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Iatrogenic renovascular injuries treated by transarterial embolization

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Abstract. – BACKGROUND: Renal vascular injury may be secondary to blunt or penetrating trauma, iatrogenic injuries or spontaneously with or without underlying pathology. The study aims to evaluate the effectiveness and safety of transarterial embolization (TAE) for the treatment of iatrogenic renovascular injuries (IRVIs).

PATIENTS AND METHODS: Thirty-six patients (27 males, 9 females, aged 14-79 years) with IRVIs were treated with TAE. Preprocedure computed tomography (CT) and/or ultrasound (US) and/or digital subtraction angiography (DSA) confirmed the presence of IRVIs in all 36 patients. The embolic materials include metallic coils, polyvinyl alcohol particles (PVA), gelfoam and n-butyl cyanoacrylate (NBCA) iodized oil mixture were used. The results of the embolization procedure were recorded. Patients were followed up, and complications of the procedure were noted.

RESULTS: A total of 40 embolization procedures were performed in 36 patients, and technical success was achieved in all procedures. Medical successes were achieved in 32 (89%) patients. Postembolization syndrome (back pain and fever) were detected in 12 patients (22%). Perirenal abscess was seen in one patient (3%). Puncture-site bleeding, nontarget embolization, decrease in renal function, and arterial hypertension were not detected in any of the patients.

CONCLUSIONS: TAE is an effective, minimally invasive treatment method for IRVIs. Therefore, TAE should be the first preferred treatment modality.

Key Words:
Kidney, Renal arteries, Therapeutic embolization, Injuries.

Introduction

Renal vascular injury may be secondary to blunt or penetrating trauma, iatrogenic injuries or spontaneously with or without underlying pathology[1]. Iatrogenic injuries are the most common (>50%) cause of renal vascular lesions; they may present as pseudoaneurysm, arteriocalyceal fistula (ACF), arteriovenous fistula (AVF) or perinephric hematoma[2-4]. In most cases renal injuries are self-limiting and can be effectively managed by conservative therapy[5,6], but if the lesions cause continuous hematuria or life-threatening massive bleeding, the expeditious intervention should be necessary[1]. Control of bleeding can be achieved either by open surgical procedures or minimally invasive transarterial embolization (TAE)[3,7]. TAE is a well-established endovascular treatment of renovascular injuries, and with the development of interventional radiology it is now possible to perform superselective embolization with minimal tissue loss[1,3,6,7].

The purpose of our study was to assess the feasibility and efficacy of TAE in IRVIs.

Patients and Methods

We reviewed the case histories of 36 patients including 27 males and 9 females, with an average age of 50 years (range: 14-79 years). All of them underwent TAE procedures between November 2003 and December 2012 at a single centre (The Chinese PLA General Hospital). 14 had a history of renal biopsy, 9 had partial nephrectomy, 8 had percutaneous nephrolithotomy (PCNL), 3 had percutaneous nephrostomy (PNT), 1 had nephrectomy, and 1 had percutaneous argon-helium knife. All patients were examined and treated as a part of routine care and gave informed consent.

17 patients underwent digital subtraction angiography (DSA) as the first imaging modality. 19 patients underwent computed tomography (CT) (15 patients) or ultrasound (US) (4 patients) as the first imaging modality. The indications for DSA were perirenal hematoma and/or hematuria caused heamodynamic instability in 16 patients (Table I), and continuous hematuria or drainage

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Table I. Clinical and angiographic data of 16 Patients with perirenal hematoma and/or hematuria caused heamodynamic instability.

