Clinical Research Report

Superselective renal artery embolization for bleeding complications after percutaneous renal biopsy: a single-center experience

Wang Haochen, Wang Jian, Song Li, Lv Tianshi, Tong Xiaoqiang and Zou Yinghua

Abstract

Objective: This study aimed to determine if superselective renal artery embolization is a safe and effective method of treating bleeding complications after percutaneous renal biopsy.

Methods: From January 2006 to December 2017, 43 patients (22 men and 21 women, mean age: 44.5 ± 14.0 years) underwent angiography for post-biopsy bleeding complications following percutaneous biopsy. Patients underwent angiography and superselective artery embolization. We recorded serum creatinine and hemoglobin values to assess the effect of embolization.

Results: Successful embolization was achieved in all patients. There was a pseudoaneurysm in 10 cases, arteriovenous fistula in eight, contrast media extravasation in 16, arteriovenous fistula combined with contrast media extravasation in five, and pseudoaneurysm combined with arteriovenous fistula in four. The embolic substance was a microcoil only or combined with a gelatin sponge. The mean creatinine value was not different at 1 day and 1 week after embolization compared with before embolization. Mean hemoglobin values were significantly higher at 1 day and 1 week after embolization than before embolization.

Conclusions: Superselective renal artery embolization is a safe and effective treatment for post-biopsy bleeding complications after percutaneous renal biopsy. Lumbar or iliolumbar artery angiography is necessary if renal arteriography shows no signs of hemorrhage.
Keywords
Superselective renal artery embolization, percutaneous renal biopsy, bleeding complications, angiography, pseudoaneurysm, arteriovenous fistula

Introduction
At present, percutaneous renal biopsy (PRB) is widely used in clinical diagnosis and treatment of kidney diseases. Despite development of new technique and skills, post-biopsy bleeding is still unable to be completely avoided and thought to be a severe or even life-threatening complication of PRB.1–4 Clinical findings of post-biopsy bleeding include formation of para-renal hematoma, hematuria, and the onset of loin and abdominal pain. Treatment for post-biopsy bleeding includes administration of hemostatic drugs or sometimes surgical repair or renal resection. However, transarterial embolization is the preferred approach for renal injury.5

A few reports have described embolization therapy of post-biopsy bleeding complications.6,7 Most of these reports were small studies with a sample size of 20 to 30 cases. In this study, we report our experience of trans-arterial superselective embolization for treating bleeding complications of PRB and its complex causes of disease with a relatively large number of cases.

Materials and methods
General information
From January 2006 to December 2017, 43 patients underwent angiography for post-biopsy bleeding complications following percutaneous biopsy. The initial diagnosis included glomerular disease (n = 17), type II diabetes (n = 5), hypertensive nephropathy (n = 5), antineutrophil cytoplasmic antibody (ANCA)-associated vasculitis (n = 9), and lupus nephritis (n = 7) (Table 1). All renal biopsies were performed under ultrasound guidance with an 18-gauge needle. The symptoms of bleeding included hematuria (n = 43), back pain (n = 41), and decreased blood pressure (n = 39). Computed tomography (CT) was performed for all of the patients and showed para-renal hematoma in all of them (Figure 1). Blood transfusion was performed in 23 patients with hemoglobin levels ≤60 g/L. This study was in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) and approved by the Institutional Review Board of Peking University First Hospital. Informed consent was signed by every patient.

