

The Analysis of Risk Factors Associated with Transcatheter Arterial Embolization for Percutaneous Nephrolithotomy

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Research article

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Abstract

Abstract Background: This study aimed to evaluate the risk factors of transcatheter arterial embolization (TAE) in managing haemorrhage associated with percutaneous nephrolithotomy (PCNL) to improve the surgical effect. **Methods:** From May 2007 to June 2018, 112 patients (31–60 years) who underwent TAE treatment for haemorrhage after PCNL were retrospectively analyzed. All patient data and embolization details were retrieved from medical records. Univariate analysis was used to identify the risk factors related to clinical outcomes. **Results:** Technical and clinical success rates were 100% and 93%, respectively. On angiography, we observed injury to the main artery in 1 patient, to secondary branch in 22, to tertiary branch in 58, and to both secondary and tertiary branches in 31. Embolic agents were coils (n =31), gelatin sponge (n=15), and gelatin sponge with coils/microcoils (n =66). Bleeding control failed in 8 patients. Eight patients opted for a second operation, 6 by repeat TAE and 2 by surgery. Bleeding was eventually controlled in all patients. Univariate analysis indicated that extent of transfusion, embolic material used, and injured branches were significantly associated with clinical failure. **Conclusions:** TAE is effective and safe in treating postoperative bleeding after PCNL. Massive transfusion, embolic material used, and injured branches were related to failure of bleeding control.

Background

With the development of endoscopy, Percutaneous nephrolithotomy (PCNL) has transcended traditional open surgery for renal stone management because it is less injurious and leads to faster recovery [1]. However, postoperative haemorrhage is a life-threatening illness and remains one of the major causes of death after PCNL [2]. Although conservative approaches such as staying in bed, blood transfusion, and haemostatic drug use can control most haemorrhaging after PCNL, patients with refractory bleeding have been referred to angiography for diagnosis. Moreover, TAE has been regarded as a safe and effective method to treat postoperative bleeding from PCNL, with embolization rates varying from 0.6% to 3.9%[3, 4]

Previous studies have described risks connected with bleeding after PCNL[5, 6], although there is a paucity of risk factors regarding the role of transcatheter arterial embolization (TAE) in the treatment of PCNL. The purpose of this study is to evaluate the efficacy and safety of TAE for treating bleeding after PCNL and to determine the factors associated with clinical outcomes of TAE in a single centre.

Methods

This retrospective study of patient medical and imaging records was approved by the ethics committee and institutional review board of our centre. From our medical review system we identified 371 patients treated with TAE caused by renal haemorrhage from May 2007 to June 2018. After exclusion of the patients with renal haemorrhage from other causes such as renal arteriovenous malformation, partial nephrectomy and renal biopsy, the final patient study consisted of 112 patients managed by TAE for the treatment of postoperative haemorrhage after PCNL.

Angiography and embolisation technique

Transfemoral arteriography was performed under local anaesthesia and performed by five radiologists with 8 to 17 years' experience of interventional radiology work. Firstly, a 5-F vascular sheath was inserted into the right or left common femoral artery. The pigtail catheter was directed to the abdominal aorta for branch angiography to determine the renal artery, accessory renal artery, or other potential bleeding site. A 5-F catheter (Cordis, Miami, FL, USA; Terumo, Tokyo, Japan) was introduced into both internal renal arteries. Superselective aortography of bleeding arteries was conducted by microcatheter (Tracker-18 or Renegade: Boston Scientific, Natick MA, USA; SP or Progreat: Terumo, Tokyo, Japan).

When a bleeding lesion was detected on angiography, embolisation was initiated. Extravasation of contrast media, arteriovenous fistulae, and pseudoaneurysm were considered active bleeding foci. A variety of embolic materials was used. Gelatin sponge (GS) particles were cut with scissors to about 500–1,000 μm . Coils (stainless steel; Cook, Bloomington, MA, USA) or microcoils (Boston Scientific; Fibered platinum coils, Cook) were used for the feeding arteries, causing rapid extravasation to avoid extensive non-targeted embolisation, or occluding arteriovenous fistulae to avoid pulmonary embolism. After embolisation, angiography was performed through a Cobra diagnostic catheter to identify target vessel occlusion and identify any other potentially bleeding arteries. The end point of embolisation was reached when the contrast agent stopped completely on angiography without further active bleeding.

