the vasculature.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
E. CTA abdomen and pelvis with bilateral lower extremity runoff with IV contrast

There is no relevant literature supporting the use of CTA abdomen and pelvis with bilateral lower extremity runoff with IV contrast in the initial imaging evaluation for NIVL. This study is designed to highlight the arterial anatomy, and as such, evaluation of the venous structures is severely limited.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
F. CTA abdomen and pelvis with IV contrast

There is no relevant literature supporting the use of CTA abdomen and pelvis with IV contrast in the initial imaging evaluation for NIVL. This study is designed to highlight the arterial anatomy, and as such, evaluation of the venous structures is severely limited.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
G. CTV abdomen and pelvis with bilateral lower extremity runoff with IV contrast

CTV abdomen and pelvis is a powerful screening method to determine venous obstruction and may serve as a first-line study for evaluation. The addition of the inflow vessels in imaging with a lower extremity runoff may aid in procedural planning and serve in the evaluation of varicose veins or alternative pathology as a source of lower extremity swelling.

In a study comparing CTV to IVUS for the evaluation of NIVL, CTV had a sensitivity of 93.1% and specificity of 77.5%[14]. CTV for the evaluation of both NIVL as well as postthrombotic iliac vein lesions has a PPV of 94%, NPV of 79.1%, and overall accuracy of 86.7%, demonstrating CTV as a good screening tool. In another study, CTV showed excellent agreement with IVUS for both mild stenosis (<50%) and more severe stenosis (>50%) with sensitivities and specificities of 96% and 95% versus 100% and 100%, respectively [17].

CTV in combination with DSA leads to a higher predictive accuracy. A cutoff percentage of 46.67% compression on CTV provided the highest sensitivity and specificity of 83.44% and 69.31%, respectively, for diagnosing NIVL [16]. When combined with DSA with evidence of collateral vessel and internal iliac vein reflux, the sensitivity rose to 94.48% with an accuracy of 84.85%. CTV can serve as a good screening study and ultimately be combined with DSA and IVUS for confirmatory testing and intervention as warranted.

Evaluation of both the common iliac vein and external iliac veins, yielding two data points instead of a single point, were studied to see if it aided in CT diagnostic capabilities compared to IVUS. For a single data point, the diagnostic sensitivity of CTV was 83% and 73% for the common iliac vein and external iliac vein, respectively. These numbers rose to 97% when two data points were studied with a single stenotic caliber in one of the two segments considered diagnostic of NIVL, with a PPV and accuracy of 93% and 91%, respectively [15].

For patients in whom lymphedema is the suspected etiology of lower extremity swelling, CTV demonstrated NIVL in only 6% of patients studied where under 3% derived clinical benefit from that finding [28]. Patients with isolated left-sided edema compared to bilateral edema were more likely (14% versus 4%) to be identified with NIVL on imaging, indicating CTV may be warranted in this patient population.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
H. CTV abdomen and pelvis with IV contrast

CTV abdomen and pelvis is a powerful screening method to determine venous obstruction and may serve as a first-line study for evaluation. CT has the added benefit over US of being able to evaluate for alternative pathology as the source of edema. In addition to evidence of venous compression, CTV can demonstrate venous dilation or pooling proximal to the site of stenosis and the presence of collateral vessels. These may not be fully evidence on venography alone based on flow dynamics. The presence of collaterals within the pelvic and paravertebral spaces may more strongly indicate the presence of hemodynamic significance.

In a study comparing CTV to IVUS for the evaluation of NIVL, CTV had a sensitivity of 93.1% and specificity of 77.5%[14]. CTV for the evaluation of both NIVL as well as postthrombotic iliac vein lesions has a PPV of 94%, NPV of 79.1%, and overall accuracy of 86.7%, demonstrating CTV as a good screening tool. In another study, CTV showed excellent agreement with IVUS for both mild stenosis (<50%) and more severe stenosis (>50%) with sensitivities and specificities of 96% and 95% versus 100% and 100%, respectively [17].

CTV in combination with DSA leads to a higher predictive accuracy. A cutoff percentage of 46.67% compression on CTV provided the highest sensitivity and specificity of 83.44% and 69.31%, respectively, for diagnosing NIVL [16]. When combined with DSA with evidence of collateral vessel and internal iliac vein reflux, the sensitivity rose to 94.48% with an accuracy of 84.85%. CTV can serve as a good screening study and ultimately be combined with DSA and IVUS for confirmatory testing and intervention as warranted.

Evaluation of both the common iliac vein and external iliac veins, yielding two data points instead of a single point, were studied to see if it aided in CT diagnostic capabilities compared to IVUS. For a single data point, the diagnostic sensitivity of CTV was 83% and 73% for the common iliac vein and external iliac vein, respectively. These numbers rose to 97% when two data points were studied with a single stenotic caliber in one of the two segments considered diagnostic of NIVL, with a PPV and accuracy of 93% and 91%, respectively [15].

For patients in whom lymphedema is the suspected etiology of lower extremity swelling, CTV demonstrated NIVL in only 6% of patients studied where under 3% derived clinical benefit from that finding [28]. Patients with isolated left-sided edema compared to bilateral edema were more

likely (14% versus 4%) to be identified with NIVL on imaging, indicating CTV may be warranted in this patient population.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
I. MRA abdomen and pelvis with bilateral lower extremity runoff with IV contrast

There is no relevant literature supporting the use of MR angiography (MRA) abdomen and pelvis with bilateral lower extremity runoff with IV contrast in the initial imaging evaluation for NIVL. This study is designed to highlight the arterial anatomy, and as such, evaluation of the venous structures is limited.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
J. MRI abdomen and pelvis with IV contrast

There is no relevant literature supporting the use of a standard MRI abdomen and pelvis with IV contrast in the initial imaging evaluation for NIVL. With standard sequences including FLAIR, T2-weighted, T1-weighted pre- and postcontrast, diffusion-weighted imaging (DWI), and apparent diffusion coefficient (ADC), there are no designated sequences optimal for the evaluation of the venous structures. Though venous structures may be seen on this study, overall evaluation will be suboptimal and thus, limits definitive characterization. However, MRI often will be able to identify an alternative pathology as the source of swelling if present.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
K. MRI abdomen and pelvis without and with IV contrast