Superselective renal artery embolization
A 5 F pigtail catheter was introduced first and whole descending aorta angiography was performed to determine if there was extravasation of contrast medium from the intercostal arteries or the lumbar arteries. A cobra catheter was then introduced into the ipsilateral renal artery and angiography was performed to evaluate the target vessel. A 2.8 F microcatheter (Asahi Intecc Co. Ltd., Aichi, Japan) was superselectively introduced into the target artery of the bleeding site. Metallic fibred platinum microcoils (Tornado Embolization Microcoil; Cook Medical, Bloomington, IN, USA) were used for all patients.
Table 1. Clinical data and angiographic data of the patients.

| Sex/age (years) | Pathological type          | Symptom                | Serum creatinine value (μmol/L) | Hemoglobin value (g/L) | Angiographic manifestation | Embolic agent                  |
|----------------|----------------------------|------------------------|---------------------------------|------------------------|-----------------------------|--------------------------------|
|               |                            |                        | Day 0                           | Day 1                  | Day 7                       |                                 |
|               |                            |                        | Day 0                           | Day 1                  | Day 7                       |                                 |
| M/62          | Glomerular disease         | Back pain/hematuria    | 324                             | 335                    | 321                         |                                |
|               |                            |                        | 72                              | 90                     | 135                         | Pseudoaneurysm                 |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |
| M/52          | Glomerular disease         | Back pain/hematuria    | 465                             | 464                    | 463                         |                                |
|               |                            |                        | 66                              | 87                     | 120                         | Arteriovenous fistula          |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |
| M/52          | Type II diabetes           | Hematuria              | 389                             | 377                    | 375                         |                                |
|               |                            |                        | 84                              | 100                    | 110                         | Pseudoaneurysm                 |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |
| M/48          | Glomerular disease         | Back pain/hematuria    | 498                             | 487                    | 483                         |                                |
|               |                            |                        | 92                              | 120                    | 130                         | Arteriovenous fistula          |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |
| F/27          | Lupus nephritis            | Hematuria              | 711                             | 710                    | 721                         |                                |
|               |                            |                        | 55                              | 88                     | 130                         | Pseudoaneurysm                 |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |
| F/59          | ANCA-associated vasculitis | Hematuria              | 432                             | 434                    | 410                         |                                |
|               |                            |                        | 62                              | 90                     | 128                         | Pseudoaneurysm                 |
|               |                            |                        | Microcoil                        |                        |                             |                                |
| M/50          | Glomerular disease         | Back pain/hematuria    | 233                             | 255                    | 234                         |                                |
|               |                            |                        | 77                              | 100                    | 139                         | Contrast media extravasation   |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |
| F/64          | Lupus nephritis            | Hematuria              | 220                             | 201                    | 210                         |                                |
|               |                            |                        | 84                              | 105                    | 136                         | Contrast media extravasation   |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |
| F/51          | ANCA-associated vasculitis | Back pain/hematuria    | 459                             | 454                    | 448                         |                                |
|               |                            |                        | 66                              | 99                     | 126                         | Arteriovenous fistula          |
|               |                            |                        | Microcoil                        |                        |                             |                                |
| M/50          | Hypertensive nephropathy   | Hematuria              | 127                             | 110                    | 118                         |                                |
|               |                            |                        | 69                              | 80                     | 140                         | AVF, contrast media extravasation |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |
| M/51          | Glomerular disease         | Back pain/hematuria    | 477                             | 476                    | 476                         |                                |
|               |                            |                        | 78                              | 100                    | 132                         | AVF, contrast media extravasation |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |
| F/49          | ANCA-associated vasculitis | Hematuria              | 466                             | 466                    | 456                         |                                |
|               |                            |                        | 64                              | 61                     | 89                          | AVF, contrast media extravasation |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |
| M/43          | Glomerular disease         | Hematuria              | 322                             | 321                    | 333                         |                                |
|               |                            |                        | 90                              | 110                    | 120                         | AVF, pseudoaneurysm            |
|               |                            |                        | Microcoil                        |                        |                             |                                |
| F/22          | Lupus nephritis            | Hematuria              | 435                             | 435                    | 438                         |                                |
|               |                            |                        | 55                              | 80                     | 90                          | Contrast media extravasation   |
|               |                            |                        | Microcoil                        |                        |                             |                                |
| M/72          | Glomerular disease         | Hematuria/shock        | 274                             | 263                    | 271                         |                                |
|               |                            |                        | 49                              | 78                     | 89                          | AVF, contrast media extravasation |
|               |                            |                        | Microcoil                        |                        |                             |                                |
| F/43          | Type II diabetes           | Hematuria              | 728                             | 723                    | 710                         |                                |
|               |                            |                        | 67                              | 78                     | 107                         | Arteriovenous fistula          |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |
| M/42          | Glomerular disease         | Back pain/hematuria    | 322                             | 321                    | 355                         |                                |
|               |                            |                        | 80                              | 100                    | 106                         | Pseudoaneurysm                 |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |
| F/37          | ANCA-associated vasculitis | Back pain/hematuria    | 222                             | 240                    | 240                         |                                |
|               |                            |                        | 70                              | 90                     | 110                         | AVF, pseudoaneurysm            |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |
| M/37          | Hypertensive nephropathy   | Hematuria              | 433                             | 444                    | 442                         |                                |
|               |                            |                        | 84                              | 100                    | 110                         | Contrast media extravasation   |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |
| F/17          | ANCA-associated vasculitis | Back pain/hematuria    | 121                             | 122                    | 100                         |                                |
|               |                            |                        | 55                              | 87                     | 100                         | Pseudoaneurysm                 |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |
| M/38          | Glomerular disease         | Back pain/hematuria    | 588                             | 589                    | 587                         |                                |
|               |                            |                        | 72                              | 100                    | 120                         | Pseudoaneurysm                 |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |
| M/45          | Glomerular disease         | Back pain/hematuria    | 328                             | 340                    | 320                         |                                |
|               |                            |                        | 64                              | 89                     | 118                         | Arteriovenous fistula          |
|               |                            |                        | Microcoil, gelatin sponge       |                        |                             |                                |