No.	Sex/ age	Cause of bleeding	Imaging and angiographic finding	Embolic materials (materials used in the 2nd procedure)	Outcome	Complication
1	F/33	Biopsy	Perirenal hematoma/ CE/pseudoaneurysm	Coils/Gelfoam	Died of heart failure 10 days later	Back pain and fever
2	F/48	Biopsy	Perirenal hematoma/CE	Coils/Gelfoam	Medical success	None
3	F/50	Biopsy	Perirenal hematoma/ pseudoaneurysm	Coils/Gelfoam	Medical success	fever
4	M/49	Biopsy	Perirenal hematoma/AVF	Coils/Gelfoam	Medical success	fever
5	M/52	Biopsy	Perirenal hematoma/CE/ AVF	Coils/Gelfoam	Died 1 day later.	Back pain
6	M/31	Biopsy	Perirenal hematoma/ pseudoaneurysm	Coils/PVA	Medical success	None
7	M/47	Biopsy	AVF	Coils/Gelfoam	Medical success	None
8	M/39	Biopsy	Perirenal hematoma / pseudoaneurysm	Coils/PVA	Medical success	Back pain and fever
9	M/26	Biopsy	Perirenal hematoma/CE	Coils/Gelfoam (Coils/PVA)	Medical success	Back pain and fever
10	M/60	Biopsy	Perirenal hematoma/CE	Coils/PVA (PVA)	Died of gastrointestinal bleeding 7 days later	Back pain
11	F/74	Biopsy	AVF	Coils/Gelfoam	Medical success	None
12	F/64	Biopsy	Perirenal hematoma/CE	Coils/NBCA	Died 1 day later	None
13	M/63	Partial nephrectomy	Pseudoaneurysm	Coils/PVA	Medical success	fever
14	F/74	Partial nephrectomy	Pseudoaneurysm	Coils/PVA	Medical success	None
15	M/52	Partial nephrectomy	AVF/pseudoaneurysm	Coils/Gelfoam	Medical success	None
16	M/41	Percutaneous argon-helium knife	Perirenal hematoma/CE	Coils/Gelfoam	Medical success	Back pain and fever

Percutaneous nephrolithotomy (PCNL), Percutaneous nephrostomy (PNT), Arteriovenous fistula (AVF), Contrast extravasation (CE), NBCA-iodized oil mixture (NBCA).

tube hemorrhage more than 72 hours and necessitating blood transfusion in 18 patients (Table II), and huge aneurysm and/or arteriovenous fistula without bleeding in 2 patients (Table II). Embolization was performed when the contrast extravasation, pseudoaneurysm, aneurysm, or arteriovenous fistula (AVF) was detected.

For the DSA procedure, the femoral artery was punctured and a 4F sheath was inserted. An abdominal aortography was obtained with a 4-Fr pigtail and thereafter a selective renal DSA was performed with a 4-Fr catheter. For selective embolization we used microcatheter (Progreat, TERUMO, Tokyo, Japan). The microcatheters were inserted as near as possible to the lesion, and the embolic materials inserted. Embolic materials consisted coils (COOK Medical, Bloomington, IN, USA), polyvinyl alcohol (PVA) (COOK Medical, Bloomington, IN, USA), gelfoam (Alicon, Hangzhou, China), NBCA (Braun, Melsungen, Germany) iodized oil (Lipiodol, Andre Guerbe Lab, Saint Qen, France) mixture. The N-butylcyanoacrylate (NBCA)-iodized oil mixture was prepared by hand, which was obtained by mixing NBCA and iodized oil at a 1:4 ratio. The procedure was completed when total occlusion of the lesion and cessation of the hemorrhage on control angiogram was seen.

Close observation was performed for all of the patients after the procedure. After discharge the patients were followed up by Outpatient Service or telephone. The technical and medical success, and complications of the procedure were extracted from the radiological records, close observation and follow-up visiting. Complete cessation of contrast extravasation, and disappear of pseudoaneurysm, aneurysm and arteriovenous fistula (AVF) after the embolization procedures

Table II. Clinical and angiographic data of 18 Patients with continuous bleeding without heamodynamic instability and the other 2 patients (No. 35, 36) without bleeding.

