



## Superselective transcatheter arterial embolization to control renal hemorrhage after partial nephrectomy for renal tumors: A report of 9 cases and a literature review

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### ABSTRACT

**Objective:** This study aimed to evaluate the efficacy and safety of selective arterial embolization for hemorrhage after renal surgery and to summarize the clinical experience.

**Materials and methods:** A total of 9 patients underwent arterial embolization after partial nephrectomy from 2010 to 2018.

**Results:** Technical success was achieved in all patients; however, 3 patients underwent a secondary arterial embolization because of short-term re-hemorrhage or the co-occurrence of accessory renal arterial hemorrhage. No serious complications occurred during the follow-up.

**Conclusions:** Superselective arterial embolization is an effective and minimally invasive treatment for hemorrhage after partial nephrectomy. To improve the success rate of surgery, attention should be paid to the evaluation of accessory renal arteries and the management of suspected bleeding arteries.

### Background

Renal tumors are common tumors of the urinary system with high morbidity and mortality rates. Currently, surgical excision is the primary treatment for these tumors. Initially, radical nephrectomy combined with renal replacement therapy was the standard surgical therapy for renal tumors. With increased understanding of the intrinsic nature of the tumors and refinement of surgical skills, the application of partial nephrectomy (PN) has been gradually increasing. At present, PN has become the standard of care as a nephron-sparing surgery for isolated renal tumors ( $\leq 4$  cm)<sup>1</sup> and is also the treatment of choice in selected cases of tumors  $> 4$  cm.<sup>2</sup> Compared with radical nephrectomy, PN could preserve the renal function to the greatest extent while maintaining almost the same oncologic prognosis, thus reducing the risk of chronic renal failure.<sup>3</sup> In addition, because of its minimally invasive nature, laparoscopic or robot-assisted laparoscopic PN could improve the outcomes of some cases and its accepted indications have been expanded.<sup>4,5</sup>

However, the operative procedure of PN remains challenging. The postoperative complications have increased, including urethral fistula, bleeding, and infection.<sup>6</sup> Although postoperative bleeding is not the most

common complication, it is a potentially serious and emergent event that may cause hemorrhagic shock and threaten the lives of patients. Clinical data show that the incidence hemorrhage after laparoscopic PN is 4–7.5%,<sup>4,6–8</sup> which is higher than that after open PN (1.4–3.7%).<sup>4,6</sup> In recent years, the trend of increasing application of laparoscopic PN and the increased discovery of asymptomatic renal tumors have led to a relatively higher incidence of hemorrhage after surgery, which is challenging in the clinical setting.

Since 1973, renal artery embolization (RAE) has been used in the treatment of clinical issues related to renal tumors, including preoperative occlusion of blood supply to avoid intraoperative bleeding and salvage therapy of metastatic tumors.<sup>9</sup> The use of superselective RAE to control hemorrhage after renal surgery was first reported in 1977,<sup>10</sup> and this procedure has been proven to be minimally invasive and effective in managing bleeding complications.<sup>11,12</sup> In the clinical setting, coils or microcoils have been the most commonly used embolic materials. The overall success rate of embolization is about 90%.<sup>13</sup> However, there are relatively few reports about embolization after PN as a nephron-sparing surgery for the treatment of renal tumors, and there is no systematic summary and analysis of failed cases. In this study, we aimed to

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retrospectively analyze the efficacy and safety of superselective RAE after PN in patients with renal tumors, summarize the existing literature, and analyze the causes of failure, in order to provide guidance for clinical practice.

## Patients and methods

### Patients

This study retrospectively reviewed cases of emergency RAE performed for the treatment of hemorrhage after PN for a renal tumor. The institutional ethical committee of Sun Yat-sen University Cancer Center approved this study. The clinical characteristics and images of patients were collected, including age, sex, number and size of tumors, clinical manifestations, blood pressure and heart rate, hemoglobin level, angiography findings, operative notes, complications, renal function, and prognosis. All patients underwent conservative treatment immediately after the diagnosis of hemorrhage, including hemostasis, anti-shock therapy, and symptomatic treatment. Accordingly, RAE was performed under digital subtraction angiographic guidance as soon as possible.

