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Successful endovascular treatment of chronic renal artery occlusion: a preliminary retrospective case series including 15 patients

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Abstract

Purpose To evaluate in a retrospective, single-center, case series if percutaneous transluminal renal angioplasty/stenting of chronic renal artery occlusion is beneficial to renal function and blood pressure control, which remains controversial.

Methods Data from 15 consecutive patients with renal artery stump who underwent successful percutaneous transluminal renal angioplasty/stenting only for unilateral chronic renal artery occlusion at our center from January 2007 to February 2018 and completed follow-up were retrospectively evaluated. Of the 15 patients, 14 (93.3%) were treated with stenting and 1 with only balloon angioplasty. Estimated glomerular filtration rate (eGFR) was calculated using the Modification of Diet in Renal Disease (MDRD) formula corrected for Chinese, and changes in blood pressure and need for antihypertensive medications were recorded.

Results At median 1.5-year (interquartile range 0.5–5.0) follow-up, restenosis rate was 20.0%. Renal function improved or remained stable in 26.7% and 53.3% of patients, respectively, and blood pressure normalized or improved in 13.3% and 40.0% of patients, respectively. Young patients with Takayasu's arteritis or fibromuscular dysplasia appeared to benefit the most from revascularization.

Conclusions In this preliminary retrospective series of select patients with renal artery stump, endovascular treatment of chronic renal artery occlusion appeared to preserve renal function and improve blood pressure.

Keywords Renal artery occlusion · Percutaneous transluminal renal angioplasty · Renal artery stenting · Blood pressure · Renal function

Introduction

Chronic renal artery stenosis (RAS) is a leading cause of secondary hypertension and also an important cause of renal failure [1, 2]. Renal artery occlusion (RAO) is defined as occlusion without anterograde perfusion of the renal artery, and if a patient with RAO has found hypertension or renal insufficiency for more than 3 months, the occlusion is considered chronic. As an end stage of RAS, chronic RAO is very rare and secondary to atherosclerosis, Takayasu's arteritis, and fibromuscular dysplasia [3]. The endovascular treatment of RAO is challenging but controversial. In the few studies published [3], the benefits of this treatment on kidney function and blood pressure control have been inconsistent, and are therefore the subject of the present case series analysis.

Patients and methods

Patient population

The indications for trying revascularization for patients with chronic RAO in our center were as follows: (a) patients had suffered hypertension or renal insufficiency for more than 3 months, with a kidney length more than 7 cm and unilateral GFR more than 10 ml/min; (b) patients with a kidney length less than 7 cm, or unilateral GFR less than 10 ml/min, refused to undergo nephrectomy, and were willing to

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try revascularization. Of the 52 patients with chronic renal artery occlusion who underwent endovascular treatment at our center from 2007 to 2018, revascularization was successful in 39 among whom the 15 who only received revascularization of the unilateral renal artery were routinely followed up and enrolled in the present study. Data on demographics, baseline clinical characteristics, and follow-up parameters including blood pressure, creatinine, and need for antihypertensive drugs were collected from the hospital information system and the medical notes.

Procedures

Pre procedure, the cause of chronic renal artery occlusion was established; in patients with Takayasu's arteritis, inflammatory status was stabilized; bilateral kidney size and renal artery stenosis were assessed by ultrasound, and renal function by radionuclide renal dynamic imaging; and oral aspirin (100 mg daily) and clopidogrel (75 mg daily) were administered for at least 2 days.

Procedures were performed via femoral approach under local anesthesia by the same team of interventionalists. Three thousand units of heparin were injected intravenously according to our experience during operation. The extent of renal artery stenosis was assessed by non-selective abdominal aorta angiography (Fig. 1a). Revascularization was not attempted in the absence of a renal artery stump. If no contrast agent passed the renal artery, we used a telescope technique to select the stump of the renal artery ostium, with a 7F Renal Double Curve guide catheter (Boston Scientific®, USA), a 5F Simon catheter (Cordis®, USA), and occasionally a 2.6F CXI supporting catheter (COOK®, USA). Next, we attempted to break through the occlusion with various guidewires (0.035-inch hydrophilic guidewire [Terumo®, Japan], 0.014-inch Command [Abbott®, USA], Pilot 50 [Abbott, USA], or 0.018-inch treasure 12 [Asahi Intecc®, Japan]). If the guidewire crossed the lesion, we used the catheter to confirm that the guidewire was in the true lumen (Fig. 1b). A 0.014-inch guidewire was exchanged to facilitate the dilatation procedure. Sequential dilatations were carried out with balloon dilatation catheters (Ultra-soft SV 3 × 20 mm or 4 × 20 mm [Boston Scientific, USA]; Sterling 5 × 20 mm [Boston Scientific, USA]) (Fig. 1c). Procedural success was defined as < 30% residual stenosis. If residual stenosis exceeded 30% after dilatations, a stent (PALMAZ BLUE 5 × 18 mm, 6 × 15 mm or 7 × 18 mm [Cordis, USA]) was deployed (Fig. 1d). In patients with contralateral stenosis, both lesions were treated during a single procedure.