MRI abdomen and pelvis without and with IV contrast will provide similar details as MRI abdomen and pelvis with IV contrast. The addition of an MRI without IV contrast is inferior for the evaluation of the vasculature. With standard sequences including FLAIR, T2-weighted, T1-weighted pre- and postcontrast, DWI, and ADC, there are no designated sequences optimal for the evaluation of the venous structures. Though venous structures may be seen on this study, overall evaluation will be suboptimal and thus, limits definitive characterization. However, MRI often will be able to identify an alternative pathology as the source of swelling if present.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
L. MRI abdomen and pelvis without IV contrast

There is no relevant literature supporting the use of a standard MRI abdomen and pelvis without IV contrast in the initial imaging evaluation for NIVL. With standard sequences including FLAIR, T2-weighted, T1-weighted without contrast, DWI, and ADC, there are no designated sequences optimal for the evaluation of the venous structures. Although these structures may be seen on the study, overall evaluation will be suboptimal and thus, limits definitive characterization. However, MRI often will be able to identify alternative pathology as the source of swelling if present.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
M. MRV abdomen and pelvis with IV contrast

MRV can serve as a first-line imaging study for the evaluation of NIVL.

In a study comparing the diagnostic accuracy of duplex US, MRV, multiplanar venography, and

IVUS, the sensitivity of detecting NIVL was 90% for MRV (95% confidence interval (CI), 68%-97%) [29]. This percentage was significantly higher than with duplex US (90% sensitivity) and comparable to venography (95% sensitivity).

Standard MRV imaging was further compared to IVUS and multiplanar venography with a sensitivity of 100%, but only had a specificity of 22.7% [30]. The positive predicative value (PPV) was 58.5% and the negative predicative value (NPV) was 100%. This study indicates that MRV may be a reasonable screening tool to rule out proximal venous outflow obstruction but has limited ability to confirm the diagnosis with a false-positive rate of 41.5%.

Time-resolved contrast-enhanced MRV also demonstrates dynamic flow evaluation, which is a limitation of CT imaging. This imaging modality can demonstrate the directionality of venous flow and potential reflux patterns [7].

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
N. MRV abdomen and pelvis without and with IV contrast

MRV can serve as a first-line imaging study for the evaluation of NIVL.

In a study comparing the diagnostic accuracy of duplex US, MRV, multiplanar venography, and IVUS, the sensitivity of detecting NIVL was 90% for MRV (95% CI, 68%-97%) [29]. This percentage was significantly higher than with duplex US (90% sensitivity) and comparable to venography (95% sensitivity).

Standard MRV imaging was further compared to IVUS and multiplanar venography with a sensitivity of 100%, but only had a specificity of 22.7% [30]. The PPV was 58.5% and NPV 100%. This study indicates that MRV may be a reasonable screening tool to rule out proximal venous outflow obstruction but has limited ability to confirm the diagnosis with a false-positive rate of 41.5%.

Time-resolved contrast-enhanced MRV also demonstrates dynamic flow evaluation, which is a limitation of CT imaging. This imaging modality can demonstrate the directionality of venous flow and potential reflux patterns [7].

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
O. MRV abdomen and pelvis without IV contrast

MRV can serve as a first-line imaging study for the evaluation of NIVL. Although more limited than MRV with IV contrast, the addition of specialized sequences can aid in detection and quantification of NIVL.

Black-blood venous imaging (BBVI) is a newer noncontrasted imaging technique, which has been studied in the diagnosis of iliac vein compression. A proof of concept study demonstrated that BBVI had high diagnostic performance for the detection of NIVL, with a sensitivity and specificity of 68% and 95%, respectively, in comparison to digital subtraction angiography (DSA) [12]. The associated sensitivity suggests that it may not detect more mild stenosis, but all clinically significant compressions were identified with a PPV of 98%. BBVI imaging is a reasonable alternative for noninvasively diagnosing clinically significant NIVL.

Shi et al [11] tested multimodal MRI protocols to evaluate for NIVL without IV contrast. Sequences including balanced turbo field echo with spectral attenuated inversion recovery (BTFE-SPAIR) and multidimensional 2-D time-of-flow phase encoding and rephasing (M2DIPEAR) provided superior anatomical clarity to improve identification of an iliac vein obstruction. M2DIPEAR is a 2-D time-of-flight (TOF) sequence defined by the authors. T1 high-resolution isovolumetric examination (THRIVE) and fluid-attenuated inversion recovery (FLAIR) improved detection of coexisting thrombosis. This combination had a sensitivity, specificity, PPV, and NPV of 96.9%, 88.9%, 98.4%, and 80%, respectively, compared to DSA. Together, these sequences provide an alternative for evaluation of NIVL.

Use of a modified TOF-MRV protocol can also improve the image quality and accuracy for the evaluation of significant NIVL. By tailoring the 3-D TOF to venous flow, the sensitivity and specificity rose to 100% and 95%, respectively, for the detection of iliac vein stenosis >50% [13].

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
P. Radiography abdomen

There is no relevant literature supporting the use of abdominal radiography in the initial imaging evaluation for NIVL. Venous compression would not be evident on radiography.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
Q. US duplex Doppler lower extremity

Lower extremity duplex US can be used to evaluate the venous structures within the superficial and deep venous systems of the leg. In a patient with unilateral leg edema, it is crucial to determine if the swelling is related to superficial or deep venous disease. A duplex US can be very useful in determining the underlying source of suspected venous etiology. Sonography offers insight into vascular changes that static imaging studies may miss. Duplex US of the iliac vessels may be limited by imaging techniques and patient characteristics. Duplex US is the only initial imaging modality that allows evaluation in the supine, upright, and decubitus positions . Nonclinically significant compression can appear exaggerated in the supine position or in dehydrated patients. Imaging in the upright or decubitus position can exclude false-negative studies.

For superficial veins, evaluation of reflux should be performed including assessment of the perforating veins and saphenous vein and tributaries with compression and/or Valsalva maneuver. Reflux, defined as the flow of blood in the opposite direction than expected, can aid in the diagnosis of superficial venous reflux disease and is a common cause of lower extremity swelling and varicosities. Although evaluation of reflux does not exclude deep venous disease, it is less common to see these concurrently.