### Methods

All intravascular interventions were performed by interventional radiologists with >5 years of clinical experience in the department of minimal invasive intervention. A 5-F catheter sheath was placed into the right femoral artery as an introducer using the Seldinger technique. First, we performed renal arteriography on the operative side after catheterization (cobra catheter and Rosch hepatic catheter) in order to reveal the vascular lesions (contrast flow rate, 5 mL/s × 3 s). A microcatheter (Progreat [Terumo, Tokyo, Japan] and Renegade [Boston Scientific, Natick, MA, USA]) were used for super-selective catheterization of the problematic renal artery. Thereafter, the pathological arteries were embolized using coils or microcoils (Tornado; Cook Medical Technologies, Bloomington, IN, USA). The size and number of coils or microcoils used were determined by the diameter and number of problematic arteries. We additionally used other embolic agents, including gelatin sponge, Lipiodol, and polyvinyl alcohol particles, according to the specific situation. Postembolization angiography was performed to estimate the efficacy of the surgery. The technical success of embolization was defined as the absence of flow in the target artery during angiography. The clinical success of embolization was defined as stable vital signs and termination of clinical bleeding with disappearance of symptoms within 1 week.

**Table 1**  
Characteristics of 9 patients who underwent renal artery embolization after hemorrhage.

| Patient number | Sex    | Age (years) | Tumor     |                          | Pathology       | Surgery for renal tumor | TOE (days) | Interventional therapy  |                          | Clinical Success | Follow-up (months) |
|----------------|--------|-------------|-----------|--------------------------|-----------------|-------------------------|------------|-------------------------|--------------------------|------------------|--------------------|
|                |        |             | Size (mm) | Location                 |                 |                         |            | Angiography             | Embolization             |                  |                    |
| 1              | Female | 42          | 28        | Mesorenal                | RCCC            | OPN                     | 6          | RAP                     | Coil, Lipiodol, PVA      | Yes              | 96                 |
| 2              | Male   | 40          | 50        | Lower pole               | Renal hamartoma | OPN                     | 1          | Hemorrhage              | Gelfoam                  | Yes              | 85                 |
| 3              | Female | 42          | 30        | Mesorenal                | CRCC            | OPN                     | 5          | Hemorrhage (suspicious) | Microcoil                | Yes              | 84                 |
| 4              | Male   | 71          | 30        | Lower pole               | RCCC            | OPN                     | 15         | RAP                     | Microcoil, coil          | Yes              | 82                 |
| 5              | Male   | 26          | 83        | Mesorenal                | Renal hamartoma | OPN                     | 30         | Hemorrhage, RAVF        | Microcoil, Gelfoam       | No               | 68                 |
| 6              | Male   | 43          | 42        | Lower pole               | RCCC            | LPN                     | 8          | Hemorrhage              | Microcoil                | Yes              | 37                 |
| 7              | Female | 34          | 39        | Lower pole               | RCCC            | LPN                     | 1          | Hemorrhage, RAP         | Microcoil, coil, Gelfoam | No               | 35                 |
| 8              | Female | 44          | 30        | Mesorenal                | RCCC            | LPN                     | 11         | RAP, RAVF               | Microcoil, Coil, Gelfoam | Yes              | 8                  |
| 9              | Male   | 76          | 40        | Mesorenal and lower pole | RCCC            | RLPN                    | 1          | RAP                     | Microcoil, Gelfoam       | No               | 6                  |

RCCC = renal clear cell carcinoma, LPN = laparoscopic partial nephrectomy, OPN = open partial nephrectomy, RLPN = robot-assisted laparoscopic partial nephrectomy, RAP = renal arterial pseudoaneurysm, RAVF = renal arteriovenous fistula, TOE = time to embolization (days), PVA = polyvinyl alcohol.

## Results

### Patient characteristics

From June 2010 to March 2018, a total of 9 patients with renal hemorrhage after PN were treated with RAE. Table 1 shows the clinical characteristics of the patients. The size of the renal tumor ranged from 2.8 to 8.3 cm. For the treatment of the renal tumor, 5 patients underwent open PN, 3 patients underwent laparoscopic PN, and 1 patient underwent robotic-assisted laparoscopic PN. The intraoperative blood loss of all patients was about 50–400 mL, and the vascular occlusion time was 6.5–32 min. Three patients manifested immediate bleeding after surgery, whereas 6 patients had delayed bleeding after surgery. Most patients with hemorrhage presented with hematuria, other symptoms including abdominal bloating and pain, fever, and bleeding from a drain or surgical wound. All patients had signs of hypotension and tachycardia. The hemoglobin level was 73–111 g/L, with a mean value of 90.6 g/L. All patients underwent conservative treatment upon diagnosis and were immediately transferred to the department of minimal invasive intervention for RAE therapy.

### Renal artery radiography and embolization

During renal arteriography, extravasation of contrast from columnar or segmental arteries was seen in 4 patients, among whom 3 patients had multiple lesions (up to 3 lesions in a single case). Besides, arteriovenous fistula and pseudoaneurysm were identified 2 in cases and 5 case, respectively, as shown in Table 1. There was no specific contrast leakage seen in the 1 patient, with identification of a suspicious lesion in the segmental artery.

