Feasibility and long-term effectiveness of endovascular therapy for renal artery aneurysms: a retrospective analysis of cases done over 1 year

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Introduction
True renal artery aneurysms (RAAs) are uncommon, and their actual prevalence is unknown. The indications for treating RAAs include symptomatic aneurysms, larger than 20 mm or enlarging aneurysms during follow-up, aneurysms in patients in childbearing age or in pregnant women, ruptured aneurysms, false aneurysms, and aneurysms associated with arteriovenous fistulas or dissection.

Aim
This retrospective study describes our experience with the endovascular treatment of RAAs with special consideration given to the indications, technical considerations, and complications.

Patients and methods
Endovascular therapy techniques were offered to selected patients with RAAs presented at Vascular Surgery Department, Cairo University Hospitals, between December 2017 and December 2018.

Results
During the study period, five patients diagnosed with RAAs were selected for endovascular therapy. Their age range was 35–57 years (mean, 46 years). From the five patients (four males and one female), three patients with RAAs (two true and one false aneurysm) underwent coil embolization, whereas two patients (one female and one male) with true aneurysms underwent stent graft therapy. The average length of postoperative hospital stay was 4.0 days. Technical success was achieved in all patients. Perioperative morbidity was not observed in any patients, and there were no postoperative mortalities. No evidence of growth of the aneurysm sac or endoleak was observed during follow-up in any patient.

Conclusion
Current data support the high safety of endovascular treatment of RAAs with all of its available techniques.

Keywords:
coil embolization, renal artery aneurysm, stent graft therapy

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Introduction

A renal artery aneurysm (RAA) is defined clinically as a localized focal dilatation of renal artery that exceeds twice the diameter of a normal renal artery [1]. RAAs can cause a lot of symptoms like secondary hypertension, loin pain, hematuria, and various degrees of renal parenchymal infarction [2]. RAAs may remain asymptomatic, but with further increase in size, they might end up with aneurysm rupture and/or renal arteriovenous fistula formation. For that reasons, patients with symptomatic RAAs should be referred for elective repair, but if patients are asymptomatic, further workup with possible intervention may be considered. The prevalence of true RAAs is unknown. Autopsy studies revealed an incidence of one per 8000 to one per 10 000 [3,4]; however, other studies revealed a prevalence of 9.7% [5]. The prevalence of RAAs as detected in angiographic studies varies between 0.3 and 0.7% in the general population [6–8]; a higher prevalence was reported in patients with hypertension (2.5%) and fibromuscular dysplasia (9.2%) [9,10]. The actual prevalence of false RAAs is unknown, but with the widespread use of minimally invasive kidney procedures such as biopsy and nephrostomy, an increase in incidence of RAAs has recently been reported [10]. Symptoms from RAAs occur in less than 50% of patients and include mainly hypertension, hematuria, and abdominal dull aching loin pain from aneurysm expansion or rupture. The pathophysiology of hypertension in patients with RAAs is not well explained but may be related to kinking of the renal artery branch from enlarging nearby aneurysm,

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turbulent flow in the aneurysm, distal embolization from the aneurysm, or an associated stenosis of the renal artery [11]. The incidence of RAAs rupture increases in pregnant women and in aneurysms larger than 2 cm [12]. During pregnancy, the mortality from rupture is high with a reported maternal and fetal mortality of 50 and 80%, respectively [12]. The mortality in non-pregnant women is less than 10% [13]. The indications for treating RAAs include symptomatic aneurysms, aneurysms larger than 2 cm or progressively enlarging aneurysms, aneurysms in patients in childbearing age or in pregnant women, ruptured aneurysms, false aneurysms, and aneurysms associated with arteriovenous fistulas or aneurysms associated with renal artery dissection [13]. For decades, surgery either through aneurysmorrhaphy, resection and bypass grafting, ex-vivo repair, or nephrectomy was the standard treatment for RAAs [14]. Recently, with advances of endovascular techniques, endovascular treatment has become the first choice therapy with a high technical success rate, a low procedure-related morbidity and mortality, little postoperative discomfort, and rapid recovery. An angiographic RAA classification has been proposed by Rundback and colleagues. Type I RAAs are saccular in shape and arise from the main renal artery or from proximal large segmental artery. Type I RAAs can be successfully treated with covered stent or stent/balloon-assisted coil embolization. Type II RAAs are fusiform in shape, occur at the main renal artery or proximal segmental arteries, and are best treated surgically. Type III RAAs are intraparenchymal aneurysms affecting the small segmental or accessory arteries. These are best treated with coil embolization with minimal loss of parenchyma [13]. Based on the recent advances of endovascular therapy of RAA, we report a five-patient retrospective study. This retrospective review describes our treatment of RAAs with special consideration given to the indications, technical considerations, and complications.