Patients were monitored by electrocardiography after TAE and remained in bed. Haemoglobin levels were examined daily until no significant change was noted. Long-term follow-up included renal ultrasonography or computed tomography at 3 and 9 months, along with routine haemoglobin and kidney function tests.

Definitions and statistical analysis

Technical success was defined as the absence of the original bleeding lesion on angiography. Clinical success was defined as stable haemoglobin, absence of clinical symptoms, and radiographic absence of bleeding. The Society of Interventional Radiology divides the postoperative complications into minor or major[7].

Imaging and clinical outcomes of successful and failed TAE were compared with regard to postoperative haemorrhage after PCNL. The differences between the clinical and failed groups were assessed by Fisher's exact test or χ^2 test for categorical variables. Univariate analysis of continuous data was conducted using the Mann–Whitney U test. $P < 0.05$ was considered statistically significant. All statistical analyses were performed by the Statistical Package for the Social Sciences (SPSS, Chicago, IL, USA).

Results

Patients' characteristics

Characteristics of the cohort of 112 patients, including 66 males and 46 females with an average age of 54.3 years (range, 31–60 years), are summarised in Table 1. The right kidney was involved in 49 patients and the left kidney in 63 patients. There were 108 cases of primary PCNL and four cases of secondary PCNL. Clinical manifestations of the 112 patients included haematuria and/or bloody nephrostomy drainage with ipsilateral or diffuse abdominal pain. Fifty-seven patients presented with sudden bleeding, especially when a fistula was pulled out, which caused their urine to suddenly turn red with a rapid decrease in haemoglobin. Twenty-nine patients suffered acute haemodynamic instability. Thirty-three patients presented with intermittent bleeding, whereby their urine turned red discontinuously with gradual decrease in haemoglobin. Haemodynamic stability was observed in all of these patients. Twenty-two patients presented with slow continuous bleeding, whereby their urine turned reddish-tan without blood clots. Their haemoglobin declined slowly and haemodynamic stability was maintained.

Characteristics of TAE

Bleeding lesions were revealed on angiography in 106 patients, including 56 cases of pseudoaneurysm (Fig. 1), 33 cases of arteriovenous fistula (Fig. 2) (19.4%), 14 cases of other lesions, and nine cases of arterial laceration. Vascular injuries were found in the main artery, secondary branch, tertiary branch, and both secondary and tertiary branches in 1, 22, 58, and 31 patients, respectively.

A total of 136 PCNL-related arteries were embolised in 106 patients. Bleeding arteries were embolised by coils/microcoils in 31 cases, GS particles in 15 cases, and both coils/microcoils and GS particles in 15 cases. Six patients had negative angiographic findings.

Outcome of TAE

TAE-related results are shown in Tables 1 and 2. All patients with vascular disease were successfully embolised. Ninety-three percent of patients achieved clinical success in their first treatment with TAE. The eight remaining patients presented with persistent or recurrent haematuria with decreased haemoglobin and were managed by a second TAE (n = 6) or by surgery (n = 2). In all six repeat TAE patients, arteriography showed new bleeding foci in one case and original bleeding foci in five cases. In six patients, bleeding was eventually controlled by repeat TAE with coils/microcoils. In two patients, arteriography showed haemorrhage in the superior mesenteric artery, which was controlled by surgery.

Clinical failure of TAE occurred in eight patients (Table 2). Two patients with concomitant superior mesenteric artery haemorrhage were managed by surgery at the discretion of the bedside clinician.

Minor complications occurred in 23 patients who underwent TAE, comprising 14 (40.9%) with fever alone (38.0°C–39.2°C) and nine (32.1%) with acute abdominal pain. The mean length of stay in hospital was 4.9±2.2 days. Pneumonia occurred in two patients, who recovered after 2 weeks in intensive care and were discharged.

