Prior Authorization Review
Panel MCO Policy Submission

A separate copy of this form must accompany each policy submitted for review.
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<th>Plan: Aetna Better Health</th>
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Type of Submission – Check all that apply:
- [x] Revised Policy*
- [ ] Annual Review – No Revisions

*All revisions to the policy must be highlighted using track changes throughout the document. Please provide any clarifying information for the policy below:

**CPB 382 Intravascular Ultrasound**

This CPB has been revised to state that low-dose computed tomography is considered experimental and investigational as a screening test for asbestos-exposed individuals.

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<tr>
<th>Name of Authorized Individual (Please type or print):</th>
<th>Signature of Authorized Individual:</th>
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<tr>
<td>Dr. Bernard Lewin, M.D.</td>
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www.aetnabetterhealth.com/pennsylvania

Revised 04/12/2018
Intravascular Ultrasound

Policy

I. Aetna considers intravascular ultrasound (IVUS) medically necessary for any of the following situations:

A. As a clinical decision-making tool to evaluate the need for an intracoronary interventional procedure in a symptomatic member whose angiogram shows 50 to 70% stenosis(es); or

B. As a conclusive study to assess suspected left main stem coronary artery disease not revealed by coronary angiography; or

C. As a guidance for placement of vena caval filter; or

D. As a method for both guidance of placement of endoluminal devices and immediate assessment of the results of intracoronary interventional procedures (i.e., angioplasty, atherectomy, stenting), including those performed on coronary grafts; or

*Please see amendment for Pennsylvania Medicaid at the end of this CPB.*

Policy History

Last Review 04/12/2018
Effective: 02/01/2000
Next Review: 04/11/2019

Review History

Definitions

Additional Information

Clinical Policy Bulletin Notes
E. As a method for evaluation of cardiac allograft vasculopathy in post-cardiac transplantation recipients; or
F. Diagnosis of iliac vein compression syndrome (May-Thurner syndrome) of the left lower extremity.

II. Aetna considers the clinical application of IVUS experimental and investigational in screening for coronary artery disease, diagnosing coronary vulnerable plaques, and its use in other coronary procedures because its effectiveness for these indications has not been established.

III. Aetna considers the clinical application of IVUS experimental and investigational for any of the following (not an all-inclusive list) because its use for these indications has not been validated by clinical studies:

- Diagnosis of aortic dissection
- During endovascular interventions of failing hemodialysis access grafts
- Evaluation of chronic venous obstruction/venous stenting
- Evaluation of carotid artery stenosis
- Stenting of non-coronary arteries
- Diagnosis and treatment of functional popliteal artery entrapment syndrome
- Guidance during endovascular treatment of subclavian artery disease
- Prediction of clinical improvement following ilio-femoral vein stenting
- Other non-coronary vascular (i.e., including veins) procedures (other than those listed above)
See

CPB 0520 - Magnetic Resonance Imaging of the Cardiovascular System - Cardiac MRI
also (../500_599/0520.html)

Background

Angiography is limited in determining the anatomic severity of coronary artery stenoses because it represents only a projectional image of the vessel lumen without providing any information concerning vascular wall architecture. Catheter-based intravascular ultrasound (IVUS) has been developed in the last few years to provide this unique perspective for viewing vascular disease and the effects of intervention. As a complement to the information provided by coronary angiography, it has the unique ability to study vessel wall morphology in vivo, accurately displaying the details of vessel structure and tissue characterization by providing such critical information as the presence and degree of calcified plaque, quantifying luminal dimensions, and characterizing the composition of stenotic lesions into soft plaque, hard plaque, calcification, and type of thrombus.

Although these devices have only been available for a relatively short time, an array of studies demonstrating numerous diagnostic and therapeutic applications in interventional cardiology have been reported. The maturity of the technology is such that IVUS currently has a place as a clinical decision-making tool in patients with symptoms and intermediate
lesions, as a provisional study to assess left main stem disease suspected but not disclosed by coronary angiography, and as a method for both guidance of endoluminal devices and immediate assessment of the results of therapeutic techniques, including balloon angioplasty, atherectomy, and intravascular stent deployment.

More research is needed to answer some important questions regarding the whole array of potential applications of IVUS. Newer developments under scrutiny include combined devices, looking-forward ultrasound, high-frequency probes, imaging wires, tissue characterization and three dimensional (3-D) technology.

Its use in peripheral vascular disease remains as a research tool for investigation of blood vessel compliance, dynamic changes in the vessel wall caused by disease or pharmacologic intervention, and elucidation of the morphologic changes associated with the natural history of atherosclerosis. It has not been proven that changes in treatment made based on the results of intravascular ultrasound improve health outcomes in patients with non-coronary vascular diseases.

Intravascular ultrasound has been used as a guidance for placement of inferior vena cava filters. Ashley et al (2001) reported that IVUS is a more accurate method of localizing the renal veins and measuring vena cava diameter for placement of vena cava filters than contrast venography. Mathews et al (2003) noted that imaging of the vena cava prior to the insertion of
an inferior vena cava (IVC) filter is mandatory to assess IVC diameter and patency, delineate anatomy and venous anomalies, and to direct filter placement for appropriate deployment and avoidance of complications. The standard imaging technique is vena cavography, although alternative methods to evaluate the IVC include carbon dioxide venography, trans-abdominal duplex ultrasound, and IVUS.

Wellons et al (2004) stated that reports have demonstrated the benefit of prophylactic inferior vena cava filter (IVCF) placement to prevent pulmonary embolism. This study evaluated the potential for the bedside placement of a removable IVCF under "real-time" IVUS guidance. A total of 20 trauma patients underwent intensive care unit placement of a removable IVCF with IVUS guidance. All patients had ultrasonography of the femoral veins after placement to rule out post-procedure femoral vein thrombosis and radiographs to identify filter location. Nineteen of 20 IVCFs were placed at approximately the L2 level as verified by radiography. One patient had a large IVC (34 mm) and underwent bilateral common iliac IVCF placement under IVUS. Within 3 weeks of placement, 12 IVCFs were retrieved. Of the remaining 8 patients, 6 had indications for permanent implantation, 2 had contralateral deep venous thrombosis, and 1 had ipsilateral deep venous thrombosis. The authors concluded that bedside insertion of a removable IVCF with IVUS guidance and its removal are simple, safe, and accurate.
Passman et al (2005) stated that bedside placement of ICVF by using either trans-abdominal duplex ultrasonography or IVUS has been shown to be safe and effective. The authors reviewed techniques for bedside filter placement with trans-abdominal duplex ultrasonography, IVUS with dual venous access, and IVUS with single venous access. They noted that trans-abdominal duplex ultrasonography and IVUS remain their preferred techniques for filter placement when feasible, especially in critically ill and immobilized patients.

de Ribamar Costa et al (2007) stated that in the drug-eluting stent (DES) era, stent expansion remains an important predictor of re-stenosis and sub-acute thrombosis. Compliance charts are developed to predict final minimum stent diameter (MSD) and area (MSA). The objectives of the study were 2-fold: (i) to evaluate DES expansion by comparing IVUS-measured MSD and MSA against the values predicted by compliance charts and (ii) to compare each DES against its bare-metal stent (BMS) equivalent. These researchers enrolled 200 patients with de novo coronary lesions treated with single, greater than 2.5-mm Cypher (Cordis, Johnson & Johnson, Miami Lakes, FL) (sirolimus-eluting stent [SES], n = 133) or Taxus (Boston Scientific, Natick, MA) (paclitaxel-eluting stent [PES], n = 67) stent under IVUS guidance without another post-dilation balloon. They used a comparison cohort of 65 equivalent BMS (Express 2 [Boston Scientific], n = 37; Bx Velocity [Cordis, Johnson & Johnson], n = 28) deployed under similar conditions. The DES achieved only 75 % +/- 10 % of predicted MSD and 66 % +/- 17 % of predicted MSA; this was similar for SES and PES.
Furthermore, 24% of SES and 28% of PES did not achieve a final MSA of 5 mm(2), a consistent predictor of DES failure. The SES achieved 75% +/- 10% of predicted MSA versus 75% +/- 9% for Bx Velocity (p = 0.9). The PES achieved 79.9% +/- 14% of predicted MSA versus 79% +/- 10% for Express 2 (p = 0.8). Lesion morphology, arc and length of calcium, stent diameter and length, and implantation pressures did not affect expansion. The authors concluded that compliance charts fail to predict final MSD and MSA. A considerable percentage of DES does not achieve minimum standards of stent expansion. The SES and PES achieve similar expansion to their BMS platform, indicating that the polymer coating does not affect DES expansion in vivo. However, stent expansion can not be predicted from pre-intervention IVUS lesion assessment.