Patients and methods

We retrospectively collected data of patients with RAAs who presented to our Vascular Surgery Department and were managed by endovascular techniques over the past 1 year from December 2017 till December 2018. The study was approved by the ethical committee to retrieve the required data from archived files and a written consent was found in all patient's file declaring the nature of the procedure with all possible complications. The patient's data reviewed included age, sex, presenting symptoms, size and type of aneurysm (true or false), type of endovascular technique used, outcomes, and complications. The serum creatinine levels before the procedures and during the follow-up period were checked. Preoperative and postoperative images were reviewed from our stored images archives. The procedures were all performed in the angiography suite. All procedures were done under local anesthesia (2% lidocaine), and intravenous sedation was occasionally used in some cases once the patients started feeling discomfort. Access in all cases was gained under local anesthesia through a single transfemoral arterial route. Selective renal angiography was performed at the start of the procedure via 5-F C2 Cobra 2 catheter (Cook Inc., Bloomington, Indiana, USA) in an anteroposterior and oblique views, to clearly demonstrate the anatomy of RAAs. A single bolus of 5000 U of heparin was given in the femoral sheath at the start of the procedure. After angiography, cannulation of the renal artery ostium was done by 6-F renal double curved sheath (Destination peripheral guiding sheath; Terumo, Tokyo, Japan) to obtain a stable platform for the rest of the procedure.

Coil embolization

The procedures were performed by placing the coils via microcatheter (Progreat; Terumo) telescoped through the 5-F catheters to the aneurysm sacs distally at the level of efferent branches and proximally in the feeding arteries. Herein, 0.018-inch detachable coils (Interlock; Boston Scientific, Natick, Massachusetts, USA) were used in embolization, and 0.35 pushable coils (2D Helical-35; Boston Scientific,) were selectively used in large aneurysm sacs. After coil embolization, gelfoam was injected via the microcatheter to fill the aneurysm sac, an adjunctive that is commonly used by some interventional radiologists to temporarily abolish residual flow inside the aneurysm sacs until complete coli-induced thrombosis happens.

Covered stent therapy

The exact anatomical locations of the aneurysms together with proximal and distal artery diameters were determined with routine initial angiography at the start of the procedure, and a final decision regarding stent graft treatment was then determined. The lesion was crossed with a 0.014-inch guide wire (Crusier-14; Bitronik AG, Bűlach, Switzerland). A balloon-expandable covered stent (Advanta V12; Atrium Medical; Maquet, Merrimack, New Hampshire, USA) was introduced over the guide wire and deployed across the lesion. A completion angiography at the end of the procedure was done to

show graft position, aneurysm exclusion, and any signs of endoleak. Technical success was defined as exclusion of the true aneurysm and cessation of blood flow through the aneurysm sac without evidence of contrast extravasation. Follow-up after discharge from hospital was done in outpatient clinic by clinical examination and duplex ultrasound or CTA, at 3, 6, and 12 months after the procedure.

