

Emergency Transcatheter Arterial Embolization for Acute Renal Hemorrhage

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Abstract: The aims of this study were to identify arteriographic manifestations of acute renal hemorrhage and to evaluate the efficacy of emergency embolization. Emergency renal artery angiography was performed on 83 patients with acute renal hemorrhage. As soon as bleeding arteries were identified, emergency embolization was performed using gelatin sponge, polyvinyl alcohol particles, and coils. The arteriographic presentation and the effect of the treatment for acute renal hemorrhage were analyzed retrospectively. Contrast extravasation was observed in 41 patients. Renal arteriovenous fistulas were found in 12 of the 41 patients. In all, 8 other patients had a renal pseudoaneurysm, 5 had pseudoaneurysm rupture complicated by a renal arteriovenous fistula, and 1 had pseudoaneurysm rupture complicated by a renal artery-calyceal fistula. Another 16 patients had tumor vasculature seen on arteriography. Before the procedure, 35 patients underwent renal artery computed tomography angiography (CTA). Following emergency embolization, complete hemostasis was achieved in 80 patients, although persistent hematuria was present in 3 renal trauma patients and 1 patient who had undergone percutaneous nephrolithotomy (justifying surgical removal of the ipsilateral kidney in this patient). Two-year follow-up revealed an overall effective rate of 95.18 % (79/83) for emergency embolization. There were no serious complications. Emergency embolization is a safe, effective, minimally invasive treatment for renal hemorrhage. Because of the diversified arteriographic presentation of acute renal hemorrhage, proper selection of the embolic agent is a key to successful hemostasis. Preoperative renal CTA plays an important role in diagnosing and localizing the bleeding artery.

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Abbreviations: CT = Computed tomography, CTA = Computed tomography angiography, PVA = polyvinyl alcohol.

INTRODUCTION

Acute renal hemorrhage is the most common medical emergency seen in urology departments. When complicated by hemorrhagic shock, it can be life-threatening, requiring

immediate diagnosis and treatment.¹⁻³ Conservative treatment is mostly ineffective in the event of acute renal arterial bleeding, and is associated with a high recurrence rate. However, complete nephrectomy, the commonly used emergency surgery, may involve several surgical injuries and postoperative complications. With the development of interventional radiology in recent years, selective angiography and embolization have been widely used to treat acute renal bleeding disorders.⁴⁻⁶ In this study, the clinical data of patients with acute renal hemorrhage due to varying causes were analyzed retrospectively to evaluate the performance of emergency renal arteriography and the efficacy of embolization for treating this condition.

MATERIALS AND METHODS

Data were collected from 83 patients who underwent emergency transcatheter arterial embolization for acute renal hemorrhage after failure of nonsurgical treatment and confirmation of intolerance to surgery in our hospital from January 2006 to February 2011. The data were obtained from the database of the Department of Interventional Radiology, Second Affiliated Hospital of Harbin Medical University, Harbin, China. The patient cohort included 53 men and 30 women aged 14 to 70 years (median 43 years). The local ethics committee approved this retrospective study. Informed consent was obtained from each subject.

Acute renal hemorrhage was defined as persistent gross hematuria for ≥ 72 hours; decreased hemoglobin, red blood cell count, and hematocrit below their normal ranges for routine blood testing; and the presence of significantly increased red blood cells during routine urine testing. The main clinical manifestations of acute renal hemorrhage include gross hematuria, abdominal or lower back pain, and hypovolemic shock symptoms when massive blood loss occurs. All of our patients underwent routine blood and kidney function testing, routine urine testing, and renal computed tomography (CT) scanning before embolization. A total of 35 patients underwent renal arterial computed tomography angiography (CTA) before the procedure. The attending physician made the decision about whether to manage acute renal hemorrhage using emergency embolization. All patients gave signed informed consent before surgical intervention.

The devices used for digital subtraction angiography were Angiostar Plus and Artis Zee systems (Siemens, Erlangen, Germany), with 4-Fr or 5-Fr RH and Cobra catheters (Cook, Bloomington, IN), 5-Fr PIG catheter (Codis, Japan), and 2.7-Fr microcatheters (Terumo, Tokyo, Japan). The contrast agent was Visipaque (GE Healthcare, Cork, Ireland). Embolic agents included gelatin sponge (Kaikang, Guangzhou, China), coils (Cook), and polyvinyl alcohol (PVA) particles (Cook). There were 3 types of coil (MWCE35-3-3, MWCE35-4-3, MWCE35-5-3) and 2 types of PVA particles (300-500 μm and 500-710 μm).

Embolization was performed using the modified Seldinger technique. Following femoral arterial puncture, the PIG catheter

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There are no conflicts of interest in this study.

