

Percutaneous embolization of renal pseudoaneurysms: A retrospective study

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ABSTRACT

Introduction: We evaluated the efficacy of the mixture of autologous blood and a hemostatic agent, oxidized regenerative cellulose (ORC), as an alternative material for ultrasound (US)-guided percutaneous embolization of renal pseudoaneurysm (PA).

Methods: In this retrospective study, consecutive patients diagnosed with renal PA were included. The exclusion criteria were: PA of the main renal artery, tiny PA not visualized on the colour doppler ultrasonography, PA more than 3 cm in max diameter or extracapsular PA with the possibility of massive bleeding, and patients with a history of coagulation disorders. After localizing the PA, a mixture of autologous blood and ORC was injected under US guidance with a 15G coaxial needle. Patients were followed up for at least 6 months.

Results: Twenty-nine patients with PA were included, of which 26 had a history of percutaneous nephrolithotomy, and three patients had a history of renal biopsy (24 men and five women with an average age of 44.3 years). Gross hematuria was the most common mode of presentation. The mean size of the PA was 16.6 mm and the mean duration of follow-up was 9 months. The clinical and the technical success rate was 100%. The PA could be thrombosed in all the patients with a single-session of injection. No acute (hematoma, infection, and bleeding) or chronic (thromboembolic events, renal cortical atrophy, and recurrence) complications were seen.

Conclusion: Percutaneous embolization of renal PA under US guidance with a mixture of autologous blood and ORC is an efficient and easily available first-line method to treat this potentially life-threatening condition when endovascular embolization or other expensive thrombotic agents are not available.

INTRODUCTION

Pseudoaneurysm (PA) is a false lumen secondary to a defect in the layers of the arterial wall.^[1] A hematoma forms around the defect and the reactive fibrosis leads to the formation of a sac-like structure connected to the arterial lumen with a neck. Depending on the surrounding tissues, width of the neck, and the intraluminal pressure, the hematoma might be compressed and get resolved or extend in size.^[2] In general, gross hematuria is the chief clinical finding of a renal PA and pain and hypertension might be present in patients with PA secondary to trauma.^[3,4]

PA has the potential to bleed profusely and progress into a life-threatening condition which necessitates urgent treatment.

Renal PA results from an injury to the wall of the main or the segmental renal arteries. The injury could be traumatic (mostly penetrating) or iatrogenic or occasionally could be secondary to an inflammatory or neoplastic lesion. The main iatrogenic etiologies include percutaneous nephrolithotomy (PCNL), percutaneous renal biopsy, percutaneous nephrostomy, and partial nephrectomy.^[5,6] The diagnosis is primarily made on

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the colour doppler ultrasonography and contrast-enhanced computed tomography angiography (CTA) and the treatment options depend on the site of the injury. The first-line therapy is endovascular embolization and surgical intervention is reserved for patients with refractory bleeding.^[1] Unfortunately, the lack of accessibility combined with its high cost, contrast-induced complications and contrast nephropathy, and radiation exposure are significant limitations of the endovascular treatment. While percutaneous embolization has been evaluated for non-renal PA, limited studies that have proposed the possibility of percutaneous embolization of a renal PA using thrombin, cyanoacrylate glue, and autologous blood clot; however, all of these are case reports.^[7-9] In this study, we evaluated a hemostatic agent, oxidized regenerative cellulose (ORC), as a new thrombotic agent for ultrasound (US)-guided percutaneous embolization of the renal PAs.

MATERIALS AND METHODS

Patients

The Institutional Review Board approved this retrospective study (Protocol Number: IR. IUMS.FMD.REC.1399.890). The patients provided written consent to use their medical data for publication. The authors confirm the availability of, and the access to, all the original data reported in this study.

