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CASE SERIES
Other

Optical coherence tomography in varying aetiologies of renal artery stenosis: a case series

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Background Renal artery stenosis (RAS) is a common cause of secondary hypertension. The most common aetiology is atherosclerosis; however, other causes like fibromuscular dysplasia (FMD) and Takayasu arteritis (TA) are also frequently encountered. The lesion characteristics and its response to percutaneous intervention depend upon the aetiology of RAS. Optical coherence tomography (OCT) is an excellent imaging modality to analyse coronary lesions during percutaneous coronary interventions. The data regarding the utility of OCT in renal artery imaging is limited, consisting of a few case reports.

Case summary We hereby report four cases of RAS, each of different aetiology (atherosclerotic, FMD, post-transplant, and TA), who underwent OCT imaging of the renal artery along with percutaneous renal angioplasty.

Discussion The advantages of OCT imaging include demonstration of the arterial wall, pathological features of the disease, and to guide percutaneous interventions. The major limitation of OCT is its lower imaging depth, which may render imaging of large vessels difficult.

Keywords Case series • Fibromuscular dysplasia • Optical coherence tomography • Post-transplant • Renal artery stenosis • Takayasu arteritis

Learning points

- Optical coherence tomography (OCT) can be a useful adjunct in the imaging of renal artery stenosis (RAS) and in guiding percutaneous renal angioplasty.
- Optical coherence tomography may be useful in the evaluation of aetiology of RAS.
- The lower imaging depth of OCT may hinder with the acquisition of good-quality images.

Introduction

Renal artery stenosis (RAS) is a common and treatable cause of secondary hypertension. While non-invasive tests like Doppler-ultrasound, computed tomography (CT) and magnetic resonance imaging are commonly used to quantify luminal stenosis, contrast angiography remains the gold standard for the diagnosis of RAS.[1,2] Intravascular imaging such as optical coherence tomography (OCT) is widely used to assess plaque morphology and luminal narrowing in obstructive coronary artery disease (CAD). The use of OCT in RAS

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has not been explored. We hereby report a series of RAS cases of varying aetiology, who had OCT imaging (C7 Dragonfly Catheter™ ILUMIEN™ Optis PCI Optimisation System, St. Jude Medical, St Paul, MN, USA) along with percutaneous renal artery revascularization. The characteristic findings of OCT in a series of patients with RAS of different aetiologies [hypertension, fibromuscular dysplasia (FMD), Takayasu arteritis (TA), and post-transplant] are discussed in this article.

Timeline

Patient 1	
Prior to index procedure	Resistant hypertension despite four anti-hypertensive drugs. Known case of coronary artery disease (old inferior infarction on medical treatment).
Index procedure	Successful optical coherence tomography (OCT)-guided percutaneous transluminal renal angioplasty (PTRA) of the right renal artery.
One year post-index procedure	Blood pressure controlled with two drugs.
Patient 2	
Prior to index procedure	Resistant hypertension despite four anti-hypertensive drugs
Index procedure	Successful OCT-guided PTRA of the right renal artery.
Three years post-index procedure	Blood pressure normal without any drugs.
Patient 3	
Four months prior to index procedure	Renal transplant done. Normal post-operative course.
Index presentation	Renal dysfunction of unknown aetiology. Graft rejection excluded by renal biopsy and tacrolimus levels.
Index procedure	Successful OCT-guided PTRA of transplanted renal artery.
Three and a half years post-index procedure	Normal renal functions. Repeat imaging demonstrated normal transplant renal artery.
Patient 4	
Prior to index procedure	Diagnosed as Takayasu arteritis. Had resistant hypertension in spite of five anti-hypertensive drugs.
Index procedure	Successful stenting of abdominal aorta and OCT-guided PTRA of bilateral renal arteries.
Three month post-index procedure	Blood pressure controlled with two drugs.