No.	Sex/ age	Cause of bleeding or injury	Imaging and angiographic finding	Embolic materials (materials used in the 2nd procedure)	Outcome	Complication
17	M/14	Biopsy	AVF	Coils/Gelfoam	Medical success	None
18	F/58	Biopsy	Perirenal hematoma/ pseudoaneurysm	Coils/Gelfoam	Medical success	None
19	m/39	Partial nephrectomy	Pseudoaneurysm	Coils/Gelfoam	Medical success	Fever
20	M/47	Partial nephrectomy	Pseudoaneurysm	Coils	Medical success	None
21	M/57	Partial nephrectomy	Pseudoaneurysm	Coils/Gelfoam	Medical success	None
22	M/37	Partial nephrectomy	Pseudoaneurysm	Coils/NBCA	Medical success	None
23	F/33	Partial nephrectomy	Pseudoaneurysm	Coils/Gelfoam	Medical success	None
24	M/79	PNT	Aneurysm	Coils/Gelfoam	Medical success	None
25	M/55	PNT	CE	Coils/PVA	Medical success	None
26	M/55	PNT	Pseudoaneurysm	Coils/PVA	Medical success	None
27	M/49	PCNL	AVF	Gelfoam	Medical success	None
28	M/55	PCNL	AVF/Pseudoaneurysm	NBCA	Medical success	None
29	M/52	PCNL	Pseudoaneurysm	Coils/ PVA	Medical success	None
30	M/46	PCNL	Pseudoaneurysm	Coils	Medical success	None
31	M/49	PCNL	Perirenal hematoma/ CE/ Pseudoaneurysm	Coils/Gelfoam (NBCA)	Medical success	Back pain/ perirenal abscess
32	M/55	PCNL	CE	Coils/PVA (Coils/Gelfoam)	Medical success	None
33	M/55	PCNL	Pseudoaneurysm	Coils/ PVA	Medical success	None
34	F/51	PCNL	Perirenal hematoma/ pseudoaneurysm	NBCA	Medical success	None
35	M/52	Partial nephrectomy	Aneurysm	Coils/Gelfoam	Medical success	None
36	M/59	Nephrectomy	Pseudoaneurysm/AVF	Coils/NBCA	Medical success	Back pain

Percutaneous nephrolithotomy (PCNL), Percutaneous nephrostomy (PNT), Arteriovenous fistula (AVF), Contrast extravasation (CE), NBCA-iodized oil mixture (NBCA).

were regarded as technical success. Absence of bleeding, no recurrent decrease of hemoglobin, no need for blood transfusion, no need for subsequent renal surgery and being discharged after recovery were defined as medical success. Medical complications included postembolization syndrome (back pain and fever), perirenal abscess or renal abscess, decrease in renal function, and arterial hypertension. Renal artery dissection, non-target embolization, and puncture site bleeding were defined as technical complications.

Results

A total of 40 embolization procedures were performed in 36 patients, and technical success was achieved in all procedures. Medical successes were achieved in 32 (89%) patients. In 27 cases bleeding was effectively controlled with embolization in a single session (Figure 1). Three cases bleeding were controlled on the second attempt (Figure 2). Two cases without bleeding (Figure 3), the aneurysms and AVF disappeared after TAE. Four cases were died in 10 days after the embolization, two of them died of heart failure and gastrointestinal bleeding, and the other two patients died of recurrence of bleeding before the surgical intervention, all of them accompanied with heamodynamic instability before the embolization.

After the procedures, postembolization syndrome (back pain and/or fever) were detected in 12 patients (22%), and 9 of them were accompanied with perirenal hematoma. Perirenal abscess was seen in one patient (3%). Puncture-site