All the patients diagnosed with renal PA, between January 2017 and December 2021, were screened for inclusion into this study. The diagnosis of PA was made on US examination in all the cases and was confirmed by two radiologists with more than 10 years' of experience. If there was any doubt about the location of the PA (especially its vicinity to the major vessels), CTA was obtained for a detailed anatomical information. The exclusion criteria were: 1-PA of the main renal artery, 2-tiny PA not visualized on the colour Doppler ultrasonography, 3-PA more than 3 cm in max diameter or extracapsular PA with the possibility of massive bleeding, and 4-patients with a history of coagulation disorders (e.g., hemophilia). A check-list was filled for all the patients, recording demographic data, lab data, previous history of renal procedures, and characteristics of the diagnosed PA.

Procedure

All patients received 10 mg of Vitamin K intramuscularly and three units of FFP, 3-4 h before the procedure. To reduce the pain during the intervention, 3 mg of subcutaneous morphine sulfate was injected before the procedure. All the patients had an indwelling Foley's catheter for irrigation of the bladder to manage hematuria.

Patients were placed in a contra-lateral decubitus position. Colour Doppler US was performed with a 3.5 MHz convex transducer to localize the PA [Figure 1]. The volume of PA was measured using the following formula:

Length × width × height × 0.52. After prep and drape, a 15-gauge coaxial needle was gently inserted into the sac of the PA under the US guidance [Figure 2]. After removing the inner core, a jet of arterial blood confirmed the proper position of the needle. Immediately, the patient's own blood, two-folds in amount to the measured volume of the PA, was aspirated and mixed with ORC powder. For every ten ml of blood, 1 g of ORC powder was used to produce a concentrated and cream-like mixture [Figure 3]. If the mixture's density did not reach the desired level after 2 min, another gram of the powder was added. The goal was to create a mixture which had the maximum concentration and still could be injected by a 15-gauge coaxial needle. Once this concentration was achieved, the mixture was forcefully injected into the sac of PA. Given the high density of the mixture produced, the lumen of the needle usually got occluded during the injection and thus, the inner core was introduced to push the mixture in the barrel of the needle into the PA and to clear the lumen so that the rest of the mixture could be injected. Complete closure of the PA as detected on the simultaneous US exam and the absence of colour flow were considered as the end points of the procedure, and it took about 5 min per patient. After injecting the mixture completely, a colour Doppler US was performed to ensure the occlusion of the sac (revealed as a hyperechoic thrombosed area) [Figure 4]. Finally, the needle was gently removed, while injecting a minimal amount of the mixture, and the injection site was manually compressed for 15 min. A check US was performed after 30 min, to confirm the complete occlusion of the PA and to evaluate for possible complications (i.e., hematoma). Bladder irrigation was continued for at least 6 h post procedure to prevent clot formation. Another follow-up colour Doppler US was performed the next day, and unless any complications were detected, the patient was discharged [Figure 5].

Follow-up

Patients were followed, clinically and by US, for at least 6 months to evaluate for the long-term complications. Technical success was defined as the resolution of PA on the colour Doppler US performed 24-h after the intervention. Clinical success was defined as complete resolution of gross hematuria within 48-h. The renal parenchyma's cortical thickness at the site of PA was measured before the treatment and at follow up US exams.

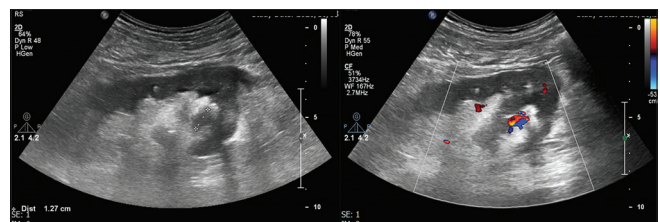


Figure 1: Gray scale and color Doppler US show a 12.7 mm PA in the lower pole of the left kidney. US = Ultrasound, PA = Pseudoaneurysm

Statistical analysis

SPSS for Windows, version 16 (Chicago, Illinois, USA) was used for the statistical evaluation of the data. Frequencies and descriptive statistics were calculated for all variables. The Chi-square test was used to evaluate the relationship between the categorical variables. Wilcoxon signed-rank test was used to compare the numerical data (pre-and post-treatment cortical thickness). $P < 0.05$ was considered significant.