Case presentation

Patient 1

A 55-year-old female presented with resistant hypertension (blood pressure 170/100 mmHg) despite treatment with amlodipine, telmisartan, prazosin, and furosemide. She had an old inferior myocardial infarction and distal right CAD, for which she was managed with optimal medical treatment. Her serum creatinine was 1.4 mg/dL with an estimated glomerular filtration rate (eGFR) of 42 mL/min, which was suggestive of chronic kidney disease (CKD)—stage 3. Doppler-ultrasound imaging was suggestive of right RAS, and an atrophic right kidney, i.e. 6 cm. In view of resistant hypertension and right RAS on Doppler, she was referred to us for possible percutaneous transluminal renal angioplasty (PTRA). An invasive angiogram showed occluded right renal artery (*Figure 1A*). It was cannulated with 6 F renal guide catheter (Medtronic Inc., Minneapolis, MN, USA) and the lesion was crossed with 0.014″ coronary guide wire. Following 2 × 12 mm balloon dilatation, OCT imaging revealed a thin cap fibroatheroma (*Figure 1C*) with plaque rupture (*Figure 1B*) and white thrombus (*Figure 1D*). A 3 × 32 mm coronary drug-eluting stent (Synergy™ stent, Boston Scientific, Natick, MA, USA) was deployed and post-dilated with a 3.5 × 12 mm non-compliant balloon as part of the stent was malapposed on OCT imaging. There was good flow across the renal artery with no residual stenosis (*Figure 1E*). During 1 year of follow-up, her blood pressure remained under control (110/80 mmHg) with drugs—telmisartan and amlodipine. Her follow-up serum creatinine and eGFR were 1.5 mg/dL and 39 mL/min, respectively.

Patient 2

A 22-year-old male presented with resistant hypertension (190/100 mmHg) despite anti-hypertensive therapy consisting of amlodipine, losartan, furosemide, and clonidine. His serum creatinine was 0.8 mg/dL. Ultrasound revealed normal sized bilateral kidneys with good cortico-medullary differentiation. Renal Doppler showed right distal RAS. Selective renal angiography revealed 80% stenosis of distal right renal artery with a classic 'string of beads' appearance suggestive of FMD (*Figure 2A*). Optical coherence tomography showed thickened media with areas of low backscatter (*Figure 2B, C*), luminal stenosis of 78% and wavy endoluminal surface (*Figure 2D*), consistent with FMD. The left renal artery was normal on selective angiography. In view of resistant hypertension, he was considered for PTRA of the right renal artery. Following the cannulation of right renal artery with 7 F renal guide catheter (Medtronic Inc., Minneapolis, MN, USA), the diseased segment was sequentially dilated with 2.5, 4 and then 6 mm balloon. There was good flow across the renal artery with no residual stenosis or dissection (*Figure 2E*). A repeat OCT imaging revealed no significant residual stenosis. Post-intervention, his blood pressure got

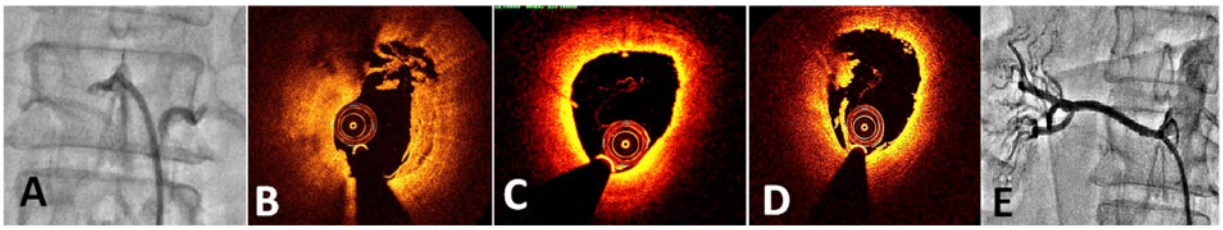

Figure 1 Percutaneous transluminal renal angioplasty of atherosclerotic renal artery stenosis. Optical coherence tomography imaging of totally occluded right renal artery (*A*) revealed ruptured plaque (*B*), thin cap fibroatheroma (*C*), and overhanging white thrombus (*D*). Post-stenting, there is normal flow across the renal artery (*E*).