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was placed at the level of the first lumbar body for angiography of the abdominal aorta. This step was performed to identify the openings of the bilateral renal arteries and the renal blood supply. It also allowed observation of any blood supply to the lesion from accessory renal arteries, lumbar arteries, or collateral vessels. Selective renal angiography of the contralateral and ipsilateral kidneys was then conducted successively with 4-Fr and 5-Fr Cobra or RH catheters to reveal the conditions of renal vessels on both sides. As soon as superselective catheterization into the target branch of the renal artery with suspicious lesions was confirmed by angiography, embolization was performed using coils, PVA particles, and/or gelatin sponge based on the corresponding angiographic presentation and cause of hemorrhage. After the operation, repeat angiography was conducted to confirm complete occlusion of the affected artery. The catheter was then removed, and the wound was wrapped and closed with a pressure dressing.

Vital signs were closely monitored after the interventional treatment so the embolization could be managed in a timely manner, if needed. The patients were followed for 2 years to identify any hemorrhage recurrence or serious complications.

RESULTS

There were 39 patients with traumatic renal hemorrhage, 28 with iatrogenic renal hemorrhage, and 16 with hemorrhage associated with renal tumors. Major angiographic presentation of acute renal hemorrhage included contrast agent extravasation, renal pseudoaneurysms, and renal tumor vessels. The classification of causes of acute renal hemorrhage and the numbers of cases with various abnormalities on renal arterial angiography are shown in Table 1.

Each of the 83 patients underwent embolization with the proper embolic agents based on the bleeding sites as confirmed by selective renal arteriography, resulting in a technical success rate of 100%. Following emergency embolization, complete hemostasis was achieved in 80 patients, although hematuria persisted in 3 renal trauma patients and 1 patient who had undergone percutaneous nephrolithotomy (justifying surgical removal of the ipsilateral kidney). In all, 35 patients underwent renal artery CTA before the surgery. The causes of renal

TABLE 2. Causes of Renal Hemorrhage and the Number of Bleeding Renal Arteries Found By Preoperative Renal CTA and Angiography*

Cause	No. of Bleeding Renal Arteries	
	Renal Artery CTA Before Surgery	Renal Artery Angiography
Closed renal contusion	12	15
Open renal contusion	6	7
After percutaneous nephrolithotomy	9	11
After renal biopsy	4	4
Renal angiomyolipoma	6	6
Renal cancer	5	5
Total	42	49

CTA = computed tomography angiography.

*Patients who did not undergo renal artery CTA before the interventional treatment are not included.

hemorrhage and the number of bleeding renal arteries found by preoperative renal CTA and angiography are shown in Table 2. The diagnostic sensitivity of preoperative renal artery CTA was 85.71% (42/49). A 2-year follow-up revealed an overall effective rate of 95.18% (79/83) for emergency embolization. There were no serious complications in any of the patients.

DISCUSSION

Acute renal hemorrhage, one of the most common clinical emergencies, can be caused by a number of factors. They include common conditions (eg, closed or open renal trauma) and iatrogenic renal vascular injuries that occurred during renal

TABLE 1. Classification of Causes of Acute Renal Hemorrhage and the Number of Cases With Different Abnormalities on Renal Arterial Angiography

Cause	Contrast Extravasation	Contrast Extravasation and Renal Arteriovenous Fistula	Pseudoaneurysm	Pseudoaneurysm Rupture and Renal Arteriovenous Fistula	Pseudoaneurysm Rupture and Renal Artery–Renal Pelvis Fistula	Tumor Blood Vessels	Total
(Trauma) closed renal injury	18	4	5	2	0	0	29
(Trauma) open renal injury	6	3	0	1	0	0	10
After percutaneous nephrolithotomy	9	2	1	2	0	0	14
After renal biopsy	6	2	2	0	1	0	11
After nephrostomy	2	1	0	0	0	0	3
Renal angiomyolipoma	0	0	0	0	0	9	9
Renal cancer	0	0	0	0	0	7	7
Total	41	12	8	5	1	16	83

biopsies, percutaneous nephrolithotomy, nephrostomy, or other procedures.^{7–10} Renal tumors, such as renal angiomyolipoma and renal cell carcinoma, are also important causes of acute renal hemorrhage. Since Bookstein and Ernst first used renal arterial embolization to manage acute renal hemorrhage in 1973,^{11,12} it has become the treatment of choice. It is a less invasive yet effective method to control bleeding while sparing the ipsilateral kidney.¹⁰

The arteriographic presentation may vary to some degree based on the cause of the acute renal hemorrhage. The embolic agent should be chosen based on the type of arteriography and the cause of acute renal hemorrhage. During interventional treatment, the selection of appropriate embolic agents for superselective embolization is the key to achieving desirable

outcomes. The embolic agents used for the present cohort included PVA particles, coils, and gelatin sponge strips.

