Intra-vascular Optical Coherence Tomography

Number: 0829

Policy

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

Aetna considers intra-vascular optical coherence tomography (OCT) experimental and investigational for any indications, including the following because of insufficient evidence of its effectiveness.

- Assessment of acute coronary syndrome Assessment
- of carotid artery stenosis/stroke risk
- Assessment of pulmonary arterial wall fibrosis (as a prognostic marker of pulmonary arterial hypertension)
- Assessment of severity of coronary artery lesion (identification and risk stratification of vulnerable plaque)
- Diagnosis and rupture assessment of intracranial aneurysm
- Evaluation of arterial bifurcations covered by flow diverting stents
- Follow-up evaluation of renal arteries after radiofrequency catheter-based renal denervation
- Guidance of intra-coronary stenting and follow-up evaluation of post-stent placement
- Prediction of periprocedural myocardial injury in persons

Policy History

Last Review 10/13/2016
Effective: 07/17/2012
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Review History

Definitions

Additional Information

Clinical Policy Bulletin Notes
with stable angina pectoris

- Treatment (as an adjunct to percutaneous coronary interventions)

See also CPB 0382 - Intravascular Ultrasound (../300_399/0382.html), and CPB 0520 - Magnetic Resonance Imaging of the Cardiovascular System - Cardiac MRI (../500_599/0520.html).

Background
Disruption of a vulnerable coronary plaque with subsequent thrombosis is currently recognized as the primary mechanism for acute myocardial infarction. Although such plaques are considered to have a thin (less than 65 microns) fibrous cap overlying a lipid pool, imaging modalities in current clinical practice do not have sufficient resolution to identify thin fibrous caps. Optical coherence tomography (OCT) is a new imaging technology capable of obtaining cross-sectional images of coronary vessels. As an optical analog of ultrasound, OCT uses a high-bandwidth infra-red light source instead of an ultrasound-emitting crystal to create high-resolution cross-sectional images of coronary vessels. The resolution of the current OCT system is 10 to 20 microns, which is approximately 10-fold higher than that of intra-vascular ultrasound (IVUS). Furthermore, OCT can visualize stent mal-apposition and tissue protrusion after stenting and neointimal hyperplasia at follow-up.

While there is extensive research on intra-vascular OCT, this new imaging modality has not been adequately assessed. Thus, its clinical value has yet to be established. Stamper et al (2006) stated that the identification of unstable plaque is central in risk-stratifying patients for acute coronary events; and OCT is a modality that has shown considerable promise for the identification of high-risk plaques. The authors summarized the current state of intra-vascular OCT imaging, focusing on potential markers of instability and current limitations. They concluded that OCT is a promising technology for the assessment of vulnerable and unstable plaque. The advantages
of OCT include its high-resolution, fast data acquisition rate, small inexpensive designs, as well as its ability to be combined with adjuvant techniques. They stated that future work will focus on improving plaque risk-stratification, especially the identification of reliable markers within the images. Manfrini et al (2007) stated that intra-vascular OCT's high-resolution (10 to 20 microns) makes it a very interesting method for assessing atherosclerotic plaque microstructure in patients suffering from coronary artery disease (CAD). However, significant limitations still exist, including poor penetration in non-transparent tissue. Moreover, Kubo and Akasaka (2008) noted that OCT is a specialized research tool that might provide new insights into the diagnosis and treatment of CAD.

Jang et al (2005) examined the use of intra-vascular OCT for evaluating vulnerable plaques in persons undergoing cardiac catheterization for acute and stable coronary syndromes. Patients undergoing cardiac catheterization were enrolled and categorized according to their clinical presentation: recent acute myocardial infarction (AMI), acute coronary syndromes (ACS) constituting non-ST-segment elevation AMI and unstable angina pectoris (UAP), or stable angina pectoris (SAP). Two observers independently analyzed the images using the previously validated criteria for plaque characterization. Of 69 patients enrolled, 57 (20 with AMI, 20 with ACS, and 17 with SAP) had analyzable images. In the AMI, ACS, and SAP groups, lipid-rich plaque (defined by lipid occupying greater than or equal to 2 quadrants of the cross-sectional area) was observed in 90 %, 75 %, and 59 %, respectively (p = 0.09). The median value of the minimum thickness of the fibrous cap was 47.0, 53.8, and 102.6 microns, respectively (p = 0.034). The frequency of thin-cap fibro-atheroma (TCFA), defined by lipid-rich plaque with cap thickness less than or equal to 65 microns, was 72 % in the AMI group, 50 % in the ACS group, and 20 % in the SAP group (p = 0.012). No procedure-related complications occurred. The authors concluded that OCT is a safe and effective modality for characterizing coronary atherosclerotic plaques in-vivo; TCFA was more frequently observed in patients with AMI or ACS than SAP. This was the
first study to compare detailed in-vivo plaque morphology in patients with different clinical presentations. Drawbacks of this study included: (i) interference from blood, (ii) poor tissue penetration, and (iii) relatively small sample size.