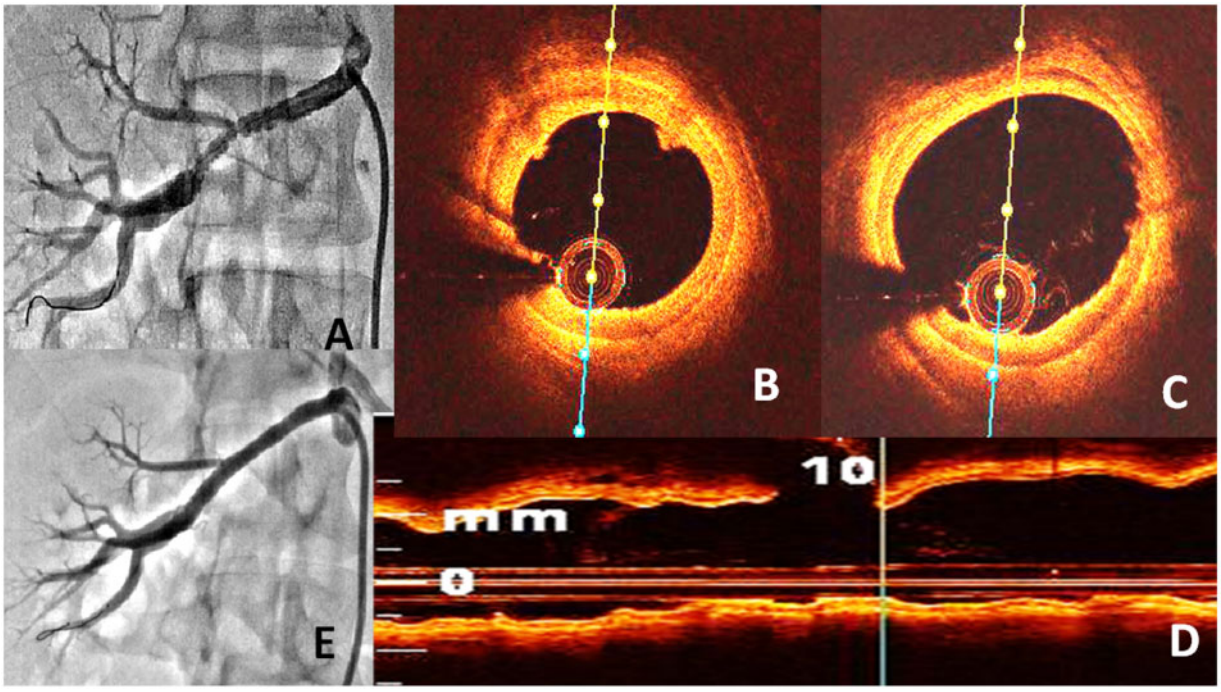

Figure 2 Percutaneous transluminal renal angioplasty of fibromuscular dysplasia related renal artery stenosis. Selective renal angiography revealed 'string of beads' appearance of the right renal artery with distal stenosis (*A*). Optical coherence tomography imaging revealed medial thickening (*B*, *C*), and wavy endoluminal surface (*D*). Post-percutaneous transluminal renal angioplasty, there is normal flow across the renal artery (*E*).

normalized (120/80 mmHg) without any drug during the next 3 years of follow-up.