Post procedure, oral aspirin (100 mg daily) and clopidogrel (75 mg daily) were continued for 3 months and one of them was taken for life. Patients with atherosclerotic chronic renal artery occlusion received appropriate medications to control glucose and lipid levels.

Follow-up

At follow-up visits, we assessed in-stent restenosis of the renal artery, adjusted as needed the dose of antihypertensive drugs, and monitored renal function. Restenosis was assessed preliminarily by renal artery ultrasound. Renal angiography was performed if restenosis was suggested by ultrasound. Patients diagnosed with in-stent restenosis, i.e., ≥ 50% reduction in luminal diameter, underwent dilatation again. Blood pressure was measured in the right arm in the supine position after 5-min rest in the clinic, and defined daily dose (DDD) recommended by the World Health Organization (WHO) was used to represent the need of antihypertensive drugs. Renal function was evaluated by calculating estimated glomerular filtration rate (eGFR) using the Modification of Diet in Renal Disease (MDRD) formula corrected for Chinese [4]:

$$\text{Male:eGFR}\left(\text{mL/ min /1.73 m}^2\right) = 175 \times \text{serum creatnine (mg/dL)}^{-1.234} \times \text{age}^{-0.179}$$

$$\text{Female:eGFR}\left(\text{mL/ min /1.73 m}^2\right) = 175 \times \text{serum creatnine (mg/dL)}^{-1.234} \times \text{age}^{-0.179} \times 0.79$$

The criteria for evaluation of renal function were as follows [5]: (a) improvement: ≥ 20% increase in the absolute value of eGFR after versus before treatment; (b) stabilization: absolute value of the eGFR within ± 20% of pretreatment values; (c) failure: ≥ 20% deterioration in eGFR after versus before treatment; and (d) benefit: improvement or stabilization. Blood pressure was evaluated according to the following criteria [6]: (a) cured: discontinued antihypertensive drugs, and blood pressure < 140/90 mmHg; (b) improved: using the same or less antihypertensive drugs as pre-operatively, with > 10% or > 15% decrease in systolic or diastolic blood pressure, respectively; and (c) ineffective: different from (a) or (b).

Statistical analyses

Continuous data with normal distribution, as verified with the Shapiro–Wilk test, are expressed as mean ± standard deviation and were compared using the paired Student t test, whereas non-normally distributed data are expressed as median and interquartile range and were compared using the Wilcoxon test. Categorical data are expressed as frequencies and percentages. A two-sided p value < 0.05 was considered statistically significant. Statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS) (version 22.0).