Raffel et al (2008) evaluated the in-vivo association between coronary artery remodeling and underlying plaque characteristics identified by OCT. Optical coherence tomography and IVUS imaging were performed at corresponding sites in patients undergoing catheterization; OCT plaque characteristics for lipid content, fibrous cap thickness, and macrophage density were derived using previously validated criteria. Thin-cap fibro-atheroma was defined as lipid-rich plaque (2 or more quadrants) with fibrous cap thickness less than 65 microns. Remodeling index (RI) was calculated as the ratio of the lesion to the reference external elastic membrane area. A total of 54 lesions from 48 patients were imaged. Positive remodeling compared with absent or negative remodeling was more commonly associated with lipid-rich plaque (100 versus 60 versus 47.4 %, p = 0.01), a thin fibrous cap (median 40.2 versus 51.6 versus 87 microns, p = 0.003) and the presence of TCFA (80 versus 38.5 versus 5.6 %, p < 0.001). Fibrous cap macrophage density was also higher in plaques with positive remodeling showing a positive linear correlation with the RI (r = 0.60, p < 0.001). The authors concluded that coronary plaques with positive remodeling exhibit characteristic features of vulnerable plaque. This may explain the link between positive remodeling and unstable clinical presentations. They noted that prospective, longitudinal studies with a larger cohort are needed to confirm these findings and to investigate their clinical significance. Drawbacks of this study included: (i) potential selection bias, (ii) blood interference, (iii) limited penetration depth (2 to 3 mm), and (iv) the small size of the cohort.

Yamaguchi et al (2008) evaluated the safety and feasibility of intra-coronary imaging with OCT in the clinical setting; 76 patients with CAD from 8 centers were enrolled. The OCT imaging system (ImageWire, Light Imaging Inc., Westford, MA)
consists of a 0.006-inch fiberoptic core that rotates within a 0.016-inch transparent sheath. Optical coherence tomography imaging was performed during occlusion of the artery with a compliant balloon and continuous flushing. Intra-vascular ultrasound imaging was performed in the same segments. Vessel occlusion time was 48.3 +/- 13.5 seconds and occlusion-balloon pressure was 0.4 +/- 0.1 atmospheres. Flushing with lactated Ringer's solution was performed at a rate of 0.6 +/- 0.4 ml/s. No significant adverse events, including vessel dissection or fatal arrhythmia, were observed. Procedural success rates were 97.3 % by OCT and 94.5 % by IVUS. The OCT image wire was able to cross 5 of 6 tight lesions that the IVUS catheter was unable to cross. Of the 98 lesions in which both OCT and IVUS were successfully performed, OCT imaging had an advantage over IVUS for visualization of the lumen border. Minimum lumen diameter and area measurements were significantly correlated between OCT and IVUS imaging (r = 0.91, p < 0.0001 and r = 0.95, p < 0.0001, respectively). The authors concluded that this study demonstrated the safety and feasibility of OCT imaging in the clinical setting. They stated that further analysis with large populations are needed to establish and refine clinical applications and safety of the intra-vascular OCT imaging system. Drawbacks of this study included (i) small sample size, (ii) the study was not designed to evaluate potential advantages of intra-vascular OCT over IVUS resulting from an increase in resolution.

Kawamori et al (2010) examined the usefulness of OCT to evaluate vessel response after stent implantation by comparing with that of IVUS. A total of 18 patients undergoing percutaneous coronary intervention (PCI) who provided consent for both IVUS and OCT usage pre- and post-PCI procedure were enrolled. The lumen area at the distal site of the culprit lesion was smaller on OCT images than on IVUS images due to proximal vessel occlusion, whereas the lumen area at the proximal site of the lesion did not differ between OCT and IVUS images (distal site: 4.6 +/- 2.0 versus 5.0 +/- 1.8 mm2; p = 0.0004; proximal site: 5.5 +/- 2.3 versus 5.6 +/- 2.3 mm2; p = 0.8160). Stent mal-apposition was more frequently
observed by OCT (30 %) than by IVUS (5 %, p = 0.0381). Stent edge dissection was not detected by IVUS, but was detected in 10 % by OCT. Tissue prolapse was identified in all stents by OCT and in 5 % by IVUS. Thrombus was observed in 15 % by OCT and in 5 % by IVUS. The authors concluded that proximal coronary occlusion during OCT imaging was possibly related to under-estimation of vessel sizing at distal reference. These findings suggested that OCT might provide more detailed information on the presence of tissue prolapse, thrombus formation and edge dissection than IVUS. The authors stated that further study is needed to assess the clinical utility of OCT. Drawbacks of this study included: (i) this is a non-randomized, retrospective study based on a small sample size, raising the possibility of selection bias, (ii) OCT has limited ability to visualize certain lesions, such as ostial lesions due to the risks associated with producing a blood-free environment by occlusion balloon. Non-occlusion flushing technique may be an alternative for visualizing proximal lesion, however, it has a limitation for scanning length. Also, severely calcified tortuous vessels could not be imaged with OCT due to the difficulty of passing the occlusion balloon through the lesion, (iii) the current OCT system has a limited penetration depth, which can be a disadvantage in visualizing whole vessel structure. Thus, if a new imaging device can achieve greater penetration depth without sacrificing its resolution (e.g., combined imaging device of IVUS and OCT), this may provide more comprehensive information, possibly offering more benefit during PCI.