Patient 3

An 18-year-old girl had renal transplantation for CKD in January 2015. She had an uneventful recovery and her creatinine level remained normal (0.88 mg/dL) till 4 months following surgery. Later, she had persistently raised creatinine levels (3.1 mg/dL). The possibility of renal graft rejection was excluded by normal renal biopsy and maintaining adequate immune-suppressive therapy. A renal Doppler of the transplanted renal artery was suggestive of transplant renal artery stenosis (TRAS). A selective angiography of the right internal iliac artery revealed 80% bifurcation stenosis of the transplanted renal artery (*Figure 3A*). Optical coherence tomography showed severe luminal stenosis due to intimal hyperplasia and fibrosis (*Figure 3B, C*). Successful PTRA was performed using sequential balloon dilatation with 3 mm followed by 3.5 mm balloon. Post-PTRA, there was a brisk flow across bifurcated renal artery without any significant residual stenosis (*Figure 3D*). A repeat OCT showed significant luminal gain without any residual stenosis or dissection. Her creatinine level got normalized (1.1 mg/dL) in 1-month period. Her renal functions

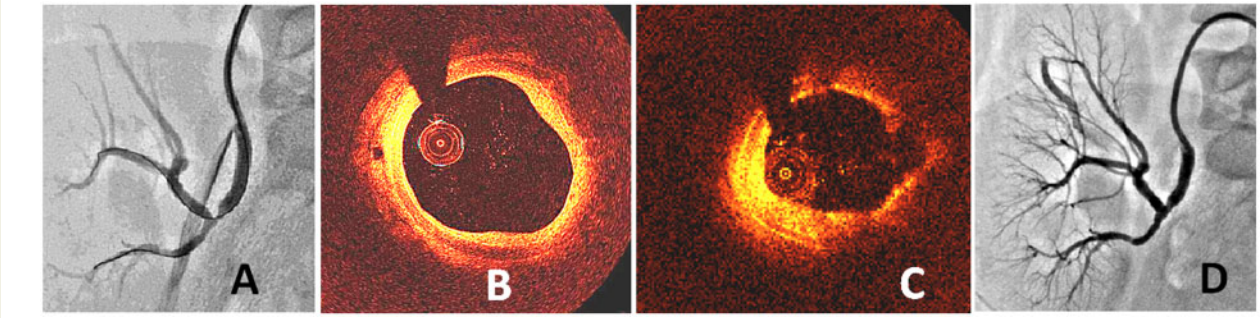

Figure 3 Percutaneous transluminal renal angioplasty of post-transplant renal artery stenosis. Selective angiogram of the right internal iliac artery showed significant transplant renal artery stenosis (*A*). Optical coherence tomography imaging revealed marked intimal thickening with fibrous (*B*) and fibro-lipidic plaques with thin cap fibroatheroma (*C*). Post-percutaneous transluminal renal angioplasty, there is normal flow across the renal artery (D).

remained persistently normal during next three and half years of follow-up. A follow-up check angiogram and ultrasound Doppler showed normal transplanted renal artery.

Patient 4

A 9-year-old girl, diagnosed as Takayasu arteritis (TA), on immunosuppressive therapy from last 6 months, was referred to us for management of resistant hypertension. Her blood pressure (164/100 mmHg, >99 percentile) was poorly controlled on optimal doses of torsemide, spironolactone, enalapril, propranolol, and amlodipine. Her serum creatinine was 0.4 mg/dL and ultrasound Doppler revealed normal sized bilateral kidneys. A CT-angiogram revealed stenosis of the abdominal aorta, left subclavian artery, and bilateral renal arteries. An invasive angiogram revealed stenosis of the juxtarenal abdominal aorta (pressure gradient of 45 mmHg) and bilateral RAS (95% stenosis of the right renal artery and 90% stenosis of left renal artery). The abdominal aorta was stented with a 14 × 60 mm self-expanding stent (EPIC stent, Boston Scientific, Natick, MA, USA). Successful PTRA of right renal artery was performed using 2.75 mm followed by 3 mm balloon. Left renal PTRA was performed using 3 mm followed by 5 mm balloon (*Figure 4A*). The hard, fibrotic left renal artery lesion could not be fully dilated with 5 mm non-compliant balloon (*Figure 4B*). Optical coherence tomography imaging of the left renal artery showed extensive three-layer fibrosis, medial calcification, iatrogenic intimal dissection, and white fresh thrombus overlying the intima (*Figure 4C–E*). The angiographic end-result showed good flow across left renal artery with residual proximal stenosis (*Figure 4F*). During 3 months of follow-up, her blood pressure remained normal (120/84 mmHg) on enalapril and furosemide.