RESULTS

Thirty-one patients with renal PA were referred to our radiology department for treatment. One patient was excluded due to a 30 mm PA adjacent to the renal pelvis without sufficient surrounding tissue and a high risk of bleeding. The CTA exam of this patient revealed that the PA was in close vicinity to the main renal artery. Another patient was excluded due to the history of anticoagulation therapy with warfarin. None of the patients had PA of the main renal artery. Twenty-nine patients were included in the study. Table 1 demonstrates the demographic data of the patients. The average age of the patients was 44.3 years. All the patients except three had PA secondary to a previous PCNL. Three patients had a history of multiple percutaneous renal biopsies. The mean interval between the diagnosis of the PA and the renal intervention was 8.1 days (range 4–12 days). The size of the largest PA was 28 mm × 16 mm, while the smallest one was 10 mm × 8 mm (mean in maximum diameter = 16.6 ± 6.8 mm). The mean amount of

blood aspirated was 8.4 cc (maximum 10cc and minimum 6cc) and mean amount of ORC used was 1.5 g (maximum 2g and minimum 1 g).

Gross hematuria was the chief complaint in all the patients; however, none had massive bleeding or hemorrhagic shock. Mild anemia (Hb <12) was present in 24 patients. Table 2 shows the patients' laboratory data before and after (24 h) the procedure.

Eight (27.6%) patients had concomitant other iatrogenic complications secondary to PCNL. A perinephric hematoma was present in five (17.2%), a perinephric infected collection in two (6.9%), and a psoas muscle hematoma was present in 1 (3.4%) patient. These were acute complications and were treated before referring the patient to our center for the management of PA. The perinephric hematoma was managed conservatively however, an external drainage catheter was placed for both the infected collections.

All the patients were successfully treated with the a single-session of percutaneous embolization and none required further intervention. The following day's US exam revealed that the PA was resolved in all the patients, and the technical success rate was 100%. Gross hematuria also resolved in all the patients 24 h after the intervention (clinical success rate 100%). In contrast, micro-hematuria was still present on the urine analysis obtained at 24 h in 22 patients (75.9%) and after 48 h in four patients (13.8%) which resolved at 1 week in all these cases. Since all the patients had concomitant other urological problems, the length of hospitalisation postembolization, was influenced by them.

The mean duration of follow-up was 9 months (range 6–15 months). No complications related to the embolisation (hematoma, bleeding, or infection) were detected on the clinical and US follow-up. Flank pain was the only complaint of the patients during and after the procedure. However, none of the patients experienced flank pain for more than 24 h. All the patients were followed-up clinically to detect probable thromboembolic complications during the follow up examinations. To avoid further radiation and cost, the patients were carefully examined for any potential acute pulmonary, gastro-intestinal, neurologic or peripheral vascular symptoms. Although, clinical examination alone

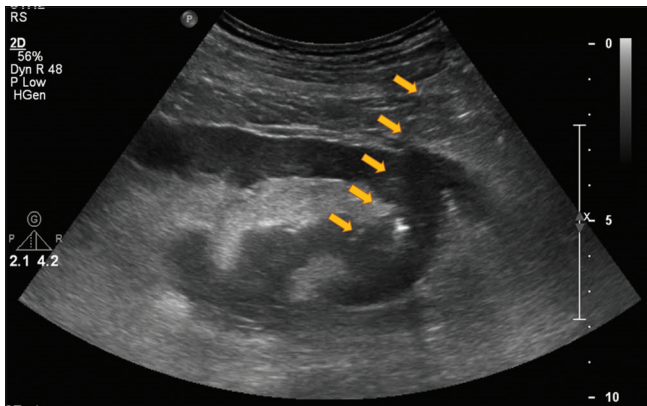


Figure 2: 15-gauge needle was gently inserted into the PA sac under the US guidance. US = Ultrasound, PA = Pseudoaneurysm