Results

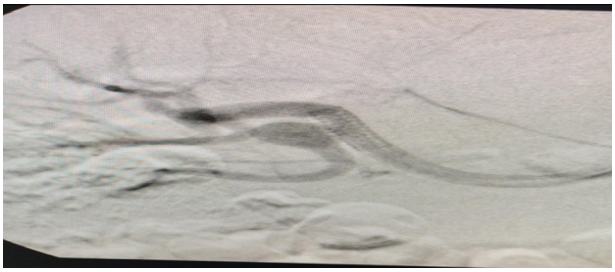
During the period from December 2017 till December 2018, we found seven patients who were diagnosed in our department by RAAs; of them, five patients (four males and one female) underwent endovascular therapy. The other two patients were managed conservatively with follow-up owing to small size of the aneurysm (<20 mm) and asymptomatic presentation and were not included into our review. The five patients who underwent endovascular therapy (four males and one female) had age range between 35 and 57 years (mean, 46 years). Three male patients with RAAs (two true and one false aneurysm) underwent coil embolization, whereas two patients (one female and one male) with true aneurysms arising from the left and right main renal artery, respectively, underwent stent graft therapy utilizing one balloon-expandable covered stent for each case. In one patient with true RAA, a false aneurysm was suspected to arise from contained rupture of the true aneurysm arising from the left inferior segmental artery (Fig. 1).

Case 1 was a 35-year-old man with a history of hypertension, on medical treatment (angiotensin receptor blockers) for one and half years. He presented with acute left loin pain, and a huge (8.5×7.2×8.2 cm) left renal artery false aneurysm was detected by multidetector contrast-enhanced-CT of the abdomen. The false aneurysm was seen connected to a true aneurysm (1.2×1 cm) arising from abnormally ectatic inferior segmental branch to the lower pole of the kidney. Coils embolization was done utilizing four detachable coils to embolize the false aneurysm sac and three pushable coils with gelfoam injection to exclude the whole ectatic inferior segmental artery together with the true aneurysm arising from its distal end (Fig. 2).

Case 2 was a 43-year-old diabetic and hypertensive women (on oral hypoglycemic treatment and calcium channel blockers) discovered accidently to have left RAAs during abdominal ultrasound examination for non-specific abdominal pain. Multidetector CTA of the renal arteries showed a saccular aneurysm (1.7×2.1 cm) arising by a narrow neck (1.9 mm) from the distal left main renal artery 1.5 cm before bifurcations. A single balloon-expandable covered stent (Advanta V12, 5× 22 mm, Atrium Medical; Maquet) was positioned opposite the aneurysm neck for exclusion.

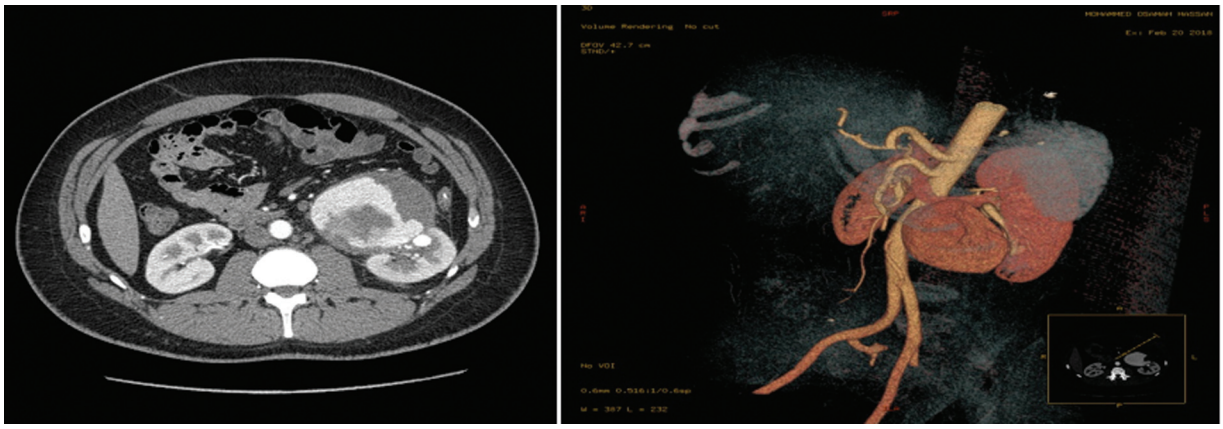
Case 3 was a 49-year-old diabetic man referred from Urology Department following previous left-side nephrostomy for urinary tract stone obstruction done