The randomized TAXUS II trial evaluates the polymer-based paclitaxel-eluting Taxus stent in slow- and moderate-release formulations. Tsuchida et al (2007) examined the consistency between angiographic and IVUS outcomes of late lumen loss (late loss) and neointimal growth to measure restenotic plaque load in Taxus and BMS. Serial angiographic and IVUS analyses were available in 155 event-free patients (BMS, n = 74; Taxus stent, n = 81) after the procedure, at 6 months, and at 2 years. For this sub-analysis, quantitative coronary angiographic (QCA) and IVUS measurements were used to derive late loss and neointimal volume. From after the procedure to 6 months, QCA and IVUS showed matching results for the 2 groups with significant decreases in late loss and neointimal volume in the Taxus versus the control group. From 6 months to 2 years, QCA and IVUS measurements
also showed results similar to those in the control group, demonstrating neointimal compaction over time. However, in the Taxus group, QCA late loss showed a non-significant decrease from 6 months to 2 years, whereas IVUS neointimal volume increased. The authors concluded that although QCA and IVUS results were similar over the first 6 months, long-term assessment of changes in re-stenotic plaque load showed discrepant findings for the Taxus stent. These findings suggest the need for critical re-evaluation of current end points and the use of more precise techniques to detect lumen and stent boundaries.

Hoffmann and colleagues (2008) stated that the impact of incomplete stent apposition (ISA) after drug-eluting stent implantation determined by IVUS on late clinical events is not well-defined. These researchers assessed the clinical impact of ISA after sirolimus-eluting stent (SES) placement during a follow-up period of 4 years.

Intravascular ultrasound at angiographic follow-up was available in 325 patients (SES, n = 180; BMS, n = 145); IVUS images were reviewed for the presence of ISA defined as one or more unapposed stent struts. Frequency, predictors and clinical sequel of ISA at follow-up after SES and BMS implantation were determined. Incomplete stent apposition at follow-up was more common after SES (n = 45 (25 %)) than after BMS (n = 12 (8.3 %), p < 0.001). Canadian Cardiology Society class III or IV angina at stent implantation (odds ratio (OR) = 4.69, 95 % confidence interval [CI]: 2.15 to 10.23, p < 0.001) and absence of diabetes (OR = 3.42, 95 % CI: 1.05 to 11.1, p = 0.041) were predictors of ISA at follow-up after SES placement. Rate of
myocardial infarction tended to be slightly higher for ISA than for non-ISA patients. When only SES patients were considered, major adverse cardiac event free survival at 4 years was identical for those with and without ISA at follow-up (11.1 % versus 16.3 %, \( p = 0.48 \)). The authors concluded that ISA at follow-up is more common after SES implantation than after BMS implantation. Considering the current very sensitive IVUS definition, ISA appears to be an IVUS finding without significant impact on the incidence of major adverse cardiac events even during long-term follow-up.

García-García et al (2008) stated that detection of coronary vulnerable plaques in vivo is essential for studying their natural history and assessing potential treatment modalities and, therefore, may have an important impact on the prevention of acute myocardial infarction and death. Currently, conventional grayscale IVUS, IVUS-virtual histology (IVUS-VH) and palpography data are being collected with the same catheter during the same pullback. A combination of this catheter with either thermography capability or additional imaging, such as optical coherence tomography or spectroscopy, would be an exciting development. Intravascular magnetic resonance imaging also holds much promise. To date, none of the techniques described above has been sufficiently validated and, most importantly, their predictive value for adverse cardiac events remains elusive. The authors noted that very rigorous and well-designed studies are needed for defining the role of each diagnostic modality. In this regard, Ibanez and colleagues (2009) consider IVUS as an
investigational technique for the visualization as well as the compositional characterization of atheromatous plaques.

Clementi et al (2009) noted that plaque reduction with the use of pioglitazone and statin combination therapy has been observed in carotid plaque. These researchers examined the effect of combination therapy with statins and pioglitazone on coronary plaque regression and composition with the use of IVUS and IVUS-VH. These investigators analyzed 29 plaques in 25 diabetic patients with angiographic evidence of non-significant coronary lesions with IVUS-VH. Patients were treated with 80 mg of atorvastatin and 30 mg of pioglitazone daily for 6 months. After 6 months of therapy, IVUS-VH of each lesion was re-acquired. Mean elastic external membrane volume was significantly reduced between baseline and follow-up (343.0 mm versus 320.5 mm; p < 0.05) as was mean total atheroma volume (179.3 mm versus 166.6 mm; p < 0.05). Change in total atheroma volume showed a 6.3 % mean reduction. Areas of fibrous tissue, fibro-lipidic tissue and calcium decreased over the 6 months of follow-up, although not significantly. On the other hand, the necrotic core increased from 9 % to 14 % (p < 0.05). The authors concluded that these findings demonstrated that atorvastatin/pioglitazone association is able to induce significant regression of coronary atherosclerosis, acting on plaque composition. Moreover, they noted that their findings are preliminary results and will be confirmed in an ongoing randomized placebo-controlled multi-center trial.
An assessment prepared for the Agency for Healthcare Research and Quality (Lau et al, 2004) concluded that currently, neither IVUS nor other imaging technologies can reliably identify vulnerable plaque prospectively, i.e., before rupture.

Konig et al (2008a) noted that cardiac allograft vasculopathy (CAV) is the major limitation in survival of patients following heart transplantation. Cardiac allograft vasculopathy is angiographically silent in the early phase after operation. Intravascular ultrasound is a more sensitive method to detect the early stages of CAV and provides information about its development. Recent IVUS studies demonstrated a rapid progression of CAV within the 1st year after transplantation as a predictor of morbidity and mortality. These investigators evaluated the plaque composition of early atherosclerosis in transplant patients by radiofrequency (RF) analysis. Coronary angiography and IVUS with Virtual Histology (VH) software were used to assess 18 patients early after heart transplantation (1.71 +/- 0.47 months). The plaque composition was determined by IVUS radiofrequency data analysis. Tissue maps were reconstructed from RF data using VH-IVUS software. The VH-IVUS acquisition was performed with standardized IVUS and the VH-IVUS console. Coronary angiography did not show any wall irregularities; IVUS demonstrated donor-transmitted atherosclerosis in 6 of 18 patients (33.33 %). The incidence, amount of plaque burden, and plaque composition was significantly related to donor age. By VH-IVUS analysis, the plaque composition consisted
mainly of fibrotic tissue. The authors concluded that donor-transmitted coronary atherosclerosis is present early after heart transplantation and can not be detected by coronary angiography; VH-IVUS gives detailed information about the plaque distribution and the plaque composition.

