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Renal Artery Pseudo-aneurysms: Do All of Them Require Endovascular Management?

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Abstract

Purpose: Our study examines the etiological profile, clinical and imaging features of renal artery pseudo aneurysms (RAPs), as well as the efficacy and need for the angioembolization of RAPs in a resource-constrained setting.

Materials and Methods: A total of 36 patients with RAPs were included in our study. Initial diagnosis was made by Doppler Ultrasonography (USG) followed by CT renal angiography in all cases. DSA was performed in 28 patients, as eight patients showed spontaneous resolution by thrombosis on immediate pre-procedure Doppler study. Angioembolization with a microcoil was performed for 30 aneurysms in 28 patients. Technical success was confirmed at the end of the procedure by a renal angiogram. To assess clinical success, we followed up with patients (with clinical and Doppler USG) for a period of six months.

Results: The most common cause of RAPs in our study was percutaneous nephrolithotomy (PCNL), seen in 21 patients (58.3%), followed by trauma (25%), and partial nephrectomy (11%). All patients presented to us were within 21 days of the etiological event of hematuria or flank pain. USG was able to detect the RAP in 22 cases (61%). CT renal angiography was diagnostic in all patients but failed to demonstrate two additional aneurysms in one patient. RAP size ≤ 4 mm and absence of brisk filling on CT renal angiography was associated with spontaneous resolution in eight patients, probably an indication of the beginning of spontaneous thrombosis. Angioembolization was done using microcoils and showed 100% technical and clinical success.

Conclusion: PCNL is the most common etiological factor for RAPs in our setting. Such patients should have a Doppler USG done prior to discharge from the hospital. CT angiographic flow dynamics (delayed peak enhancement) may be helpful in the identification of RAPs with a high probability of subsequent spontaneous resolution. Angiography followed by embolization using microcoils is the most effective and safe treatment for RAPs with no significant loss of renal parenchyma, although cost remains a limiting factor in our setting.

Introduction

Renal artery aneurysms can be divided into true or pseudo aneurysms, depending upon the composition of the wall of the aneurysm. While true aneurysms have all three layers (intima, media, and adventitia) in their walls, pseudo aneurysms have an extravasation of blood outside the artery surrounded by periarterial tissue [1]. Renal artery pseudo aneurysms (RAPs) are encountered in post-percutaneous renal interventions, renal surgeries, renal biopsies, and trauma and renal transplants. They are most frequently encountered in iatrogenic and trauma cases [2-4]. Clinically, the most common presentation is hematuria, which results from the gradual erosion of the pseudo aneurysm into a calyx. A high degree of caution must be shown towards patients with hematuria, especially those who have undergone any renal intervention or trauma. Patients with RAPs may present either immediately following the intervention/trauma or within a few days following the event. In rare cases, presentation may be months later [5].

The diagnosis of a RAP is based on clinical suspicion followed by Doppler ultrasonography (USG), CT renal angiography, catheter arteriography, or magnetic resonance imaging (MRI). Doppler USG is a non-invasive modality, though it is operator dependant and may not detect a small RAP. CT renal angiography can provide an overall picture of the urinary system including the vasculature and any anatomical variations, but CTA involves the use of a contrast agent. A RAP on CT renal angiography is seen as a well-defined hypodense area before contrast. After contrast administration, it follows the blood pool attenuation. MRI is not commonly used for the assessment of a RAP, but it may occasionally be useful in patients with an allergy to iodinated contrast [6]. These imaging modalities are best used when the patient is hemodynamically stable [5]. In patients with inconclusive non-invasive imaging and strong clinical suspicion of a RAP, or for those with hemodynamic instability, catheter angiography is necessary. Digital subtraction angiography (DSA) is the gold standard for the diagnosis of RAPs. It also provides valuable information regarding the exact number, size and orientation of the pseudo aneurysm, as well as any active contrast leak. DSA can also be used to guide embolization of any RAP in the same setting, which provides a therapeutic advantage [6].

The treatment of RAPs can be surgical or endovascular, depending on the clinical signs of the patient. Nephrectomy and open vascular surgery are suggested for RAPs greater than two centimeters, or when associated with complications such as severe hemorrhage and renovascular hypertension [5]. However, endovascular management is now the gold standard for the treatment of RAPs. Embolization of selected intrarenal feeding arteries can be done using microcoils, though gel foam and n-butyl cyanoacrylate have been used in some circumstances [7].

