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Outcome of Selective Renal Artery Embolization in Managing Severe Bleeding after Percutaneous Nephrolithotomy

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Keywords
Percutaneous nephrolithotomy · Severe bleeding · Renal arteriography · Postoperative complication · Embolization

Abstract
Objectives: The aim of this study was to evaluate the characteristics of the renal arterial segment bleeding and assess the outcome of selective renal artery embolization (SRAE). ***Methods:*** Data on 35 patients in whom SRAE was performed after percutaneous nephrolithotomy (PCNL) from January 2005 to December 2015 in our institute were retrospectively analyzed. All patients had severe bleeding but failed to respond to conservative therapy. ***Results:*** Forty-four SRAEs were performed in 35 patients (36 kidney units) after PCNL. The findings of 44 renal arteriographies before embolization revealed bleeding in 44 renal artery branch segments. Upper artery segment bleeding in 0, upper and anterior segment bleeding in 3, lower and anterior artery segment bleeding in 6, lower artery segment bleeding in 9, posterior artery segment bleeding in 24, and negative finding in 2 patients. Renal arteriography revealed pseudoaneurysms in 20 (45.5%) patients, arteriovenous fistulas in 6 (13.6%) patients, renal artery branch laceration in 16 (36.4%) patients, and negative angiography finding in 2 (4.5%) patients. Acute bleeding in 7 patients (20.0%) and delayed bleeding in 28 patients (80.0%) were observed. The target vascular lesions were successfully treated by embolization in the first time in 28 cases. Six patients underwent 2 sessions and 1 had 3 sessions. New vascular lesions were the most common cause of failure of initial SEAE in our hospital. Abnormal renal function was observed in 5 patients, and they recovered to preoperative or normal level within 3 weeks. ***Conclusions:*** The posterior artery segment of the kidney is the most common bleeding site due to the choice of puncture site. Delayed bleeding (>24 h) was the most common type of bleeding. SRAE is an effective and safe method to treat the severe bleeding after PCNL.
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Introduction

Percutaneous nephrolithotomy (PCNL) is the preferred method to treat bulk and complex kidney stones [1]. PCNL is a minimally invasive technique, but severe bleeding can also be encountered. Severe bleeding of kidney is a rare but worrisome complication of PCNL, and it usually does not respond to the conservative measurements. In this report, all patients had undergone renal arteriography, and subsequent selective renal artery embolization (SRAE) was done. The rate of

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Table 1. Characteristics of patients receiving SRAE

	n (%)	Mean (range)
Patients	35	
Age, years		49.4 (19–70)
Sex (male/female)	26 (74.3)/9 (25.7)	
Hypertension (present/absent)	8 (22.9)/27 (77.1)	
Diabetes mellitus (present/absent)	4 (11.4)/31 (88.6)	
Positive preoperative urine culture (present/absent)	25 (71.4)/10 (28.6)	
Renal intervention history (present/absent)	9 (25.7)/26 (74.3)	
Stone side (bilateral/unilateral)	13 (37.1)/22 (62.9)	
Stone type		
Staghorn	12 (34.2)	
Multiple	18 (51.4)	
Single	3 (8.6)	
Ureteral calculi	1 (2.9)	
Pus substance	1 (2.9)	
Solitary kidney (present/absent)	2 (5.7)/33 (94.3)	
Stone burden, cm		2.9 (1.5–7.0)
Hydronephrosis (present/absent)	31 (88.6)/4 (11.4)	
Operative time (<90/≥90 min)	14 (40.0)/21 (60.0)	
Calix of puncture		
Lower	7 (20.0)	
Middle	19 (54.3)	
Upper	9 (25.7)	
Method of dilation (Amplatz/balloon)	30 (85.7)/5 (14.3)	
Number of tracts (single/multiple)	24 (68.6)/11 (31.4)	

SRAE, selected renal artery embolization.

transfusion was reported between 1 and 55%, while the percentage of embolization varied from 0.6 to 1.5% in previous reports [2, 3]. Although several studies had identified the risk factors of vascular complications after PCNL [4–9], the related studies are still few in number. Therefore, this study was to reveal the characteristic of severe renal arterial segment bleeding and to assess the outcome of SRAE.

Materials and Methods

From January 2005 to December 2015, the clinical data on 35 cases who underwent renal arteriography and subsequently SRAE were retrospectively reviewed. More than 3,000 cases underwent PCNL during this period. SRAE was performed in patients with severe bleeding after PCNL that failed conservative treatments. Patients who had renal angiography but did not undergo embolization were excluded from this study.

Age, sex, hypertension, diabetes mellitus, stone size and location, procedure duration, history of renal surgery, number of renal punctures, method of dilation, degree of hydronephrosis, number of tracts, and site of puncture were recorded. Detailed information can be seen in Table 1.