Konig and associates (2008b) stated that the survival of heart transplant recipients is limited by CAV. Intravascular ultrasound and IVUS-derived RF plaque composition analysis (IVUS-RF) provide further information about the process of coronary atherosclerosis. These researchers assessed the time-dependent differences in disease progression in patients with CAV. A total of 56 patients were divided into 3 groups according to time interval after transplantation: (i) Group I: 1 to 3 months (n = 18); (ii) Group II: 1 to 5 years (n = 20); and (iii) Group III: 5 to 15 years (n = 18). IVUS-RF revealed time-dependent increases in all plaque components. The largest increase was shown for fibrotic, fibro-fatty and necrotic tissue between Groups I and II. Dense calcium area increased uniformly in all groups. IVUS-RF-derived plaque type analysis revealed predominantly fibrotic plaques in all groups with a decrease of frequency over time. Fibro-lipidic and fibrotic-calcific plaques increased uniformly. High-risk lesions, such as thick-cap fibro-atheromas (FAs), increased in Groups I and II and decreased in Group III. Thin-cap FAs were detected only in Group III. The authors concluded that IVUS-RF, as compared with gray-scale IVUS, provides better detailed information regarding the development of CAV by plaque morphology and composition analysis in different stages after heart transplantation. Serial IVUS-RF analysis in these patients may
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improve the stratification of heart transplant recipients.

Hernandez et al (2009) characterized graft coronary artery disease by means of VH-IVUS at different time-points of follow-up and correlated plaque composition with clinical factors. These investigators included 67 patients (mean age of 7.6 +/- 5.7 years post-heart transplant (HTx); and IVUS gray-scale evaluation was performed on all patients. VH-IVUS analysis was done in those patients showing intimal thickening greater than 0.5 mm at the 3 more significant lesions (3 cross-sections for each) of the left anterior descending artery. VH-IVUS analysis was obtained on 58 patients (86.5 %). They found a significant correlation between time of HTx and IVUS gray-scale parameters (plaque area and plaque burden), with both increasing over time. They also found a significant correlation between time and VH-IVUS-derived plaque components, necrotic core and calcium, which increased with time, and fibrous and fibrofatty components, both decreased at follow-up. VH-IVUS results were also related to donor age and cardiovascular risk factors. The authors observed a time-related change in VH-IVUS-derived plaque composition. Necrotic core and calcium, typical atheromatous components, become more prevalent with time after HTx, especially when influenced by cardiovascular risk factors. The presence of a necrotic core in the early stages was linked to older donor age.

Raichlin et al (2009a) investigated tissue characterization of the coronary allograft atherosclerotic plaque with VH-IVUS imaging to assess the presence and predictors of vessel wall
inflammation and its significance in CAV progression. A total of 86 patients with CAV underwent VH-IVUS examination of the left anterior descending coronary artery 3.61 +/- 3.04 years following cardiac transplantation. Based on the VH-IVUS plaque characteristics, coronary allograft plaque was divided on VH-IVUS-derived "inflammatory" (VHD-IP) (necrotic core and dense calcium greater than or equal to 30 %) and "non-inflammatory" plaque (VHD-NIP) (necrotic core and dense calcium less than 30 %). Total rejection scores were calculated based on the 2004 International Society of Heart and Lung Transplantation rejection grading system. Overall, the mean percentage of fibrous, fibro-fatty, dense calcified, and necrotic core plaques in a mean length of 62.3 +/- 17.4 mm of the left anterior descending coronary artery were 50 +/- 17 %, 16 +/- 11 %, 15 +/- 11 %, and 18 +/- 9 %, respectively. Patients with a 6-month total rejection score greater than 0.3 had significantly higher incidence of VHD-IP than those with a 6-month total rejection score less than or equal to 0.3 (69 % versus 33 %, p = 0.011). The presence of VHD-IP at baseline was associated with a significant increase in plaque volume (2.42 +/- 1.78 mm(3)/mm versus -0.11 +/- 1.65 mm (3)/mm, p = 0.010), plaque index (7 +/- 9 % versus 0 +/- 8 %, p = 0.04), and re-modeling index (1.24 +/- 0.44 versus 1.09 +/- 0.36, p = 0.030) during 12 months of follow-up when compared with the presence of VHD-NIP at baseline and during follow-up. The authors concluded that the presence of VHD-IP as assessed by VH-IVUS is associated with early recurrent rejection and with higher subsequent progression of CAV. A
VH-IVUS assessment may add important information in the evaluation of transplant recipients.

Raichlin et al (2009b) investigated the role of cellular rejection in CAV development. The study comprised 252 cardiac transplant recipients (mean age of 49.02 +/- 17.05 years; mean follow-up of 7.61 +/- 4.49 years). Total rejection score (TRS) based on the 2004 International Society of Heart and Lung Transplantation R grading system (0R = 0, 1R = 1, 2R = 2, 3R = 3) and any rejection score (ARS; calculated as 0R = 0, 1R = 1, 2R = 1; 3R = 1, or the number of rejections of any grade) were normalized for the total number of biopsy specimens. Cardiac allograft vasculopathy was defined as coronary stenosis of 40 % or more and/or distal pruning of secondary side branches. A total of 32 patients had undergone 3-dimensional IVUS at baseline and with VH-IVUS at 24 months. In uni-variate analysis, 6-month TRS (hazard ratio [HR], 1.9; 95 % CI: 0.99 to 3.90, p = 0.05) and ARS (HR, 2.22; 95 % CI: 1.01 to 4.95; p = 0.047) were associated with increased risk of CAV. In multi-variate analysis, 6-month TRS (HR, 2.84; 95 % CI: 1.44 to 6.91, p = 0.02) was significantly associated with increased risk of CAV onset. The 12- and 24-month rejection scores were not risk factors for the onset of CAV. By Kaplan-Meier analysis, 6-month TRS exceeding 0.3 was associated with a significantly shorter time to CAV onset (p = 0.018). There was direct correlation (r = 0.44, p = 0.012) between TRS at 6 months and the percentage of necrotic core shown by VH-IVUS at 24 months. The authors concluded that recurrent cellular rejection has a cumulative effect on the onset of CAV. The mechanism may
be due to increased inflammation resulting in increased plaque burden suggesting a relationship between the immune basis of cellular rejection and CAV.

Sarno and colleagues (2009) used VH-IVUS to characterize plaque burden and tissue composition over time in heart transplant recipients. These researchers recruited patients undergoing heart transplantation in 4 centers in Europe and the U.S. between 2004 and 2006. They used IVUS to obtain morphological plaque measurements and to perform virtual histology in the left anterior descending coronary artery. Data were characterized according to the duration between transplantation and IVUS assessment: less than or equal to 24, greater than 24 to 60, greater than 60 to 120 and greater than 120 to 192 months. They assessed vessels from 152 patients (mean age of 58 +/- 12 years) a mean of 70 +/- 53 months (range of 1 week to 16 years) after transplantation. Plaque burden of greater than 40% was observed in 26% of vessels analyzed, with increases from baseline being seen in all time categories. If assessed greater than 24 months after transplantation, necrotic core and dense calcified volumes were significantly greater than at baseline (p = 0.0005 and p = 0.01, respectively). Time since heart transplantation and donor age and recipient age were independent predictive factors of increased necrotic core content. Necrotic core volume greater than 2.01 mm(3), diabetes mellitus, donor age older than 40 years, follow-up from transplantation longer than 5 years and recipient age older than 58 years were associated with the need for re-vascularization. The authors concluded that in CAV, plaque burden and
composition change over time and seem to affect clinical outcome. This relationship might facilitate identification of high-risk patients in whom the value of more aggressive medical therapy should be tested.