Kubo et al (2011) noted that recent IVUS studies have demonstrated that hypo-echoic plaque with deep ultrasound attenuation despite absence of bright calcium is common in ACS. Such "attenuated plaque" may be an IVUS characteristic of unstable lesion. These investigators used OCT in 104 patients with UAP to compare lesion characteristics between IVUS-detected attenuated plaque and non-attenuated plaque. Intra-vascular US-detected attenuated plaque was observed in 41 (39 %) patients; OCT-detected lipidic plaque (88 % versus 49 %, p < 0.001), TCFA (48 % versus 16 %, p < 0.001), plaque rupture (44 % versus 11 %, p < 0.001), and intra-coronary
thrombus (54 % versus 17 %, p < 0.001) were more often seen in IVUS-detected attenuated plaques compared with non-attenuated plaques. The authors concluded that IVUS-detected attenuated plaque has many characteristics of unstable coronary lesion. The presence of attended plaque might be an important marker of lesion instability. They stated that well-designed studies are needed to ascertain the prognostic values of OCT in the setting of ACS. Drawbacks of this study included: (i) this was a retrospective study in non-consecutive UAP patient. Thus, the prevalence, clinical feature, and prognostic implication of IVUS-detected attenuated plaque need to be examined in a larger population study, (ii) lack of a comparison group with stable presentation, (iii) in the IVUS analysis, acoustic shadowing in attenuated plaques may interfere with calculation of remodeling and plaque burden, (iv) in the OCT analysis, signal attenuation of lipidic tissue or thrombus may preclude visualization and measurement of the entire atherosclerotic plaque, and (v) 40-MHz IVUS transducers were used according to the most previous studies of attenuated plaques. These findings may be not applicable for the IVUS images acquired by other frequency transducers, because the IVUS frequency can affect the degrees of signal penetration (e.g., 20-MHz transducers utilized in virtual histology IVUS have greater penetration than 40-MHz transducers).

Miyamoto et al (2011) evaluated plaque characteristics of OCT-derived TCFA by integrated backscatter IVUS (IB-IVUS). A total of 81 coronary lesions with plaque burden greater than 40 % were selected and analyzed with both IB-IVUS and OCT. The OCT-derived TCFA was defined as a presence of thin fibrous cap (less than 65 microns) overlying a signal-poor lesion with diffuse border representing a lipid-rich plaque. By conventional gray-scale IVUS, external elastic membrane (EEM) cross-sectional area (CSA), lumen CSA, plaque plus media (P+M) CSA, plaque burden and RI were measured. By IB-IVUS, plaque characteristics were further classified as fibrosis, dense fibrosis, calcification, or lipid pool. Optical coherence tomography identified 40 TCFAs (49 %) and 41 non-TCFAs. The EEM CSA,
P+M CSA, plaque burden, and RI were significantly larger in OCT-derived TCFA than non-TCFA. By IB-IVUS, percentage lipid pool area (= lipid pool area/P+M CSA × 100) was significantly higher (62.4 +/- 12.8 % versus 38.4 +/- 13.1 %, p < 0.0001) and percentage fibrosis area (= fibrosis area/P+M CSA × 100) was significantly lower (34.6 +/- 11.4 % versus 50.5 +/- 8.7 %, p < 0.0001) in OCT-derived TCFA than non-TCFA. By receiver-operator characteristic curve analysis, percentage lipid pool area greater than or equal to 55 %, percentage fibrosis area less than or equal to 41 %, and RI greater than or equal to 1.0 were predictors of OCT-derived TCFA. The authors concluded that OCT-derived TCFA had larger plaque burden and positive remodeling with predominant lipid component and less fibrous plaque assessed by IB-IVUS. Drawbacks of this study included (i) a relatively small number of patients, (ii) OCT image artifacts may have resulted in some mis-interpretations, and (iii) only limited vessel areas were observed due to system limitations for imaging certain complex lesions.

Uemura et al (2012) clarified the morphological characteristics of non-significant coronary plaques (NSCPs) in patients with CAD using intra-vascular OCT. A total of 53 consecutive CAD patients undergoing PCI were enrolled and 69 NSCPs (percent diameter stenosis less than 50 %) were identified on baseline angiogram. Baseline characteristics of NSCPs were evaluated by OCT, and patients were followed-up prospectively. At the second coronary angiography, the baseline OCT characteristics and plaque progression were correlated. During the 7-month follow-up period, 13 NSCPs showed angiographic progression and 56 NSCPs did not. Baseline minimum lumen diameter and diametric stenosis were similar between NSCPs with and without progression. Compared with NSCPs without progression, those with progression showed a significantly higher incidence of intimal laceration (61.5 versus 8.9 %, p < 0.01), micro-channel (76.9 versus 14.3 %, p < 0.01), lipid pools (100 versus 60.7 %, p = 0.02), TCFA (76.9 versus 14.3 %, p < 0.01), macrophage images (61.5 versus 14.3 %, p < 0.01), and intra-luminal thrombi (30.8 versus 1.8 %, p < 0.01). Uni-variate regression analysis showed that TCFA and micro-channel
images showed high correlation with subsequent luminal progression [odds ratio (OR): 20.0, p < 0.01 and OR: 20.0, p < 0.01, respectively]. The authors concluded that OCT-based complex characteristics of TCFA and micro-channel were the potential predictors of subsequent progression of NSCPs in patients with CAD. Drawbacks of this study included (i) small sample size, (ii) limited penetration depth of intra-vascular OCT made it difficult to assess plaque features deep in coronary artery walls, (iii) technical complexity of procedures needed to get high-quality OCT images, and (iv) it could not be completely ruled out that image wire and occlusion balloon may have injured the vessel contributing to subsequent plaque progression.