In comparison with CTV, duplex US was less sensitive, particularly for mild lesions (<50% stenosis) with sensitivity and specificity of 63.9% and 65%, respectively [17]. These numbers improved with severe lesions of ≥80% stenosis to a sensitivity of 70% and specificity of 85%. Duplex US may serve as a reasonable initial screening tool as it provides good hemodynamic data compared to CTV; however, direct CTV is far more accurate and reproducible for precise assessment and grading.

Waveform evaluation can help assess for more central obstruction but cannot differentiate the cause or exact location of the obstruction. Waveforms may be continuous rather than respirophasic in the common femoral vein in the setting of a more central obstruction such as iliac vein compression[21]. Duplex US is also noted to be less reliable than IVUS for quantification of iliac vein stenosis. A study by Raju et al [22] evaluated duplex US compared to IVUS and noted that US underestimates the degree of stenosis compared to IVUS.

In patients with chronic iliac vein obstruction, duplex US can also be used to evaluate for more long-term clinical success following intervention. The PRedict MIdterm outcome after endovenous StEnting in patients with chronic PTO or NIVLs (PROMISE trial) evaluated peak velocities of the common femoral and femoral veins both pre- and postiliac vein stenting to evaluate risk for stent occlusion [23]. Notably, preintervention peak velocity of the common femoral vein was related to a higher rate of stent occlusion postprocedurally [23]. This finding further solidifies the concept of adequate inflow, which is needed to maintain stent patency. For chronic venous stenosis, US may only demonstrate moderately impaired venous flow in the presence of collateral formation, leading to an underdiagnosis of NIVL [24].

Duplex US can be further supplemented with the addition of air plethysmography (APG), an uncommonly performed diagnostic study. In evaluation of calf pump failure, which is defined by APG as a residual volume fracture of >50% following exercise and a low ejection fraction of <50%, 16% of limbs with calf pump failure did not have duplex US identified reflux disease [25]. As such, duplex US alone would miss many causes of outflow obstruction contributing to calf pump function.

Furthermore, by combining the use of duplex US and plethysmography, evaluations of venous flow hemodynamics can be performed. This combination can effectively identify blood flow disturbances, which potentially correlates to the degree of iliac vein stenosis and chronic venous insufficiency symptoms [26].

Maximal venous outflow velocity (MVOV) can also be used as an adjuvant to duplex US. Symptomatic patients with NIVL had a mean right to left MVOV ratio of 2.0, which decreased to 1.2 (P = .043) following stenting and was more representative of control patients with a mean ratio of 1.3 (P = .004) [27]. This finding demonstrates the use of MVOV in combination with duplex US as an effective, noninvasive imaging technique to detect NIVL. In this same study, only 53% of patients had positive cross-sectional CT or MRI indicative of NIVL, which was identified by MVOV, highlighting the value added by dynamic duplex US assessment.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
R. US intravascular iliac veins

There is no relevant literature supporting the use of IVUS in the initial imaging evaluation for NIVL. Noninvasive techniques to evaluate NIVL make this invasive option less reasonable. There is ample literature demonstrating the significant use of IVUS during intervention; however, this should not serve as a first-line imaging study.

IVUS is considered the reference standard for evaluation of NIVL once diagnosed and can aid in better lesion localization and characterization. IVUS is noted to have better sensitivity and PPV compared to conventional venography for the evaluation of lesions >70% [18, 31]. IVUS also provides a more accurate localization of the anatomic location of the NIVL [2]. One study showed that use of IVUS led to a change in the intraprocedural plan for 57% of cases, often leading to the need for additional stenting; these findings underscore the limited sensitivity of venography [18].

IVUS can also identify NIVL variants that may be missed on catheter venography . For example, diffuse Rokitansky stenosis, which represents long segment diffuse narrowing, may appear normal on venography, but IVUS can identify this variant and other diffusely narrowed iliac veins. Lesions resistant to balloon angiography or patients who have persistent symptoms following stenting are also better evaluated with postangioplasty IVUS as this modality can identify extrinsic compression by fibroids tissue.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
S. US lower extremity

US evaluation can elucidate the appearance of the venous structure to evaluate for the appearance of postthrombotic changes. These changes are characterized by vein wall thickening and decreased venous diameter. The vessel may also be more echogenic and have an irregular surface. In comparison to IVUS, diagnostic accuracy of NIVL with US of the external iliac vein and common iliac vein were 71.4% and 56.7%, respectively [33]. This may be secondary to the high location and challenge in visualization in larger patients. US is heavily dependent on patient characteristics, which make usefulness and appropriateness variable across centers. Lower extremity US is not the optimal US study for the diagnosis of NIVL as it lacks duplex and therefore hemodynamic significance.

Variant 1:Adult. Unilateral lower extremity edema. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
T. US lower extremity with IV contrast

Contrast-enhanced US (CEUS) has little data to support its use in the evaluation of chronic iliac vein obstruction. CEUS was evaluated in a single study in comparison to conventional US and IVUS [33]. In this study, diagnostic accuracy for CEUS versus IVUS of the external iliac vein and common iliac vein were 71.3% and 53.2%, respectively. The intraclass correlation coefficient between enhanced and unenhanced US was 0.9, indicating very good agreement between the two imaging modalities. As CEUS is limited by technical considerations, it is not considered an ideal initial imaging study.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.

Left common iliac vein stenosis may be detected on imaging by the radiologist who may not have the necessary clinical information to determine clinical significance. Therefore, for patients without symptoms, the evaluating and ordering clinician should be familiar with the next appropriate step to avoid ordering subsequent inappropriate imaging, which may further inconvenience the patient. In adolescents, severe iliac vein compression can affect over 50% of asymptomatic patients [36]. In adults, iliac vein compression can be identified in 20% to 50% of asymptomatic patients on imaging, which raises the possibility that it may merely represent a normal anatomic pattern [1].

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
A. Catheter venography pelvis and lower extremity

There is no relevant literature supporting the use of catheter venography as a subsequent imaging study after the initial diagnosis of NIVL. Noninvasive techniques to evaluate NIVL make this invasive option less reasonable.

Historically, catheter venography was used for confirmatory intraprocedural diagnosis. More recently, catheter venography has been evaluated in comparison to IVUS [31]. Studies demonstrated that venography had poor sensitivity of 45% and an NPV of 49% in the detection of venous stenosis >70% when compared to IVUS. This is favored to be secondary to the noncircular lumen geometry of the stenosis, which is inadequately evaluated by single-plane venography. Pancaking is described as an increase in the vessel diameter relative to the normal proximal or distal segments noted on venography. When seen in combination with collateral vessels, this identified a left common iliac vein lesion with 97% sensitivity [19].