Diethrich and colleagues (2007) determined the diagnostic accuracy of virtual histology IVUS imaging (VH IVUS) of carotid plaque and assessed the feasibility of VH IVUS to identify plaque with embolic potential in patients undergoing carotid artery stenting (CAS). A total of 30 patients (17 men; mean age of 74 +/- 7 years) were entered non-randomly into a single-center, prospective, 2-arm study following FDA and Institutional Review Board approval. In the 1st arm, 15 patients underwent VH IVUS examination of carotid plaque with a cerebral protection device immediately followed by carotid endarterectomy (CEA). A comparison of "virtual" with true histology was then performed, classifying plaque type by VH IVUS and histopathology in a blinded study. In the 2nd arm, 15 patients undergoing CAS had a preliminary VH IVUS scan performed with cerebral protection. Debris collected from the filter following stenting was examined histologically and compared with the VH IVUS data. The diagnostic accuracy of VH IVUS to agree with true histology in different carotid plaque types was 99.4 % in thin-cap fibroatheroma, 96.1 % for calcified thin-cap fibroatheroma, 85.9 % in fibroatheroma, 85.5 % for fibrocalcific, 83.4 % in pathological intimal thickening, and 72.4 % for calcified fibroatheroma. Filter debris was captured in 2 patients prior to CEA and in 4 patients undergoing CAS for restenosis; VH IVUS
classification of plaque composition was consistent with the histological evaluation of filter fragments. Calcified nodules projecting into the carotid artery lumen were associated with a higher incidence of previous neurological symptoms (66.7 % versus 33.3 %, p < 0.05), while patients on aspirin has significantly less necrotic lipid core plaque detected by VH IVUS than patients not taking aspirin (6.4 % +/- 4.7 % versus 9.7 % +/- 2.8 %, p < 0.05). The authors concluded that these findings showed a strong correlation between VH IVUS plaque characterization and the true histological examination of the plaque following endarterectomy, particularly in "vulnerable" plaque types. The feasibility study to examine VH IVUS data and the filter debris histology in CAS patients supports a larger prospective study.

Mokin et al (2013) noted that IVUS is an important diagnostic tool in many interventions, particularly coronary and carotid artery angioplasty and stenting. In contrast, its application in the management of diseases of the cerebral venous system remains an unexplored territory. These investigators reported the findings of 3 patients in whom IVUS was used during angiography for the evaluation of venous flow obstruction secondary to venous sinus thrombosis, venous sinus stenosis, and a transverse sinus mass lesion, respectively. In addition, these researchers reviewed current literature to summarize previous experience, focusing on the advantages and limitations of IVUS technology in interventional cardiology, carotid artery disease, and venous disease. In all 3 cases, IVUS was used without any complications and provided critical information
that guided further management of these distinct diseases. Intravascular US helped diagnose the presence of intraluminal thrombus, severe stenosis, and a mass lesion in the transverse sinuses and also helped assess the response to angioplasty of the stenotic regions. The authors concluded that IVUS is a promising tool that has potential to improve diagnostic accuracy and to guide the management of several diseases of the cerebral venous system.

Hitchner et al (2014) stated that the clinical use of IVUS in carotid intervention is not well characterized. These investigators evaluated the role of IVUS in carotid plaque characterization and determined whether it could be predictive of procedure-related microemboli. From July 2010, patients with severe carotid stenosis who underwent elective carotid stenting procedures were prospectively enrolled. Intravascular US evaluation was performed before stent placement. Patient demographics, co-morbidities, and pre-operative images were recorded. Comparison of pre- and post-operative diffusion-weighted magnetic resonance images was used to identify the number of procedure-related microemboli. Intravascular US-derived minimal lumen diameter and vessel wall plaque characteristics were collected. Uni-variate and multi-variate logistic regressions were used to search for associations between IVUS-derived virtual histology (VH) data and incidence of microemboli. A total of 38 high-risk patients receiving carotid stenting were enrolled. Among them, 25 patients had type I aortic arches and 17 of the patients were symptomatic (pre-operative stroke or transient ischemic attack). Virtual
histology IVUS data did not show strong associations with microemboli, however, a trend was found between the area of fibrous tissue and median or more incidence of microemboli ($p = 0.099$). Intravascular US-defined vessel diameter maximum was associated with median or more incidence of microemboli ($p = 0.042$). In addition, median or more incidence of microemboli showed trends with proximal common carotid artery calcification ($p = 0.056$) and with being over the age of 80 ($p = 0.06$). Contralateral carotid occlusion or high-grade stenosis was associated with post-operative contralateral microemboli ($p = 0.036$). The authors concluded that they demonstrated that peri-procedural carotid IVUS is clinically feasible. Moreover, they stated that VH IVUS may be helpful in better understanding plaque morphology and determining optimal stent placement. However, its use in predicting microembolization remains limited.

Witzenbichler et al (2014) examined if IVUS guidance is associated with improved clinical outcomes after DES implantation in an unrestricted patient population. Assessment of Dual Antiplatelet Therapy With Drug-Eluting Stents (ADAPT-DES) was a prospective, multi-center, non-randomized "all-comers" study of 8,583 consecutive patients at 11 international centers designed to determine the frequency, timing, and correlates of stent thrombosis and adverse clinical events after DES. Propensity-adjusted multi-variable analysis was performed to examine the relationship between IVUS guidance and 1-year outcomes. IVUS was utilized in 3,349 patients (39 %), and larger-diameter devices, longer stents, and/or higher
Inflation pressures were used in 74% of IVUS-guided cases. IVUS guidance compared with angiography guidance was associated with reduced 1-year rates of definite/probable stent thrombosis (0.6% [18 events] versus 1.0% [53 events]; adjusted HR, 0.40; 95% CI: 0.21 to 0.73; p = 0.003), myocardial infarction (MI) (2.5% versus 3.7%; adjusted HR, 0.66; 95% CI: 0.49 to 0.88; p = 0.004), and composite adjudicated major adverse cardiac events (i.e., cardiac death, MI, or stent thrombosis) (3.1% versus 4.7%; adjusted HR, 0.70; 95% CI: 0.55 to 0.88; p = 0.002). The benefits of IVUS were especially evident in patients with acute coronary syndromes (ACS) and complex lesions, although significant reductions in major adverse cardiac events were present in all patient subgroups those with including stable angina and single-vessel disease. The authors concluded that in ADAPT-DES, the largest study of IVUS use to date, IVUS guidance was associated with a reduction in stent thrombosis, MI, and major adverse cardiac events within 1 year after DES implantation.

Ahn et al (2014) stated that there are conflicting data regarding the benefit of IVUS-guided percutaneous coronary intervention (PCI) over angiography-guided PCI. Since the last meta-analysis was published, several new studies have been reported. These researchers performed a comprehensive meta-analysis to evaluate the clinical impact of IVUS-guided PCI with DES compared with conventional angiography-guided PCI. This meta-analysis included 26,503 patients from 3 randomized and 14 observational studies; 12,499 patients underwent IVUS-guided PCI and 14,004
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underwent angiography-guided PCI. Main outcome measures were total mortality, MI, stent thrombosis, and target lesion revascularization (TLR). IVUS-guided PCI was significantly associated with more stents, longer stents, and larger stents. Regarding clinical outcomes, IVUS-guided PCI was associated with a significantly lower risk of TLR (OR 0.81, 95 % CI: 0.66 to 1.00, p = 0.046). In addition, the risk of death (OR 0.61, 95 % CI: 0.48 to 0.79, p < 0.001), MI (OR 0.57, 95 % CI: 0.44 to 0.75, p < 0.001), and stent thrombosis (OR 0.59, 95 % CI: 0.47 to 0.75, p < 0.001) were also decreased. The authors concluded that the findings of this meta-analysis demonstrated that IVUS-guided PCI was associated with lower risk of death, MI, TLR, and stent thrombosis after DES implantation.