Technical success of surgery was achieved in all patients, as confirmed by completion renal arteriography. After embolization, the target arteries were completely obstructed with no signs of contrast extravasation, pseudoaneurysm, and arteriovenous fistula (Fig. 1).

The right renal arteriogram of patient 5 showed contrast extravasation in the lower segmental artery, and 2 fiber-coated microcoils (3 mm × 3 cm) were used to completely occlude the blood flow in the injured artery. However, the patient developed recurrent hematuria 7 days after embolization. The second renal arteriography showed arteriovenous fistula on the upper pole of the right kidney. Two microcoils (3 mm × 3 cm) and additional gelatin sponges were deployed.

Patient 7 experienced bleeding in a branch of the posterior segmental artery in the left kidney. After embolization with 2 microcoils (3 mm × 3 cm), no contrast leakage was observed. However, the patient's



**Fig. 1.** (A) Right renal arteriogram showing the formation of an arteriovenous fistula and a pseudoaneurysm in the lower anterior segmental artery and upper anterior segmental artery. (B) Two microcoils (3 mm × 3 cm) and two coils (5 mm × 5 cm) were used to completely occlude the blood flow in the injured artery.

blood pressure was still 60–70/40 mmHg at 1 h after the operation and did not recover after sufficient intravenous fluid replacement. We performed renal arteriography again. Global aortography with a multiple-hole pigtail catheter revealed bleeding of an accessory renal artery, and 6 coils (5 mm × 5 cm) combined with gelatin sponge were applied for embolization (Fig. 2).

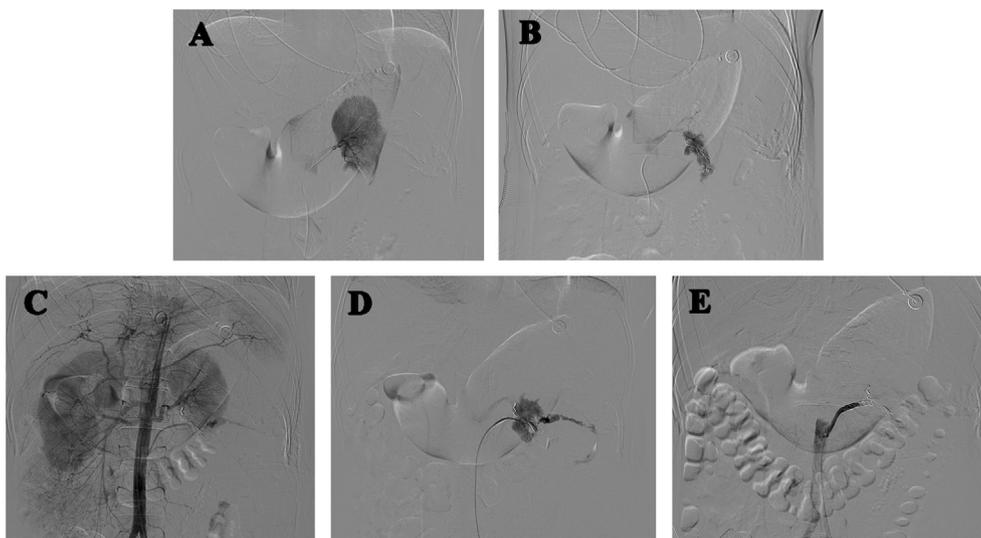
Left renal arteriography identified bleeding in the left anterior segment of the renal artery. Contrast leakage disappeared after embolization with 2 microcoils (2 mm × 2 cm), as shown in Fig. 3. After 25 h of embolization, the patient had hematuria again and the hemoglobin level decreased from 135 to 74 g/L. Considering the presence of recurrent active hemorrhage, we performed renal artery embolization again. Left renal arteriography showed vasospasm, ectasia, and contrast extravasation in multiple branches of the posterior segmental artery and upper anterior segmental artery. After selective catheterization to each injured artery, 8 microcoils (2 mm × 2 cm [6 microcoils], 3 mm × 3 cm [2 microcoils]) and gelatin sponge were deployed through the microcatheter. No lesion was observed during postoperative arteriopathy (Fig. 3). The hemoglobin level was stable after surgery; however, the patient developed acute heart and kidney failure owing to insufficient blood volume and was transferred to the intensive care unit for further therapy. The patient recovered and was discharged after 1 week.