In addition to lacking in the identification of NIVL, catheter venography may also over identify nonsignificant variants. For example, in a study of 30 healthy asymptomatic subjects (median age 21), catheter venography found two or more venographic signs of NIVL in 80% of the patients [34]. Signs on venography of NIVL included >50% diameter narrowing of the left common iliac vein, deformity or translucency of the lumen by the overlying artery, and presence of collateral veins. These findings demonstrated a significant imbalance between clinical signs and imaging findings of young patients with central venous obstruction, which may potentially lead to overtreatment based on venography. This type of potential misrepresentation is further substantiated by a study by Kibbe et al [1], which demonstrated NIVL as a potential normal variant.

In comparison to catheter venography, 3-D rotational venography has a higher detection rate of pelvic collateral veins (P = .03), contralateral iliac vein filling (P = .002), and external iliac vein indentation (P = .001), which all correlate with a higher sensitivity for the detection of NIVL. Although 3-D rotation venography and standard DSA identify similar stenosis, 3-D rotational venography provides richer diagnostic information while also reducing procedure time (P < .01) and contrast usage [35]. Although 3-D rotational venography is relatively new in its implementation, it may serve as a reliable and safe adjuvant to standard venography for vessel evaluation.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
B. CT abdomen and pelvis with IV contrast

In an asymptomatic patient, there is no relevant literature to necessitate further workup of NIVL with CT abdomen and pelvis with IV contrast.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
C. CT abdomen and pelvis without and with IV contrast

In an asymptomatic patient, there is no relevant literature to necessitate further workup of NIVL with CT abdomen and pelvis with and without IV contrast.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
D. CT abdomen and pelvis without IV contrast

In an asymptomatic patient, there is no relevant literature to necessitate further workup of NIVL with CT abdomen and pelvis without IV contrast.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
E. CTA abdomen and pelvis with bilateral lower extremity runoff with IV contrast

In an asymptomatic patient, there is no relevant literature to necessitate further workup of NIVL with CTA abdomen and pelvis with bilateral lower extremity runoff with IV contrast.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
F. CTA abdomen and pelvis with IV contrast

In an asymptomatic patient, there is no relevant literature to necessitate further workup of NIVL with CTA abdomen and pelvis with IV contrast.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
G. CTV abdomen and pelvis with bilateral lower extremity runoff with IV contrast

CTV is an effective screening tool to determine venous obstruction and may serve as a first-line study for evaluation. In a patient with known iliac vein stenosis, in whom there are no clinical symptoms, no additional imaging is warranted.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
H. CTV abdomen and pelvis with IV contrast

CTV is an effective screening tool to determine venous obstruction and may serve as a first-line study for evaluation. In a patient with known iliac vein stenosis, in whom there are no clinical symptoms, no additional imaging is warranted.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
I. MRA abdomen and pelvis with bilateral lower extremity runoff with IV contrast

There is no relevant literature supporting the use of MRA abdomen and pelvis with bilateral lower extremity runoff with IV contrast in an asymptomatic patient with known NIVL.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
J. MRI abdomen and pelvis with IV contrast

There is no relevant literature supporting the use of MRI abdomen and pelvis with IV contrast in an asymptomatic patient with known NIVL.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
K. MRI abdomen and pelvis without and with IV contrast

There is no relevant literature supporting the use of MRI abdomen and pelvis without and with IV contrast in an asymptomatic patient with known NIVL.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
L. MRI abdomen and pelvis without IV contrast

There is no relevant literature supporting the use of MRI abdomen and pelvis without IV contrast in an asymptomatic patient with known NIVL.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
M. MRV abdomen and pelvis with IV contrast

MRV abdomen and pelvis with IV contrast is a reasonable screening method to determine venous obstruction and may serve as a first-line study for evaluation. In a patient with known iliac vein stenosis, in whom there are no clinical symptoms, no additional imaging is warranted.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
N. MRV abdomen and pelvis without and with IV contrast

MRV abdomen and pelvis with and without IV contrast is a reasonable screening method to determine venous obstruction and may serve as a first-line study for evaluation. In a patient with known iliac vein stenosis, in whom there are no clinical symptoms, no additional imaging is warranted.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
O. MRV abdomen and pelvis without IV contrast

MRV is a reasonable screening method to determine venous obstruction and may serve as a first-line study for evaluation. In a patient with known iliac vein stenosis, in whom there are no clinical symptoms, no additional imaging is warranted.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
P. Radiography abdomen

There is no relevant literature supporting the use of abdominal radiography in the follow-up evaluation for NIVL. Venous compression would not be evident on radiography.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
Q. US duplex Doppler lower extremity

The Society of Interventional Radiology position statement on chronic iliofemoral venous obstruction, considers lower extremity duplex US as the first-line diagnostic study to evaluate the venous structures within the superficial and deep venous systems of the leg [4, 7]. For an asymptomatic patient with known NIVL, there is no relevant literature to support further evaluation with duplex US of the lower extremities.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
R. US intravascular iliac veins

In an asymptomatic patient, there is no relevant literature supporting the use of IVUS for further evaluation for NIVL.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
S. US lower extremity

In an asymptomatic patient, there is no relevant literature supporting the use of lower extremity US for further evaluation for NIVL.

Variant 2:Adult. Asymptomatic. Known left common iliac vein stenosis. Nonthrombotic iliac vein lesion found on US, CT, or MRI. Next imaging study.
T. US lower extremity with IV contrast

In an asymptomatic patient, there is no relevant literature supporting the use of US lower extremity with IV contrast for further evaluation for NIVL.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.

CPP can be caused by a number of etiologies including gynecological, musculoskeletal, gastrointestinal, genitourinary, arterial, and venous disease. When symptoms of CPP are due to a venous etiology, patients may experience perineal heaviness, urinary urgency, postcoital pain, and possibly lower extremity thrombosis. When venous disease is suspected as the cause of CPP, it is critical to differentiate between NIVL, pelvic venous disease, or a combination of both [7]. It is not infrequent to see both NIVL and pelvic venous disease concurrently as the common iliac vein obstruction uses the internal iliac veins and escape points to the lower extremity, vulvar veins, or gonadal veins for the venous obstruction leading to venous bed overdistension. This venous overdistension can lead to stimulation of vascular nociceptors causing pelvic pain symptoms. Appropriate diagnosis is essential to reduce a delay in initiating the appropriate treatment and thus, hasten the patient's recovery.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
A. Catheter venography pelvis and lower extremity

There is no relevant literature supporting the use of catheter venography in the initial imaging evaluation for NIVL. Noninvasive techniques to evaluate NIVL make this invasive option less reasonable.