Univariate analysis showed that the injured branch, massive transfusion, and embolic material used were related to clinical failure (Table 1). Clinical success was not associated with age, gender, angiographic findings, number of bleeding arteries, and days spent in hospital.

Discussion

PCNL has now become the first line of treatment for the management of complex renal calculi. However, postoperative bleeding is still a common and serious complication, which is self-limiting in most cases. TAE has been considered as an effective treatment for patients with PCNL who cannot be prevented from bleeding by conservative treatments such as staying in bed, haemostatic drugs, and renal fistula clamping [8, 9]. At present, there is little information available regarding the risk factors associated with clinical efficacy of TAE in postoperative haemorrhage after PCNL.

In our cohort, patients with TAE achieved a primary clinical success rate of 93% in the first session of TAE, similar to the results of Li's report of clinical efficacy of primary TAE being obtained in 130 cases (94.9%) [10]. Although most haemorrhaging can be controlled by TAE, approximately 4%–5% of TAE patients require a second operation[11]. Therefore, in the treatment of PNCL it is important to identify the risk factors that may affect TAE and to take active measures to improve the success rate.

Although PCNL is a well-established and minimally invasive technique, it may sometimes cause massive bleeding. In contemporary reports transfusion rates vary widely, ranging from 1% to 7%[12, 13]. The association between extensive transfusion and clinical failure of TAE is understandable, as transfusions are employed to tackle massive bleeding or severe coagulation. Because severe bleeding and haemodynamic disorders can affect the clinical prognosis of patients after TAE for PCNL, large amounts of transfused blood are associated with clinical failure. For patients undergoing massive transfusions, strict monitoring is required even after TAE and embolisation of the bleeding lesion. Furthermore, effective measures such as TAE should be used before haemodynamic instability occurs.

In our study, patients who underwent TAE using gelfoam alone had a statistically significantly higher reoperation rate than those with steel coils as embolisation materials. The incidence of arterial laceration and pseudoaneurysm was high in patients with bleeding after PCNL, and the use of coils/microcoils was more effective than GS particles in achieving devascularisation, especially in the event of coagulation disorders and haemodynamic instability. In addition, in some patients with arteriovenous fistula the use of GS alone may lead to potential pulmonary embolism. Therefore, regardless of angiographic findings on TAE and the size of the haemorrhage, coils/microcoils should be the agents of first choice, followed by gelfoam[14].

With regard to bleeding arteries, in the present study the tertiary branch of the renal artery is the most commonly involved at 70%, compared with the main artery at 4.5%. The clinical success rate of patients with haemorrhage in the main renal artery was significantly lower than that in patients with branch and peripheral vascular haemorrhage. Patients with injury to the primary artery were more likely to lose more blood than counterparts with collateral vessel injury, and most were already haemodynamically unstable

prior to TAE. The reason for main renal artery embolisation may be distal blood reflux leading to continuous postoperative haemorrhage. Moreover, embolisation of the main artery may lead to further loss of renal function, thereby affecting cardiopulmonary function and potentially ending in death. At best, embolisation should occlude both the upstream and downstream vessels of the primary artery injury.

It has been reported that complications of embolisation such as coil migration, loss of renal function, renal artery dissection, and post-embolisation are rare[15]. In this study, minor complications occurred in 11 patients after TAE but with self-limited recovery. Pneumonia was observed in two patients with arteriovenous fistulae found on angiography, in both of whom gelfoam alone was used. It is thus reasonable to surmise that GS escape to the lungs and cause obstructive pneumonia. After 2 weeks in intensive care, both pneumonia patients were discharged after complete recovery. The clinical success rate in the current study was 93% for the first TAE and 100% for repeat TAE. TAE was thus considered an effective method to resolve post-PCNL severe haemorrhage.

There are several limitations to our study. First, it was retrospective and introduced selection bias. Second, the statistical power of comparing clinical success with clinical failure is low because the latter is a rare event owing to the small sample size (n = 8). Third, the current study lacks some important variables, such as surgical experience, which may affect the incidence of vascular complications.