(continued)
| Sex/age (years) | Pathological type | Symptom | Serum creatinine value (μmol/L) | Hemoglobin value (g/L) | Angiographic manifestation | Embolic agent |
|----------------|------------------|---------|---------------------------------|------------------------|---------------------------|---------------|
|                |                  |         | Day 0   | Day 1   | Day 7   | Day 0   | Day 1   | Day 7   |                                      |               |
| F/45           | ANCA-associated vasculitis | Back pain/hematuria | 432     | 433     | 422     | 78      | 76      | 109     | Pseudoaneurysm | Microcoil     |
| M/64           | Type II diabetes  | Hematuria | 333     | 322     | 328     | 54      | 87      | 129     | Contrast media extravasation | Microcoil     |
| F/22           | Glomerular disease | Back pain/hematuria | 476     | 480     | 472     | 92      | 121     | 125     | Contrast media extravasation | Microcoil, gelatin sponge |
| F/31           | ANCA-associated vasculitis | Back pain/hematuria | 667     | 664     | 663     | 62      | 90      | 109     | Arteriovenous fistula | Microcoil |
| M/63           | Type II diabetes  | Back pain/hematuria | 432     | 410     | 422     | 62      | 79      | 134     | AVF, contrast media extravasation | Microcoil, gelatin sponge |
| M/52           | Glomerular disease | Back pain/hematuria | 226     | 243     | 225     | 76      | 99      | 124     | Contrast media extravasation | Microcoil, gelatin sponge |
| F/43           | Lupus nephritis   | Hematuria | 346     | 376     | 352     | 87      | 101     | 119     | Contrast media extravasation | Microcoil, gelatin sponge |
| F/42           | Lupus nephritis   | Back pain/hematuria | 656     | 631     | 649     | 67      | 98      | 103     | Pseudoaneurysm | Microcoil |
| F/42           | ANCA-associated vasculitis | Hematuria | 555     | 555     | 547     | 73      | 100     | 142     | Contrast media extravasation | Microcoil |
| M/57           | Glomerular disease | Back pain/hematuria | 341     | 329     | 339     | 68      | 89      | 104     | Contrast media extravasation | Microcoil |
| M/64           | Hypertensive nephropathy | Back pain/hematuria | 145     | 130     | 147     | 76      | 87      | 126     | Contrast media extravasation | Microcoil, gelatin sponge |
| F/43           | Lupus nephritis   | Back pain/hematuria | 511     | 521     | 520     | 64      | 79      | 118     | AVF, pseudoaneurysm | Microcoil |
| F/51           | Type II diabetes  | Back pain/hematuria | 280     | 276     | 282     | 99      | 120     | 122     | Contrast media extravasation | Microcoil, gelatin sponge |
| M/54           | Glomerular disease | Back pain/hematuria | 222     | 229     | 230     | 68      | 90      | 99      | Pseudoaneurysm | Microcoil |
| M/63           | Hypertensive nephropathy | Back pain/hematuria | 444     | 432     | 440     | 81      | 90      | 107     | AVF, pseudoaneurysm | Microcoil |
| F/38           | Hypertensive nephropathy | Back pain/hematuria | 365     | 380     | 363     | 101     | 112     | 130     | Contrast media extravasation | Microcoil, gelatin sponge |
| F/22           | Glomerular disease | Back pain/hematuria | 654     | 666     | 653     | 57      | 90      | 129     | Contrast media extravasation | Microcoil, gelatin sponge |
| F/18           | Lupus nephritis   | Back pain/hematuria | 333     | 321     | 329     | 55      | 78      | 119     | Contrast media extravasation | Microcoil, gelatin sponge |
| M/31           | Glomerular disease | Back pain/hematuria | 213     | 252     | 217     | 70      | 100     | 126     | Arteriovenous fistula | Microcoil |
| F/22           | ANCA-associated vasculitis | Back pain/hematuria | 200     | 210     | 200     | 83      | 100     | 110     | Arteriovenous fistula | Microcoil |
| M/36           | Glomerular disease | Back pain/hematuria | 701     | 710     | 701     | 76      | 98      | 135     | AVF, contrast media extravasation | Microcoil |