#### Prognosis/outcome

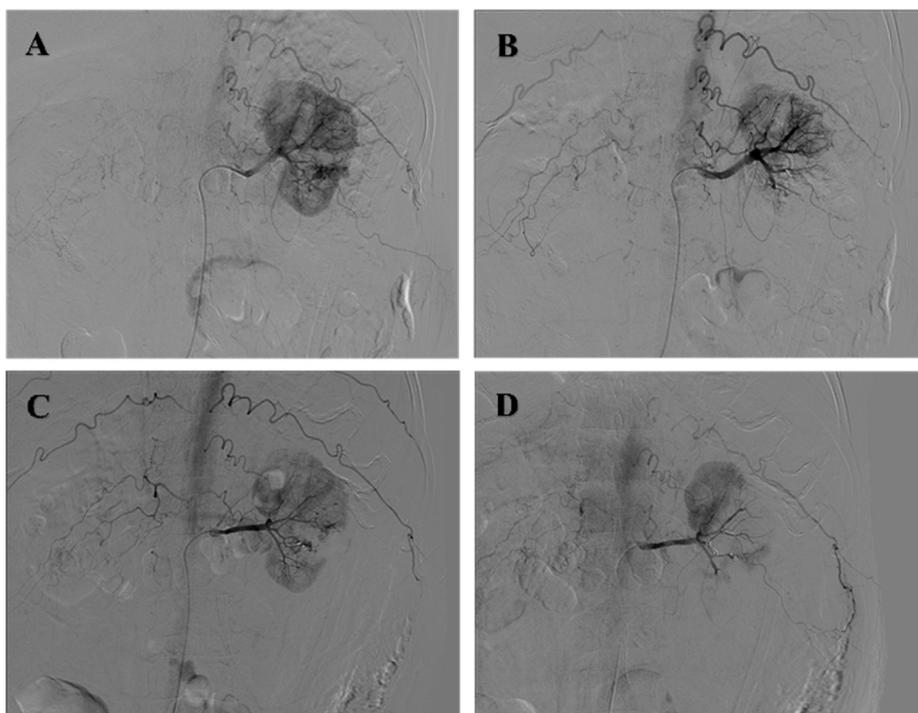
Clinical success was achieved in 6 patients, and no patient complained of hematuria, abdominal pain, fever, and other symptoms after the surgery, with hemoglobin recovering to normal levels. Patients 5 and 9 presented with bleeding 7 days and 25 h after embolization, respectively, and underwent a repeated course of RAE. Patient 7 had accessory renal arterial hemorrhage at the same time, which was not revealed by the first arteriography. Therefore, another session of RAE was required for embolization of the accessory renal artery. The postoperative hospital stay was 1–20 days with an average of 9 days. None of the patients had postembolization syndrome or surgery-associated death. The hemoglobin and serum creatinine levels of all patients gradually normalized within 1 month. The mean follow-up time was 55.7 months, without recurrence of bleeding events in any of the patients.

#### Discussion

Renal hemorrhage is a relatively rare but severe complication after PN. Mild postoperative hemorrhage may be relieved by conservative treatment; however, most patients with postoperative hemorrhage eventually require surgical intervention. All patients with renal hemorrhage after PN at our hospital underwent surgery to control bleeding. There are two types of renal hemorrhage after PN.<sup>6</sup> The first is immediate



**Figure 2.** (A, B) First renal artery embolization (RAE): contrast extravasation from the lower segmental artery was revealed by the left renal arteriogram. (C, D) Second RAE: global aortogram showed bleeding of an accessory renal artery. (E) Six coils (5 mm × 5 cm) combined with gelatin sponge were applied for embolization of the accessory renal artery.



**Fig. 3.** First renal artery embolization (RAE): contrast extravasation into the abdominal cavity from the lower anterior segmental artery was identified in the left renal arteriogram. (C) Contrast extravasation was stopped after 2 microcoils (2 mm × 2 cm) were deployed. (D) Second RAE: the left renal arteriogram showed vasospasm, ectasia, and contrast extravasation in multiple branches of the posterior segmental artery and upper anterior segmental artery. (E) Eight microcoils (2 mm × 2 cm [6 microcoils], 3 mm × 3 cm [2 microcoils]) plus gelatin sponge were used to control bleeding.

hemorrhage, which is defined as bleeding that occurs in a short time after surgery. The common reasons for immediate hemorrhage are incomplete vascular ligation, bleeding around the wound, and coagulopathy. With improvements in perioperative management and refinement of surgical skills, the occurrence of immediate bleeding after surgery has been significantly reduced. The second type is delayed hemorrhage, which often refers to bleeding that occurs 3 or more days after surgery. The main causes of delayed hemorrhage are pseudoaneurysms and arteriovenous fistulas.<sup>14,15</sup> In this study, 66.7% patients presented with delayed hemorrhage, which occurred at a mean time of 12.5 days (range 5–30 days) after surgery, consistent with previous reports.<sup>7,16,17</sup>