Conclusions

TAE for haemorrhage after PCNL was effective and safe in this single-centre study. Massive transfusion, embolic material used, and injured branches were related to clinical failure. TAE should be initiated in patients before haemodynamic instability occurs. Coils/microcoils are considered the agents of first choice for embolisation, and both the upstream and downstream vessels of the primary artery injury should be occluded.

Abbreviations

GS: gelatin sponge particles; PCNL: Percutaneous nephrolithotomy; TAE: Transcatheter arterial embolisation

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Declarations

Ethics approval and consent to participate

Consent in written format was obtained from the participant included in this study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the Medical ethics committee of Nanfang hospital of southern medical university and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

HM analyzed and interpreted the patient data regarding the TAE. HM, YC, ZQ, HP and PY designed and performed the operation of TAE. HM was a major contributor in writing the manuscript. Besides, ZQ, HP and YC contributed in collecting the follow-up data afterwards. All authors helped in giving important revising suggestions. All authors read and approved the final manuscript.

Consent for publication

Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor of this journal.

Competing interests

The authors declare that they have no competing interests.

Tables

Table 1 Patient characteristics and embolisation details with transcatheter arterial embolization

Characteristic	All(n=112)	Success (n =104)	Failure (n = 8)	p value
Age (years)	54.3	55.6	50.6	0.58
gender				0.69
male	66	61	5	
female	46	43	3	
Side				0.15
Right	49	46	3	
Left	63	58	5	
Units of transfusion		3.7 ± 3.4	7.8± 1.2	<0.001*
No of bleeding arteries				0.09
None	6	6	0	
Single	68	62	6	
Multiple	38	36	2	
Angiographic findings				0.32
Negative angiographic finding	6	6	0	
Pseudoaneurysm (PSA)	56	53	3	
Arteriovenous fistula(AVF)	33	31	2	
PSA +AVF	14	12	2	
Arterial laceration	9	8	1	
Embolic material used				<0.001*
Coils/microcoils alone	31	29	2	
GS alone	15	13	4	
Coils/microcoils +GS	66	64	2	
Hospital stay (days)	4.9± 2.2	4.5 ± 3.1	6.2 ± 2.5	0.07
Injured branch				<0.001*
Maid artery	1	1	0	
Secondary branch	22	24	3	
Tertiary branch	58	76	1	
Secondary+Tertiary branch	31	28	4	

Table 2 Characteristics of the 8 patients with clinical failure of transcatheter arterial embolization

No	gender	Age	Angiographic findings	Transfusion (RBC units)	Embolic material used	Injured branch	Remark
1	M	61	AVF	8	coils	MA	2nd TAE
2	F	37	PSA +AVF	8.5	GS	TA	2nd TAE
3	M	49	PSA	10	GS+coils	MA	2nd TAE
4	M	53	PSA +AVF	8	coils	SA	Surgery
5	F	59	PSA	7.5	GS	SA	Surgery
6	M	46	AVF	6	GS	TA	2nd TAE
7	F	48	AL	6	GS+coils	SA	2nd TAE
8	M	52	PSA	8	GS	TA	2nd TAE

PSA Pseudoaneurysm AVF arteriovenous fistula AL: Arterial laceration GS: gelatin sponge particles