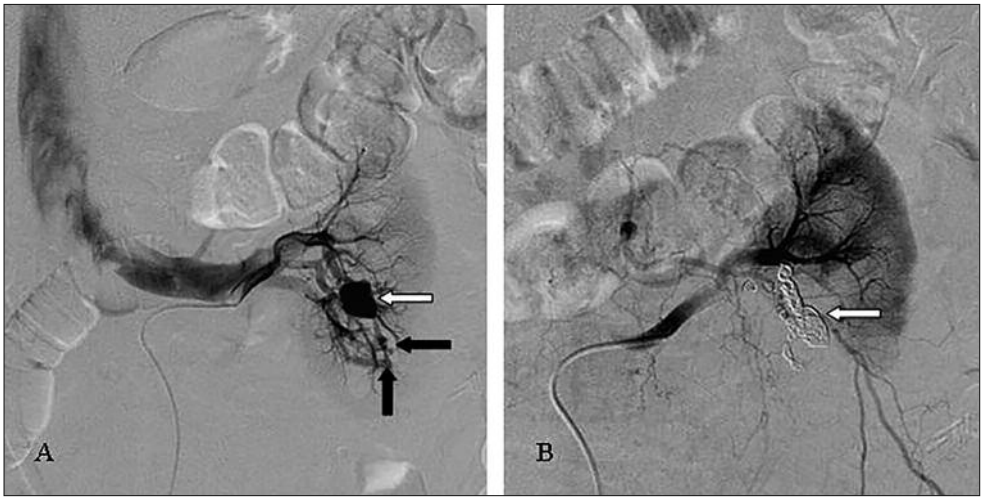

Figure 1. Pre- ***(A)*** and postembolization ***(B)*** DSA images of a 52 year-old man who presented with hematuresis after partial nephrectomy. Preembolization DSA shows a pseudoaneurysm *(white arrow, A)* and AVFs *(black arrow, A)* at the lower pole subsegmental artery of the left kidney. The lesions were selectively catheterized and embolized with coils and gelfoam *(arrow, B)*, and the pseudoaneurysm and AVFs were disappeared.

