Chapter 2
Intravascular Image Interpretation

Katerina K. Naka
University of Ioannina, Greece

Nikolaos D. Papamichael
University of Ioannina, Greece

ABSTRACT

Intravascular ultrasound (IVUS) is an imaging modality often used as a supplement to coronary angiography and allows accurate assessment of the lumen, vessel wall, and atherosclerotic plaque. A coherent interpretation of the IVUS images requires identification of the image artefacts that emerge during IVUS interrogation and can often be quite difficult. This chapter describes the morphologic appearance of the structures seen in IVUS, presents the morphologic characteristics of the different types of plaque, and summarizes the nomenclature and definitions used during IVUS interpretation. Moreover, it focuses on the quantitative analysis and reports the measurements obtained during IVUS processing. Finally, it presents some of the clinical (e.g. assessment of the extent and severity of a lesion, treatment planning) and research (e.g. evaluation of atherosclerotic progression/regression, transplant vasculopathy, peripheral arterial disease) applications of this modality aiming to highlight its value in the clinical and research arena.

INTRODUCTION

Coronary angiography is the principal imaging modality used to assess coronary vessel anatomy and morphology. However, despite the broad implementation and the unanimous acceptance of this technique for the evaluation of the extent and severity of coronary artery disease, it is well known that it has limited ability in assessing the atherosclerotic disease process as the obtained two-dimensional images cannot accurately depict the complex three-dimensional anatomy of the vessel and cannot give any information regarding the type of the plaque and its burden (Mintz et al., 2001). To address these limitations, Intravascular

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Ultrasound (IVUS) was introduced that provides high resolution cross-sectional imaging of the vessel which permits identification of the lumen, the plaque and the outer vessel wall and accurate evaluation of the plaque burden. Several studies have confirmed that IVUS is safe and thus today it is often used in clinical practice as a complementary to coronary angiography tool (Di Mario et al., 1998; Hausmann et al., 1995). IVUS appears to be useful in assessing the severity of ambiguous lesions and guiding complex percutaneous coronary interventions (PCIs). In addition, it is also valuable in research and has been implemented in a number of studies that examined the impact of several interventional and non-interventional treatments on the evolution of the atherosclerotic process (Schoenhagen et al., 2006). The present chapter focuses on the interpretation of IVUS images and discusses some of the clinical and research applications of this technique.

BACKGROUND

Normal Arterial Anatomy

In a normal coronary artery the following structures are identified: the vessel lumen (blood), the vessel wall and the adjacent structures (Mintz et al., 2001; Schoenhagen et al., 2006).

The Lumen

At frequencies >20 MHz, flowing blood presents a specific echogenic pattern called speckle. The blood speckle may be described as finely textured echoes moving in a swirling pattern in video loops/sequences. The blood speckle can provide valuable help in image interpretation as its typical morphology may facilitate differentiation between lumen and vessel wall and identification of vessel dissection which appears as a communication between the lumen and the dissected vascular wall. However, problems may arise in a substantial proportion of cases and diagnosis may elude. Blood speckle can be much more prominent in higher imaging frequencies and might interfere with the delineation of the wall tissue rendering image interpretation a demanding process. Interrogating video sequences rather than frozen images and flushing the vessel with saline or contrast medium during IVUS imaging may help this differentiation, especially in cases of dissections.

The Vessel Wall

Previous IVUS studies performed on pressure-distended coronary arteries have provided the characteristic appearance of normal coronary arteries (Nissen et al., 1991; Potkin et al., 1990; Schoenhagen et al., 2006) (Figure 1). There are two distinct changes in acoustic impedance as ultrasound waves are reflected on vessel wall tissues. The first is created at the border between blood and the leading edge of the vessel intima and this trailing edge can be used reliably for measurements. The second is sited at the external elastic membrane (EEM) that is located at the media-adventitia interface. The outer border of the adventitia cannot be easily differentiated from the surrounding tissue. In high-quality images, the tunica media can be possibly visualized as an echolucent, lower density, layer. In young healthy subjects the intima thickness is normally reported to be 0.15±0.07 mm, while a thickness of 0.25-0.50 mm is usually considered as the upper reference limit for intima (Schoenhagen et al., 2006).

The Adjacent Structures

Arterial side branches, cardiac veins and the pericardium constitute the adjacent structures that can be recognized during pull-back of the IVUS catheter. Vessel bifurcations are frequently identified as the sites of early and eccentric plaque development which is due to the unique hemodynamic patterns seen in these areas. As the IVUS