Discussion

Renal artery stenosis is a common cause of secondary hypertension. Atherosclerosis is the most common aetiology for RAS, especially in the elderly, while FMD and TA are the common causes in young individuals. Percutaneous or surgical renal artery revascularization is considered in those patients who have resistant hypertension, deteriorating renal function or have bilateral RAS with recurrent flash pulmonary oedema. Percutaneous transluminal renal angioplasty is the preferred mode of therapy compared with surgical revascularization. Intravascular imaging is extensively used to study atherosclerotic plaque morphology and characteristics in CAD, however, its use in atherosclerotic RAS is limited to few case reports.[3] Optical coherence tomography revealed a thin cap fibro-atheroma, plaque rupture, and thrombosis in Patient 1, which is the hallmark of vulnerable plaque morphology of atherosclerosis in RAS.[3]

Fibromuscular dysplasia is the second most common cause of renovascular hypertension, accounting for 10% of all cases.[1,2,4] It typically presents in young patients and involves non-ostial mid to distal renal artery. A 'string of beads' appearance of the diseased artery (*Figure 2A*) on angiography is the most striking feature of FMD. Histologically, FMD is characterized by medial dysplasia, which includes medial fibroplasia, perimedial fibroplasia and medial hyperplasia.[4,5] Medial fibroplasia is characterized by alternating areas of medial thinning and thickening due to collagen deposition.[5] On imaging, it is characterized by a string of beads appearance, where the bead diameter is larger than the proximal vessel.[4,5] Optical coherence tomography can clearly visualize the medial thickening and wavy intimal lining of FMD, as demonstrated in Patient 2 and by few other authors.[6,7]

Transplant renal artery stenosis is uncommon, but a treatable cause of refractory hypertension and allograft dysfunction after renal transplant. Its incidence ranges from 1% to 23% of post-transplant cases and accounts for 1–5% of cases of post-transplant hypertension.[8,9] It is an important cause of graft loss following graft rejection in renal transplant patients. The incidence of TRAS peaks between 3 and 6 months following transplant. The usual presentation is refractory hypertension, fluid retention, and graft dysfunction, in the absence of graft rejection. Anastomotic site TRAS is usually secondary to scarring at the suture site as was present in Patient 3. In contrast, late-onset TRAS is usually due to atherosclerosis or immune-mediated vascular damage.[8] Percutaneous transluminal renal angioplasty is considered to be the primary treatment modality in symptomatic TRAS patients. Optical coherence tomography