The bleeding type was divided into acute and delayed bleeding according to the onset time of bleeding. Acute bleeding occurred <24 h after PCNL. Patients with acute hemorrhage presented with red urine, blood clot, persistent bleeding, and a notable hemoglobin drop. Patients also manifested with the symptom of shock in severe condition. Delayed bleeding is in which the bleeding time was over 24 h after PCNL. These patients also had some symptoms which were similar to the acute bleeding like red urine, blood clot, and the drop of hemoglobin and hematocrits. But, it usually has slow progression of bleeding.

All angiographic results were analyzed by an interventional radiologist. Offending vessels were classified according to the type and location of the segmental artery involved. The characteristic of arteriovenous fistulas was early filling of the venous system during renal arteriography. Pseudoaneurysm was regarded as cystic dilation of arterial branches. Renal artery branch laceration was characterized by the overflow of contrast from a blunt ending arterial branch. The bleeding vascular injuries and type of embolic materials were recorded.

PCNL Procedure

All procedures were performed under spinal anesthesia (lumbar anesthesia or combined with spinal anesthesia). A ureteral catheter was inserted in a retrograde fashion through the cystoscope in the lithotomy position. Then, patients were transferred to the prone position. An 18-gauge needle was introduced into the

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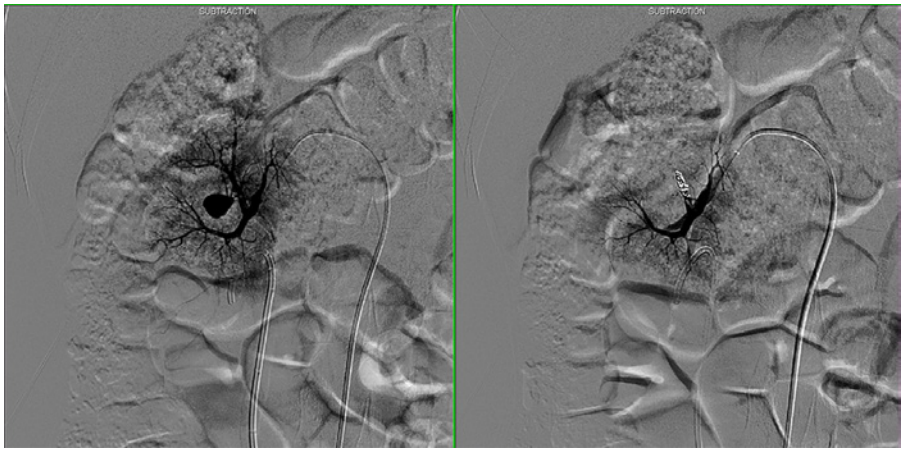

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Fig. 1. Angiography reveals a pseudoaneurysm in the middle of the right kidney. Embolization via micro-coil was conducted. No overflow of contrast medium could be seen after embolization and bleeding ceased.

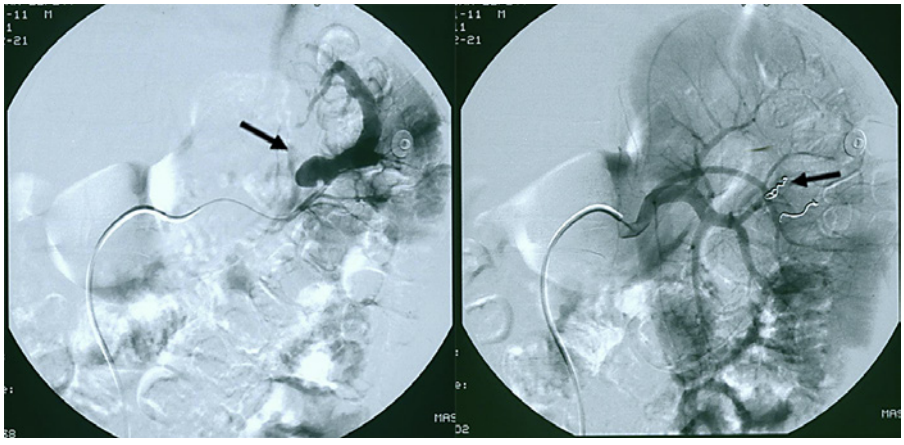

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Fig. 2. The black arrow shows that the arteriovenous fistula was completely occluded by 2 micro-coils.