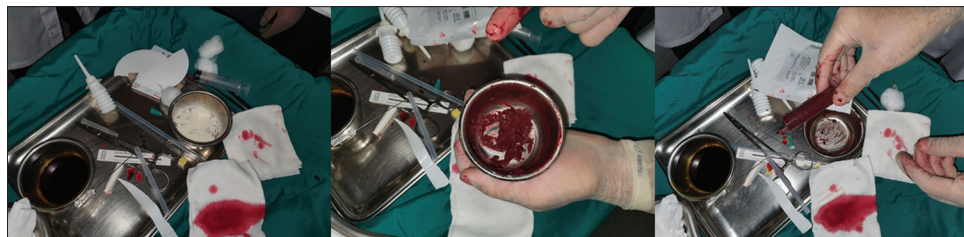


Figure 3: ORC powder was mixed with autologous blood and forms a dense mixture. ORC = Oxidized regenerative cellulose

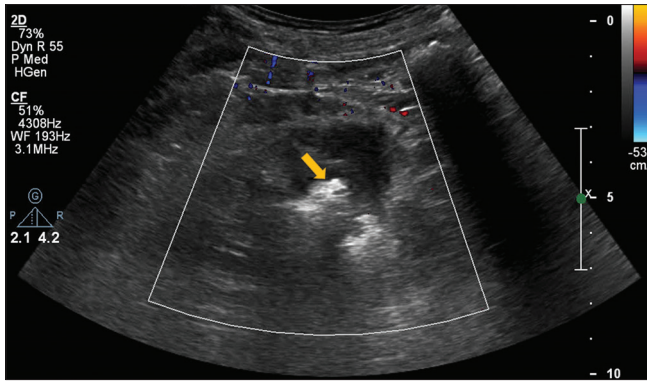


Figure 4: After the injection of the mixture, the color Doppler US reveals a hyperechoic area without any color flow (arrow). US = Ultrasound

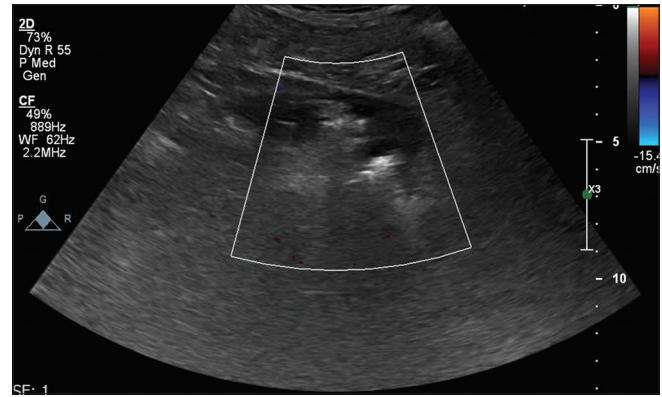


Figure 5: The next day color Doppler US shows no signs of PA. US = Ultrasound, PA = Pseudoaneurysm

Table 1: Demographic data of the patients

Data	n (%)
Gender	
Male	24 (82.8)
Female	5 (17.2)
Age	44.3
Male	43.2
Female	49.6
Kidney side	
Right	12 (41.4)
Left	17 (57.6)
PA location	
Upper pole	3 (10)
Mid pole	14 (48)
Lower pole	12 (42)
Etiology of PA	
PCNL	26 (90)
Renal biopsy	3 (10)
Comorbidity	
Diabetes	6 (21)
Hypertension	11 (38)
Chronic kidney disease	4 (14)
Cardiovascular disease	1 (4)

PCNL= Percutaneous nephrolithotomy, PA=Pseudoaneurysm

Table 2: Laboratory data of the patients before and after the pseudoaneurysm treatment

Laboratory factor	Mean±SD		P
	Before	After	
Hemoglobin	9.7±3.45	10.4±2.11	0.77
White blood cell	9456±4542	8855±3725	0.12
Platelet×10 ³	261±211	266±213	0.41
Creatinine	1.67±0.63	1.48±0.53	0.23
INR	1.17±0.61	1.11±0.62	0.29
PT	11.6±3.4	11.4±3.2	0.66
PTT	28±4	28.1±4.11	0.87

PT=Prothrombin time, INR=International normalised ratio, PTT=Partial thromboplastin time, SD=Standard deviation

cannot rule out minor micro-embolisms, asymptomatic events are clinically insignificant and do not require therapy. No thromboembolic complications were seen in the patients included in our study. The mean renal cortical thickness prior to and after the procedure was 10.1 mm (9–12 mm) and 9.8 mm (9–12 mm), respectively. The pre and post intervention US did not detect a significant difference in

the cortical thickness of the renal parenchyma at the site of embolisation (P = 0.08) and no obvious cortical scars were seen.