May-Thurner syndrome (MTS), also known as the iliac vein compression syndrome, is a rare condition in which compression of the common venous outflow tract of the left lower extremity may cause discomfort, swelling, pain or deep venous thrombosis (DVT) in the iliofemoral vein. May-Thurner syndrome should be considered in patients who have no other obvious reason for hypercoagulability and who present with left lower extremity thrombosis. Venography will demonstrate the classical syndrome when causing deep venous thrombosis. Intravascular ultrasound can detect nonthrombotic iliac vein lesions in symptomatic patients.

Hong et al (2015) examined if the long-term clinical outcomes with IVUS-guided drug-eluting stent implantation are superior to those with angiography-guided implantation in patients with long coronary lesions. The Impact of
Intravascular Ultrasound Guidance on Outcomes of Xience Prime Stents in Long Lesions (IVUS-XPL) randomized, multi-center trial was conducted in 1,400 patients with long coronary lesions (implanted stent greater than or equal to 28 mm in length) between October 2010 and July 2014 at 20 centers in Korea. Patients were randomly assigned to receive IVUS-guided (n = 700) or angiography-guided (n = 700) everolimus-eluting stent implantation. Primary outcome measure was the composite of major adverse cardiac events, including cardiac death, target lesion-related MI, or ischemia-driven TLR at 1 year, analyzed by intention-to-treat. Overall, 1-year follow-up was complete in 1,323 patients (94.5%). Major adverse cardiac events at 1 year occurred in 19 patients (2.9%) undergoing IVUS-guided and in 39 patients (5.8%) undergoing angiography-guided stent implantation (absolute difference, -2.97% [95% CI: -5.14% to -0.79%]) (HR, 0.48 [95% CI: 0.28 to 0.83], p = 0.007). The difference was driven by a lower risk of ischemia-driven TLR in patients undergoing IVUS-guided (17 [2.5%]) compared with angiography-guided (33 [5.0%]) stent implantation (HR, 0.51 [95% CI: 0.28 to 0.91], p = 0.02). Cardiac death and target lesion-related MI were not significantly different between the 2 groups. For cardiac death, there were 3 patients (0.4%) in the IVUS-guided group and 5 patients (0.7%) in the angiography-guided group (HR, 0.60 [95% CI: 0.14 to 2.52], p = 0.48). Target lesion-related MI occurred in 1 patient (0.1%) in the angiography-guided stent implantation group (p = 0.32). The authors concluded that among patients requiring long coronary stent implantation, the use of IVUS-guided everolimus-eluting stent implantation, compared with
angiography-guided stent implantation, resulted in a significantly lower rate of the composite of major adverse cardiac events at 1 year. These differences were primarily due to lower risk of TLR.

In reviewing the afore-mention study, Meyer (2015) noted that “Despite strikingly low adverse event rates with drug-eluting stent placement, intravascular ultrasound-guided stent implantation yielded modest benefits over angiography-guided implantation”. The editorial comment stated that “Although these findings show that everolimus-eluting stents are safe and effective in patients with long coronary lesions, IVUS-guided stent implantation yielded a relatively small absolute reduction in coronary events (2.9 %) over angiography-guided stent implantation -- a difference primarily related to fewer TLRs. Considering this modest advantage (as well as the higher costs of IVUS-guided implantation), IVUS should be used only for selected lesions”.

**Diagnosis of Aortic Dissection:**

The diagnosis of aortic dissection is generally made non-invasively using computed tomography (CT), magnetic resonance imaging (MRI), or trans-esophageal echocardiography (TEE).

On behalf of the American College of Emergency Physicians, Diercks et al (2015) stated that in adult patients with suspected non-traumatic thoracic aortic dissection, emergency physicians may use CT angiogram (CTA) to exclude thoracic
aortic dissection because it has accuracy similar to that of magnetic resonance angiogram (MRA) and TEE. It did not mention IVUS.

Furthermore, an UpToDate review on “Clinical features and diagnosis of acute aortic dissection” (Manning and Black, 2016) does not mention IVUS as a diagnostic tool.

**Diagnosing Functionally Significant Non-Left Main Coronary Artery Disease and Determining Whether or Not To Proceed With the PCI of Intermediate Non-Left Main Coronary Artery Stenosis:**

Jang and colleagues (2016) noted that IVUS-guided PCI frequently results in unnecessary stenting due to the low positive predictive value of IVUS-derived minimal lumen area (MLA) for identification of functionally significant coronary stenosis. In a meta-analysis, these investigators appraised the diagnostic accuracy of IVUS-derived MLA compared with the fractional flow reserve (FFR) to assess intermediate coronary stenosis. These investigators searched Medline and Cochrane databases for studies using IVUS and FFR methods to establish the best MLA cut-off values to predict significant non-left main coronary artery stenosis. Summary estimates were obtained using a random-effects model. The 17 studies used in this analysis enrolled 3,920 patients with 4,267 lesions. The weighted overall mean MLA cut-off value was 2.58 mm2. The pooled MLA sensitivity that predicted functionally significant coronary stenosis was 0.75 (CI: 0.72 to 0.77) and the specificity was 0.66 (CI: 0.64 to 0.68). The positive likelihood ratio (LR) was 2.33 (CI: 2.06 to 2.63) and LR (-) was 0.33
(CI: 0.26 to 0.42). The pooled diagnostic OR (DOR) was 7.53 (CI: 5.26 to 10.76) and the area under the summary receiver operating characteristic curve (ROC) for all the trials was 0.782 with a Q point of 0.720. Meta-regression analysis demonstrated that an FFR cut-off point of 0.75 was associated with a 4 times higher diagnostic accuracy compared to that of 0.80 (relative DOR: 3.92; 95% CI: 1.25 to 12.34). The authors concluded that IVUS-derived MLA has limited diagnostic accuracy in predicting functionally significant coronary artery disease and cannot be used alone to make the decision whether or not to proceed with the PCI of intermediate non-left main coronary artery stenosis.

This study had several drawbacks: (i) the majority of studies included in this analysis were observational studies from different cohorts with no randomized controlled trials (RCTs). This caused the findings to have insufficient power, (ii) the proportion of the involved coronary arteries and extent of coronary diseases were different across the included studies. It was not possible to suggest the diagnostic performance of IVUS-MLA according to the lesion location, (iii) the researchers could not perform separate subgroup analyses of all coronary arteries and their location (proximal-, mid-, distal-) because very few studies presented such data, (iv) these investigators could not differentiate patients presenting with stable angina and acute coronary syndrome, despite differences in clinical significance of IVUS-derived MLA and FFR, (v) the IVUS criteria to discriminate the functional significance of lesions in different locations were applied differently across studies, and (vi) the
authors did not take into account the plaque composition that can affect clinical outcomes.

During Endovascular Interventions of Failing Hemodialysis Access Grafts:

Ross and colleagues (2016) noted that arteriovenous (AV) access graft complications represent a serious complication in patients undergoing hemodialysis. Angiography is one method of visualizing them. However, angiography is not always an effective means of detecting lesions that occur in this context. Intravascular ultrasound is an adjunct modality used to identify stenoses responsible for failing access by identifying multiple stenoses, including those that are most severe. In a pilot, single-center randomized study, these researchers examined the value of IVUS in patients with failing AV access grafts by comparing digital subtraction angiography (DSA) alone with DSA followed by IVUS. They compared IVUS with DSA in patients with failing hemodialysis access grafts. It consisted of 100 randomized hemodialysis patients presenting with failing AV access who were being considered for endovascular intervention. Interventions in the control group were guided by DSA alone, whereas interventions in the test group were guided by DSA followed by IVUS. Patients were observed for 6 months after intervention. The primary end-point was the time in days to AV access graft failure after the index intervention, expressed as median and interquartile range (IQR). Secondary analyses included influence of DSA and IVUS on index procedure decision-making and percentage of patients with AV access graft re-interventions or discontinuation through 3 and 6
months. Median time to first AV graft re-intervention or discontinuation was 61 days in the test group and 30 days in the control group (p = 0.16), with analysis limited to patients who experienced re-intervention or discontinuation (n = 59). Intravascular US resulted in a change in treatment plan in 76 % (44/58) of patients, with no treatment change after IVUS in 24 % (14/58) of patients. At 6 months, approximately 35 % of patients in both the control and test groups remained free from re-interventions (p = 0.88).