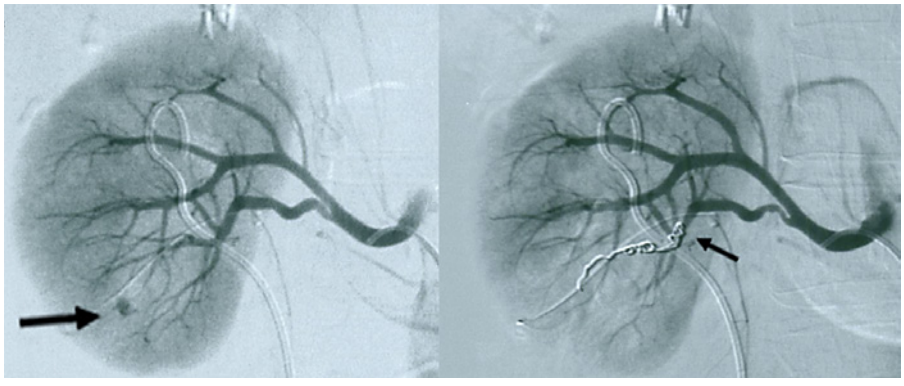

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Fig. 3. The black arrow shows that the bleeding site was completely occluded by 2 micro-coils and 1 sponge.

targeted calyx under ultrasound guidance. A J-shaped guide-wire was inserted into the collecting system through the needle after observing the urine reflux. The tract was dilated with matched peel-away sheath or dilator from 16 to 24 Fr. The 20.8-Fr nephrostomy tube (produced by German WOLF Company) was placed. At the end, a Double-J stent was placed. The equipment of Switzerland EMS company's third-generation ultrasonic joint pneumatic ballistic was used for stone fragmentation and removal (Fig. 1, 2, 3).

SRAE Procedure

All embolizations were completed by experienced interventional radiologists. At first, renal arteriography was used to detect the site of bleeding under local anesthesia using 5 mL of 1% lido-

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Table 2. Outcome of SRAE

	n (%)	Mean (range)
Postoperative mean hemoglobin drop, g/L		48.2 (13–99.9)
Postoperative mean hematocrit decrease, %		14.0 (3.2–27.6)
Findings on angiography		
Pseudoaneurysm	20 (45.5)	
Arteriovenous fistula	6 (13.6)	
Laceration of artery	16 (36.4)	
Negative angiography finding	2 (4.5)	
Type of bleeding		
Acute (≤24 h)	7 (20.0)	
Delayed (>24 h)	28 (80.0)	
Number of embolizations		
1 session	28 (80.0)	
2 sessions	6 (17.1)	
3 sessions	1 (2.9)	
Material of embolization		
Micro-coils	27 (61.4)	
Sponge	5 (11.4)	
Both	12 (27.2)	

SRAE, selective renal artery embolization.

caine. Then embolic materials were inserted into the bleeding site through a micro-catheter. Generally, micro-coils which cannot be absorbed were used for the pseudoaneurysm and arteriovenous fistula, while the gelatin sponge was chosen for the microscopic bleeding. Renal arteriography was performed to confirm the effective of embolization on the damaged blood vessels after the embolization. The details of vascular lesions and the outcome of embolization were collected. No bleeding site in the repeated renal arteriography and stable renal function was defined as clinical success.

Patients were managed by complete blood counts and renal ultrasound every day until no significant change. Follow-up contained evaluation of hemoglobin and serum Cr after embolization procedure before discharge. The next review was performed at 3 and 6 months and 1 year using renal ultrasound or CT, serum Cr, and hemoglobin.

Statistical Analysis

Mean ± SD and median were used for numerical variables. Student's *t* test was used for continuous variables and statistical significance was set at $p < 0.05$.

Results

Forty-four SRAE were performed in 35 patients (36 kidney units) after PCNL (Table 2). The group included 26 men and 9 women. The target vascular injury was successfully managed by embolization in 28 patients (80.0%) for the first time. The initial clinical success was 80.0% (28/35). Seven patients (20.0%) underwent repeated embolization. There were 6 (17.1%) patients who had second embolization and 1 (2.9%) had 3 embolization.

New vascular lesions occurred in 5 patients (5/35, 14.3%) and was the major finding on the repeated arteriography. One patient performed second embolization due to the inappropriate choice of sponge in the first embolization procedure. One patient underwent another embolization may be due to the size of the micro-coil used. There was no nephrectomy in the study. Among the new lesions, new pseudoaneurysm in 1 (14.3%) patient, new arteriovenous fistula in 2 (28.6%) patients, and renal artery branch laceration in 4 (57.1%) patients.

The mean decrease of hematocrit was 14.0% (range from 3.2 to 27.59%), and the mean decrease of hemoglobin was 48.20 g/L (range, 13–99.9 g/L). Acute bleeding was observed in 7 patients (20.0%) and delayed bleeding in 28 patients (80.0%). Blood transfusion was performed in 24 (68.6%) patients. The average blood transfusion of patients was 760 mL of packed RBCs (range, 200–2,200 mL). Among 44 renal artery segment bleeding, upper artery segment bleeding was observed in 0, upper and anterior segment bleeding in 3, lower and anterior artery segment bleeding in 6, lower artery segment bleeding in 9, posterior artery segment bleeding in 24, and negative findings in 2. Forty-four renal angiography findings before embolization included 20 (45.5%) pseudoaneurysms, 6 (13.6%) arteriovenous fistula, 16 (36.4%) renal artery branch laceration, and 2 (4.5%) negative angiography findings.