Figure 1



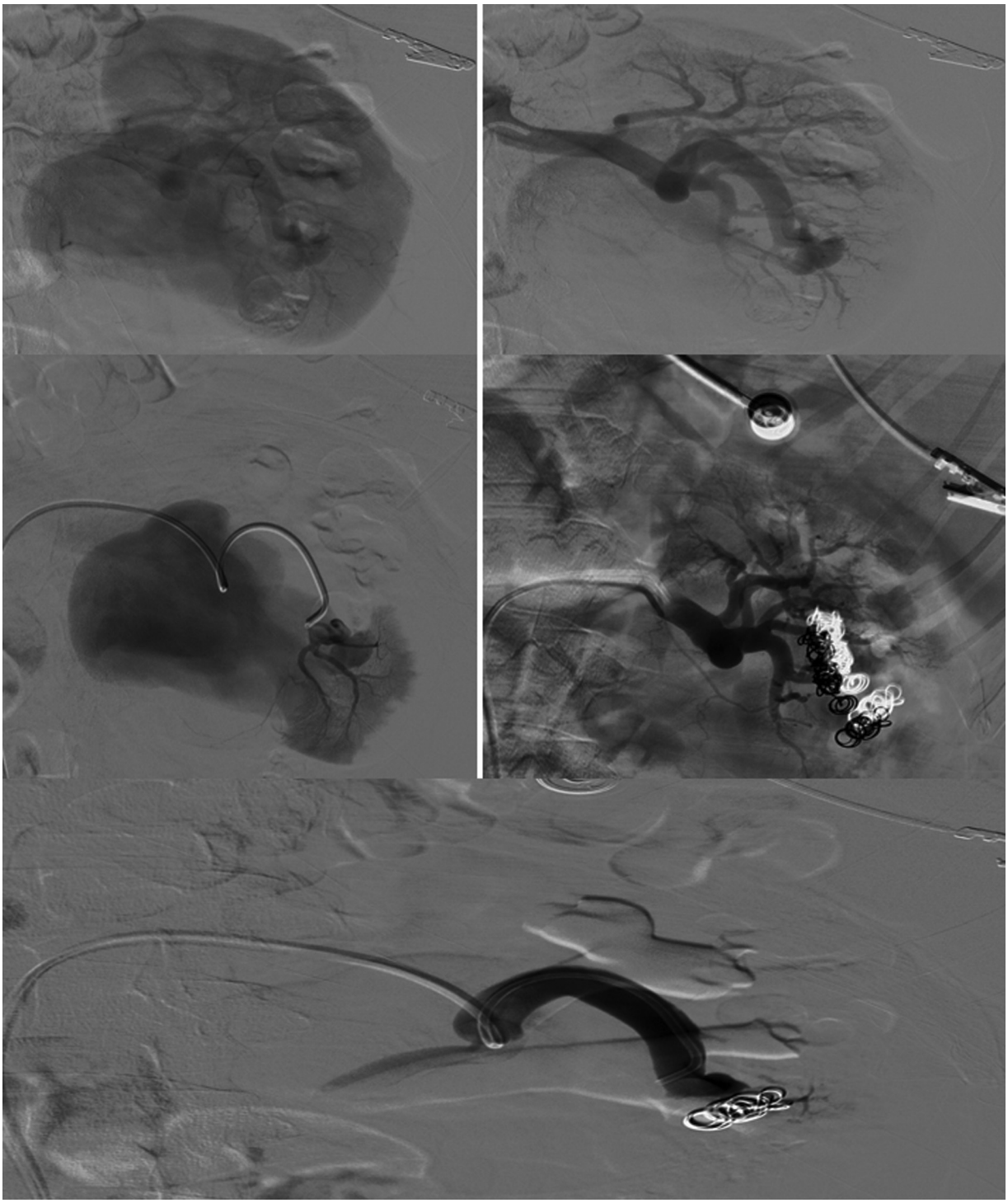
Preoperative CT angiography of patient in case 1. CT, computed tomography.