DISCUSSION

Renal PA is a rare but life threatening complication of traumatic or iatrogenic renal injuries. While angiographic embolization is the most widely used and acceptable treatment option, percutaneous injection of thrombotic agents or coils have also been proposed. However, the prohibitive cost and the limited availability of these materials (e.g., Gelfoam®, Onyx®, and thrombin) restricts the access to treatment in the developing countries and result in unfortunate morbidity and mortality. Furthermore, the acceptance of percutaneous embolisation by the clinicians is still debated. This study evaluated the results of percutaneous embolization of renal PA using a new embolic agent which is a mixture of autologous blood clot and ORC powder, a nonexpensive and readily available material. No acute or chronic complications were noted and we believe that this technique is a suitable alternative whenever angiographic embolization or other thrombotic agents are not available.

Different substances have been described for the embolization of PA. Patients autologous blood clot has been previously used as a thrombotic agent.^[9] The high efficacy of ORC as a hemostatic agent in surgical procedures, led us to develop this novel mixture to be used as a material for embolisation. ORC is a natural based biocompatible polymer with high local hemostatic and bactericidal effects, with more than 50 years of clinical application.^[10-12] It is widely used in endoscopic and open or laparoscopic surgeries.^[13,14] It is easily accessible and is less expensive than other thrombotic agents, considering that most of the thrombotic agents are not available in our country due to the high costs. In addition to the hemostatic effect, it induces minimal immunologic reactions^[15] and has antibacterial properties against both the Gram-negative and Gram-positive organisms due to

its acidic nature.^[16,17] The ORC absorbs water and swells up, thus causing a tamponade effect on the site of bleeding which results in hemostasis.

Meanwhile, the fibers entrap the platelets, red blood cells, fibrin, and other proteins and produce a gel-like “pseudo-clot” that blocks the blood flow. Finally, the ORC is fully reabsorbed without any significant tissue reaction.^[18] Although this method is effective in the majority, it is unsuitable for patients with coagulopathies.^[19] On the other hand, because of the acidic nature of ORC, its application in sensitive tissues such as the nervous and the cardiac systems is limited.^[20] In our study, no immunologic reaction or secondary infectious complications were seen in any of the patients, which demonstrates the clinical safety of ORC in the renal tissues.

Angioembolisation is the modality of choice for the management of renal PA. It was first introduced in 1975 by injecting an autologous blood clot into the PA.^[21] In the recent years, thrombotic agents or endovascular coils have been used with acceptable success rates. Sam *et al.* reported 50 cases of renal artery angioembolization in patients with iatrogenic renal injuries with severe bleeding and found a 96% and 98% technical and clinical success rate. Two patients required repeat embolization due to clinical and technical failure.^[22] Guo *et al.* reported trans-arterial embolization in 27 cases with 100% technical success and 96.3% clinical success rate.^[23] In another similar study by Ierardi *et al.*, the technical and clinical success rates were reported to be 100% and 95%, respectively, in 21 patients.^[24] On the other hand, Chiramel *et al.* reported a 71.7% clinical success rate in 53 patients treated with coil angioembolization.^[25]

Despite the clinical benefits, there are some limitations of endovascular embolisation. In a study by Zhang *et al.*, endovascular treatment was performed on 15 patients with renal artery aneurysm and arteriovenous fistula (main artery and segmental branches). Renal infarction after angioembolisation (<30% of the renal parenchyma) was seen in five patients and nine patients developed post embolization syndrome (fever, leukocytosis, abdominal pain, nausea, and vomiting).^[26] This can be ascribed to the concurrent thrombosis of some segmental arteries. Such complications were not recorded in our study. Comparison of renal cortical thickness before and after the treatment did not reveal atrophy of the cortex or scar in any of the patients.