The aim of our study was to elucidate the etiological profile of RAPs in our population and assess the suitability of endovascular management of these pseudo aneurysms in our setting. We also sought pre-embolization imaging features that could guide the management of RAPs.

Materials and Methods

We conducted a retrospective study in our Department of Radio Diagnosis and Imaging, SKIMS, including patients referred to us by the Department of Urology with cases of hematuria or abdominal pain after trauma or post-renal intervention. The study was conducted over a period of 3.5 years from 2017-2020 and included 36 patients. The demographics of each patient were recorded, along with a note of their hemodynamic condition and renal functions. The cause of the RAP was also recorded in each case.

All the patients with a clinical suspicion of RAPs were initially evaluated by a color Doppler USG (GE LOGIC P5) at the time of presentation. While performing the USG, we made note of any RAP, including its size, its flow on Doppler, any associated collection/hematoma, and any clots within the collecting system. All our patients underwent CT renal angiography irrespective of the presence or absence of RAPs on color Doppler examination. All CT angiographies were performed on CT SOMATOM SENSATION 64 using iodixanol (Visipaque 100 ml) as the contrast agent. Non-contrast, arterial phase and venous phase images were obtained according to the departmental protocol. The contrast agent was given at a rate of 4 ml/sec and bolus tracking was done at the abdominal aorta just above the origins of renal arteries. This was done at a trigger of 160 HU and a delay of four seconds for the arterial phase and 15 seconds for the venous phase. The images were viewed on a dedicated workstation and source where 3D Maximum Intensity Projection (MIP) and Virtual Reality (VR) images were reconstructed. A note on an RAP included its size, the feeding segmental branch artery, and any active leak. Any renal arterial variations were noted using MIP images. CT images were also used as a guide to the origin of the renal artery and its branching pattern. We also observed the rate of contrast filling and the time at which the peak enhancement of the RAP occurred, as well as the speed with which the RAP was enhanced after contrast administration.

After the confirmation of diagnosis, patients with RAPs were taken up for therapeutic catheter embolization. Transfemoral access was achieved and a 6F vascular sheath was secured. An RDC or COBRA catheter was used access the renal artery. The presence of a RAP was confirmed on a selective renal angiogram and a search for any other pseudo aneurysm was made. Selective and super selective angiograms were obtained using micro-catheters (PROGREAT/COBRA) and the size of the feeding vessel was measured. All patients underwent embolization of the feeding vessel using microcoils at least 20% larger in size than the feeding vessel. Microcoils (HILAL embolization microcoils) were used to exclude the RAP from the circulation. A complete selective renal angiogram was obtained in each case to ascertain the technical success.

We followed up with all patients for a period of six months. Follow-up included post-embolization hemodynamic stability and renal function during the time of the hospital stay and USG Doppler follow-up at two, four, and six months, unless indicated earlier.

Results

36 patients (24 (66%) males and 12 (34%) females) were included in our study. The mean age was 46.08 ± 10.8 years (range from 14 to 65 years).

In our 36 patients, the etiology was percutaneous nephrolithotomy (PCNL) in 21 patients (58%), trauma in nine patients (25%), partial nephrectomy in four patients (11%) and post-percutaneous nephrostomy (PCN) in two patients (6%). All 36 patients had hematuria, 29 patients (81%) with gross and seven (19%) with microscopic hematuria. All seven patients with microscopic hematuria showed no flank pain. The main feature present in 21 patients (58%) was flank pain. Of the 36 patients, 32 (89%) were hemodynamically stable, while four (11%) of post-trauma patients were not.

In our study, the most common time of presentation was three to seven days after the etiological event. Of the 36 patients, 28 (78%) presented between three to seven days and eight (22%) presented between seven and fourteen days. The mean time of presentation in our study was 5.4 ± 3.1 days.

Diagnosis was made on Doppler USG in 22 patients (61%). The characteristic anechoic area was noted on color Doppler imaging that showed to- and fro- vascular flow, signified by a ying yang sign. USG also depicted perinephric hematoma in two patients (5%) and renal calyceal/urinary bladder clots in eight patients (22%).