Figures

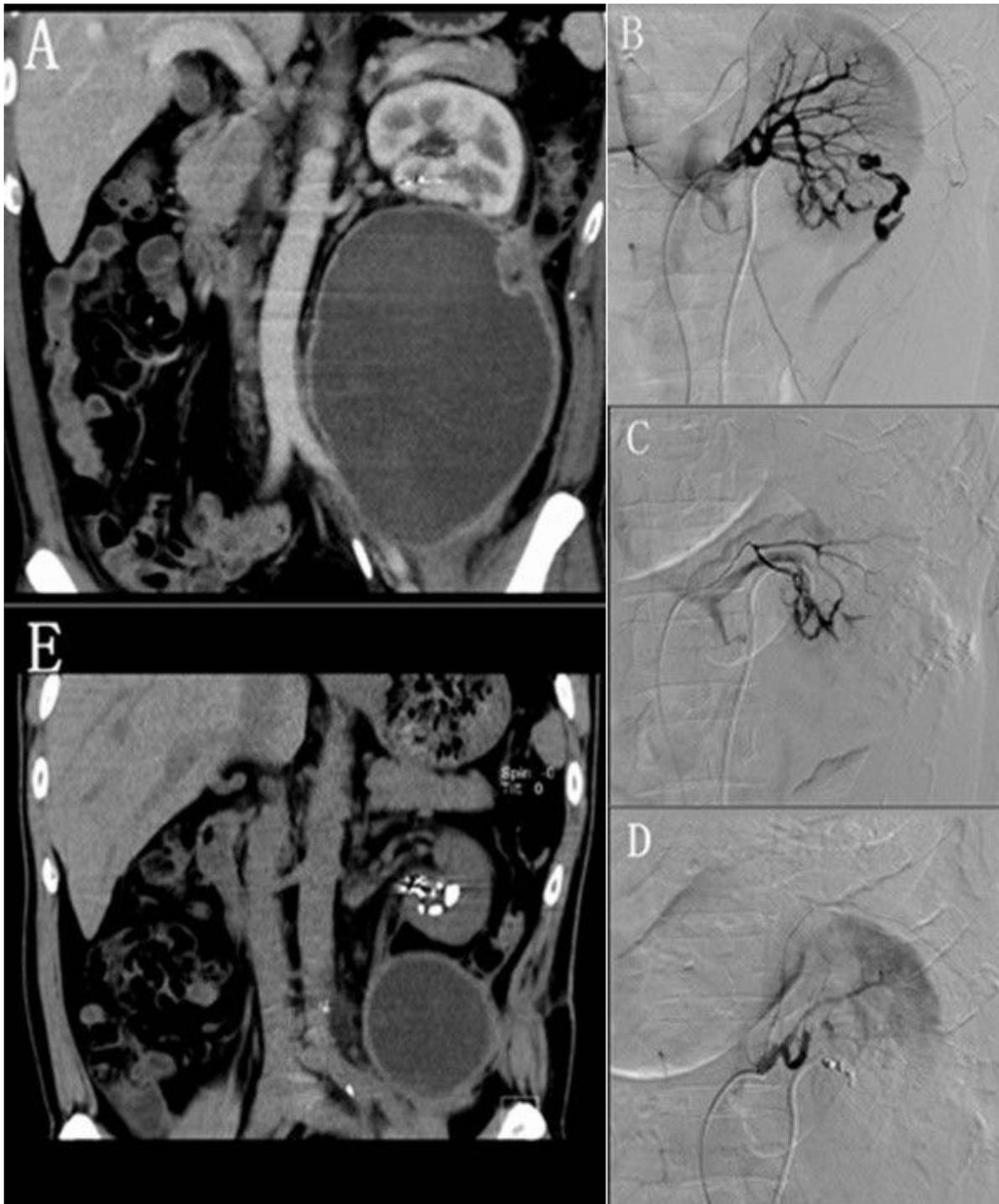


Figure 1

(a) Preoperative CT scan revealed a massive hematoma in the abdominal cavity caused by renal hemorrhage. (b) The left renal artery angiography revealed a PA and AVF and Contrast extravasation (CE) from the inferior segmental branch. (c) The parent arterial branch of the hemorrhage was catheterized superselectively using the microcatheter. (d) The left renal arteriography showed that the parent arterial branch of the hemorrhage was completely occluded by microcoil and gelatin sponge particles. (e) CTscan at 3month follow-up showed the normal homogeneous density throughout the left renal parenchyma and abdominal hematoma was obviously absorbed.