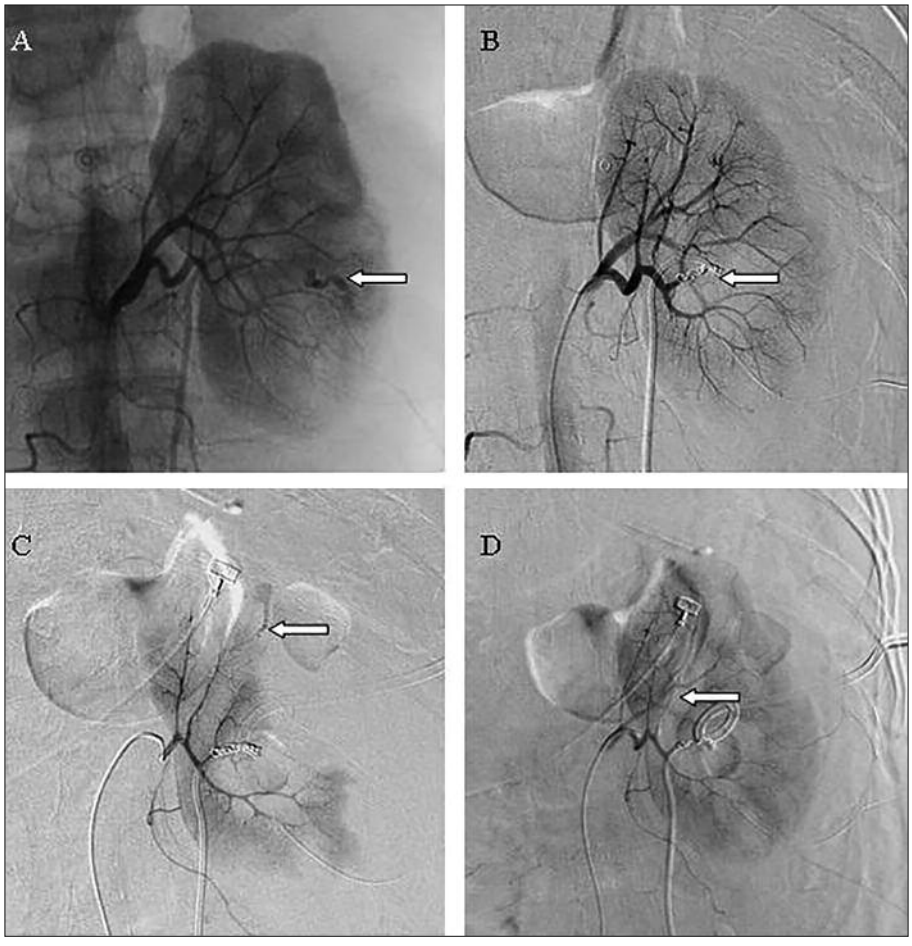

Figure 2. A 49 year-old man who presented with hematuresis and perirenal hematoma after percutaneous nephrolithotomy was rebleeding in the other sites *(arrow, **C**)* because of drainage for hematoma 2 days later after TAE, and the bleeding was controlled on the second attempt. Preembolization DSA shows contrast extravasation *(arrow **A**)* at the right kidney. The lesion was selectively catheterized and embolized with coils *(arrow, **B**)*. On the second attempt, the lesion was embolized with NBCA mixture *(arrow, **D**)*.

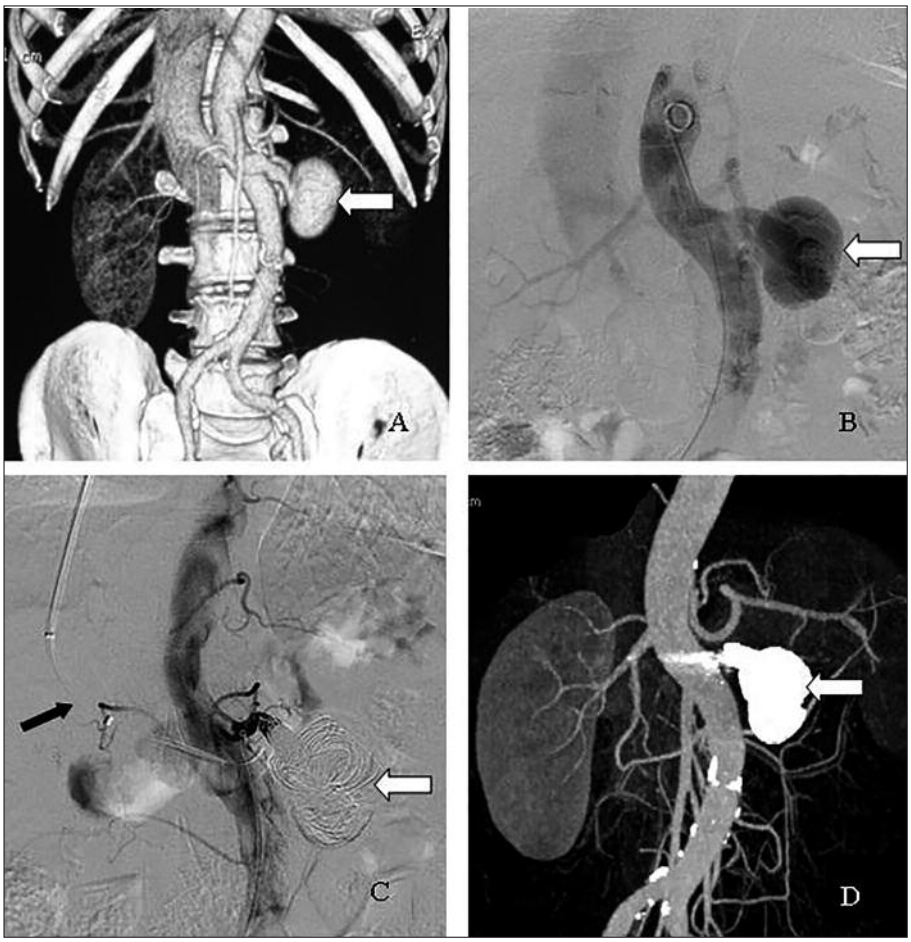

Figure 3. CT and DSA images ***(A, B)*** of a 59 year-old man who presented with heart failure 8 years later after nephrectomy because of nephrophthisis. Preembolization images show a huge aneurysm and AVF *(arrow,* ***A, B****)* at the left renal artery stump. The aneurysm and AVF were embolized with coils and NBCA mixture *(arrow*, ***C, D****)*. In order to avoid the escape of the coils from the AVF, a balloon catheter was placed in the renal vein *(black arrow,* ***C****)*.