Figure 2



Coil embolization of case 1 RAA. RAA, renal artery aneurysm.

Figure 3



The case of stent graft therapy for right main RAAs. RAA, renal artery aneurysm.

2 years before. The patient started to experience a left loin dull aching pain. CT examination showed left renal false aneurysm (2×3×1.5 cm) near the left renal pelvis. Coil embolization was done utilizing 3 detachable coils with gelfoam injection to completely exclude the aneurysm sac.

Case 4 was a 57-year-old nondiabetic man with hypertension (on treatment with calcium channel blockers CCB) who was diagnosed with an intra-renal small true aneurysm (1.5×2×0.7 cm) arising from the right inferior segmental branch of the right renal artery with mild renal impairment (serum creatinine: 1.7 mg ?dl) and was referred to vascular clinic for management. Coil embolization was done utilizing 3 detachable coils followed by gelfoam injection to completely exclude the aneurysm sac.

Table 1 Preoperative and postoperative main laboratory clinical findings

	Preoperative					Postoperative				
Serum creatinine	0.86	0.85	0.95	1.7	0.7	0.82	0.77	0.8	1.29	0.72
Hemoglobin	13.77	14.1	16.1	16.9	12.5	12.8	14.9	15.8	16.2	12.0

Case 5 was a 56-year-old diabetic man who was diagnosed to have a small fusiform right main RAA. Over 4 months, it increased in size progressively to reach the size of 2×1.9 cm. Elective stent graft therapy was done utilizing one covered stent (Advanta V12® 5×22 mm, Atrium; Maquet) (Fig. 3).

Baseline patients' clinical characteristics and postoperative findings before discharge are shown in Table 1.

The average length of postoperative hospital stay was 4.0 days. Technical success was achieved in all patients. Perioperative morbidity was not observed, and there were no postoperative mortalities. The 3 patients presented with RAAs and hypertension showed no improvement or worsening of their hypertension illness during follow-up. The patients who presented with loin pain showed total or partial improvement of their symptoms. No access site complications happened. No evidence of growth of the aneurysm sac or endoleak was observed during follow-up in any patient. Post-embolization syndrome (PES), defined as a combination of fever, leukocytosis, abdominal pain, nausea, and vomiting, was not observed in any of the three patients after embolization. Only one patient (the female patient who underwent stent graft therapy for her left renal artery true aneurysm) was lost to follow-up after 3 months from the procedure.

Discussion

RAAs are asymptomatic in most cases and are incidentally found during routine workup for other abdominal complaints with diagnostic imaging studies such as CT, duplex ultrasonography, CTA, MRI, or magnetic resonance angiography. According to Dzsinich *et al*. [15], only 34% (11 of 32) of patients who underwent surgery were symptomatic. In asymptomatic patients, complications from RAA are relatively infrequent. In a report by Hubert and colleagues, 62 asymptomatic patients who had solitary saccular aneurysms with a mean size of 1.5 cm (range, 0.3–4.0 cm) were followed over a mean period of 5.7 years (median, 8 years). No ruptures, need for surgery, or new symptoms developed. Eight (12%) patients died, but all of these deaths were unrelated to the aneurysm [16]. In another series by Henriksson and colleagues, 34 RAAs were managed conservatively and followed with serial angiography. Over a mean follow-up period of 35 months, no detectable size changes were found in 28 (82.4%) RAAs, and relatively mild changes were found in the other six (17.6%) aneurysms. Most importantly, no ruptures were found during follow-up. Hypertension is the most common presenting symptom in RAA, with an incidence as high as 90% [17]. A poststenotic fusiform aneurysm is often found associating renal artery stenosis. In this case, the hypertension can be attributed to the renal artery stenosis with activation of the renin–angiotensin system and increased angiotensin II levels resulting in sodium and water retention with systemic vasoconstriction [18]. Hypertension in RAA without a renal artery stenosis is not as well understood. Possible causes may be related to renal ischemia secondary to distal embolization; in cases of aneurysms near bifurcation areas, anatomic kinking of the renal artery branches has been reported [19]. Saccular and intraparenchymal aneurysms are less likely to be associated with hypertension [20].