The extravasation of contrast medium is the most common and direct sign of acute renal hemorrhage^{13–16} (Fig. 1). Based on the cause, the diameter, and the presence of an arteriovenous fistula, PVA particles or coils can be used for the embolization. They are both permanent embolic agents with proven effects. PVA particles of different diameters can be used to occlude the entire segment of a target artery. Recanalization is unlikely to occur after embolization using these agents. Coils can be applied to occlude a thick artery for quick and effective hemostasis. They are mainly used for embolization of large branches of a renal artery. For a renal pseudoaneurysm, aneurysm-like enlargement of the bleeding artery is visible on

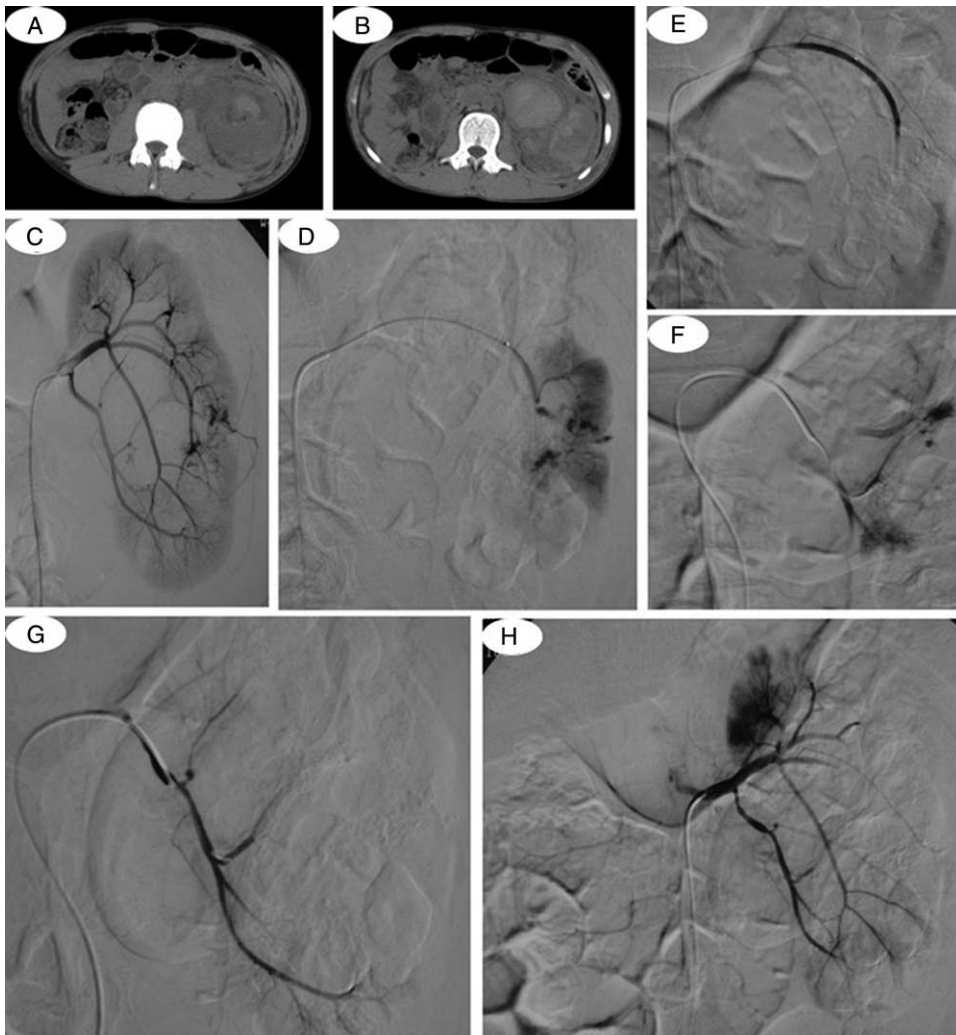


FIGURE 1. A 14-year-old boy who had undergone surgical resection of the right kidney presented with persistent hematuria after surgery for left renal trauma. (A, B) Renal CT images before embolization show that the left kidney is enlarged, the capsule is not intact, and a high-density hematoma is obvious in the renal pelvis and hilum. (C, D) Angiography with a Cobra catheter and microcatheter reveal contrast extravasation in the lower branch of the left renal artery. (E) Microcatheter angiography following polyvinyl alcohol (PVA) (300–500 μm) embolization. The previously bleeding artery is successfully occluded. (F) Contrast extravasation of the posterior branch of the left renal artery. (G) Cobra angiography following PVA embolization (300–500 μm). The previously bleeding artery has been successfully occluded. (H) Angiography with the Cobra catheter. All bleeding arteries have been completely occluded. Normal renal arteries and the renal parenchyma are visible.