bleeding and nontarget embolization were not detected in any of the 36 patients. After discharge from hospital, the 32 patients were followed up for at least 5 months, no bleeding recurred, decrease in renal function and arterial hypertension were not detected in any of them.

Discussion

Iatrogenic renovascular injury (IRVI) is a rare complication secondary to open surgical intervention or percutaneous minimally invasive procedures such as renal biopsy, PCNL, PNT, radiofrequency ablation and argon-helium knife[8,9]. In most cases, the renovascular injuries present as bleeding such as hematuria and perirenal hematoma, and heal spontaneously do not need any intervention[5,9]. Surgical or TAE is recommended when there is life-threatening or continuous hemorrhage persisting for more than 72 hours and need blood transfusion[1,3,7,8]. On the other hand, the IRVIs may have no bleeding and was detected accidentally several months or several years later after the surgical operation. In our study, two patients (5.6%) without bleeding were detected by CT.

Review the imaging and angiographic findings, the renovascular injuries may present as aneurysm, pseudoaneurysm, AVF, aorto-caval fistula (ACF), contrast extravasation and perinephric hematoma[3,4,9]. In our study, aneurysm was detected in 3 patients (8%), pseudoaneurysm in 21 patients (58%), AVF was detected in 9 patients (25%), contrast extravasation in 10 patients (28%), and perinephric hematoma in 14 patients (39%).

Findings of the present study suggest that TAE is a highly effective method to control urological bleeding, especially in emergency situations [1,10]. The IRVIs can be accurately diagnosed using angiography and treated by the percutaneous embolization techniques. Compared with the surgical treatment, superselective embolization reduces tissue loss because the embolization material can be deployed immediately proximal

to the bleeding site[3,4,7]. If embolisation facilities were not available or failed, open surgical intervention would be required to control haemorrhage[1]. In our study, four (25%) patients of the 16 patients with massive bleeding and heamodynamic instability died in 10 days after the embolization, and the medical successes were achieved in all of the other 20 patients without heamodynamic instability.

The embolic material is the major determinant of the efficacy of TAE. A variety of embolic materials are available for TAE, such as metal coils, sclerosants (NBCA, absolute ethanol, lipiodol), and particulate embolic agents (polyvinyl alcohol particles and gelfoam)[11]. The material should be chosen according to the site, size and the flow pattern of the vessels to be occluded, the knowledge of the radiologist, and the availability of the material[3]. The duration of occlusive effect and preservation of normal tissue should also be considered. Coils, gelfoam, and PVA are the most common and effective agents for TAE of renovascular injuries. The application of NBCA for transcatheter embolization of renal artery has been reported to be feasible and safe[12-14]. We also used NBCA-iodized oil mixture successfully in 6 patients (Figure 4).

Each material has its own advantages and disadvantages. Coil was the most effective tool. The main disadvantage of coil is that usually more than one coil is required for adequate occlusion which increases the cost and procedure time[13]. Gelfoam is cost-effective, and the size can be controlled. However recanalization can occur faster than other material, because gelfoam is absorbed spontaneously[15]. PVA is a biocompatible permanent material and can occlude a vessel at the small arteriolar level, but it is difficult to control reflux and inadvertent embolization during injection[15,16]. NBCA offers immediate and effective occlusion of the pathologic vessel and it can be used to avoid proximal embolization of the visceral arteries that could not be catheterized selectively because of tortuosity, vessel size, or anatomic location[12-14]. NBCA must be mixed with iodized oil in order to delays the polymerization time and gives radiopacity. During the injection, we must avoid reflux which may be caused by a too large volume and/or an inappropriate speed of injection of the glue. During retrieval of the microcatheter, gluing of NBCA to the catheter tip and inadvertent embolization should be avoided too. In order to avoid the disadvantages, we often combine two materials together.

