Fibromuscular dysplasia (FMD) is a group of both non-atherosclerotic and non-inflammatory vascular diseases. Although the strict diagnosis of FMD should be decided via histopathological examination, the gold standard for diagnosing FMD is an arterial angiogram. The characteristic “string-of-beads” feature is found in the majority of such patients. In focal and tubular FMD stenosis cases, a differential diagnosis also needs to be performed. Such arterial diseases include both atherosclerotic and/or inflammatory types. IVUS is a useful tool, in addition to the angiography for evaluation of both the anatomical changes of structures of the vessel layer and observation of tissue characteristics. Currently, it is understood that publications related to IVUS images of focal or tubular types of FMD are limited. This report therefore presents IVUS images of focal type FMD.

**Case Report**

A 20-year-old man with resistant hypertension was admitted. His initial arteriogram highlighted a focal stenosis of the right renal artery. His intravascular ultrasound (IVUS) revealed increasing medial layer thickness accompanied by a mixture of both high and low echoic materials in this layer. There was also mild thickening of the intimal layer. The diagnosis of medial fibroplasia and intimal fibromuscular dysplasia (FMD) was made. Balloon angioplasty decreased the volume of dysplastic tissue. The IVUS images facilitated both the initial diagnosis of focal renal arterial stenosis and the evaluation of the mechanism of dilatation by angioplasty.

**Key words:** fibromuscular dysplasia, intravascular ultrasound, percutaneous renal angioplasty

**Focal Renal Arterial Fibromuscular Dysplasia Demonstrated via Intravascular Ultrasound Image**

Osamu Ogawa, MD, Ritsuo Watanabe, MD, Hiroshi Shimizu, MD, and Fumiaki Masani, MD

A young male suffering from renovascular hypertension was admitted. His initial arteriogram highlighted a focal stenosis of the right renal artery. His intravascular ultrasound (IVUS) revealed increasing medial layer thickness accompanied by a mixture of both high and low echoic materials in this layer. There was also mild thickening of the intimal layer. The diagnosis of medial fibroplasia and intimal fibromuscular dysplasia (FMD) was made. Balloon angioplasty decreased the volume of dysplastic tissue. The IVUS images facilitated both the initial diagnosis of focal renal arterial stenosis and the evaluation of the mechanism of dilatation by angioplasty.

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**INTRODUCTION**

Fibromuscular dysplasia (FMD) is a group of both non-atherosclerotic and non-inflammatory vascular diseases. Although the strict diagnosis of FMD should be decided via histopathological examination, the gold standard for diagnosing FMD is an arterial angiogram. The characteristic “string-of-beads” feature is found in the majority of such patients. In focal and tubular FMD stenosis cases, a differential diagnosis also needs to be performed. Such arterial diseases include both atherosclerotic and/or inflammatory types. IVUS is a useful tool, in addition to the angiography for evaluation of both the anatomical changes of structures of the vessel layer and observation of tissue characteristics. Currently, it is understood that publications related to IVUS images of focal or tubular types of FMD are limited. This report therefore presents IVUS images of focal type FMD.

**Case Report**

A 20-year-old man with resistant hypertension was admitted. He suffered from occasional headaches over a period of two years. His blood pressure was approximately 180/110 mmHg, despite consistently following his prescription of calcium channel blockers over a period of six months. Although the previous medical history was sound, his grandparents had suffered as well from hypertension. A closer inspection of secondary hypertension was carried out. Urinalysis showed proteinuria, while the blood chemistry demonstrated normal renal function. However, both plasma aldosterone concentration (PAC) and plasma rennin activity (PRA) were elevated (PAC was 39.2 ng/dL, PRA was 37.39 ng/mL/hr). In the abdominal duplex scanning, peak systolic velocity of the right renal artery and renal aortic ratio of his right kidney were high (303 cm/s and 2.0 respectively). Enhanced abdominal computed tomography revealed a severe focal stenosis in the mid portion of his right renal artery. Renal arterial stenosis with both hyperreninemia and hyperaldosteronemia indicated the diagnosis of renovascular hypertension. Since this patient was a young adult with no other atherosclerotic risk factors, and since the arterial lesion existed in the mid portion of the renal artery, it was suggested to be caused by a non-atherosclerotic mechanism.