Historically, catheter venography was used for confirmatory intraprocedural diagnosis. More recently, catheter venography has been evaluated in comparison to IVUS [31]. Studies demonstrated that venography had poor sensitivity of 45% and a NPV of 49% in the detection of venous stenosis >70% when compared to IVUS. This is favored to be secondary to the noncircular lumen geometry of the stenosis, which is inadequately evaluated by single-plane venography. Pancaking is described as an increase in the vessel diameter relative to the normal proximal or distal segments noted on venography. When seen in combination with collateral vessels, this identified a left common iliac vein lesion with 97% sensitivity [19].

Catheter venography in a study of 30 healthy asymptomatic subjects (median age 21) demonstrated 80% of patients with two or more venography signs of NIVL, 15% with iliac vein narrowing without collateral vessels, and only one patient without obstructive symptoms [34]. Signs on venography of NIVL included >50% diameter narrowing of the left common iliac vein, deformity or translucency of the lumen by the overlying artery, and presence of collateral veins. This represents a significant imbalance between clinical signs and imaging findings of young patients with central venous obstruction, which may potentially lead to overtreatment based on venography. This is further substantiated in the study by Kibbe et al demonstrating NIVL as a potential normal variant.

In comparison, 3-D rotational venography has a higher detection rate of pelvic collateral veins ($P = .03$), contralateral iliac vein filling ($P = .002$), and external iliac vein indentation ($P = .001$), which are all correlated with a higher sensitivity for the detection of NIVL. Although 3-D rotation venography and standard DSA identified similar stenosis, 3-D rotational venography provided richer diagnostic information while also reducing procedure time ($P < .01$) and contrast usage [35].

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
B. CT abdomen and pelvis with IV contrast

Currently, there is no relevant literature supporting the use of the conventional CT abdomen and pelvis in the initial imaging evaluation for NIVL. CT abdomen and pelvis with IV contrast in the standard portal venous phase may highlight a NIVL; however, CTV will allow for a better evaluation given the optimal contrast bolus timing for the evaluation of venous structures. The advantage of CT abdomen and pelvis is that it can identify alternative sources of compression such as tumors or masses that may mimic the signs and symptoms of NIVL.

In a study by Pei et al [26] computational fluid dynamic evaluation was performed using a 3-D modeling of the IVC and iliac veins. This was developed to evaluate hemodynamic metrics on static CT imaging. The velocity within the stenotic segment of the vessel was noted to increase with severity of compression ($R = 0.9$, $P < .001$). Furthermore, the pressure differential between the cranial and caudal extent of the stenosis correlated strongly with the clinical classification of degree of severity ($R = 0.94$, $P < .001$). This successfully quantified flow disturbances caused by NIVL closely reflecting the severity of the stenosis.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
C. CT abdomen and pelvis without and with IV contrast

CT abdomen and pelvis without and with IV contrast will provide similar details as a CT abdomen and pelvis with IV contrast. The addition of the CT abdomen and pelvis without IV contrast is inferior for evaluation of the vasculature, although it can add additional diagnostic value, particularly in cases where there may be underlying contrast or calcifications within the system.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
D. CT abdomen and pelvis without IV contrast

There is no relevant literature supporting the use of conventional CT abdomen and pelvis without IV contrast in the initial imaging evaluation for NIVL. The lack of IV contrast limits evaluation of the vasculature.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
E. CTA abdomen and pelvis with bilateral lower extremity runoff with IV contrast

There is no relevant literature supporting the use of CTA abdomen and pelvis with bilateral lower extremity runoff with IV contrast in the initial imaging evaluation for NIVL. This study is designed to highlight the arterial anatomy, and as such, evaluation of the venous structures is severely limited.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.

F. CTA abdomen and pelvis with IV contrast

There is no relevant literature supporting the use of CTA abdomen and pelvis with IV contrast in the initial imaging evaluation for NIVL. This study is designed to highlight the arterial anatomy, and as such, evaluation of the venous structures is limited.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
G. CTV abdomen and pelvis with bilateral lower extremity runoff with IV contrast

CTV abdomen and pelvis is a powerful screening method to determine venous obstruction and may serve as a first-line study for evaluation. The addition of the inflow vessels in imaging with a lower extremity runoff may aid in procedural planning and serve in the evaluation of varicose veins or alternative pathology as a source of lower extremity swelling.

In a study comparing CTV to IVUS for the evaluation of NIVL, CTV had a sensitivity of 93.1% and specificity of 77.5%[14]. CTV for the evaluation of both NIVL as well as postthrombotic iliac vein lesions has a PPV of 94%, NPV of 79.1%, and overall accuracy of 86.7%, demonstrating CTV as a good screening tool. In another study, CTV showed excellent agreement with IVUS for both mild stenosis (<50%) and more severe stenosis (>50%) with sensitivities and specificities of 96% and 95% versus 100% and 100%, respectively [17].

CTV in combination with DSA leads to a higher predictive accuracy. A cutoff percentage of 46.67% compression on CTV provided the highest sensitivity and specificity of 83.44% and 69.31%, respectively, for diagnosing NIVL [16]. When combined with DSA with evidence of collateral vessel and internal iliac vein reflux, the sensitivity rose to 94.48% with an accuracy of 84.85%. CTV can serve as a good screening study and ultimately be combined with DSA and IVUS for confirmatory testing and intervention as warranted.

Evaluation of both the common iliac vein and external iliac veins, yielding two data points instead of a single point, were studied to see if it aided in CT diagnostic capabilities compared to IVUS. For a single data point, the diagnostic sensitivity of CTV was 83% and 73% for the common iliac vein and external iliac vein, respectively. These numbers rose to 97% when two data points were studied with a single stenotic caliber in one of the two segments considered diagnostic of NIVL, with a PPV and accuracy of 93% and 91%, respectively [15].