RAPs were identified on triple phase CT renal angiography in all 36 patients. The mean size of the RAPs in our study was 5.3 ± 1.6 mm (range 3mm to 9 mm). All RAPs that showed subsequent spontaneous resolution measured ≤ 4 mm in size. In 28 of 36 patients (78%), the RAPs showed brisk arterial enhancement. In the remaining eight patients (22%), there was slow opacification with delayed peak enhancement.

Catheter angiography was done in 28 of the 36 patients (78%). A conservative approach was adopted in eight patients (22 %) in whom CT renal angiography demonstrated delayed enhancement of RAPs. In these patients immediate pre-procedure Doppler USG confirmed spontaneous resolution with thrombosis. We found 29 RAPs in 27 patients on DSA, with two additional RAPs compared to those on CT renal angiography. One post-PCNL patient showed evidence of an AV fistula on DSA. One patient with evidence of a CT-detected RAP showed no evidence for an RAP on DSA, but a large retroperitoneal hematoma was noted in this patient, suggesting interval rupture [Table 1].

All 29 RAPs were embolized in the time of DSA using microcoils. In 19 out of the 29 RAPs, a single coil was enough for embolization, while in ten others two microcoils had to be used. A complete angiography showed technical success in the complete exclusion of RAPs from the renal circulation in all 29 cases (100 %) of pseudo-aneurysms.

No major complications were encountered in any of our patients undergoing endovascular management. Six patients had fevers and tachycardia, probably due to post embolization syndrome. No major loss of renal parenchyma was seen. Renal functions were maintained in all the patients.

We followed up with all patients for resolution. All 27 patients showed resolution of hematuria within one week after embolization. Eight patients, managed conservatively, showed no evidence of clinical deterioration and were discharged when follow-up Doppler USG showed resolution of the RAP. One patient with a ruptured RAP also showed spontaneous resolution. Clinical follow-ups and laboratory and USG Doppler evaluation at two, four and six months showed no cases of recurrence.

Table 1. Details of the profile, imaging characteristics, and treatment results in all patients. Pseudo Aneurysm (PA), Percutaneous Nephrolithotomy (PCNL), Percutaneous Nephrostomy (PCN), Spontaneous Resolution (SP), Not Done (ND), Hematuria (H), Microscopic Hematuria (mH), Flank Pain (FP).

S NO.	Etiology	No. of PA	Clinical presentation	CT findings	Angiographic findings	Technical success	Follow up
1	PCNL	1	H/FP	PA with brisk filling	PA	achieved	stable
2	TRAUMA	1	H/FP	PA with brisk filling	PA	achieved	stable
3	PCNL	NONE	H	PA with brisk filling	No PA visualized	SP	stable
4	PCNL	1	H/FP	PA with brisk filling	PA	achieved	stable
5	PCNL	1	H	PA with brisk filling	PA	achieved	stable
6	PCNL	1	H/FP	PA with brisk filling	PA with AV fistula	achieved	stable
7	TRAUMA	1	H/FP	PA with brisk filling	PA	achieved	stable
8	PCN	1	mH	PA with slow filling	ND	SP	stable
9	PCNL	3	H/FP	Single PA with brisk filling	3 PAs	achieved	stable

Table 1. (continued)

10	Post partial nephrectomy	1	H	PA with brisk filling	PA	achieved	stable
11	PCNL	1	mH	PA with slow filling	ND	SP	stable
12	PCNL	1	H/FP	PA with slow filling	ND	SP	stable
13	PCNL	1	H	PA with brisk filling	PA	achieved	stable
14	PCNL	1	H/FP	PA with brisk filling	PA	achieved	stable
15	PCNL	1	mH	PA with brisk filling	PA	achieved	stable
16	PCNL	1	H/FP	PA with brisk filling	PA	achieved	stable
17	PCNL	1	H	PA with brisk filling	PA	achieved	stable
18	PCNL	1	H/FP	PA with brisk filling	PA	achieved	stable
19	TRAUMA	1	H/FP	PA with brisk filling	PA	achieved	stable
20	PCN	1	mH	PA with slow filling	ND	SP	stable
21	PCNL	1	H	PA with brisk filling	PA	achieved	stable
22	PCNL	1	H/FP	PA with brisk filling	PA	achieved	stable
23	PCNL	1	H	PA with brisk filling	PA	achieved	Stable
24	TRAUMA	1	H/FP	PA with brisk filling	PA	achieved	Stable
25	TRAUMA	1	H/FP	PA with brisk filling	PA	achieved	Stable
26	PCNL	1	H/FP	PA with slow filling	ND	SP	stable
27	PCNL	1	H/FP	PA with brisk filling	PA	achieved	stable
28	TRAUMA	1	H/FP	PA with brisk filling	PA	achieved	stable
29	Post partial nephrectomy	1	Mh	PA with slow filling	ND	SP	stable
30	TRAUMA	1	H	PA with brisk filling	PA	achieved	stable
31	Post partial nephrectomy	1	H/FP	PA with brisk filling	PA	achieved	stable
32	PCNL	1	H/FP	PA with slow filling	ND	SP	stable
33	PCNL	1	H/FP	PA with brisk filling	PA	achieved	stable
34	TRAUMA	1	mH	PA with slow filling	ND	SP	stable
35	Post partial nephrectomy	1	mH	PA with brisk filling	PA	achieved	stable
36	TRAUMA	1	H/FP	PA with brisk filling	PA	achieved	stable