The renal angiography showed focal severe stenosis in the mid portion of his right renal artery (Fig. 1A).
A percutaneous renal angioplasty of this lesion was performed. A single 20-MHz transducer (Eagle Eye, 2.9 Fr., Volcano, Fukuda Denshi Co) using auto-pullback system (0.5 mm/s) was employed to observe this lesion before and after angioplasty. Before angioplasty, the reference vessel diameter (measured between external elastic membranes) was about 4.8 mm and the minimal luminal diameter at the lesion was approximately 2.1 mm. The length of lesion was approximately 9.8 mm. Neither arterial stenosis nor arterial wall abnormalities were observed other than in this lesion (Fig. 2). Initially, the renal artery appeared to be negatively remodeling around the lesion. The cross-sectional area surrounded by internal high echoic lines appeared to diminish (the vessel appeared to be shrunk). Following further observation, eccentric medial thickening between internal high echoic line and outer high echoic line was coexisting with mild intimal thickening (from 4 o’clock to 11 o’clock in cross-sectional view of the IVUS image in Fig. 2D and 2H). Furthermore, mottled mixtures of high and low echoic material in this thickening medial layer were recognized. An eccentric ridge due to medial thickening with mild intimal thickening caused narrowing of the vessel (Fig. 2H, Fig. 3A and 3C). These findings were clearly different from that of an atherosclerotic lesion. The high echoic materials in this thickened media perhaps signified elastin and collagen deposition in this layer. This, in turn, might be compatible with medial FMD. Intimal and subintimal layers also mildly thickened and appeared highly echogenic. A final diagnosis of the renal arterial lesion as a medial fibroplasia coexistent with mild intimal FMD was made.

A balloon angioplasty (balloon diameter of 4.5 mm) on this lesion was performed, which resulted in successful dilatation of stenosis without stent implantation (Fig 1B). After angioplasty, the IVUS images showed a decrease in thickness of eccentric ridges of the medial layer (from 2.6
mm to 1.3 mm), while a thickness of intimal layer (which was thickening mildly) also decreased (from 0.9 mm to 0.5 mm). There was a residual thickening layer from 3 o’clock to 7 o’clock in cross-sectional view of the IVUS image in Fig. 3B. The vessel diameter showed little change. In sum, a significant reduction in volume of the dysplastic tissue occurred through the balloon angioplasty. Following angioplasty, the minimal luminal diameter at the lesion increased to 4.4 mm. Area stenosis decreased from 84.2 % to 22.6 % (Fig. 3). Such findings suggested that the primary mechanism of dilatation of this focal FMD lesion could have been crashing and/or cracking of thick and dysplastic layers. This also suggested that diseased layers with fibroplasia might be softer than expected.

Following angioplasty, the patient’s blood pressure gradually returned to normality (approximately 120/80 mmHg) without the use of antihypertensives. His renal function remained to be normal. Seven months later, a peak systolic velocity of the right renal artery was 107 cm/s, and the right renal aortic ratio was 0.8 in abdominal duplex scanning.

**DISCUSSION**

FMD is a group of dysplastic changes of one or more layers of medium-sized or large arteries.1-2) FMD most commonly affects the renal and internal carotid arteries. Although the disease consists of a heterogeneous group of histologic changes, FMD lesions show dysplastic changes (pure hyperplasia in rare cases) of fibrous, smooth muscles or fibromuscular tissue. In such cases, there is neither lipid deposition nor inflammatory cell infiltration. FMD occurs predominantly in young to middle-aged female individuals with a predilection for disease in the right renal artery. Although a variety of genetic, mechanical and hormonal factors have been proposed, the actual cause of FMD remains unknown.