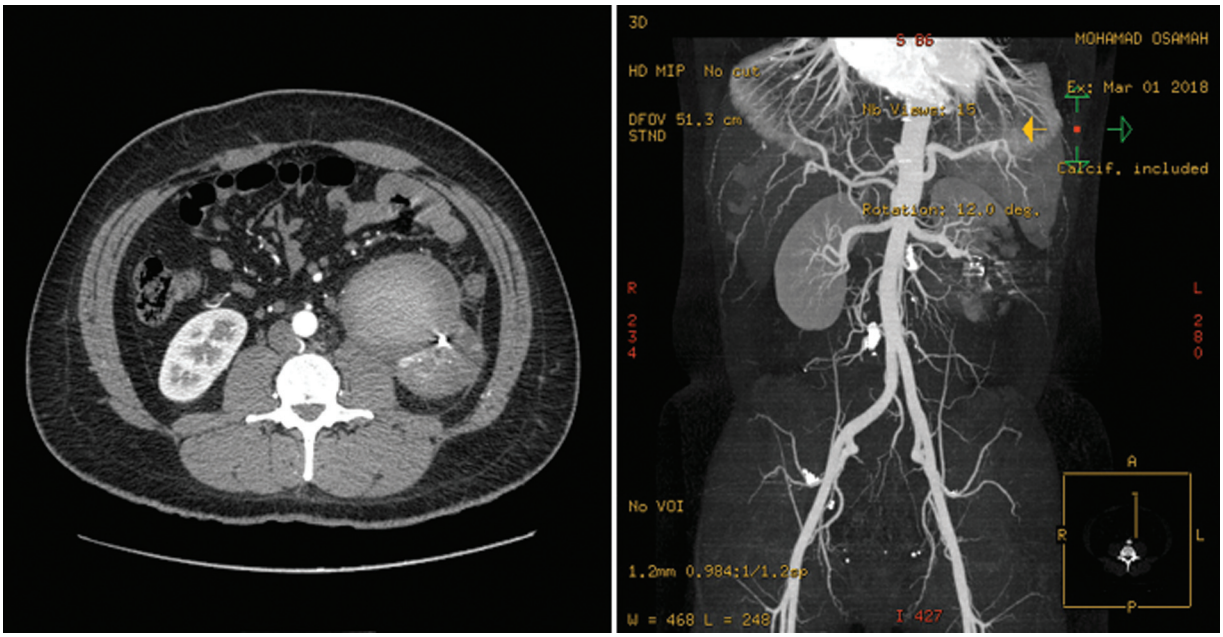
Patients with RAAs complicating a renal artery dissection may present with a dull aching flank pain, despite the fact that most of the patients with spontaneous renal artery dissections are usually asymptomatic. Acute onset of loin pain or further increase in severity of a previously existing pain or may also be a sign of a rapidly expanding aneurysm or even indicative of impending rupture aneurysm. Hematuria may result from dissecting RAA or rupture of intraparenchymal aneurysms into the collecting system [20]. Fewer than 3% of patients with RAAs experience a rupture [20]. Patients with RAA rupture typically have signs and symptoms of acute abdomen and may be in hypovolemic shock [21]. During review of our cases, we found that only two cases presented with loin pain and three patients had hypertension, which eventually showed no improvement or worsening after the intervention. None of our patients developed hematuria or massive progressive renal infraction. Patient in case 1 had a false RAA following contained rupture of a true aneurysm arising from the inferior segmental artery to the lower pole of the left kidney. The patient was stable with no signs of hypovolemia or acute blood loss. Elective repair of an RAA is generally undertaken to prevent the risk of rupture or obviate the symptoms.