Gonzalo et al (2012) stated that the value of OCT to determine stenosis severity remains unsettled. These researchers evaluated the diagnostic efficiency of OCT in identifying hemodynamically severe coronary stenoses as determined by fractional flow reserve (FFR). Concomitant OCT and IVUS area measurements were performed in a subgroup of patients to compare the diagnostic efficiency of both techniques. A total of 61 stenoses with intermediate angiographic severity were studied in 56 patients. Stenoses were labeled as severe if FFR less than or equal to 0.80. Optical coherence tomoraphy interrogation was performed in all cases, with concomitant IVUS imaging in 47 cases. Angiographic stenosis severity was 50.9 +/- 8 % diameter stenosis with 1.28 +/- 0.3 mm minimal lumen diameter. Fractional flow reserve was less than or equal to 0.80 in 28 (45.9 %) stenoses. An overall moderate diagnostic efficiency of OCT was found (area under the curve [AUC]: 0.74; 95 % confidence interval [CI]: 0.61 to 0.84), with sensitivity/specificity of 82 %/63 % associated with an optimal cutoff value of 1.95 mm(2). Comparison of the results in patients with simultaneous IVUS and OCT imaging revealed no significant differences in the diagnostic efficiency of OCT (AUC: 0.70; 95 % CI: 0.55 to 0.83) and IVUS (AUC. 0.63; 95 % CI: 0.47 to 0.77; p = 0.19). Sensitivity/specificity for IVUS was 67 %/65 % for an optimal cut-off value of 2.36 mm(2). In the subgroup of small vessels (reference diameter less than 3 mm) OCT
showed a significantly better diagnostic efficiency (AUC: 0.77; 95 % CI: 0.60 to 0.89) than IVUS (AUC: 0.63; 95 % CI: 0.46 to 0.78) to identify functionally significant stenoses (p = 0.04). The authors concluded that OCT has a moderate diagnostic efficiency in identifying hemodynamically severe coronary stenoses. Although OCT seems slightly superior to IVUS for this purpose (particularly in vessels less than 3 mm), its low specificity precludes its use as a substitute of FFR for functional stenosis assessment.

In an assessment of clinical applications of OCT, Prati et al (2010) stated that OCT is a novel intra-vascular imaging modality that enables a high-resolution arterial wall imaging, in the range of 10 to 20 microns. These investigators stated that OCT has the potential to become the most accurate imaging modality to assess lumen dimensions and facilitate the application of automatic algorithms of measurements. However, further studies are needed to address both this point and the identification of lumen area values that discriminate lesions capable of inducing effort ischemia. These researchers also noted that it has to be emphasized that identification of atherosclerotic plaque components by OCT depends on the penetration depth of the incident light beam into the vessel wall. The depth of penetration is greatest for fibrous tissue and least for thrombi with calcium and lipid tissue having intermediate values. They stated that additional clinical–pathological correlation studies, particularly with the new upcoming technologies, are important to further define tissue characteristics by OCT. The main limitation of OCT centers on its inability to measure plaque burden whose thickness exceeds 1.3 to 1.5 mm. This drawback may affect the role of OCT in the setting of interventional procedures guidance, as well as overall disease severity. Furthermore, these researchers noted that while OCT may prove to be an important addition to IVUS because it can discriminate among the different plaque components whose changes may be important in serial studies, robust validation studies are needed to verify whether OCT is capable of measuring serial changes in plaque components indicative of vulnerability such as fibrous cap thickness or lipid
pool extension. Furthermore, due to its ability to address plaque components related to vulnerability, OCT may have a role for assessing the risk of myocardial infarction. This clinical application, however, needs to be proven in the future.

Elmariyah and Jang (2011) stated that "[a]lthough the ability to identify and characterize thrombus using OCT is an advance over other imaging modalities, the clinical implications of this information remain unclear. In the setting of PCI, angiographically obvious intra-coronary thrombus is a known risk factor for adverse cardiovascular events; however, at high-resolution, thrombus is a very common finding on OCT after PCI. Further quantification and characterization of intra-coronary thrombus using OCT may effectively risk-stratify patients undergoing PCI and may guide anti-thrombotic therapy. The ongoing Massachusetts General Hospital OCT Registry, an international collaborative effort that will include 3,000 patients, may ultimately answer questions regarding the impact of thrombus burden and characteristics on patient outcomes".

Cambon et al (2011) stated that OCT is a new imaging technique recently applied to coronary arteries. With a resolution 10 times higher than that of IVUS, it allows an analysis of the atherosclerotic plaque and its components, indicating its possible vulnerable character, and can identify the culprit lesion and the presence of thrombus in the course of acute events. It allows quality control of good apposition of stents to the wall and essentially tracks the downstream dissection. In the longer term, it evaluates the endothelization and in-stent re-stenosis. Its scope thus extends to basic research and the pharmaceutical industry where it plays a new reference tool in the monitoring of atherosclerotic plaques and stents with drug treatment. This invasive imaging technique is limited by its cost and artifacts but new generation OCT can better overcome them. The authors concluded that OCT appears to be a promising intra-vascular imaging technique whose feasibility and clinical applications, however, require confirmation by randomized, clinical trials to better define its
place in the cardiac catheterization laboratory.

Gutierrez-Chico et al (2012) stated that in cardiology, OCT has remained hitherto as a research tool for characterization of vulnerable plaques and evaluation of neointimal healing after stenting. However, OCT is now successfully applied in different clinical scenarios, and the introduction of frequency domain analysis simplified its application to the point that it can be considered a potential alternative to IVUS for clinical decision-making in some cases. These investigators reviewed the use of OCT for assessment of lesion severity, characterization of ACS, guidance of intra-coronary stenting, and evaluation of long-term results.