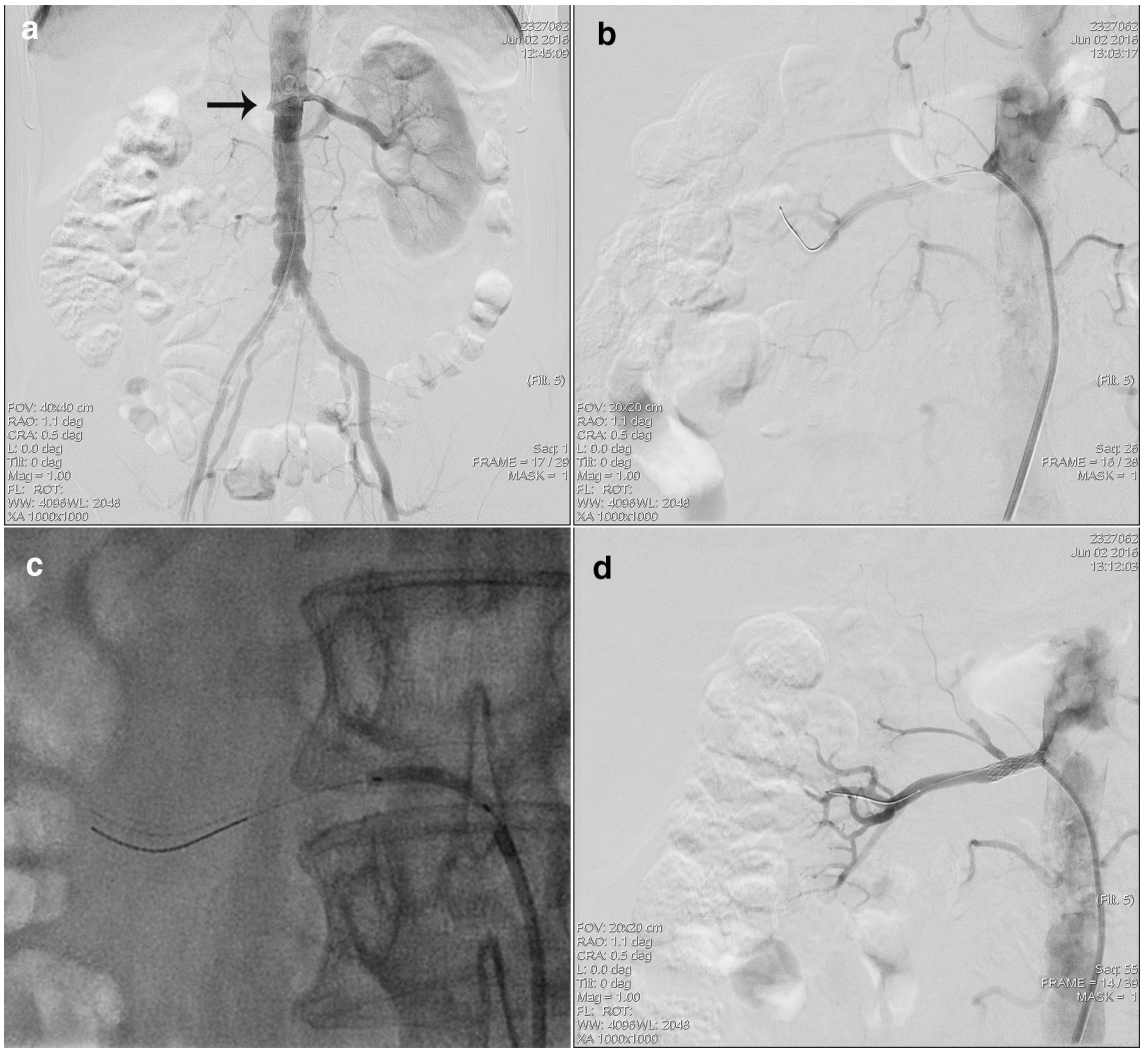

Fig. 1 Endovascular treatment of a 60-year-old patient. **a** The right renal artery was completely occluded with the stump (as indicated by the arrow). **b** Break through the occlusion with 0.035-inch super smooth guidewire (Terumo®, Japan) and 0.014-inch Command guidewire (Abbott®, USA) and it was confirmed in the true lumen. **c** Dilatation using Ultra-soft SV 3×20 mm balloon (Boston Scientific, USA). **d** Revascularization using PALMAZ BLUE 5×18 mm stent (Cordis, USA) and post-procedural angiography showed good renal artery perfusion

Results

Baseline characteristics (Table 1)

Among the 15 patients studied (mean age, 58.0 [range 21–73] years old; 13 males [86.7%]; 2 with diabetics [13.3%]), chronic renal artery occlusion was secondary to atherosclerosis in 12 patients, Takayasu's arteritis in 2, and fibromuscular dysplasia in 1, a 30-year-old male (Table 1). All patients had hypertension, 5 of whom suffered renal insufficiency. Except patient 13 whose contralateral renal artery was also occluded, none had severe contralateral renal artery stenosis (> 70%). Ipsilateral versus contralateral kidney was smaller (8.2 ± 1.4 cm vs. 10.8 ± 1.2 cm, $p < 0.001$) with lower pre-procedural GFR (11.0 ± 6.0 ml/min vs. 35.5 ± 16.3 ml/min, $p < 0.001$, respectively). None of them were on hemodialysis before the procedure.