Various operations have been described including tangential excision with primary repair or patch angioplasty, aneurysm excision with reconstruction using bypass, extracorporeal vascular reconstruction with auto-transplantation, and nephrectomy; the morphology and anatomic location of the aneurysm determine which operation to use [14]. In some cases, partial nephrectomy may be obligatory, but with improved surgical techniques, renal preservation is now the standard of care [11]. Open surgery for treatment of RAAs is considered a major abdominal surgery which may be associated with a lot of morbidities or even mortalities. In a study of 215 patients, open surgery was associated with more complications such as cardiovascular and cerebrovascular complications, and infections [22]. For that reason, endovascular approach has recently become an increasingly popular route of repair. Variable endovascular therapeutic options exist for management of RAAs. These options fall basically into two categories: sac embolization with either metallic or liquid embolic agents or aneurysm exclusion through covered stents (stent grafts). Stent graft implantation is often suitable for the treatment of aneurysms arising from the main branch of the renal artery. Coil embolization uses microcatheters to inject coils into the aneurysm sac to induce sac thrombosis, which is suitable in the case of narrow aneurysm neck to prevent dislodgment of the coils [23].

Another endovascular technique that we did not use in our patients is stent implantation- assisted coil embolization. It is suitable for the situation when the aneurysm neck is wide or irregular tumor shape [24,25]. Two patients had undergone stent graft implantation whereas the rest of the three patients had undergone coil embolization of the aneurysm sac with injection of gel foam particles to induce rapid thrombosis of the aneurysms. We did not find any problems in the registered operative notes related to difficulties in cannulation of the main renal artery to obtain a stable platform for the intervention nor any problems in accessing the aneurysm neck for cases of aneurysm embolization. Moreover, there were no operation-related complications during postoperative observation and follow-up. Only in cases 1 and 4, patients develop mild to moderate acute dull aching pain at the right and left loins, respectively, on the next day, which was explained by infraction of the renal area supplied by the target branch that was treated by coil embolization. The renal infraction was limited and was not associated with any change in serum creatinine levels (Fig. 4). Moreover, the patient in case 4 started to show mild improvement of his renal function (from 1.7 to 1.29 mg?dl). The pain was controlled by NSAIDs and subsided gradually over the next days.

Considering the effect of endovascular coil embolization on renal artery branch blood flow with the possible effect on the kidney function, we did not found any increase of creatinine or decrease in hemoglobin concentration in the early postintervention period or during the follow-up, except for mild changes. According to the results, these two parameters were in the controllable normal

Figure 4



Follow up CT angiography done 1 year after coil embolization of case 1 RAA. CT, computed tomography; RAA, renal artery aneurysm.

range and had no significant effect on the patient's life and disease prognosis, as shown in Table 1. We did not found any evidence of the possible complications from using the steel ring used in the coils reported by Soga *et al.* [26], including renal pedicle vascular injury, peripheral renal ischemic infarction, or ectopic embolization. A potential bias in our study was that the selection between open repair and endovascular repair was determined by surgeon preference. The purpose of our study is not to express superiority of one approach over the other, as it is not a comparative study, but we believe that in some selected patients stent grafts offer an alternative way of dealing with these problems. Limitations of our study include the relatively small number of patients (only five patients); although the largest retrospective series to date reported 168 patients [1] and most series include from 21 to 43 patients [27,28]. A large series with long-term follow-up comparing endovascular therapy with surgical options for RAAs is still needed to safely confirm the widespread adaption of endovascular management in such lesions.

Conclusion

Endovascular intervention for RAAs is a safe treatment modality that can be offered to selected cases. Further studies are needed to compare the outcome of endovascular therapy for RAAs with that of open surgical repair.

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Conflicts of interest

The authors declare no association with any company having a financial interest in the catheters, stents or embolization materials used in this paper.

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