Tsimikas and DeMaria (2012) stated that OCT is an emerging technology. They noted that "due to its limited penetration and high attenuation by some plaque components, it remains to be seen whether it will ultimately discriminate lipid versus nonlipid components such as the necrotic cores that are associated with high potential for plaque rupture. It also can not fully measure plaque burden, particularly in large arteries, or adequately assess remodeling due to depth of penetration issues, and may not be amenable to testing pharmacological therapeutic interventions as IVUS .... Several gaps of knowledge remains: (i) most of the data come from small studies and largely descriptive datasets; (ii) limitations in imaging the vessel wall related to the procedure and generation of imaging artifacts will likely become more apparent as more experience is obtained; (iii) the OCT evidence based on plaque composition will need to be supported by future studies ..... To define the ultimate clinical utility of OCT, standards will need to be defined prospectively and linked to outcomes with appropriate studies".

In a guideline for percutaneous coronary intervention, the American College of Cardiology (Levine et al, 2011) stated that "[t]he appropriate role of optical coherence tomography in routine clinical decision making has not been established". Furthermore, an UpToDate review on "Intravascular ultrasound, optical coherence tomography, and angioscopy of coronary
circulation" (Regar et al, 2012) states that "[t]oday, no clinical indications for OCT imaging are established. There are no randomized data supporting a prognostic role for OCT in catheter-based intervention .... Preliminary data on OCT indicate that it can change the operator’s intention-to-treat and modify the overall revascularization strategy, potentially avoiding unnecessary interventional procedures. OCT might be efficient in complex interventions including treatment of left main stem, bifurcations as well as in all cases of angiographically ambiguous lesions, and in-stent failures. Two other potential uses of OCT are identification of an angiographically unclear lesion and assessment of stent failure".

Yonetsu et al (2013) stated that since its invention in the late 1990s, intra-vascular OCT has been rapidly adopted in clinical research and, more recently, in clinical practice. Given its unprecedented resolution and high image contrast, OCT has been used to visualize plaque characteristics and to evaluate the vascular response to PCI. In particular, OCT is becoming the standard modality to evaluate in-vivo plaque vulnerability, including the presence of lipid content, thin fibrous cap, or macrophage accumulation. Furthermore, OCT findings after stent implantation, such as strut apposition, neointimal hyperplasia, strut coverage, and neoatherosclerosis, are used as surrogate markers of the vascular response. New applications for OCT are being explored, such as transplant vasculopathy or non-coronary vascular imaging. The authors concluded that although OCT has contributed to cardiovascular research by providing a better understanding of the pathophysiology of CAD, data linking the images and clinical outcomes are lacking. Moreover, they stated that prospective data are needed to prove that the use of OCT improves patient outcomes, which is the ultimate goal of any clinical diagnostic tool.

Jia and colleagues (2013) characterized the morphological features of plaque erosion and calcified nodule in patients with ACS by OCT. A total of 126 patients with ACS who had undergone pre-intervention OCT imaging were included. The culprit lesions were classified as plaque rupture (PR), erosion
(OCT-erosion), calcified nodule (OCT-CN), or others using a new set of diagnostic criteria for OCT. The incidences of PR, OCT-erosion, and OCT-CN were 43.7 %, 31.0 %, and 7.9 %, respectively. Patients with OCT-erosion were the youngest compared with those with PR and OCT-CN (53.8 ± 13.1 years versus 60.6 ± 11.5 years, 65.1 ± 5.0 years, p = 0.005).

Compared with patients with PR, presentation with non-ST-segment elevation ACS (NSTE-ACS) was more common in patients with OCT-erosion (61.5 % versus 29.1 %, p = 0.008) and OCT-CN (100 % versus 29.1 %, p < 0.001). Optical coherence tomography-erosion had a lower frequency of lipid plaque (43.6 % versus 100 %, p < 0.001), thicker fibrous cap (169.3 ± 99.1 μm versus 60.4 ± 16.6 μm, p < 0.001), and smaller lipid arc (202.8 ± 73.6° versus 275.8 ± 60.4°, p < 0.001) than PR. The diameter stenosis was least severe in OCT-erosion followed by OCT-CN and PR (55.4 ± 14.7 % versus 66.1 ± 13.5 % versus 68.8 ± 12.9 %, p < 0.001). The authors concluded that OCT is a promising modality for identifying OCT-erosion and OCT-CN in-vivo.

Optical coherence tomography-erosion is a frequent finding in patients with ACS, especially in those with NSTE-ACS and younger patients; whereas OCT-CN is the least common etiology for ACS and is more common in older patients.