For patients in whom lymphedema is the suspected etiology of lower extremity swelling, CTV demonstrated NIVL in only 6% of patients studied where under 3% derived clinical benefit from that finding [28]. Patients with isolated left-sided edema compared to bilateral edema were more likely (14% versus 4%) to be identified with NIVL on imaging, indicating CTV may be warranted in this patient population.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
H. CTV abdomen and pelvis with IV contrast

CTV abdomen and pelvis is a powerful screening method to determine venous obstruction and may serve as a first-line study for evaluation. CT has the added benefit over US of being able to evaluate for alternative pathology as the source of edema. In addition to evidence of venous compression, CTV can demonstrate venous dilation or pooling proximal to the site of stenosis and the presence of collateral vessels. These may not be fully evidence on venography alone based on flow dynamics. The presence of collaterals within the pelvic and paravertebral spaces may more strongly indicate the presence of hemodynamic significance.

In a study comparing CTV to IVUS for the evaluation of NIVL, CTV had a sensitivity of 93.1% and specificity of 77.5%[14]. CTV for the evaluation of both NIVL as well as postthrombotic iliac vein lesions has a PPV of 94%, NPV of 79.1%, and overall accuracy of 86.7%, demonstrating CTV as a good screening tool. In another study, CTV showed excellent agreement with IVUS for both mild stenosis (<50%) and more severe stenosis (>50%) with sensitivities and specificities of 96% and 95% versus 100% and 100%, respectively [17].

CTV in combination with DSA leads to a higher predictive accuracy. A cutoff percentage of 46.67% compression on CTV provided the highest sensitivity and specificity of 83.44% and 69.31%, respectively, for diagnosing NIVL [16]. When combined with DSA with evidence of collateral vessel and internal iliac vein reflux, the sensitivity rose to 94.48% with an accuracy of 84.85%. CTV can serve as a good screening study and ultimately be combined with DSA and IVUS for confirmatory testing and intervention as warranted.

Evaluation of both the common iliac vein and external iliac veins, yielding two data points instead of a single point, were studied to see if it aided in CT diagnostic capabilities compared to IVUS. For a single data point, the diagnostic sensitivity of CTV was 83% and 73% for the common iliac vein and external iliac vein, respectively. These numbers rose to 97% when two data points were studied with a single stenotic caliber in one of the two segments considered diagnostic of NIVL, with a PPV and accuracy of 93% and 91%, respectively [15].

For patients in whom lymphedema is the suspected etiology of lower extremity swelling, CTV demonstrated NIVL in only 6% of patients studied where under 3% derived clinical benefit from that finding [28]. Patients with isolated left-sided edema compared to bilateral edema were more likely (14% versus 4%) to be identified with NIVL on imaging, indicating CTV may be warranted in this patient population.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
I. MRA abdomen and pelvis with bilateral lower extremity runoff with IV contrast

There is no relevant literature supporting the use of MRA abdomen and pelvis with bilateral lower extremity runoff with IV contrast in the initial imaging evaluation for NIVL. This study is designed to highlight the arterial anatomy, and as such, evaluation of the venous structures is severely limited.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
J. MRI abdomen and pelvis with IV contrast

There is no relevant literature supporting the use of a standard MRI abdomen and pelvis with IV contrast in the initial imaging evaluation for NIVL. With standard sequences including FLAIR, T2-weighted, T1-weighted pre- and postcontrast, DWI, and ADC, there are no designated sequences optimal for the evaluation of the venous structures. Though venous structures may be seen on this study, overall evaluation will be suboptimal and thus, limits definitive characterization. However, MRI often will be able to identify an alternative pathology as the source of swelling if present.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology.

Initial imaging.
K. MRI abdomen and pelvis without and with IV contrast

MRI abdomen and pelvis without and with IV contrast will provide similar details as MRI abdomen and pelvis with IV contrast. The addition of an MRI without IV contrast is inferior for the evaluation of the vasculature. With standard sequences including FLAIR, T2-weighted, T1-weighted pre- and postcontrast, DWI, and ADC, there are no designated sequences optimal for the evaluation of the venous structures. Though venous structures may be seen on this study, overall evaluation will be suboptimal and thus, limits definitive characterization. However, MRI often will be able to identify an alternative pathology as the source of pelvic pain if present.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
L. MRI abdomen and pelvis without IV contrast

There is no relevant literature supporting the use of a standard MRI abdomen and pelvis without IV contrast in the initial imaging evaluation for NIVL. With standard sequences including FLAIR, T2-weighted, T1-weighted pre- and postcontrast, DWI, and ADC, there are no designated sequences optimal for the evaluation of the venous structures. Although these structures may be seen on the study, overall evaluation will be suboptimal and thus, limits definitive characterization. However, MRI often will be able to identify alternative pathology as the source of CPP if present.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
M. MRV abdomen and pelvis with IV contrast

MRV can serve as a first-line imaging study for the evaluation of NIVL.

In a study comparing the diagnostic accuracy of duplex US, MRV, multiplanar venography, and IVUS, the sensitivity of detecting NIVL was 90% for MRV (95% CI, 68%-97%) [29]. This percentage was significantly higher than with duplex US (90% sensitivity) and comparable to venography (95% sensitivity).

Standard MRV imaging was further compared to IVUS and multiplanar venography with a sensitivity of 100%, but only had a specificity of 22.7% [30]. The PPV was 58.5% and NPV 100%. This study indicates that MRV may be a reasonable screening tool to rule out proximal venous outflow obstruction but has limited ability to confirm the diagnosis with a false-positive rate of 41.5%.

Time-resolved contrast-enhanced MRV also demonstrates dynamic flow evaluation, which is a limitation of CT imaging. This imaging modality can demonstrate the directionality of venous flow and potential reflux patterns [7].

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
N. MRV abdomen and pelvis without and with IV contrast

MRV can serve as a first-line imaging study for the evaluation of NIVL.

In a study comparing the diagnostic accuracy of duplex US, MRV, multiplanar venography, and IVUS, the sensitivity of detecting NIVL was 90% for MRV (95% CI, 68%-97%) [29]. This percentage was significantly higher than with duplex US (90% sensitivity) and comparable to venography (95%

sensitivity).

Standard MRV imaging was further compared to IVUS and multiplanar venography with a sensitivity of 100%, but only had a specificity of 22.7% [30]. The PPV was 58.5% and NPV 100%. This study indicates that MRV may be a reasonable screening tool to rule out proximal venous outflow obstruction but has limited ability to confirm the diagnosis with a false-positive rate of 41.5%.