Procedural characteristics (Table 2)

Ipsilateral renal artery stenting was performed for 14 patients and only balloon angioplasty for 1 patient. Patient 15 had fibromuscular dysplasia, and no stent was implanted because his renal perfusion recovered satisfactorily after dilatations. In patient 13, severe occlusion of the contralateral renal

Table 1 Baseline data and evaluation before endovascular treatment

Patient number	Age (years)	Sex	Diabetes Mellitus	Etiology	Contralateral RAS > 70%	Ipsilateral kidney size (cm)	Contralateral kidney size (cm)	Ipsilateral GFR (ml/min)	Contralateral GFR (ml/min)
1	56	Female	Yes	Atherosclerosis	No	9.7	10.4	20	40
2	68	Male	Yes	Atherosclerosis	No	8.4	11.7	3	33
3	58	Male	No	Atherosclerosis	No	7.8	10.3	16	27
4	62	Male	No	Atherosclerosis	No	8.5	11.0	14	42
5	59	Male	No	Atherosclerosis	No	8.5	11.1	5	51
6	60	Male	No	Atherosclerosis	No	7.5	11.0	9	44
7	61	Male	No	Atherosclerosis	No	8.8	11.0	14	41
8	61	Male	No	Atherosclerosis	No	6.0	10.0	4	42
9	41	Male	No	Atherosclerosis	No	7.7	10.6	10	38
10	53	Male	No	Atherosclerosis	No	9.7	9.8	6	8
11	73	Male	No	Atherosclerosis	No	11.2	13.9	16	26
12	49	Male	No	Atherosclerosis	No	6.2	10.0	3	26
13	25	Male	No	Takayasu's arteritis	Yes	8.0	11.2	13	24
14	21	Female	No	Takayasu's arteritis	No	6.7	11.3	11	76
15	30	Male	No	FMD	No	8.1	8.1	21	14

RAS renal artery stenosis, *GFR* glomerular filtration rate, *FMD* fibromuscular dysplasia

artery without stump precluded stenting. There were no severe procedure-related complications in these patients. In patients who had not been treated successfully, 7.7% (1/13) suffered retroperitoneal hematoma. Embolization was performed in time and the patient recovered well after operation.

Outcomes at follow-up

At median 1.5-year (interquartile range 0.5–5.0) follow-up, in-stent restenosis rate was 20.0% (3/15). Balloon angioplasty was performed successfully in two of them, while revascularization failed in patient 3 because of renal artery re-occlusion without stump (Table 2).

Pre-procedural and follow-up serum creatinine level and eGFR are shown in Table 2. Among the 15 patients studied, 12 (80.0%) benefited from endovascular treatment in terms of renal function with 8 (53.3%) with stable renal function and 4 (26.7%) with improved eGFR relative to baseline. Renal function in 20.0% (3/15) patients continued to deteriorate, with patient 3 requiring hemodialysis.

In terms of hypertension (Table 3), 6 (40.0%) patients showed improvement, 2 (13.3%) cure, and 7 (46.7%) ineffectiveness.

Discussion

In the present retrospective, single-center, case series of patients with chronic renal artery occlusion, successful unilateral percutaneous transluminal renal angioplasty/stenting was associated with improvement or stabilization of renal function in 80.0% of patients, and better blood pressure control in 53.3% of patients at median 1.5-year follow-up.

There are few studies with inconsistent results on the effects of endovascular treatment for chronic renal artery occlusion on renal function and blood pressure control. While in the study by Oskin TC [7] renal function improved in 49% of 79 patients, including 9 patients who ceased to be dialysis-dependent, in a 34-case series study [8] creatinine level did not change significantly after treatment. Both studies used serum creatinine level to evaluate renal function which would ignore the influence of age, race, gender, and other factors on glomerular filtration. In the present study, renal function was evaluated using eGFR which more accurately reflects overall renal function. Especially, the GFR of patient 11 before treatment was 42 ml/min, and according to the criteria we used, his renal function deteriorated at 11-year follow-up. However, in the study by Cheung [9] the overall rate of progressive GFR decline was 4.1 ml/min per year for patients with chronic renal artery occlusion, so we think the efficacy of this patient was reasonable, considering that he had had a significantly slower decline in kidney function over 11 years than patients who did not undergo endovascular treatment. In terms of blood pressure control, studies by Alhadad [9] and Whitehouse WJ [10] and a 16-case series study [11] documented that 71%, 89%, and 100%, respectively, of patients studied benefitted from percutaneous intervention. In the present study, only 53.3% patients benefited in terms of blood pressure, which may be