Discussion

We studied 36 patients of RAPs following renal interventions and trauma. There were more males than females, at a ratio of two to one, probably due to increased incidence of stone disease and risk of trauma in males. These results are in concordance with previous studies conducted by Guo et al. and Chiramil et al. [8,9].

PCNL was the most common cause of a RAP, followed by trauma. These results are concordant with previous studies conducted by Chiramil et al. and Lee et al. [9,10]. These studies also found PCNL as the most common cause of post-interventional RAPs. Hematuria (28 gross cases and eight microscopic) and flank pain (21 patients) were the two clinically presented features in most of our patients. These clinical features were also found to be the main presentation in patients reported by Guo et al. and Lee et al. [8,10]. In our study, PCNL was the most common etiological event, probably owing to the larger size trocars and dilators used. The sheaths used in our center are 28-30 F because of the large size of the stones. This is quite large compared to the new mini PCNL (15-18 F) and ultra-mini-PCNL (11-13 F) used in many centers around the world. In our center, PCNs outnumber the PCNL procedures, yet only two cases of post PCN RAPs were observed. This is probably because of the use of image (USG) guidance in all PCN procedures as well as in the smaller sized catheters and dilators. The Nephrostomy tube may also act as a tamponade within the track, as we have a practice of under-dilating the track in our department (e.g. 8F dilator for a 10F catheter).

Most of our patients presented within the first week after the etiological event. This is earlier than the mean time of presentation in previous studies by Venkateswarlu et al. (11.5 days) and Guo et al. (14 days) [11,8]. This difference is probably because ours is the regional referral center that performs diagnostic studies and interventions. Additionally, all of our patients presented within three weeks, which is the most commonly reported time of presentation as described in previous studies.

When indicated, our imaging protocol includes color Doppler USG followed by CT renal angiography. On Doppler USG we detected RAP in 22 patients (58%) [Figure 1]. CT renal angiography showed the RAPs in all 36 patients (100%), pinpointing their size, segmental renal artery of origin, and the presence or absence of brisk contrast enhancement [Figure 2]. The CT angiographic images served as a roadmap for planning endovascular intervention, besides showing perinephric hematoma and any accessory renal arteries. CT renal angiography is highly accurate and provides guidance during endovascular management. In our study, six post PCNL RAPs and two 3mm post-PCN RAPs thrombosed spontaneously as confirmed on CT renal angiography before discharge. These

Figure 1. a. Showing USG Doppler image of a RAP with a classic ying yang sign. b. CECT axial image confirming the presence of right renal RAP post-PCNL. c,d. Selective angiographic images showing the lower pole aneurysm before and after coiling with a four mm microcoil. A DJ stent can be seen in situ.