Time-resolved contrast-enhanced MRV also demonstrates dynamic flow evaluation, which is a limitation of CT imaging. This imaging modality can demonstrate the directionality of venous flow and potential reflux patterns [7].

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
O. MRV abdomen and pelvis without IV contrast

MRV can serve as a first-line imaging study for the evaluation of NIVL. Although more limited than MRV with IV contrast, the addition of specialized sequences can aid in detection and quantification of NIVL.

BBVI is a newer noncontrasted imaging technique, which has been studied in the diagnosis of iliac vein compression. A proof of concept study demonstrated that BBVI had high diagnostic performance for the detection of NIVL, with a sensitivity and specificity of 68% and 95%, respectively, in comparison to DSA [12]. The associated sensitivity suggests that it may not detect more mild stenosis, but all clinically significant compressions were identified with a PPV of 98%. BBVI imaging is a reasonable alternative for noninvasively diagnosing clinically significant NIVL.

Shi et al [11] tested multimodal MRI protocols to evaluate for NIVL without IV contrast. Sequences including BTFE-SPAIR and M2DIPEAR provided superior anatomical clarity to improve identification of an iliac vein obstruction. M2DIPEAR is a 2-D TOF sequence defined by the authors. THRIVE and FLAIR improved detection of coexisting thrombosis. This combination had a sensitivity, specificity, PPV, and NPV of 96.9%, 88.9%, 98.4%, and 80%, respectively, compared to DSA. Together, these sequences provide an alternative for evaluation of NIVL.

Use of a modified TOF-MRV protocol can also improve the image quality and accuracy for the evaluation of significant NIVL. By tailoring the 3-D TOF to venous flow, the sensitivity and specificity rose to 100% and 95%, respectively, for the detection of iliac vein stenosis >50% [13].

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
P. Radiography abdomen

There is no relevant literature supporting the use of abdominal radiography in the initial imaging evaluation for NIVL. Venous compression would not be evidenced on radiography.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
Q. US duplex Doppler lower extremity

Lower extremity duplex US can be used to evaluate the venous structures within the superficial and deep venous systems of the leg. In a patient with unilateral leg edema, it is crucial to determine if the swelling is related to superficial or deep venous disease. A duplex US can be very useful in determining the underlying source of suspected venous etiology. Sonography offers insight into vascular changes that static imaging studies may miss. Duplex US of the iliac vessels may be limited by imaging techniques and patient characteristics. Duplex US is the only initial imaging modality that allows evaluation in the supine, upright, and decubitus positions [9]. Nonclinically significant compression can appear exaggerated in the supine position or in dehydrated patients. Imaging in the upright or decubitus position can exclude false-negative studies.

For superficial veins, evaluation of reflux should be performed including assessment of the perforating veins and saphenous vein and tributaries with compression and/or Valsalva maneuver. Reflux, defined as the flow of blood in the opposite direction than expected, can aid in the diagnosis of superficial venous reflux disease and is a common cause of lower extremity swelling and varicosities. Although evaluation of reflux does not exclude deep venous disease, it is less common to see these concurrently.

In comparison with CTV, duplex US was less sensitive, particularly for mild lesions (<50% stenosis) with sensitivity and specificity of 63.9% and 65%, respectively [17]. These numbers improved with severe lesions of =80% stenosis to a sensitivity of 70% and specificity of 85%. Duplex US may serve as a reasonable initial screening tool as it provides good hemodynamic data compared to CTV; however, direct CTV is far more accurate and reproducible for precise assessment and grading.

Waveform evaluation can help assess for more central obstruction but cannot differentiate the cause or exact location of the obstruction. Waveforms may be continuous rather than respirophasic in the common femoral vein in the setting of a more central obstruction such as iliac vein compression [21]. A study by Raju et al [22] evaluated duplex US compared to IVUS and noted that US underestimates the degree of stenosis compared to IVUS.

In patients with chronic iliac vein obstruction, duplex US can also be used to evaluate for more long-term clinical success following intervention. The PROMISE trial evaluated peak velocities of the common femoral and femoral veins both pre- and postiliac vein stenting to evaluate risk for stent occlusion [23]. Notably, preintervention peak velocity of the common femoral vein was related to a higher rate of stent occlusion postprocedurally [23]. This finding further solidifies the concept of adequate inflow, which is needed to maintain stent patency. For chronic venous stenosis, US may only demonstrate moderately impaired venous flow in the presence of collateral formation, leading to an underdiagnosis of NIVL [24].

Duplex US can be further supplemented with the addition of APG, an uncommonly performed diagnostic study. In evaluation of calf pump failure, which is defined by APG as a residual volume fracture of >50% following exercise and a low ejection fraction of <50%, 16% of limbs with calf pump failure did not have duplex US identified reflux disease [25]. As such, duplex US alone would miss many causes of outflow obstruction contributing to calf pump function.

Furthermore, by combining the use of duplex US and plethysmography, evaluations of venous flow hemodynamics can be performed. This combination can effectively identify blood flow disturbances, which potentially correlates to the degree of iliac vein stenosis and chronic venous insufficiency symptoms [26].

MVOV can also be used as an adjuvant to duplex US. Symptomatic patients with NIVL had a mean right to left MVOV ratio of 2.0, which decreased to 1.2 (P = .043) following stenting and was more representative of control patients with a mean ratio of 1.3 (P = .004) [27]. This finding demonstrates the use of MVOV in combination with duplex US as an effective, noninvasive imaging technique to detect NIVL. In this same study, only 53% of patients had positive cross-sectional CT or MRI indicative of NIVL, which was identified by MVOV, highlighting the value added by dynamic duplex US assessment.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
R. US intravascular iliac veins

There is no relevant literature supporting the use of IVUS in the initial imaging evaluation for NIVL. Noninvasive techniques to evaluate NIVL make this invasive option less reasonable. There is ample literature demonstrating the significant use of IVUS during intervention; however, this should not serve as a first-line imaging study.

IVUS is considered the reference standard for evaluation of NIVL once diagnosed and can aid in better lesion localization and characterization. IVUS is noted to have better sensitivity and PPV compared to conventional venography for the evaluation of lesions >70% [18, 31]. IVUS also provides a more accurate localization of the anatomic location of the NIVL [2]. One study showed that use of IVUS led to a change in the intraprocedural plan for 57% of cases, often leading to the need for additional stenting; these findings underscore the limited sensitivity of venography [18].