Table 2 Procedural characteristics, ISR, and evaluation of renal function

Patient number	Ipsilateral stenting	Contralateral stenting	Follow-up duration (year)	ISR	Dilatation again	Creatinine before treatment (umol/L)	Creatinine latest follow-up (umol/L)	eGFR before treatment (ml/min/1.73 m^2)	eGFR latest follow-up (ml/min/1.73 m^2)	Renal function evaluation
1	Yes	No	8	Yes	Yes	98	106	59.2	52.5	Stabilization
2	Yes	No	5	No	–	141	135	46.2	48.1	Stabilization
3	Yes	No	3	Yes	No	232	364	25.7	14.6	Failure
4	Yes	No	1	No	–	101	134	70.9	49.9	Failure
5	Yes	No	1.5	No	–	135	105	50.0	67.9	Improvement
6	Yes	No	2	No	-	111	113	63.5	61.8	Stabilization
7	Yes	No	1	No	–	133	119	50.6	57.9	Stabilization
8	Yes	No	1	No	–	106	116	67.0	59.8	Stabilization
9	Yes	No	0.5	No	–	119	142	62.4	50.1	Stabilization
10	Yes	No	0.25	No	–	425	336	12.4	16.5	Improvement
11	Yes	No	11	No	–	140	215	46.0	26.4	Failure
12	Yes	No	0.25	No	–	138	163	50.3	40.9	Stabilization
13	Yes	No	7	Yes	Yes	236	106	29.3	75.2	Improvement
14	Yes	No	1.5	No	–	75	58	98.2	133.2	Improvement
15	No	No	0.5	No	–	103	110	78.8	72.5	Stabilization

ISR in-stent restenosis, *eGFR* estimated glomerular filtration rate

Table 3 Evaluation of blood pressure

Patient number	SBP before treatment (mmHg)	SBP latest follow-up (mmHg)	DBP before treatment (mmHg)	DBP latest follow-up (mmHg)	DDD before treatment	DDD latest follow-up	Blood pressure evaluation
1	120	130	70	70	2.0	2.0	Ineffective
2	130	160	70	90	3.2	3.0	Ineffective
3	150	190	80	100	2.3	4.3	Ineffective
4	230	138	120	78	2.7	2.7	Improved
5	145	130	114	85	1.0	0.0	Cured
6	108	120	66	80	2.0	0.0	Cured
7	140	130	100	90	1.0	1.0	Ineffective
8	150	140	100	90	1.3	2.5	Ineffective
9	153	125	104	90	2.3	2.0	Improved
10	190	130	97	85	3.5	5.4	Ineffective
11	170	140	95	60	1.1	3.5	Ineffective
12	197	130	111	90	2.0	2.0	Improved
13	200	134	120	85	3.5	1.3	Improved
14	151	150	95	90	3.1	1.8	Improved
15	159	130	124	80	5.7	3.7	Improved

SBP systolic blood pressure, *DBP* diastolic blood pressure, *DDD* defined daily dose

related to the fact that the antihypertensive drugs were not administered to a sufficient dose before the operation.

As suggested by the present study and one case report [12], endovascular treatment may be particularly beneficial for young patients with chronic RAO, which is probably related to the short course of disease. In the study by Heidemann [13], for acute RAO with short-term renal ischemia, renal function can be salvaged by revascularization. Similarly, in young patients with chronic RAO, symptoms also become severe in a relatively short time, prompting timely evaluation and treatment which might render possible to salvage the hypoxic kidney before failure of compensatory mechanisms. In patient 13, a young man with Takayasu's arteritis and bilateral renal artery occlusion, endovascular treatment was only successful in one renal artery, which went on to develop in-stent restenosis that was timely treated with balloon angioplasty. Eight years post procedure, his renal function and blood pressure remain significantly better than pre procedure, suggesting that a more aggressive treatment strategy might be appropriate in younger patients.