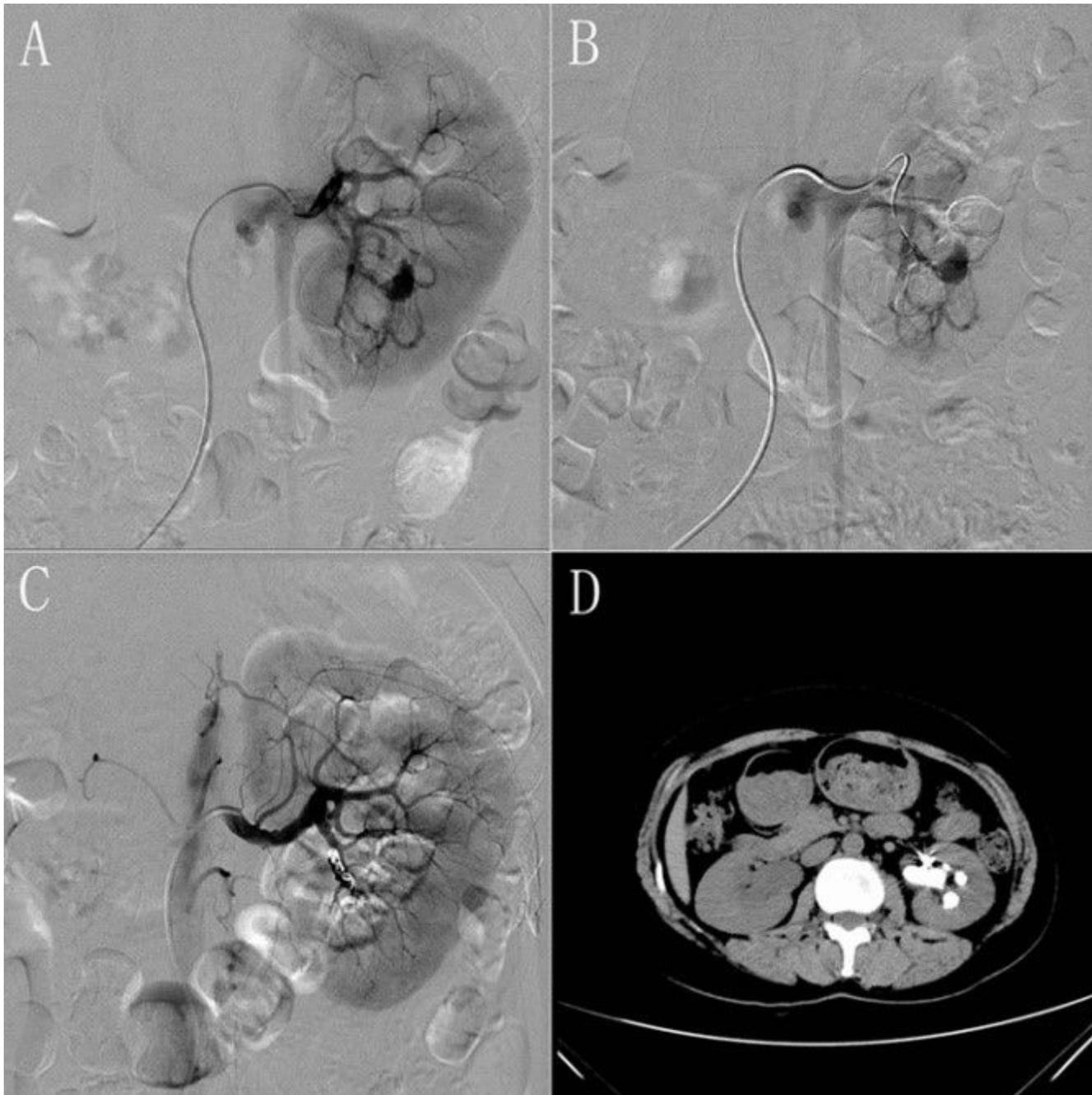


Figure 2

(a) The left renal artery angiography showed a AVF from the inferior segmental branch. (b) Superselective angiogram of the inferior segmental branch using the microcatheter revealed the abnormal arteriovenous communication. (c) The left renal arteriography demonstrated that the arteriovenous fistula have been completely occluded by microcoils. (d) CTscan at 3- month follow-up showed the normal iso-signal intensity throughout the left renal parenchyma.