M: male; F: female; ANCA: antineutrophil cytoplasmic antibody.
A gelatin sponge was used as supplementary embolization for arteries that could be superselected from normal renal arteries. The endpoint of embolization was total obliteration of the target vessel. After treatment, posterior-anterior and oblique angiography was performed again for evaluating the homeostatic effects.

Follow-up procedure

After the interventional procedure, all of the patients entered a follow-up program with continuous monitoring of vital signs for 24 hours. Relief of symptoms was recorded, and hemoglobin and serum creatinine levels were measured on days 1 and 7 after embolization therapy.

Statistical analysis

The paired t-test was used to analyze differences in mean creatinine and hemoglobin values before and after embolization. Statistical analysis was performed using SPSS version 20 (IBM, Chicago, IL, USA).

Results

We studied 22 men and 21 women (mean age: 44.5 ± 14.0 years, age range: 17–72 years). In the 43 patients, 52 branches of the renal artery were found to have an abnormal appearance. Angiography clearly showed typical signs related to bleeding complications. These findings included a pseudoaneurysm in 10 cases arteriovenous fistula in eight cases, extravasation of contrast media in 16 cases, arteriovenous fistula combined with contrast media extravasation in five cases, and pseudoaneurysm combined with arteriovenous fistula in four cases (Figure 2). Embolic material was a microcoil alone or a microcoil followed by a gelatin sponge (Table 1). Successful embolization was achieved in 42 patients by one therapy session and one patient required two therapy sessions. The patient who required two times of embolization was diagnosed with ANCA-associated vasculitis. In 29 patients with severe back pain, symptoms gradually improved 2 to 5 days after embolization. All cases of hematuria disappeared from 2 to 7 days after the operation. One patient with hypovolemic shock recovered immediately with steady vital signs after the embolization treatment. Thirty-one patients with original impaired renal function underwent hemodialysis after the operation.