IVUS can also identify NIVL variants that may be missed on catheter venography [32]. For example, diffuse Rokitansky stenosis, which represents long segment diffuse narrowing, may appear normal on venography, but IVUS can identify this variant and other diffusely narrowed iliac veins. Lesions resistant to balloon angiography or patients who have persistent symptoms following stenting are also better evaluated with postangioplasty IVUS as this modality can identify extrinsic compression by fibroids tissue.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
S. US lower extremity

US evaluation can elucidate the appearance of the venous structure to evaluate for the appearance of postthrombotic changes. These changes are characterized by vein wall thickening and decreased venous diameter. The vessel may also be more echogenic and have an irregular surface. In comparison to IVUS, diagnostic accuracy of NIVL with US of the external iliac vein and common iliac vein were 71.4% and 56.7%, respectively [33]. This may be secondary to the high location and challenge in visualization in larger patients. US is heavily dependent on patient characteristics, which make usefulness and appropriateness variable across centers. Lower extremity US is not the optimal US study for the diagnosis of NIVL as it lacks duplex and therefore hemodynamic significance.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
T. US lower extremity with IV contrast

CEUS has little data to support its use in the evaluation of chronic iliac vein obstruction. CEUS was evaluated in a single study in comparison to conventional US and IVUS [33]. In this study, diagnostic accuracy for CEUS versus IVUS of the external iliac vein and common iliac vein were 71.3% and 53.2%, respectively. The intraclass correlation coefficient between enhanced and unenhanced US was 0.9, indicating very good agreement between the two imaging modalities. As CEUS is limited by technical considerations, it is not considered an ideal initial imaging study.

Variant 3:Adult. Pelvic pain. Suspected nonthrombotic iliac vein lesion. Venous etiology. Initial imaging.
U. US pelvis transabdominal

In patients with CPP of suspected venous etiology, transvaginal and transabdominal US evaluation can serve as a useful initial imaging study for the evaluation of NIVL and the exclusion of alternative pathology. Transabdominal US is limited by patient factors including body habitus and bowel gas. These limitations can be mitigated by scanning in a fasted state and the administration of simethicone [37]. Body habitus vein diameters can be accounted for by comparison to the patients ipsilateral or contralateral vessels.

In comparison to IVUS, transabdominal US was able to identify a ≥50% stenosis in 96% of patients with a 75% sensitivity, 75% specificity, 98% PPV, and 12% NPV [38]. When used to evaluate lesions of clinical significance with a =60% area reduction, the sensitivity and specificity fell to 66.7% with a PPV of 81.5% indicating a moderate diagnostic value.

In a study evaluating the effectiveness of treating combined iliac vein stenosis and ovarian vein reflux using iliac vein stenting alone, transabdominal US examination was used as the initial screening examination followed by diagnostic venography and IVUS to confirm stenosis severity [37]. Transabdominal US was furthermore used for follow-up evaluation.

In a study by Larkin et al[39], 421 patients were evaluated with transabdominal US, identifying NIVL in 46.7% of patients, gonadal vein incompetence in 40.1% of patients, and renal vein compression in 29.9% of patients. A history of deep vein thrombosis or CPP in women were significantly associated with NIVL (ß = 0.189, P = .001 and ß = 0.246, P < .001, respectively). NIVL was more likely to be identified as a culprit lesion than gonadal vein incompetence in women with CPP , highlighting the importance of a thorough venous evaluation.

Summary of Highlights

This is a summary of the key recommendations from the variant tables. Refer to the complete narrative document for more information.

- Variants 1 and 3: US duplex Doppler lower extremity, CTV abdomen and pelvis with bilateral lower extremity runoff with IV contrast, MRV abdomen and pelvis with IV contrast, MRV abdomen and pelvis without and with IV contrast, MRV abdomen and pelvis without IV contrast, and CTV abdomen and pelvis with IV contrast are usually appropriate for the initial evaluation of unilateral lower extremity edema and/or pelvic pain with suspected venous etiology. With the exception of US, these allow for evaluation of a nonthrombotic iliac vein lesion as well as alternative etiologies. Duplex US allows for evaluation of venous origin of a patient's symptoms.
- Variant 2: For asymptomatic patients no further imaging or evaluation is warranted.

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria.

Gender Equality and Inclusivity Clause

The ACR acknowledges the limitations in applying inclusive language when citing research studies that predates the use of the current understanding of language inclusive of diversity in sex, intersex, gender, and gender-diverse people. The data variables regarding sex and gender used in the cited literature will not be changed. However, this guideline will use the terminology and definitions as proposed by the National Institutes of Health.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as “Varies.”

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Disclaimer

[a]University of North Carolina School of Medicine, Chapel Hill, North Carolina. [b]Research Author, University of North Carolina, Chapel Hill, North Carolina. [c]Panel Chair, University of Michigan, Ann Arbor, Michigan. [d]Panel Vice-Chair, University of North Carolina School of Medicine, Chapel Hill, North Carolina. [e]The University of Vermont Medical Center, Burlington, Vermont. [f]Brigham & Women's Hospital and Harvard Medical School, Boston, Massachusetts; American College of Cardiology. [g]Allegheny Health Network, Pittsburgh, Pennsylvania. [h]Medical University of South Carolina, Charleston, South Carolina; Commission on Nuclear Medicine and Molecular Imaging. [i]Alpert Medical School of Brown University, Providence, Rhode Island; Society of Cardiovascular Computed Tomography. [j]University of Michigan, Ann Arbor, Michigan. [k]Medical College of Wisconsin, Milwaukee, Wisconsin; Society for Vascular Surgery. [l]University of Washington School of Medicine, Seattle, Washington; American Vein & Lymphatic Society. [m]Massachusetts General Hospital and Harvard Medical School, Boston, Massachusetts; American Society of Hematology. [n]Mayo Clinic Arizona, Phoenix, Arizona; American Society of Echocardiography. [o]Sanger Heart and Vascular Institute, Atrium Health, Advocate Enterprise, Charlotte, North Carolina, Primary care physician. [p]University of Virginia, School of Medicine, Charlottesville, Virginia. [q]Specialty Chair, The University of Vermont Medical Center, Burlington, Vermont.