Complications related to interventional embolization procedures are rare[2,7]. Review of our case load, the most common complaints after the procedures were postembolization syndrome (back pain and fever), which was self-limited and easily controlled with medications. The postembolization syndrome is known to occur after total renal embolization for tumor ablation[16]. In our study, it may be attributed to the perirenal hematoma and undesired ablation of renal tissue after the embolization. And we found no signifi-

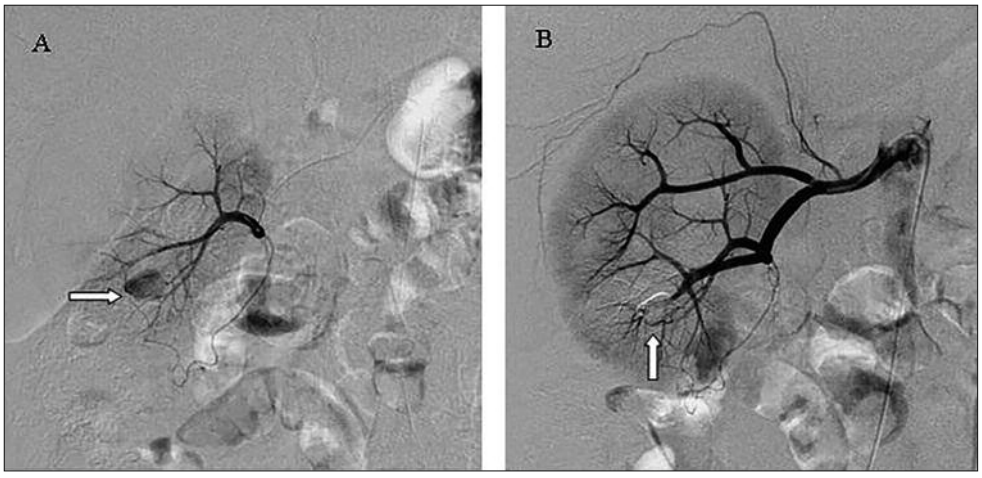

Figure 4. Pre- ***(A)*** and postembolization ***(B)*** DSA images of a 55 year-old man who presented with hematuresis after percutaneous nephrolithotomy. Preembolization DSA shows a pseudoaneurysm *(arrow A)* at the lower pole subsegmental artery of the right kidney. The lesion was selectively catheterized and embolized with NBCA-iodized oil mixture. On postembolization control angiogram, the pseudoaneurysm was filled with NBCA *(arrow, B)*.

cant difference in postembolization syndrome based on the type of embolization agent used. Arterial hypertension is a rare complication[2,7]. It may be due to the occlusion or stenosis of main renal artery after renal catheterization[2,17]. There is no indication in the literature that the appearance of renal hypertension increases after superselective renal arterial embolization. Impairment of renal function occurred mainly because of nonselective embolization of the main renal artery or occlusion of more than one branch of the renal artery, especially the patients with renal insufficiency or solitary kidney[3,7]. Because of using superselective embolization, these complications have not been noted in recent reports[1,3,4,7], and we did not encounter this complication, either. However, we found that most of the patients with renal insufficiency before the embolizations will get transient increase in creatinine levels (14 in 17 patients), which was possibly due to contrast material nephrotoxicity[7]. The technical complications could be expected to decrease due to the improvement of technology and techniques, especially the usage of the microcatheter. The complications profile, especially minor and easily manageable re-emphasised the safety of this procedure.

Conclusions

TAE is an effective, minimally invasive treatment method for IRVIs. Therefore, TAE should be the first preferred treatment modality, especially for the patients without heamodynamic instability.

Acknowledgements

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Conflict of Interest

The Authors declare that there are no conflicts of interest.

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