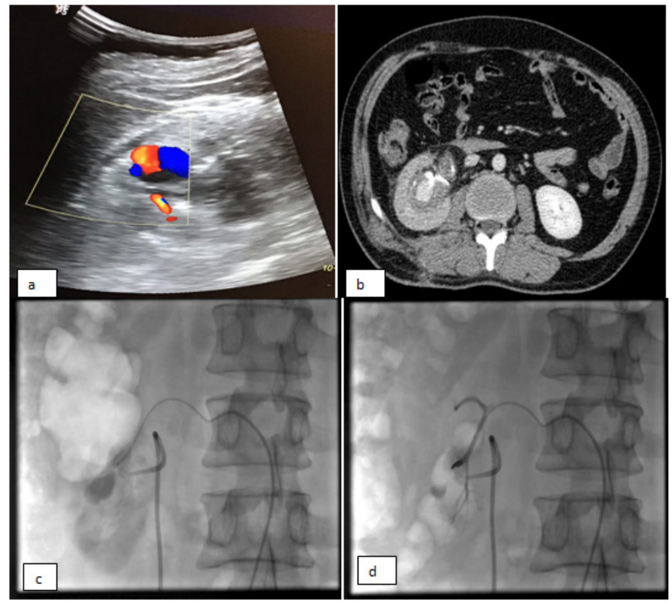


Figure 2. a,b. Coronal and Axial CECT arterial phase images clearly showing a large right renal aneurysm post-partial nephrectomy. c.DSA image showing the aneurysm being supplied by lower pole branch of the renal artery. d. Post-embolization DSA image showing the complete separation of the aneurysm from the circulation.

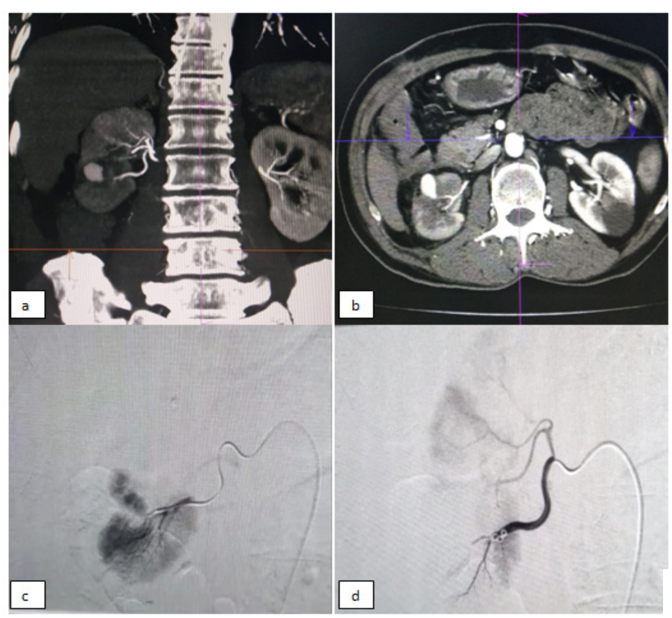


Figure 3. Post-PCNL left renal pseudo aneurysm. a. Axial arterial phase CT image showing RAP with contrast opacification similar to aorta. b. DSA image showing the aneurysm being filled by lower pole branch and also early opacification of the renal vein indicating an AV fistula. c. Post-coiling DSA image shows no evidence of wany aneurysm. The AV shunting has also disappeared.

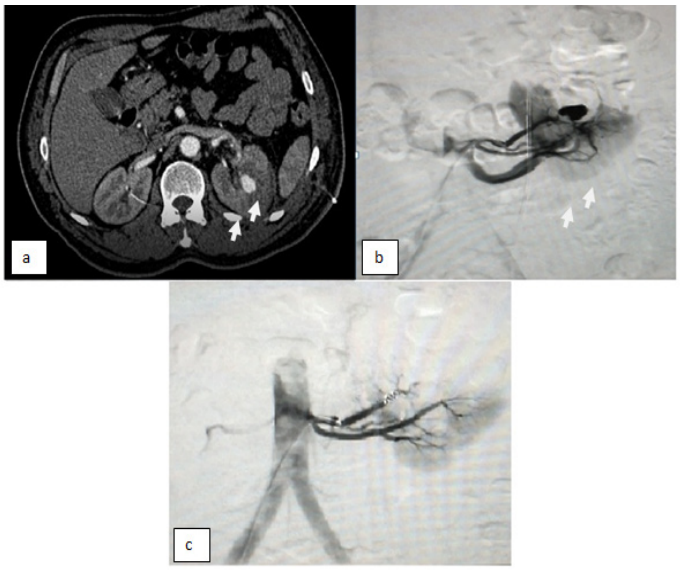
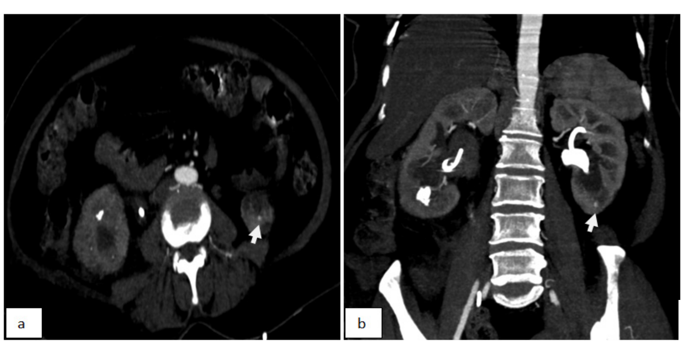


