Commentary

Using sound advice—intravascular ultrasound as a diagnostic tool

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Intravascular ultrasound (IVUS) uses varying-frequency catheter-based transducers for assessment of blood vessel dimensions and morphology. Along with advances in the field of interventional cardiology, IVUS technology has progressed in the last two decades. Dedicated training centers in combination with enthusiasm from a new generation of cardiologists complemented by well-established evidence for simplicity, safety and efficacy of IVUS systems have led to increased routine use of this imaging modality. Currently available catheters use sound frequencies in the range of 20–70 MHz, moving from older grayscale IVUS to radiofrequency IVUS (RF-IVUS) and more recently high-definition IVUS (HD-IVUS) devices, some with the ability to differentiate plaque composition.

IVUS has the ability to provide a 360° cross-sectional view of the vasculature with real time images. With excellent tissue penetration, IVUS can provide detailed and valuable information on vessel lumen dimensions including large diameter arteries such as the left main coronary artery (LMCA) as well as atherosclerotic plaque morphology and burden. Compared to other intravascular imaging modalities such as optical coherence tomography (OCT), IVUS has the advantage of not requiring blood clearance, overcoming some of the limitations of two-dimensional lumenography by angiography (1,2). For instance, clinically significant high-grade stent edge dissections that may be missed on angiography can be identified on IVUS, with the utility of IVUS becoming more evident in treatment of complex coronary lesions, including interventions performed on the LMCA (3,4). Large registry data have indicated a reduction in mortality in IVUS-guided percutaneous coronary intervention (PCI) of unprotected LMCA compared to angiography alone (6.0% *vs*. 13.6%) (5).

By extrapolation, IVUS may also have utility in the emergency setting for pathologies involving the LMCA such as spontaneous or iatrogenic dissection. The incidence of spontaneous dissection in the LMCA has been reported to be ~1% of all epicardial coronary arteries (6,7). Similar to aortic dissection, a spontaneous dissection of the LMCA leads to generation of a false lumen and intramural hematoma with or without intimal tear that may propagate retrograde into the aorta. Additionally, a type A aortic dissection may extend into the LMCA antegrade. The acute coronary syndrome (ACS) associated with acute aortic dissection may be due to compression of the LMCA ostium by the false lumen, intimal flap causing ostial LMCA obstruction or extension of the dissection plane down the coronary tree and rarely due to avulsion of the coronary arteries from the sinuses of valsalva. The clinical presentation of dissection in the LMCA can be varied, spanning from a catastrophic cardiac emergency to ACS with varying degrees of underlying ischemia. Patients with type A aortic dissection can present with ACS, in which case the presentation may mandate early revascularization therapy, which may be done by PCI depending on the context. Coronary artery occlusion secondary to aortic dissection is infrequent, but in the cases where ST-segment elevation myocardial infarction is present, early revascularization with PCI should be considered without delaying for aortic imaging as supported by various guidelines (8).

In a recent issue of *JACC Cardiovascular Interventions*, Takahashi *et al*. (9) described a case of aortic dissection, presenting as ACS, involving the LMCA. Emergency angiography revealed left main stem closure and

to investigate the cause operators performed IVUS demonstrating a dissecting hematoma extending from aorta to left main. Based on IVUS it was concluded that the etiology was a type A aortic dissection, generating a hematoma that extended into the left main causing obstruction and this was confirmed by post procedure computed tomography (CT). The use of IVUS in this emergency setting helped in reaching the correct diagnosis and guided the appropriate strategy of stenting as a bridge to definitive cardiac surgery.

In these emergency instances, the first diagnostic test may be angiography and where there is a suspicion for dissection, particularly entry into the false lumen, IVUS should be considered to confirm the diagnosis as well as the luminal position of the guidewire. Indeed, IVUS has shown to be superior to other imaging modalities in cases of LMCA dissection (10,11). For instance, compared to OCT, IVUS does not require flush clearance of the coronary artery where, particularly in a large diameter artery like the LMCA, injection may lead to hydraulic extension of the dissection. Additionally, with high tissue penetration, IVUS can evaluate the external elastic lamina and entire dissection plane in the LMCA even in the presence of large intraluminal thrombi or intramural hematoma. Additionally, it may be feasible to differentiate spontaneous LMCA dissection, often visualized as hemorrhage in the outer third of the media or between the outer media and external elastic lamina that can lead to development of hematoma causing compression of the true lumen. The direction of spread of spontaneous dissection starts from within the arterial wall extending towards the lumen. In the cases of iatrogenic dissection as the result of wires or catheters, dissection may be visualized on IVUS from the lumen towards the media (12). Critically, differentiation of the true and false lumen on IVUS is feasible as the true lumen appears smaller with branches and a three layered appearance comprising the layers of the native vessel wall. The false lumen is more often larger and contains evidence of thrombus (13). Alongside this, IVUS can localize intimal tears and extent of intramural hematoma, the site of primary fenestration, with measurements of proximal normal aorta and even real time measurement of flow in the true and false lumens (14).

Various other non-invasive modalities like CT and Magnetic resonance imaging (MRI) are not able to provide 360-degree cross sectional views of vascular lumens at the resolution provided by IVUS. In a comparative study of IVUS with non-invasive imaging modalities, IVUS had an advantage at detecting visceral artery origin in cases of aortic dissection. The detection rate of visceral arteries by IVUS was 96.4%, higher than CT (70.2%) and digital subtraction angiography (DSA) (84.5%) (13). Lastly it is important to note that despite the use of multiple non-invasive imaging modalities as well as trans-esophageal echocardiography, the possibility of not recognizing aortic dissection is estimated at ~5% (15). It is thus recommended that in cases of high suspicion of aortic dissection other imaging modalities like aortography and IVUS strongly considered.

Conclusions

IVUS is highly recommended in cases of left main coronary dissection, to not only determine the etiology but also the extent of dissection and treatment plan. The routine use of IVUS is encouraged such that interventionalist's are confident using this modality including the emergency setting.

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Footnote

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