Domingo et al (2013) correlated pulmonary arterial (PA) remodeling estimated by PA fibrosis in PA hypertension (PAH) with clinical follow-up. Histology of PA specimens was also performed. A total of 19 patients, aged 54 ± 16 (4 men), functional class II to III were studied with right heart catheterization, PA-IVUS and OCT in inferior lobe segment. Pulmonary arterial wall fibrosis was obtained by OCT (area of fibrosis/PA cross sectional area × 100). Patients’ follow-up was blind to OCT. Events were defined as mortality, lung transplantation, need of intravenous prostaglandins or onset of right ventricular failure. Optical coherence tomography measurements showed high intra- and inter-observer agreement. There was a good correlation between OCT and histology in PA fibrosis from explanted lungs. Area of fibrosis was 1.4 ± 0.8 mm², % fibrosis was 22.3 ± 8. Follow-up was 3.5 years (2.5 to 4.5). Optical coherence tomography % Fib was
significantly correlated with PA capacitance ($r = -0.536$) and with pulmonary vascular resistance ($r = 0.55$). Patients were divided according to the median value of PA fibrosis. There were 10 patients with a high (greater than or equal to 22 %) and 9 with a low fibrosis (less than 22 %). Events occurred in 6 (1 death, 1 lung transplantation, 2 intravenous prostaglandins, and 2 right heart failure) out of 10 patients with high and in 0 out of 9 patients with low fibrosis ($p < 0.01$). The authors concluded that in PAH, the severity of PA remodeling assessed by OCT wall fibrosis was significantly predictive of severely unfavorable clinical outcome. Moreover, they stated that in-vivo assessment of pulmonary arterial wall fibrosis by intravascular OCT in PAH is a promising new prognostic marker of adverse clinical outcome.

Jones and colleagues (2014) examined carotid plaque characteristics in symptomatic versus asymptomatic patients with the use of non-occlusive OCT. These researchers hypothesized that OCT might be useful for the identification of low-risk versus high-risk carotid plaque features and help to understand the relationship between carotid diameter stenosis and plaque morphology to ischemic stroke. A total of 53 patients undergoing diagnostic carotid angiography were studied with OCT. Data analysis was carried out by imaging experts who were unaware of the clinical characteristics of the study population. Plaque with American Heart Association (AHA) type VI complicated features was more common in symptomatic than asymptomatic patients (74.1 % versus 36.4 %, $p = 0.02$). This was largely driven by differences in the incidence of thin-cap fibro-atheroma with rupture (40.7 % versus 13.6 %, $p = 0.056$) and thrombus (67.7 % versus 36.4 %, $p = 0.034$). Conversely, non-type VI plaques were more common in asymptomatic than symptomatic patients (63.6 % versus 25.9 %, $p = 0.02$). No association between the degree of stenosis and plaque morphology was identified. The authors concluded that this retrospective analysis of carotid OCT data supported the hypothesis that the evaluation of carotid plaque characteristics with this high-resolution imaging technique has the potential to alter the understanding and treatment of
carotid artery disease.

Zafar et al (2014) noted that frequency domain OCT (FD-OCT) provides cross-sectional images of coronary arteries and deployed stents with micron resolution and measures lumen dimensions with excellent reproducibility. Frequency domain-OCT combined with a blood flow resistances model can overcome many limitations of conventional measures of stenosis severity based on quantitative coronary angiography (QCA) and IVUS. These researchers investigated the relationship between pressure derived FFR and FD-OCT derived FFR, a new method for quantitative measure of stenosis severity that estimates the blood flow resistance and microvascular resistance of the vessel segments imaged by FD-OCT. A total of 26 coronary stenoses in 20 patients were studied consecutively with QCA, pressure derived FFR, and FD-OCT. There was a moderate but significant correlation between pressure derived FFR and FD-OCT derived FFR (r = 0.69, p < 0.001). Bland-Altman analysis showed that the mean differences between pressure derived FFR and FD-OCT derived FFR were 0.05 ± 0.14 (limits of agreement: -0.09 to 0.19). The root mean square error (RMSE) between FD-OCT derived FFR and pressure derived FFR was found to be ± 0.087 FFR units. The authors concluded that FD-OCT derived FFR has the potential to become a valuable tool for the assessment of coronary artery stenosis.

Xie and colleagues (2015) stated that compared with IVUS, OCT has relative merits and demerits for detecting plaque characteristics. It remains unknown whether the IVUS and OCT evaluations of plaque progression/regression are consistent. These researchers analyzed the correlations between IVUS and OCT evaluations of plaques at single time-points, and compared temporal changes in the IVUS and OCT data. A total of 88 lipid-rich plaques from 65 patients with CAD were analyzed with IVUS and OCT at baseline and 12-month follow-up. Fibrous cap thickness on OCT was negatively correlated with total atheroma volume on IVUS (r = -0.28, p = 0.009), but not with percent atheroma volume (p = 0.84). Changes on OCT were not
significantly correlated with changes on IVUS. Plaques that showed progression, regression, or no change on IVUS showed no differences in terms of changes in the OCT parameters fibrous cap thickness (p = 0.199), maximum lipid core arc (p = 0.755), mean lipid core arc (p = 0.936), and lipid index (p = 0.91). The incidence of TCFA was similar among the above 3 plaque groups at baseline (p = 0.79) and follow-up (p = 0.609). The authors concluded that although fibrous cap thickness on OCT was negatively correlated with plaque size on IVUS at single time-points, changes in OCT parameters were not correlated with changes in IVUS measures over time. They stated that lesion progression/regression on IVUS was not associated with changes in OCT parameters (fibrous cap thickness, lipid core arc, lipid index, and TCFA).