The 75.0% procedural success rate without serious complications in the present study might reflect our patient selection criteria, attempting revascularization only for patients with renal artery stump, and the use of techniques and instruments that are commonly utilized for lower limb arteries, such as telescope technique, supporting catheter and CTO guidewires. Unlike acute RAO [13], the component of chronic RAO lesion is atheromatous plaque, rather than thrombus, so we did not use aspiration thrombectomy or local lysis therapy for revascularization.

The present study is limited by several sources of bias including its retrospective, single-center design without a control because most patients who failed to revascularize were lost to follow-up at our center; its wide variation of follow-up periods with a relevant percentage of patients had been followed for only 12 months or less because the patients at our center came from all over the country, resulting in their poor compliance; and its small sample size driven by the rarity of the disease. In addition, most patients did not pay attention to their health and rarely received physical examination, so we could not obtain the early data of blood pressure and renal function before operation and the long-term trends. Hopefully, with the popularity of ultrasound use for routine examination, patients with renal artery stenosis will be diagnosed and get treatment earlier, rendering chronic renal artery occlusion rarer. However, larger, prospective studies with longer-term follow-up are warranted.

Conclusion

In the present retrospective case series, endovascular treatment of chronic renal artery occlusion appeared to benefit renal function and blood pressure control.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This retrospective study was approved by the Institutional Review Board with waiver of informed consent.

References

1. Textor SC (2017) Renal arterial disease and hypertension. Med Clin N Am 101:65–79
2. Van der Niepen P, Rossignol P, Lengelé J, Berra E, Sarafidis P, Persu A (2017) Renal artery stenosis in patients with resistant hypertension: stent it or not? Curr Hypertens Rep 19:5
3. Wright MP, Persad RA, Cranston DW (2001) Renal artery occlusion. BJU Int 87:9–12
4. Ma YC, Zuo L, Chen JH, Luo Q, Yu XQ, Li Y, Xu JS, Huang SM, Wang LN, Huang W et al (2006) Modified glomerular filtration rate estimating equation for Chinese patients with chronic kidney disease. J Am Soc Nephrol 17:2937–2944
5. Rundback JH, Sacks D, Kent KC, Cooper C, Jones D, Murphy T, Rosenfield K, White C, Bettmann M, Cortell S et al (2002) Guidelines for the reporting of renal artery revascularization in clinical trials. American Heart Association. Circulation 106:1572–1585
6. Jiang X, Peng M, Li B, Dong H, Che W, Zou Y, Yang Y, Gao R (2016) The efficacy of renal artery stent combined with optimal medical therapy in patients with severe atherosclerotic renal artery stenosis. Curr Med Res Opin 32:3–7
7. Oskin TC, Hansen KJ, Deitch JS, Craven TE, Dean RH (1999) Chronic renal artery occlusion: nephrectomy versus revascularization. J Vasc Surg 29:140–149
8. Alhadad A, Mattiasson I, Ivancev K, Gottsater A, Lindblad B (2004) Sustained beneficial effects on blood pressure during long time retrospective follow-up after endovascular treatment of renal artery occlusion. J Hum Hypertens 18:739–744
9. Cheung CM, Wright JR, Shurrab AE, Mamtora H, Foley RN, O'Donoghue DJ, Waldek S, Kalra PA (2002) Epidemiology of renal dysfunction and patient outcome in atherosclerotic renal artery occlusion. J Am Soc Nephrol 13:149–157
10. Whitehouse WJ, Kazmers A, Zelenock GB, Erlandson EE, Cronenwett JL, Lindenauer SM, Stanley JC (1981) Chronic total renal artery occlusion: effects of treatment on secondary hypertension and renal function. Surgery 89:753–763
11. Dostal G, Heihoff JJ, Jakubowski HD, Eigler FW (1983) Renal revascularisation in 36 patients with chronic total occlusion of the renal artery. Proc Eur Dial Transplant Assoc 20:587–592
12. Agarwal G, Vats HS, Raval AN, Yevzlin AS, Chan MR, Gimelli G (2013) Chronic total occlusion and successful drug-eluting stent placement in Takayasu arteritis-induced renal artery stenosis. Clin Med Res 11:233–236
13. Heidemann F, Kolbel T, Debus ES, Diener H, Carpenter SW, Rohlffs F, Tsilimparis N (2018) Renal function salvage after delayed endovascular revascularization of acute renal artery occlusion in patients with fenestrated-branched endovascular aneurysm repair or visceral debranching. J Endovasc Ther 25:466–473