At 6 months, approximately 75 % of patients in the control group and 80 % of patients in the test group remained free from AV graft discontinuation or abandonment (p = 0.45). The authors concluded that the findings of this pilot study suggested that addition of IVUS to standard angiography during endovascular interventions of failing hemodialysis access grafts holds potential to extend the time to the first re-intervention. The data supported the design and execution of an adequately powered randomized trial with longer follow-up to reliably discern the clinical benefit of IVUS as an addition to standard angiography in the setting of failing AV access grafts.

Diagnosis and Treatment of Ilio-Femoral Vein Obstruction:

Neglen and Raju (2002) compared IVUS with transfemoral venography in the assessment of chronic iliac vein obstruction. IVUS and standard, single-plane, transfemoral venography were performed in 304 consecutive limbs during balloon dilation and stenting of an obstructed iliac venous segment. The appearance of the obstruction was described, and the degree of
stenosis (maximal diameter reduction) was estimated with venography and IVUS. The stenotic area was derived with diameter calculations (πr²) and also was measured with the built-in software of the IVUS apparatus before and after dilation and stenting in 173 limbs. Pre-operative hand/foot differential pressure and pre-operative dorsal foot venous and intra-operative transfemoral hyperemia-induced pressure elevations after intra-arterial injection of papaverine hydrochloride were measured. With IVUS, fine intraluminal and mural details were detected (e.g., trabeculation, frozen valves, mural thickness, and outside compression) that were not seen with venography. The median stenosis (with diameter reduction) on venographic results was 50% (range of 0 to 100%) and on IVUS results was 80% (range of 25% to 100%). In a comparison with IVUS as the standard, venography had poor sensitivity (45%) and negative predictive value (NPV; 49%) in the detection of a venous area stenosis of greater than 70%. The actual stenotic area was more severe when measured directly with IVUS (0.31 cm²; range of 0 to 1.68 cm²) versus derived (0.36 cm²; range of 0 to 3.08 cm²; p < 0.001), probably as a result of the non-circular lumen geometry of the stenosis. No correlation was found between any of the pre-operative or intra-operative pressure measurements and degree of stenosis with or without collaterals. When collaterals were present, a more severe stenosis (median of 85%; range of 25% to 100%) was observed (versus a 70% stenosis in the absence of collaterals; range of 30% to 99%; p < 0.001), along with actual stenotic area (with collaterals: median, 0.24 cm²; range of 0 to 1.18 cm²);
without collaterals: median of 0.45 cm(2); range of 0.02 to 1.68 cm(2); p < 0.01) and a higher rate of hyperemia-induced pressure gradient (greater than or equal to 2 mm Hg; with collaterals, 34 %; without collaterals, 11 %; p < 0.05). The authors concluded that venous IVUS appeared to be superior to single-plane venography for the morphologic diagnosis of iliac venous outflow obstruction and is an invaluable assistance in the accurate placement of venous stents after venoplasty. No pre-operative or intra-operative pressure test appeared to adequately measure the hemodynamic significance of the stenosis. In lieu of adequate hemodynamic tests, IVUS determination of morphologically significant stenosis appeared to be presently the best available method for the diagnosis of clinically important chronic iliac vein obstruction. Collateral formation should perhaps be looked on as an indicator of a more severe stenosis, although significant obstruction may exist with no collateral formation. Moreover, they stated that better tests for the evaluation of hemodynamic significance of venous obstruction must be developed.

Gagne and associates (2017) noted that the Venogram versus IVUS for Diagnosing Iliac vein Obstruction (VIDIO) trial was designed to compare the diagnostic efficacy of IVUS with multi-planar venography for ilio-femoral vein obstruction. During a 14-month period beginning July 2014, a total of 100 patients with chronic Clinical, Etiologic, Anatomic, and Pathophysiologic clinical class C4 to C6 venous disease and suspected ilio-femoral vein obstruction were enrolled at 11 U.S. and 3 European sites. The inferior vena cava and
common iliac, external iliac, and common femoral veins were imaged. Venograms were measured for vein diameter; IVUS provided diameter and area measurements. Multi-planar venograms included 3 views: antero-posterior and 30-degree right and left anterior oblique views. A core laboratory evaluated the de-identified images, determining stenosis severity as the ratio between minimum luminal diameter and reference vessel diameter, minimal luminal area, and reference vessel area. A 50 % diameter stenosis by venography and a 50 % cross-sectional area (CSA) reduction by IVUS were considered significant. Analyses assessed change in procedures performed on the basis of imaging method and concordance of measurements between each imaging method. Venography identified stenotic lesions in 51 of 100 subjects, whereas IVUS identified lesions in 81 of 100 subjects. Compared with IVUS, the diameter reduction was on average 11 % less for venography (p < 0.001). The intra-class correlation coefficient was 0.505 for vein diameter stenosis calculated with the 2 methods. IVUS identified significant lesions not detected with 3-view venography in 26.3 % of patients. Investigators revised the treatment plan in 57 of 100 cases after IVUS, most often because of failure of venography to detect a significant lesion (41/57 [72 %]). IVUS led to an increased number of stents in 13 of 57 subjects (23 %) and the avoidance of an endovascular procedure in 3 of 57 subjects (5 %). Overall, IVUS imaging changed the treatment plan in 57 patients; 54 patients had stents placed on the basis of IVUS detection of significant ilio-femoral vein obstructive lesions not appreciated with venography, whereas 3 patients with significant
lesions on venography had no stent placed on the basis of IVUS. The authors concluded that IVUS is more sensitive for assessing treatable ilio-femoral vein stenosis compared with multi-planar venography and often led to revised treatment plans and the potential for improved clinical outcome.

Lower Limb Re-Vascularization in Patients with Peripheral Arterial Disease:

Makris and colleagues (2017) examined the safety and effectiveness of IVUS during lower limb endovascular interventions in patients with peripheral arterial disease (PAD). These researchers carried out a systematic review of the PubMed and Scopus databases according to PRISMA guidelines. Clinical studies evaluating IVUS as an adjunct to angiography during revascularization procedures in patients with PAD were included. A total of 13 studies were identified, with a total number of 2,258 patients having had IVUS for PAD intervention; 7 studies investigated the role of IVUS for angioplasty and stenting, with the majority being retrospective cohorts. Technical success and patency rates ranged from 90 to 100 % and 45 to 100 %, respectively, with a follow-up that ranged from 4.3 to 63 months; 3 of these studies compared IVUS and non-IVUS guided angioplasty and demonstrated a significant difference in the events of amputations or re-interventions in favor of the IVUS group. Furthermore, 5 studies evaluated IVUS use in true-lumen re-entry, with the technical success ranging between 97 to 100 %. In 1 study, where IVUS was used for atherectomy, the technical success was 100 % and the long-term patency was 90 % during a 12-
month follow-up. Overall, no significant peri-/post-operative IVUS related complications were reported, whereas, 2 studies suggested an IVUS-associated increase in procedure costs that ranged from $1,080 to $1,333. The authors concluded that there is limited and heterogeneous evidence regarding the use of IVUS for the management of PAD. They stated that further research is needed to elucidate the optimal role of IVUS in PAD as well as the cost-effectiveness of this approach for routine use in the management of PAD.