Assessment of Carotid Artery Stenosis/Stroke Risk:

Blackham et al (2015) noted that OCT is a modern intra-vascular imaging modality that has the capability to provide detailed, in-vivo characterization of the arterial wall and atherosclerotic plaque. The current understanding of the appearance of atherosclerotic plaque via OCT is largely based on coronary arterial studies where OCT information has been employed to guide therapeutic management and permits the immediate evaluation of PCI. The clinical success of OCT in the coronary arteries has laid the foundation for investigation of the carotid artery and thus, stroke risk assessment. The authors reported the novel use of OCT for tissue characterization of severe stenosis subsequent to carotid artery stenting, both before and after treatment with cutting balloon angioplasty.

An UpToDate review on “Evaluation of carotid artery stenosis” (Furie, 2015) does not mention optical coherence tomography as a diagnostic tool.

Assessment of Intracranial Aneurysm:

Hoffmann et al (2016) stated that rupture risk assessment of an intracranial aneurysm (IA) is an important factor for indication
of therapy. Until today, there is no suitable objective prediction method. Conventional imaging modalities cannot assess the IA's vessel wall. These researchers investigated the ability of intra-vascular OCT as a new tool for the characterization and evaluation of IAs. An experimental set-up for acquisition of geometrical aneurysm parameters was developed. Object of basic investigation was a silicone phantom with 6 IAs from patient data. For structural information, 3 circle of Willis were dissected and imaged post-mortem. All image data were post-processed by medical imaging software. Geometrical image data of a phantom with 6 different IAs were acquired. The geometrical image data showed a signal loss, e.g., in aneurysms with a high bottle-neck ratio. Imaging data of vessel specimens were evaluated with respect to structural information that is valuable for the characterization of IAs. Those included thin structures (intimal flaps), changes of the vessel wall morphology (intimal thickening, layers), adjacent vessels, small vessel outlets, arterial branches and histological information. The authors concluded that intra-vascular OCT provides new possibilities for diagnosis and rupture assessment of IAs. However, currently used imaging system parameters have to be adapted and new catheter techniques have to be developed for a complete assessment of the morphology of IAs.

**Prediction of Periprocedural Myocardial Injury in Persons with Stable Angina Pectoris:**

Kimura et al (2015) stated that periprocedural myocardial injury (PMI) is not an uncommon complication and is related to adverse cardiac events after PCI. These researchers investigated the predictors of PMI in patients with stable angina pectoris (SAP) on intra-vascular imaging. They enrolled 193 SAP patients who underwent pre-PCI IVUS and OCT. Clinical characteristics, lesion morphology, and long-term follow-up data were compared between patients with and without PMI, defined as post-PCI elevation of high-sensitivity cardiac troponin-T. Periprocedural myocardial injuries were observed in 79 patients (40.9 %). Estimated glomerular filtration rate (OR, 0.973; 95 % CI: 0.950 to 0.996; p = 0.020), greater than or equal to 2 stents...
(OR, 3.100; 95 % CI: 1.334 to 7.205; p = 0.009), final myocardial blush grade 0 to 2 (OR, 4.077; 95 % CI: 1.295 to 12.839; p = 0.016), and IVUS-identified echo-attenuated plaque (EA; OR, 3.623; 95 % CI: 1.700 to 7.721; p < 0.001) and OCT –TCFA (OR, 3.406; 95 % CI: 1.307 to 8.872; p = 0.012) were independent predictors of PMI on multi-variate logistic regression analysis. A combination of EA and OCT-TCFA had an 82.4 % positive predictive value (PPV) for PMI. On Cox proportional hazards analysis, PMI was an independent predictor of adverse cardiac events during 1-year follow-up (hazard ratio [HR], 2.984; 95 % CI: 1.209 to 7.361; p = 0.018). The authors concluded that plaque morphology assessment using pre-PCI IVUS and OCT may be useful for predicting PMI in SAP patients.

**Assessment of Pulmonary Arteries:**

Jorge and colleagues (2016) stated that along with the new interventional procedures being introduced for pulmonary vascular disease, there is an increasing need for intravascular imaging of the pulmonary arteries. Additionally, measurements of the wall thickness of the pulmonary arteries of patients with various types of pulmonary hypertension (PH) may provide relevant diagnostic and prognostic information. These investigators summarized all the available evidence on the use of OCT for imaging the pulmonary bed and described a simple protocol for OCT image acquisition. These researchers conducted a systematic review of the literature using electronic reference databases through February 2015 (Medline, Cochrane Library, Web of Knowledge, and references cited in other studies) and the search terms "optical coherence tomography", "pulmonary hypertension" and "pulmonary arteries". Studies in which OCT was used to image the pulmonary vessels were considered for inclusion. They identified 14 studies reporting OCT imaging data from the pulmonary arteries; OCT was able to identify intravascular thrombi in patients with chronic thromboembolic PH (CTEPH), and an increase in vessel wall thickness was found in most patients with PH, compared with the controls. Optical coherence tomography has also been reported to be useful for
the selection of balloon size in the setting of balloon pulmonary angioplasty for CTEPH. The main drawbacks of this approach were lack of standardization, little data on outcomes, cost, and the technical limitations involved in visualizing small-diameter (less than 1 mm) pulmonary vessels. The authors concluded that OCT has become a potential tool for the in-vivo study of vascular changes in the pulmonary arteries, and may provide additional information in the assessment of patients with PH. They stated that prospective high-quality studies assessing the safety, validity, and clinical impact of OCT imaging for pulmonary vessels are needed.