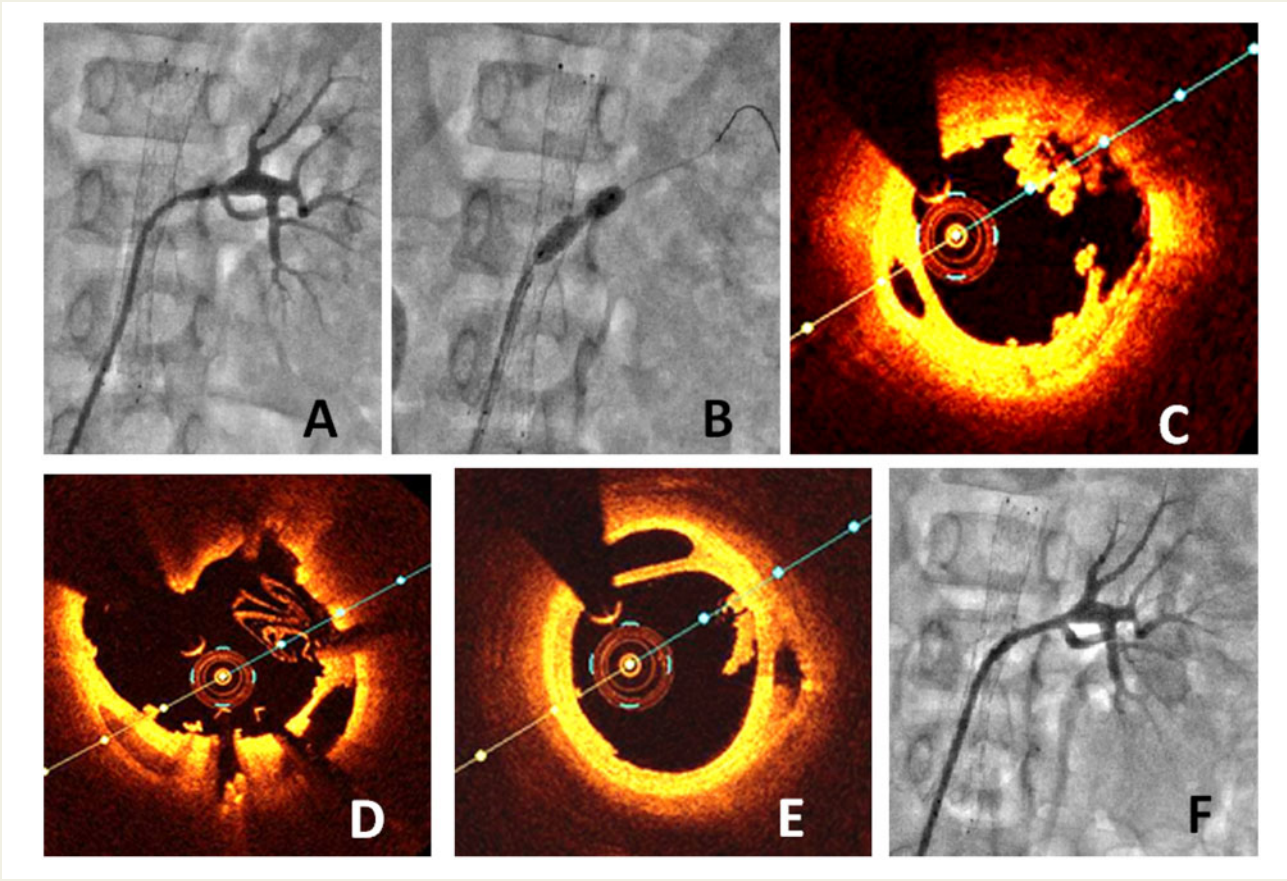

Figure 4 Percutaneous transluminal renal angioplasty of Takayasu arteritis related renal artery stenosis. Selective angiogram following abdominal aorta stenting revealed significant ostial–proximal left RAS (*A*). A residual waist of an inflated 5-mm non-compliant balloon across the proximal segment of the left renal artery (*B*) is suggestive of a hard fibro-calcified lesion, which is not amenable to balloon dilatation. Optical coherence tomography imaging revealed extensive three-layers fibrous thickening (*C*, *E*), medial calcification (*D*), and superimposed white thrombus (*C*, *E*). Honeycomb appearance is observed partially (*E*). Post-percutaneous transluminal renal angioplasty, there is normal flow across left renal artery (*F*).

demonstrated intimal proliferation with thick fibrous plaque (*Figure 3B, C*) at the stenotic anastomotic site, suggestive of scar reaction to possible intraoperative injury. To our knowledge, this is the first report of OCT imaging in TRAS.