Diagnosis and Treatment of Functional Popliteal Artery Entrapment Syndrome:

Boniakowski and associates (2017) stated that functional popliteal artery entrapment syndrome (PAES) can be difficult to diagnose, as the imaging modalities presently employed are designed to detect anatomic entrapment. These researchers described a novel imaging technique to aid in diagnosis in this cohort. A 22-year old cyclist presented with exercise-limiting claudication; MRA with provocative maneuvers was non-diagnostic. Digital subtraction angiography revealed long-segment occlusion of the popliteal artery with plantar flexion; however, the specific site of compression remained unclear; IVUS allowed specific localization of compression and further confirmed the diagnosis. The authors reported IVUs as an adjunctive imaging modality and proposed the use of this approach as a definitive diagnostic technique to aid in the diagnosis and treatment of PAES. These preliminary findings need to be validated by well-designed studies.
Furthermore, an UpToDate review on “Calf injuries not involving the Achilles tendon” (Rogers Rainbow and Fields, 2018) does not mention IVUS as a management tool.

Guidance During Endovascular Treatment of Subclavian Artery Disease:

Chung and associates (2017) evaluated the short- and long-term efficacy of IVUS guidance during endovascular treatment (EVT) of subclavian artery disease. The multi-center SCALLOP registry (Subclavian artery disease treated with endovascular therapy; multi-center retrospective registry) was interrogated to identify 542 patients who underwent successful EVT for SCAD between January 2003 and December 2012. Lesions were classified according to the use of IVUS guidance: 177 patients (mean age of 68.9 ± 8.6 years; 149 men) with and 373 patients (mean age of 69.9 ± 8.7 years; 275 men) without. The main outcome was the difference in primary patency; secondary outcomes were differences in assisted primary patency, secondary patency, overall survival (OS), freedom from major adverse cardiovascular events [MACE; all-cause mortality, MI, and stroke], and freedom from major adverse events (MAE). Multi-variate analysis of the IVUS+ group was performed to identify predictors of failure; results were presented as the HR and 95 % CI. A total of 538 (97.8 %) lesions were treated with stents and 12 lesions by balloon angioplasty alone. Peri-procedural and in-hospital overall complication rates did not differ significantly between IVUS+ (10.2 %) and IVUS- (8.8 %, p = 0.617). Long-term follow-up demonstrated no significant difference between IVUS+ and IVUS-.
groups in 5-year all-cause mortality (p = 0.37), MI (p = 0.07), stroke (p = 0.31), or MACE (p = 0.07). However, 5-year primary patency was significantly higher in the IVUS+ group (88.5 % versus 77.7 %, p = 0.03). There were no group differences in 5-year assisted primary patency (90.4 % versus 89.9 %, p = 0.81) or secondary patency (99.4 % versus 97.1 %, p = 0.25). Multivariate analysis of the IVUS+ group identified in-hospital stroke (HR 16.92, 95 % CI: 3.60 to 79.42, p < 0.01) and combined use of balloon-expandable and self-expanding stents (HR 5.59, 95 % CI: 1.22 to 25.65, p = 0.02) as independent negative predictors of primary patency. The authors concluded that these findings suggested that IVUS guidance can significantly improve long-term primary patency following endovascular treatment of subclavian artery disease. These findings need to be validated by well-designed studies.

Prediction of Clinical Improvement Following Ilio-Femoral Vein Stenting:

Gagne and co-workers (2018) noted that selecting patients for ilio-femoral vein stenting has traditionally relied on the identification and quantification of stenotic lesions with imaging such as multi-planar venography. Recently, IVUS imaging has become more available. However, to-date, the usefulness of these imaging modalities using the customary greater than 50 % treatment threshold for diameter (multi-planar venography) and area (IVUS) stenosis of ilio-femoral veins has not been validated prospectively within the context of clinical improvement. The multi-center Venogram Versus Intravascular Ultrasound for Diagnosing
and Treating Ilio-femoral Vein Obstruction (VIDIO) trial prospectively enrolled 100 symptomatic patients (Clinical Etiologic Anatomic Pathophysiologic [CEAP] classification of 4 to 6) with suspected ilio-femoral venous outflow disease. Venous stenting for presumed significant ilio-femoral vein stenosis, based on imaging and clinical findings, was performed on 68 patients. Based on imaging, stenosis was characterized as non-thrombotic in 48 patients and post-thrombotic in 20 patients. Each underwent baseline and post-stenting venography and IVUS to compare the diagnostic and clinical usefulness of the tests. The revised Venous Clinical Severity Score was used to assess clinical patient outcome. A greater than 4-point reduction in the revised Venous Clinical Severity Score (rVCSS) between baseline and 6 months was used as an indicator of clinically meaningful improvement. Receiver operating characteristic curve analysis was used to determine the optimal diameter and area thresholds for prediction of clinical improvement. Clinical improvement after stenting was best predicted by IVUS baseline measurement of area stenosis (area under the curve, 0.64; p = 0.04), with greater than 54% estimated as the optimal threshold of stenosis indicating interventional treatment. With measurement of lumen gain from baseline to after the procedure, the optimal reduction in vein stenosis correlative of later clinical improvement was greater than 41%; IVUS measurement of area stenosis was most predictive (area under the curve, 0.70; p = 0.004). Venographic measurements of baseline stenosis and stenotic change were not predictive of later improvement. In a 48-patient non-thrombotic
subset analysis, IVUS diameter rather than area measurements of baseline stenosis were significantly predictive of clinical success, but indicated a higher optimal threshold of stenosis (greater than 61 %) may be necessary. The authors concluded that this analysis found that IVUS demonstrated predictive accuracy for imaging and guiding treatment of ilio-femoral venous lesions, whereas venography did not display significant predictive usefulness. Stenosis of greater than 54 % for the entire patient cohort, as measured by IVUS area stenosis, was estimated as the threshold for clinically significant stenosis to indicate stenting. A higher threshold for treatment of non-thrombotic stenosis may be necessary. Moreover, they stated that additional analyses -- ideally larger studies with a control arm -- of venous occlusive disease are needed to further validate these findings.

The authors stated that the major drawback of this study was its relatively small sample size (n = 68), which was insufficient for robust statistical comparisons. Another significant drawback was the study design, which did not include an observational control arm. Thus, the ROC threshold used to determine procedural success or failure was perhaps less precise, because a negative cohort had to be carved somewhat arbitrarily out of patients undergoing intervention, with many patients categorized as negative despite reporting substantial improvement (up to and including a 4-point improvement) on rVCSS at 6 months. Another drawback was a much greater proportion of patients categorized as non-thrombotic (71 %)
than post-thrombotic (29 %), limiting the relevance and significance of these findings for post-thrombotic lesions.