**Evaluation of Arterial Bifurcations Covered by Flow Diverting Stents:**

Iosif and co-workers (2016) stated that due to its high spatial resolution, intravascular OCT has been used as a valid method for in-vivo evaluation of several types of coronary stents at straight lumen and bifurcation sites. These researchers evaluated its effectiveness for flow diverting stents deployed in arterial bifurcation sites involving jailing of a side branch. A total of 4 large white swine were stented with flow diverting stents covering the right common carotid artery-ascending pharyngeal artery bifurcation. After 12 weeks of follow-up the animals were evaluated by digital subtraction angiography and intravascular OCT and subsequently sacrificed. Neointimal thickness on the parent arteries and the free segments of the stent were measured. The stented arteries were harvested and underwent scanning electron microscopy (SEM) imaging. Ostia surface values were measured with OCT three-dimensional (3D) reconstructions and SEM images. All endovascular procedures and OCT pullback runs were feasible. Stent apposition was satisfactory on the immediate post-stent OCT reconstructions. At 12-week controls, all stents and jailed branches were patent. Mean neointimal thickness was $0.11 \pm 0.04$ mm on the free segments of the stent. The mean ostia surface at 12 weeks was $319,750 \pm 345,533 \mu m^2$ with 3D-OCT reconstructions and $351,198 \pm 396,355 \mu m^2$ with SEM image-derived calculations. Good correlation was found for ostia surface values between
the 2 techniques; the values did not differ significantly in this preliminary study. The authors concluded that intravascular OCT appeared to be a promising technique for immediate and follow-up assessment of the orifice of arterial branches covered by flow diverting stents.

Follow-Up Evaluation of Renal Arteries After Radiofrequency Catheter-Based Renal Denervation:

Roleder and associates (2016) noted that OCT imaging at the time of renal denervation (RDN) showed that procedure might cause spasm, intimal injury or thrombus formation. These researchers evaluated the healing of renal arteries after RDN using OCT and renal angiography in long-term follow-up. Optical coherence tomography and renal angiography were performed in 12 patients (22 arteries) 18.41 ± 5.83 months after RNS. There were no adverse events or complications during the long-term follow-up. In 10 patients (83 %), significant reductions of blood pressure was achieved without a change of the anti-hypertensive medications. These investigators demonstrated the presence of 26 areas of focal intimal thickening identified by OCT in 10 (83 %) patients and in 14 (63 %) arteries. The mean area of focal intimal thickening was 0.054 ± 0.033 mm². No vessel dissection, thrombus, intimal tear or acute vasospasm were observed during the OCT analysis. Also, the quantitative angiography analysis revealed a significant reduction of the minimal and proximal lumen diameters at follow-up as compared to measurements obtained before RDN. The authors concluded that renal arteries have a favorable "long-term" vessel healing response after RDN. Focal intimal thickening and a modest reduction of the minimal lumen diameter may be observed after RF denervation. They stated that further studies are needed to determine whether intravascular imaging may be helpful in evaluating the vessel healing of RF RDN.

In summary, there is currently insufficient evidence to support a predictive role for intra-vascular OCT for the assessment of cardiovascular risk or in catheter-based interventions or
follow-up evaluations. Prospective, randomized trials are needed to ascertain the clinical value of this emerging imaging technology.

### 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 "+":

#### CPT codes not covered for indications listed in the CPB:

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0291T</td>
<td>Intravascular optical coherence tomography (coronary native vessel or graft) during diagnostic evaluation and/or therapeutic intervention, including imaging supervision, interpretation, and report; initial vessel (List separately in addition to primary procedure)</td>
</tr>
<tr>
<td>0292T</td>
<td>each additional vessel (List separately in addition to primary procedure)</td>
</tr>
</tbody>
</table>

#### ICD-10 codes not covered for indications listed in the CPB (not all-inclusive):

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I20.0</td>
<td>Unstable angina</td>
</tr>
<tr>
<td>I20.1-I20.9</td>
<td>Angina pectoris with documented spasm and other and unspecified forms of angina pectoris [prediction of periprocedural myocardial injury in persons with stable angina pectoris]</td>
</tr>
<tr>
<td>I25.10-I25.119</td>
<td>Atherosclerotic heart disease of native coronary artery</td>
</tr>
<tr>
<td>I27.0</td>
<td>Primary pulmonary hypertension</td>
</tr>
<tr>
<td>I60.0-I60.9</td>
<td>Nontraumatic subarachnoid hemorrhage [diagnosis and rupture assessment]</td>
</tr>
<tr>
<td>I65.21-I65.29</td>
<td>Occlusion and stenosis of carotid artery [assessment of stroke risk]</td>
</tr>
<tr>
<td>I67.1</td>
<td>Cerebral aneurysm, nonruptured [diagnosis and rupture assessment]</td>
</tr>
<tr>
<td>Q28.0-Q28.3</td>
<td>Congenital malformations of precerebral and cerebral vessels [diagnosis and rupture assessment]</td>
</tr>
</tbody>
</table>
The above policy is based on the following references:


14. Regar E, Weissman NJ, Muhlestein JB. Intravascular ultrasound, optical coherence tomography, and angioscopy of coronary circulation. UpToDate Inc. Waltham, MA.


17. Tsimikas S, DeMaria AN. The clinical emergence of optical


AETNA BETTER HEALTH® OF PENNSYLVANIA

Amendment to
Aetna Clinical Policy Bulletin Number: 0829
Intra-vascular Optical Coherence Tomography

There are no amendments for Medicaid.

www.aetnabetterhealth.com/pennsylvania
Revised 04/2017