On the other hand, angioembolization requires a specialized interventional radiology suite, with trained personnel and is thus limited to a few select centers. Besides, the long distance between the centers equipped with interventional radiology suite and the other medical facilities, hinders proper treatment in the developing world. Furthermore, the cost of angioembolisation is high at most of the centers

and in our country, the cost of the described technique is less than a third of that incurred for angioembolization, considering hospitalization and the consumables used.

Percutaneous embolization of the renal PA has been reported in the literature. Although Ngo *et al.* had proposed percutaneous embolization as one of the first line treatment options for the PA of the branches of the renal artery, equivalent to angioembolization, only a few centers utilize it as the first-line therapy.^[1] In a survey by Sakr *et al.* percutaneous injection of Gelfoam® (Pharmacia and Upjohn Company, New York, USA) in the PA under US guidance was performed in 14 patients with severe hematuria and 13 patients showed clinical response with a single session treatment and only one patient required endovascular embolization for recurrent hematuria. No complications were reported in their study.^[27] These results are compatible with our study that all the patients had a clinical response with a single-session of intervention without any complications. Lal *et al.* reported a case of percutaneous embolization with direct thrombin injection under the US guidance. The complex vascular anatomy made angioembolization difficult and thus percutaneous embolisation was undertaken. However, as the hematuria did not resolve completely after the first injection, repeated percutaneous injections of cyanoacrylate glue under US and fluoroscopy guidance were required to achieve complete response.^[8] Gupta *et al.* reported a similar case of direct thrombin injection into the PA under US guidance in a patient with severe hematuria. Angioembolization was not possible by the standard catheters and the patient could not afford the microcatheters.^[7] These studies, consistent with ours, indicate that percutaneous embolization could be considered as the first-line treatment in renal PA, especially when the endovascular treatment is not available. Nevertheless, it should be noted that this treatment is only possible in cases where the PA can be visualised on the US.

One of the major concerns regarding the injection of thrombotic agents is thrombo-embolic complications. Although the data on thrombo-embolic complications after the embolisation of renal PA is limited, in a study by Kurzawski *et al.*, among 353 patients with femoral artery PA treated with percutaneous thrombin injection, arterial micro-emboli occurred in 53 patients (15%). Simultaneously, pulmonary embolism was seen in one patient with an arteriovenous fistula (0.28%).^[28] No thromboembolic complications were seen in our study. To reduce the risk of these complications, the tip of the needle should be positioned away from the neck of the PA and should be positioned in the periphery of the sac of PA. Also, particular attention should be paid to evaluate the presence of an arteriovenous fistula so as to avoid venous embolic events.

PCNL is the modality of choice for large renal calculi. Previous studies have reported a <1% incidence of PA

following PCNL.^[3,29] About 3000 PCNL procedures were performed at our urology center during the period of this study and PA developed in 26 cases (0.8%). The second most common etiology of PA, in our study, was percutaneous renal biopsy (3 patients). In a series of 72 cases, the risk of PA following percutaneous renal biopsy was estimated to be about 5%.^[30] In another study with 515 consecutive US-guided renal biopsies of the renal allografts and the native kidneys, no patients developed PA.^[31]

The present study has some limitations. First, the number of the patients enrolled patients is small and studies with a larger population are required to firmly establish the efficacy of this procedure. Second, none of the patients included had massive bleeding; therefore, it is unclear whether the technique is as efficient in this subgroup of patients or not. And finally, this technique cannot be utilised in patients with coagulability disorders and those with small PA that are not visible on the colour Doppler US exam.

CONCLUSION

Percutaneous embolization under US guidance could be an effective alternative treatment to endovascular embolization for renal PA. A mixture of autologous blood and ORC could be used for embolization since it is widely available and is inexpensive.

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