CPT Codes / HCPCS Codes / ICD-10 Codes

Information in the [brackets] below has been added for clarification purposes. Codes requiring a 7th character are represented by "+":

<table>
<thead>
<tr>
<th>Code</th>
<th>Code Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPT codes covered if selection criteria are met:</td>
<td></td>
</tr>
<tr>
<td>37252</td>
<td>Intravascular ultrasound (noncoronary vessel) during diagnostic evaluation and/or therapeutic intervention, including radiological supervision and interpretation; initial noncoronary vessel (List separately in addition to code for primary procedure)</td>
</tr>
<tr>
<td>37253</td>
<td>each additional noncoronary vessel (List separately in addition to code for primary procedure)</td>
</tr>
<tr>
<td>+92978</td>
<td>Endoluminal imaging of coronary vessel or graft using intravascular ultrasound (IVUS) or optical coherence tomography (OCT) during diagnostic evaluation and/or therapeutic intervention including imaging supervision, interpretation and report; initial vessel (List separately in addition to code for primary procedure)</td>
</tr>
<tr>
<td>+92979</td>
<td>each additional vessel (List separately in addition to code for primary procedure)</td>
</tr>
<tr>
<td>Other CPT codes related to the CPB:</td>
<td></td>
</tr>
<tr>
<td>0075T - 0076T</td>
<td>Transcatheter placement of extracranial vertebral artery stent(s), including radiologic supervision and interpretation, open or percutaneous</td>
</tr>
<tr>
<td>Code</td>
<td>Code Description</td>
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<tr>
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<tr>
<td>33500 - 33530</td>
<td>Surgery for coronary artery anomalies, endoscopy, venous grafting only for coronary artery bypass, and combined arterial-venous grafting for coronary bypass</td>
</tr>
<tr>
<td>33533 - 33536</td>
<td>Coronary artery bypass, using arterial graft(s)</td>
</tr>
<tr>
<td>33548</td>
<td>Surgical ventricular restoration procedure, includes prosthetic patch, when performed (eg, ventricular remodeling, SVR, SAVER, DOR procedures)</td>
</tr>
<tr>
<td>+ 33572</td>
<td>Coronary endarterectomy, open, any method, of left anterior descending, circumflex, or right coronary artery performed in conjunction with coronary artery bypass graft procedure</td>
</tr>
<tr>
<td>35450</td>
<td>Transluminal balloon angioplasty, open; renal or other visceral artery</td>
</tr>
<tr>
<td>35452</td>
<td>aortic</td>
</tr>
<tr>
<td>35458</td>
<td>brachiocephalic trunk or branches, each vessel</td>
</tr>
<tr>
<td>35460</td>
<td>venous</td>
</tr>
<tr>
<td>35471</td>
<td>Transluminal balloon angioplasty, percutaneous; renal or visceral artery</td>
</tr>
<tr>
<td>35472</td>
<td>aortic</td>
</tr>
<tr>
<td>35475</td>
<td>brachiocephalic trunk or branches, each vessel</td>
</tr>
<tr>
<td>35476</td>
<td>venous</td>
</tr>
<tr>
<td>Code</td>
<td>Code Description</td>
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<tr>
<td>36901</td>
<td>Introduction of needle(s) and/or catheter(s), dialysis circuit, with diagnostic angiography of the dialysis circuit, including all direct puncture(s) and catheter placement(s), injection(s) of contrast, all necessary imaging from the arterial anastomosis and adjacent artery through entire venous outflow including the inferior or superior vena cava, fluoroscopic guidance, radiological supervision and interpretation and image documentation and report</td>
</tr>
<tr>
<td>36902</td>
<td>with transluminal balloon angioplasty, peripheral dialysis segment, including all imaging and radiological supervision and interpretation necessary to perform the angioplasty</td>
</tr>
<tr>
<td>36903</td>
<td>with transcatheter placement of intravascular stent(s), peripheral dialysis segment, including all imaging and radiological supervision and interpretation necessary to perform the stenting, and all angioplasty within the peripheral dialysis segment</td>
</tr>
<tr>
<td>37191</td>
<td>Insertion, repositioning or retrieval (removal) of intravascular vena cava filter, endovascular approach including vascular access, vessel selection, and radiological supervision and interpretation, intraprocedural roadmapping, and imaging guidance (ultrasound and fluoroscopy), when performed</td>
</tr>
<tr>
<td>Code</td>
<td>Code Description</td>
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<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>37215-37216</td>
<td>Transcatheter placement of intravascular stent(s), cervical carotid artery, open or percutaneous, including angioplasty, when performed, and radiological supervision and interpretation</td>
</tr>
<tr>
<td>37217</td>
<td>Transcatheter placement of intravascular stent(s), intrathoracic common carotid artery or innominate artery by retrograde treatment, open ipsilateral cervical carotid artery exposure, including angioplasty, when performed, and radiological supervision and interpretation</td>
</tr>
<tr>
<td>37218</td>
<td>Transcatheter placement of intravascular stent(s), intrathoracic common carotid artery or innominate artery, open or percutaneous antegrade approach, including angioplasty, when performed, and radiological supervision and interpretation</td>
</tr>
<tr>
<td>37220-37223</td>
<td>Revascularization, endovascular, open or percutaneous; iliac artery</td>
</tr>
<tr>
<td>37224-37227</td>
<td>femoral, popliteal artery(s)</td>
</tr>
<tr>
<td>37228-37235</td>
<td>tibial, peroneal artery</td>
</tr>
<tr>
<td>37236</td>
<td>Transcatheter placement of an intravascular stent(s) (except lower extremity, cervical carotid, extracranial vertebral or intrathoracic carotid, intracranial, or coronary), open or percutaneous, including radiological supervision and interpretation and including all angioplasty within the same vessel, when performed; initial artery</td>
</tr>
<tr>
<td>Code</td>
<td>Code Description</td>
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</tr>
<tr>
<td>37237</td>
<td>each additional artery (List separately in addition to code for primary procedure)</td>
</tr>
<tr>
<td>37238</td>
<td>Transcatheter placement of an intravascular stent(s), open or percutaneous, including radiological supervision and interpretation and including angioplasty within the same vessel, when performed; initial vein</td>
</tr>
<tr>
<td>37239</td>
<td>each additional vein (List separately in addition to code for primary procedure)</td>
</tr>
<tr>
<td>61630</td>
<td>Balloon angioplasty, intracranial (eg, atherosclerotic stenosis), percutaneous</td>
</tr>
<tr>
<td>61635</td>
<td>Transcatheter placement of intravascular stent(s), intracranial (eg, atherosclerotic stenosis), including balloon angioplasty, if performed</td>
</tr>
<tr>
<td>75962</td>
<td>Transluminal balloon angioplasty, peripheral artery other than cervical carotid, renal or other visceral artery, iliac or lower extremity, radiological supervision and interpretation</td>
</tr>
<tr>
<td>+ 75964</td>
<td>Transluminal balloon angioplasty, each additional peripheral artery other than cervical carotid, renal or other visceral artery, iliac or lower extremity, radiological supervision and interpretation (list separately in addition to code for primary procedure)</td>
</tr>
<tr>
<td>75966</td>
<td>Transluminal balloon angioplasty, renal or other visceral artery, radiological supervision and interpretation</td>
</tr>
<tr>
<td>Code</td>
<td>Code Description</td>
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<tr>
<td>---------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>+ 75968</td>
<td>Transluminal balloon angioplasty, each additional visceral artery, radiological supervision and interpretation (List separately in addition to code for primary procedure)</td>
</tr>
<tr>
<td>+ 92973</td>
<td>Percutaneous transluminal coronary thrombectomy (List separately in addition to code for primary procedure)</td>
</tr>
<tr>
<td>92997 - 92998</td>
<td>Percutaneous transluminal pulmonary artery balloon angioplasty</td>
</tr>
</tbody>
</table>

Other HCPCS codes related to the CPB:

- C1753 Catheter, intravascular ultrasound
- C1880 Vena cava filter

ICD-10 codes covered if selection criteria are met:

- I20.0 - I25.9 Ischemic heart diseases
- I65.21 - I65.29 Occlusion and stenosis of carotid artery [chronic venous obstruction/venous stenting]
- I87.1 Compression of vein [chronic venous obstruction/venous stenting]
- T86.290 Cardiac allograft vasculopathy
- Z98.61 Coronary angioplasty status

ICD-10 codes not covered for indications listed in the CPB:

- I71.00 - I71.03 Dissection of aorta

The above policy is based on the following references:


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Amendment to
Aetna Clinical Policy Bulletin Number:
0382 Intravascular Ultrasound

There are no amendments for Medicaid.

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