As in most previous studies,<sup>18–20</sup> coils or microcoils were the main embolic materials used in our study, as they can provide satisfactory occlusion of the injured arteries. Superselection of all small feeding branches is crucial during embolization. Complete occlusion must be achieved in order to control hemorrhage, while attempting to preserve the residual renal function. Further, for cases in which hemostasis could not be achieved with coils or microcoils alone, we used other embolic materials as supplements, including cyanoacrylate glue, Lipiodol, and gelatin sponge,<sup>21,22</sup> to reinforce the embolic effect. More caution should be taken when performing embolization in patients with a pseudoaneurysm or an arteriovenous fistula, especially those with large lesions. The suitable size of embolic materials should be selected on the basis of arteriography findings, to avoid displacement and ectopic arterial embolization.

In this study, the technical success rate of surgery was 100%. However, the clinical symptoms of 3 patients relapsed or were not relieved, and another session of RAE was required. The main causes of treatment failure were accessory renal artery disease and postoperative recurrent hemorrhage. An accessory renal artery is a common type of renal arterial variation,<sup>23</sup> with a morbidity of 4–61.5%. In most cases, an accessory renal artery originates from the abdominal aorta and occurs more frequently in the right kidney than in the left kidney.<sup>24</sup> Hemorrhage and pseudoaneurysm of an accessory renal artery are also important causes of renal hemorrhage after PN, trauma, biopsy, and percutaneous nephrolithotomy. Owing to limited vision during renal arteriography, the lesion in an accessory renal artery cannot be identified, resulting in failure of hemostasis in some cases.<sup>25,26</sup> Three-dimensional

reconstruction of preoperative computed tomography (CT)/magnetic resonance imaging scans or abdominal aortic angiograms can reveal the arterial variation in advance and avoid missed diagnosis. Patient 9 in this study was diagnosed with multiple hemorrhages. However, during the first RAE, only one lesion was revealed. After 25 h, the patient underwent a second session of RAE, and renal arteriography revealed damage in multiple branches, which manifested as vasospasm, aneurysmal vascular dilations, and hemorrhage. The reason for the “false-negative” result in the first arteriography may be that some injured arteries were spastic with occlusion of arterial blood flow. Other studies also reported the recurrence of hemorrhage after embolization in some cases, probably owing to incomplete embolization and bleeding in suspicious lesions.<sup>19,27</sup> We believe that, in the premise of enough residual renal function, embolization of suspected lesions could improve the success rate of RAE. The clinical symptoms of patient 3 were massive hematuria obviously, but renal arteriography did not identify specific damaged arteries. Considering the possibility of a false-negative result resulting from angiospasm, we performed superselective embolization in the branches of suspected bleeding arteries, and the patient rapidly recovered after the operation.

Pseudoaneurysm formation is one of the most important causes of hemorrhage after PN. Early identification of a pseudoaneurysm can aid in clinical decision making and may reduce the risk of emergent hemorrhage after PN. Morita et al. performed postoperative contrast-enhanced CT in patients 3–5 days after PN. In their study, about 15% of patients were diagnosed with asymptomatic pseudoaneurysm in the early stage after the operation, which was much higher than the incidence of postoperative delayed hemorrhage. Some (8%) high-risk patients with asymptomatic pseudoaneurysm underwent preventative RAE, which ultimately reduced the incidence of postoperative hemorrhage to 0.6%.<sup>28</sup> However, relevant clinical evidence is still lacking. More studies are required to determine the optimal time and patient population for postoperative contrast-enhanced CT, to identify “high-risk” patients for preventative RAE, and to evaluate the clinical value of preventative RAE.

Consistent with other studies,<sup>13,16,19,21,22</sup> our study showed that RAE is safe and effective for the treatment of hemorrhage after PN for renal tumors, with most patients reaching complete remission. None of the patients had complications after surgery. In addition, compared with

surgical treatment, RAE is more minimally invasive and may be able to retain more residual renal function, thus avoiding the risk of renal insufficiency caused by nephrectomy. However, this study was conducted retrospectively in a single center and had a small sample size. Thus, further multicenter and clinical studies are expected in the future.

## Conclusions

In conclusion, our experience has shown that superselective embolization to stanch bleeding after PN is minimally invasive and effective while preserving the residual renal function. To improve the success rate of RAE, emphasis should be placed on the evaluation of bleeding from an accessory renal artery and the management of suspected hemorrhage.

## Statement of conflict of interest

None.

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