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Bleeding vessels were embolized using micro-coils in 27 cases (61.4%), combined use of micro-coils and sponge in 12 cases (27.2%), and sponge in 5 cases (11.4%). Staghorn and multiple stones are the more common stone types in this report. The common site of puncture was the middle calyx among these patients according to Table 1.

Abnormal renal function occurred in 5 cases. One solitary kidney patient's Cr level returned to normal within 3 weeks after the embolization procedure. One patient had bilateral kidney embolization at the same time and recovered to preoperative levels in 1 week after procedure. One patient underwent 1 embolization. One patient underwent 2 embolizations of the same kidney and 1 patient underwent 3 embolizations of the same kidney. Patients whose serum Cr was above 3 returned to normal level in 2 weeks after procedure. The level of serum Cr was normal at the 3-, 6-, and 12-month follow-up. There was no patient with recurrent bleeding after discharge.

Discussion

PCNL is a safe and effective method to treat kidney stones. It has replaced open surgery as the treatment of choice for bulk and complex kidney calculi [10–15]. When renal arterial bleeding does occur, the artery can flow into a vein and resulting in an arteriovenous fistula, or into renal parenchyma or hilar areolar tissue and thus a pseudoaneurysm [10]. In our study, pseudoaneurysm (45.5%) was the most common type of renal artery segment injury. Other studies also have suggested that pseudoaneurysms are more common [9, 12].

The results of our study reveal that renal artery segment bleeding often occurs in the posterior artery segment branch and lower and anterior artery segment branch. The results of renal arteriography agree well with our expectation. The site of bleeding is related to the site of puncture [9]. In other studies, there was the upper pole artery injury, while there was no upper renal artery bleeding lesion in our study [12]. This may result from our limited quantity of samples. In our study, delayed hemorrhage (80.0%) was the most common type. Urologists should pay more attention to those patients with high risk factors both in hospital and discharge, and on finding the symptoms of hemodynamic instability in those patients with high risk factors, the application of embolization is a good choice [2–5, 11, 12]. El-Nahas et al. [16] reported the success rate of SRAE was approximately 70%. The clinical success of SRAE for the first time is 80.0% in our study.

Two patients (5.7%) had negative findings which may be due to minor vascular injury, slow bleeding, and/or vasospasm. Besides, renal angiography has limitation of detecting venous bleeding. There was a high percentage of new renal vascular lesions occurred in the patients of repeated SRAE which was consistent with a previous report [17].

New vascular lesions were the most common reasons of failed initial SRAEs. Besides, recanalization of embolized vessel is another common reason for repeated SRAEs and may result from improper use of embolic material. When using sponge as the only embolic material, the risk of recanalization may increase in the previous study [15]. Besides, its size should be larger than the inner size of the target vessel using micro-coils for embolization. Otherwise, this could lead to migration of the micro-coil and recanalization [18].

Multiple renal vascular injuries can also contribute to severe bleeding [10]. In our study, 7 patients (20.0%) had repeated embolization, which was comparable to the rates in the reported literature [8, 9]. The decrease in hemoglobin concentration is the most commonly used index for evaluating the severity of bleeding [19–22]. The mean hemoglobin decrease was 48.2 g/L in our study.

Besides, only 5 patients had abnormal renal function in our study. One solitary kidney patient's Cr level returned to normal 3 weeks after the embolization procedure. One patient had bilateral kidney embolization at the same time and recovered to preoperative levels in 1 week after the procedure. One patient underwent one embolization. One patient underwent 2 embolizations of the same kidney, and 1 patient underwent 3 embolizations of the same kidney. Serum Cr of the above 3 patients returned to normal level in 2 weeks after the procedure. These results suggest that embolization can save the kidney function and has been proved to be a safe technique. Besides, early embolization can also reduce the use of blood transfusion in many cases.

Our study also has its limitation. Multicenter and large-scale trials would be required to further study this issue.

Conclusions

Renal artery segment bleeding often occurred in the posterior artery segment in our study. SRAE is a good choice for treatment of severe renal artery bleeding in both acute and delayed severe bleeding. Besides, it has been proved to be a safe and effective technique to preserve the kidney function and reduce the use of blood transfusion.

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Statement of Ethics

The research was approved by the Ethics Committee of Peking University People's Hospital, and informed consent was obtained from all participants.

Conflict of Interest Statement

The authors state that they have no conflicts of interest.

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Author Contributions

Yang Hong: manuscript writing. Liulin Xiong: methodology. Haiyun Ye: data collection. Lizhe An: data analysis. Xiaobo Huang: writing – review & editing. Qingquan Xu: research concept and design.

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