Figure 4. Post-PCN small aneurysm. a. Axial arterial phase image showing a small aneurysm (2.8 mm) with is not as bright as the aorta, suggesting a delayed peak enhancement. b. Coronal image of the same patient showing the lower pole aneurysm. The patient had microscopic hematuria which settled after six days. Follow-up imaging showed complete resolution of the aneurysm.



eight patients (22%) did not require intervention. In all of these eight patients, the RAPs were smaller than four mm in size and there was delayed peak enhancement on CT renal angiography indicating slow flow [Figure 4].These imaging characteristics can, therefore, be used to select the subgroup of patients for watchful surveillance versus those who require intervention. We found no other study relating delayed enhancement with spontaneous resolution.

We propose that RAPs may be present in a significant number of patients' immediate post-renal intervention, possibly with subsequent spontaneous thrombosis in many. We therefore recommend routine Doppler USG evaluation in all post-renal intervention patients before discharge. In a study of 117 CT renal angiographies post-renal intervention, Takagi et al. observed five out of 17 RAPs showing spontaneous resolution [13]. The size of the resolving aneurysms was also less than four mm.

Angiography was done in 28 patients that showed RAPs. In 27 patients, two additional RAPs were identified on DSA and one post-PCNL patient showed evidence of an AV fistula [Figure 3]. Similar angiographic results have been reported by Guo et al. Chen et al., and Venkateswarlu J et al., who found DSA to be an 100% sensitive investigation for RAPs [8,12,11]. Thus catheter angiographic studies, although invasive in nature, remain the gold standard for the diagnosis of RAPs. They may help in the diagnosis of the small pseudo aneurysms that may not be detectable on USG or CT renal angiography.

For the endovascular management, we employed microcoils in all patients using a 4F cobra catheter. In four patients, however, selective cannulation was not possible and required the use of macro-catheter for coil placement. In 19 out of the 29 RAPs, a single coil was enough for embolization. In ten RAPs, two microcoils had to be deployed. The embolic agent of choice at our institution remains microcoils, as our experience with other agents (glue and gel foam) is limited. A technical success rate of 100 % was achieved in our study with post-embolization completion angiographies that showed no residual RAP or contrast extravasation. Similar technical success rates were achieved by Venkateswarlu et al., Guo et al., Ierardi et al., and Chavali et al. in their studies [11,8,14,15].

No complications were encountered in our embolization procedures. Fever and tachycardia are expected post-embolization in some patients. Our results are similar to those of Guo et al. with no major complication in their study and four out of 27 patients (15%) developing post-embolization syndrome [8]. No major complications were noted by Phadke et al. and Fischer et al. in their studies [7,21].

Clinical and USG surveillance over six months showed no sign of recurrence, meaning our study achieved a clinical success rate of 100%. This success rate is similar to those of

Guo et al. and Ierardi et al., which showed clinical success rates of 96.5% and 95% respectively [8,14]. A success rate varying between 80-100% has been reported by other researchers [9,16-20]. Variation in the success rates of embolization may be due to the patient's clinical factors or the expertise of the interventional radiologist.

The limitations of our study included having a small number of patients, especially those with spontaneous resolution. We described the relationship of the delayed peak contrast enhancement of smaller than four mm RAPs that showed resolution only in eight patients. These new criteria for conservative management need a larger study to substantiate this observation.

Conclusion

All patients with RAPs should have a follow-up USG Doppler prior to their discharge from the hospital. CT angiographic flow dynamics (delayed peak enhancement and a size of less than four mm) may be helpful in predicting that an RAP will likely resolve spontaneously. Although angioembolization of an RAP is an effective and safe method for the treatment of post-intervention or post-trauma RAPs, the procurement of micro-catheters and coils in a resource-constrained environment can be a limiting factor and contribute to delayed or inadequate treatment.

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Conflicts of interest

The authors report no conflicts of interest.

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