In two patients, there were no abnormalities related to the renal artery. The bleeding site was finally confirmed to be a branch of

Figure 1. Computed tomography scan shows a perirenal hematoma after percutaneous renal biopsy.
the lumbar artery and iliolumbar artery by angiography for the lumbar artery (Figure 3). These patients were successfully treated by intra-arterial embolization.

Mean serum creatinine levels were 397.8 μmol/L before embolization (median: 389.0, range: 121.0–728.0, standard deviation: 163.7 μmol/L, 95% confidence interval: 347.4–448.1), 398.5 μmol/L 1 day after embolization (median: 380.0, range: 110.0–723.0, standard deviation: 162.4 μmol/L, 95% confidence interval: 348.5–448.5), and 395.6 μmol/L 1 week after embolization (median: 375.0, range: 100.0–721.0, standard deviation: 162.7 μmol/L, 95% confidence interval: 345.6–445.7). Mean creatinine values 1 day and 1 week after embolization were not significantly different compared with before embolization (95% confidence interval: −4.9–3.4 and −0.92–5.2, respectively) (Figure 4a).

Mean hemoglobin values were 72.2 g/L before embolization (median: 70.0, range: 49.0–101.0, standard deviation: 12.6 g/L, 95% confidence interval: 68.3–76.1), 93.4 g/L 1 day after embolization (median: 90.0, range: 61.0–121, standard deviation: 12.5 g/L, 95% confidence interval: 89.5–97.2), and 118.7 g/L 1 week after embolization (median: 120.0, range: 89.0–142.0,
Figure 3. Hemorrhage of the lumbar artery.

Figure 4. (a) Differences in mean creatinine values before and 1 day and 1 week after embolization ($P = 0.677$: day 1 versus day 0; $P = 0.369$: day 7 versus day 0). (b) Differences in mean hemoglobin values before and 1 day and 1 week after embolization ($P < 0.001$: day 1 vs day 0 and day 7 versus day 0). Day 0: the day before embolization; day 1: 1 day after embolization; day 7: 1 week after embolization.
standard deviation: 14.1 g/L, 95% confidence interval: 114.4–123.0). Mean hemoglobin values were significantly higher at 1 day and 1 week after embolization compared with before embolization (P < 0.001, 95% confidence interval: –23.8 to –18.5; P < 0.001, 95% confidence interval: –51.5 to –41.5, respectively) (Figure 4b).

Discussion

Some studies on post-biopsy bleeding complications that used real-time ultrasound guidance and focused on complications showed that the incidence of complications was 7.5% to 58.6%.8–10 In our center, only severe bleeding complications needed to be treated by embolization. The definition of a complication in our center is a large hematoma, decreased blood pressure, and extended hospitalization, similar to other studies.1,2

Because of considerable loss of parenchyma, surgical approaches are no longer the first choice in most circumstances of renal vascular injury.11 Otherwise, there is no need for general anesthesia in interventional therapy. Interventional treatment can locate abnormal blood vessels in a timely manner and achieve occlusion without losing normal renal parenchyma. Therefore, interventional therapy has become the first choice for treatment of iatrogenic renal vascular injury.12–15

Angiographic manifestations of renal vascular injury include pseudoaneurysm, renal arteriovenous fistula, and contrast media extravasation.13 All of these manifestations were found in our study. There were no abnormalities related to the renal artery in one patient. The bleeding site was finally confirmed to be a branch of the lumbar artery and iliolumbar artery in this patient. To the best of our knowledge, lumbar or iliolumbar artery hemorrhage rarely occurs after renal biopsy. Only a few reports have described a similar phenomenon of lumbar artery or iliolumbar artery hemorrhage.16,17