A pathological classification of renal artery FMD was proposed by McCormack et al.3-4) It was based on the dominant arterial wall layer involved: the intima, media or adventitia. Intimal FMD, which accounts for 5 % of renal artery FMD cases, is characterized by irregularly arranged mesenchymal cells within a loose matrix of sub-endothelial connective tissue and a fragmented internal elastic lamina. Medial FMD accounts for up to 95 % of cases, and has been further subdivided into medial fibroplasia, perimedial fibroplasia, and medial hyperplasia.5) Perimedial fibroplasia implies a predominance of fibrous tissue, and the proliferation is primarily at the junction of the media and adventitia. Pure medial hypertrophy is rare and represents a concentric hypertrophy of the medial wall. This is relatively smooth, lacking fibrosis, and causes severe stenosis. In adventitial fibroplasia (the rarest type of FMD), the primary lesion is a dense collagenous replacement of the loose fibrous tissues of the arterial adventitia. The above types are not mutually exclusive; indeed, medial and perimedial FMD lesions can coexist in the same arterial segment. Furthermore, more than one arterial layer can be involved in the same patient.5)

The lesions in some types of FMD are of a homogenous appearance of elastic tissue that presents itself as a multiple stenosis interspersed with aneurismal outpouchings. Such pathologic changes are demonstrated by a
“string-of-beads” appearance via angiography. The “string-of-beads” appearance, which angio graphically characterized medial FMD, occurs in about 70% of cases. Specific features of adventitial or intimal FMD cannot be shown using angiography. Focal or tubular angiographic aspects cannot be related to specific histological lesions. In cases with focal and tubular FMD stenosis, differential diagnoses are atherosclerotic or inflammatory arterial disease, vascular Ehlers-Danlos and Williams’ syndromes, and type 1 neurofibromatosis, etc. FMD lesions are typically truncal or distal, as opposed to atherosclerotic stenosis, which are mostly ostial or proximal. Ultrasonography relies on differences in both tissue reflectivity and sound penetration to determine tissue composition. Smooth muscle or lipid-containing plaques are hypo-echoic, whereas fibrous tissue, collagen, elastin, or calcified plaque are hyper-echoic. In this manner, current ultrasound imaging provides the capability for an in-vivo pathologic examination. IVUS is a method for detecting a diseased arterial wall anatomy which can be underestimated or even completely inapparent from angiography. Furthermore, IVUS can identify all three layers of an artery and also detect the mostly involved layer of a diseased artery. The published reports about relation of IVUS images with histopathological findings of renal FMD are presently limited. Although several reports show the relation of IVUS image with the “string-of-beads” type FMD, there are few reports about focal renal FMD. Furthermore, most of publications make little mention of the pathological evaluation of the lesions and describe only both the evaluation of the lesion form (size) and how to use the IVUS as a decision maker of interventional strategy.

In this present case, IVUS revealed which layer was involved, what ultrasound findings appeared in each layer, and how the diseased layer changed by angioplasty. The appearance of mottled high echoic materials in the medial layer may indicate existence of fibrous tissue, collagen and elastin in this layer and disorganization of this tissue, as well. Although this lesion represented as a focal stenosis on the angiography, it instead was medial fibroplasia, possibly with mild intimal fibroplasia. The medial fibroplasia is a major type of FMD, and 60%–70% of this type show “string-of-beads” appearance via angiography. IVUS was useful in differentiation of FMD from atherosclerosis in such a focal stenosis type via angiography. Furthermore, IVUS images were useful in not only the evaluation of both the lesion diameter and lesion form, but also decision making of both balloon size and end point of strategy. In this case, IVUS images also suggested a mechanism of dilatation of this FMD lesion.

Although IVUS can’t give full information about histopathological change, it is able to indicate which layer is predominantly involved in the lesion. Furthermore, it also suggests tissue characteristics according to echogenic types, as well. Such information enables comprehensive understanding for a correct diagnosis.

In conclusion, the potential value of IVUS imaging is investigated as a way to overcome the limitations of angiography in characterizing the renal artery structure. IVUS imaging is feasible and can be conducted without significantly prolonging the procedure time or increasing the risk of complications.

**DISCLOSURE STATEMENT**

No grants were utilized for this report.

The authors state that they have no Conflict of Interest (COI).

**REFERENCES**