Takayasu arteritis is a chronic inflammatory disease of the aorta and its major branches. The basic pathology in TA is a pan-arteritis that begins from the adventitial layer and spreads into the intima, thereby resulting in vascular complications.[10] Takayasu arteritis is an important cause of secondary hypertension in children, especially in the South Asian region.[11] It is characterized by an active inflammatory pre-pulseless phase and a healed fibrotic phase. In the active phase, there is inflammatory cellular infiltration and medial necrosis. Florid inflammation can cause loss of smooth muscle cells and weakening of media resulting in aneurysm formation. In the healed phase, there is fibrosis of adventitia and media that can clinically present as vascular insufficiency and its clinical sequelae.[12] Percutaneous transluminal renal angioplasty is considered for those with resistant hypertension and worsening renal functions. Optical coherence tomography imaging in Patient 4 revealed healed phase of TA, characterized by panvascular fibrotic thickening and medial calcification (*Figure 4C–E*). Optical coherence tomography imaging in TA related RAS has not been reported in the literature.

None of our patients had any procedure related complication with OCT imaging. It could diagnose under-expanded stent in Patient 1, while post-PTRA results were optimized with appropriate sized balloon dilatation in remaining three cases.

Conclusion

The possible advantages of OCT imaging in RAS include the demonstration of arterial wall layers, elucidation of the hallmark pathological features of individual disease, guiding the appropriate intervention and optimizing the PTRA results. Randomized trials and frequent use of OCT during PTRA might explore this area in the future. The major limitation of OCT is its limited depth of penetration in large arteries like the renal artery, which may limit the acquisition of high-quality images and their interpretation.

Lead author biography

Prof (Dr) Rajesh Vijayvergiya, MD, DM, FACC, FSCAI, FISES, is working as Director, Catheterization laboratory at Post Graduate Institute of Medical Education and Research (PGIMER), Chandigarh. His area of interest is percutaneous coronary and peripheral arterial interventions. He has published 125 articles in various national and international journals, 12 chapters in various books, and is member of editorial board of 11 national and international journals. He is the national co-ordinator from India for European Association of Percutaneous Cardiovascular Interventions (EAPCI) educational programme.

Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The authors confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

Conflict of interest: none declared.

References

1. Dworkin LD, Cooper CJ. Clinical practice. Renal-artery stenosis. *N Engl J Med* 2009;**361**:1972–1978.
2. Colyer WR, Eltahawy E, Cooper CJ. Renal artery stenosis: optimizing diagnosis and treatment. *Prog Cardiovasc Dis* 2011;**54**:29–35.
3. Tyczyński P, Kądziela J, Michałowska I, Puciłowska B, Witkowski A. Ruptured plaque in the renal artery by optical coherence tomography. *Kardiol Pol* 2016;**74**:193.
4. Slovut DP, Olin JW. Fibromuscular dysplasia. *N Engl J Med* 2004;**350**:1862–1871.
5. Begelman SM, Olin JW. Fibromuscular dysplasia. *Curr Opin Rheumatol* 2000;**12**:41–47.
6. Mizutani K, Itoh A, Sugioka K, Komatsu R, Naruko T, Yoshiyama M. Intravascular findings of fibromuscular dysplasia on optical coherence tomography. *J Cardiol Cases* 2015;**12**:39–42.
7. Sánchez-Recalde A, Moreno R, Jiménez-Valero S. Renal artery fibromuscular dysplasia: in vivo optical coherence tomography insights. *Eur Heart J* 2014;**35**:931–931.
8. Bruno S, Remuzzi G, Ruggenenti P. Transplant renal artery stenosis. *J Am Soc Nephrol* 2004;**15**:134–141.
9. Fervenza FC, Lafayette RA, Alfrey EJ, Petersen J. Renal artery stenosis in kidney transplants. *Am J Kidney Dis* 1998;**31**:142–148.
10. Mathew AJ, Goel R, Kumar S, Danda D. Childhood-onset Takayasu arteritis: an update. *Int J Rheum Dis* 2016;**19**:116–126.
11. Tyagi S, Kaul UA, Satsangi DK, Arora R. Percutaneous transluminal angioplasty for renovascular hypertension in children: initial and long-term results. *Pediatrics* 1997;**99**:44–49.
12. Miller DV, Maleszewski JJ. The pathology of large-vessel vasculitides. *Clin Exp Rheumatol* 2011;**29**:S92–S98.