Materials that are used in renal artery embolism, such as microcoils, polyvinyl alcohol (PVA) particles, a gelatin sponge, and tissue glue, are widely recognized, and can be selected according to the type of disease and personal habits. The microcoil is suitable for different diameters of arteries. The cages on the coils are easy to induce thrombosis and achieve complete embolism. Studies have shown that use of coil embolization has little effect on renal function.18 Gelatin sponge particles are large and embolized arteries can be recanalized, and thus this method is relatively safe. Therefore, gelatin sponge particles can be used as a supplementary embolization after coil embolism. PVA particles are small in diameter and are a permanent embolic material. PVA particles should not be used for a separate embolism to prevent them from entering a larger arteriovenous fistula directly.19 Our experience in treating renal artery embolization suggests the following: (1) angiography should be comprehensive and the lumbar or iliolumbar artery should not be neglected if necessary; (2) to define the site of bleeding, multi-angle angiography should be performed; (3) preservation of normal renal parenchyma is important; (4) the dosage of contrast medium should be reduced during the operation to prevent deterioration of renal function.

In our study, successful embolization was achieved in all patients, but one patient experienced two times of embolization. The pathological diagnosis of this patient was ANCA-associated vasculitis. Contrast agent extravasation sign was found in the lower pole of the right kidney in the first angiography. We used a microcoil and gelatin sponge to embolize the target artery and no bleeding signs were observed. The patient developed signs of decreased blood pressure and hemoglobin on the
second day. We performed a second angiography and found contrast agent extravasation sign in another artery. We used a microcoil and gelatin sponge to embolize the target artery again. The patient’s blood pressure was stable after the operation and the hemoglobin level was improved. The patient did not experience re-bleeding. We considered that the body’s self-protection mechanism led to renal artery contraction during bleeding. When the first angiography was performed, vascular damage of one artery was smaller than that in the other arteries and the renal artery was contracted. Therefore, there was no sign of bleeding. After the first angiography, a larger area of vascular damage was blocked. Therefore, blood pressure was increased and the mechanism of vasoconstriction weakened. Signs of bleeding occurred in vascular damage of the smaller artery (Figure 5).

Some studies have reported renal function after renal embolization. Loffroy et al.\textsuperscript{6} documented a stable glomerular

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{image}
\caption{(a) A computed tomography scan shows a hematoma. (b) The hematoma fills the posterior renal space. (c) Contrast media extravasation in the first angiography. (d) Renal angiography after the first embolization. (e) Contrast media extravasation in the second angiography. (f) Renal angiography after the second embolization.}
\end{figure}
filtration rate in six patients after embolization and improvement in four patients. Maleux et al.\textsuperscript{20} studied 13 patients with vascular lesions in renal allografts and found that renal function improved in nine patients. In our study, 31 patients (serum creatinine level $>300$ $\mu$mol/L) underwent hemodialysis after the operation because of poor renal function. Serum creatinine levels were not significantly altered before and after embolization. Because our patients had poor initial renal function, we considered that stable renal function was a good result. The patients’ hemoglobin values were significantly increased 1 day and 1 week after embolization compared with before embolization. This finding indicated that embolization was safe and effective.

The incidence of complications of renal artery embolization is relatively low. Complications include post-embolization syndrome, infection, and renal dysfunction.\textsuperscript{21} Post-embolization syndrome is characterized by fever and low back pain. After symptomatic treatment, this condition can be improved without special treatment. Patients with a risk of infection should be provided antibiotic prophylaxis after the operation. Patients with poor renal function should be provided hemodialysis after the operation. In our study, there were no obvious complications in any of the patients and 31 patients with poor renal function received hemodialysis.

**Conclusion**

This study shows that superselective renal artery embolization is a safe and effective treatment for post-biopsy bleeding complications. This technique offers maximal preservation of the renal parenchyma and protection of renal function. Other arteries should not be neglected if renal arteriography shows no signs of hemorrhage.

**Declaration of conflicting interest**

The authors declare that there is no conflict of interest.

**Funding**

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

**ORCID iD**

Wang Jian  \[http://orcid.org/0000-0002-7653-9577\]

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