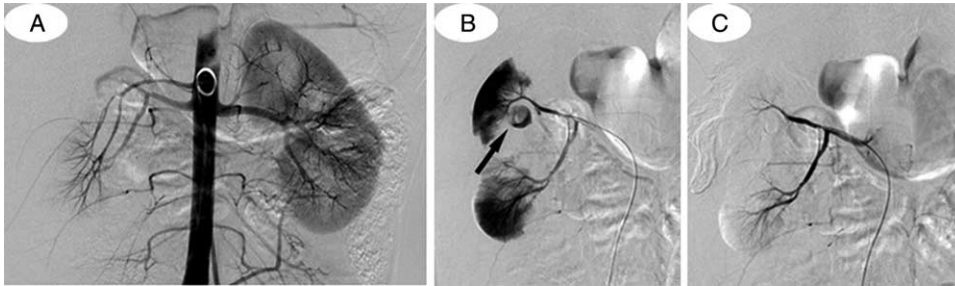


FIGURE 2. A 38-year-old man presented with persistent massive hematuria after trauma to the right kidney. (A) Angiography with the PIG catheter showed bilateral renal arteries. The left kidney appears to be normal, whereas the trunk of the right renal artery is thin, and the right renal parenchyma is unclear. (B) Microcatheter angiography reveals a pseudoaneurysm of the upper branch of the right renal artery (black arrow). (C) Polyvinyl alcohol particles (300–500 μm) angiography after embolization. The pseudoaneurysm has disappeared, and normal renal artery and renal parenchyma are visible.

angiography (Fig. 2, Fig. 3). In such cases, PVA particles and coils can be used based on the patient's medical history and the diameter of the target artery. Patients with a small renal pseudoaneurysm due to trauma should undergo embolization using PVA particles in combination with gelatin sponge strips.

Large trauma-related renal pseudoaneurysms and iatrogenic renal artery trunk hemorrhage may lead to spasm of the bleeding artery, which presents with a reduced artery diameter on angiography. Such spasm is reversible, and the artery may return to a normal diameter once the stimulus is eliminated.

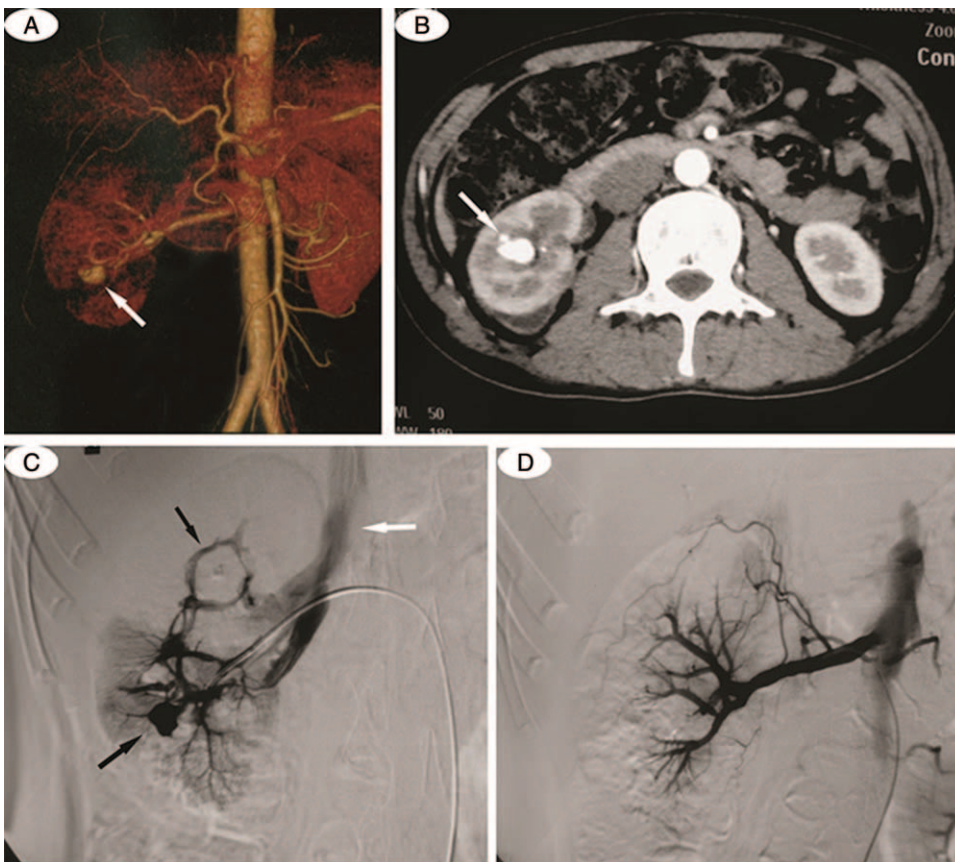


FIGURE 3. A 38-year-old man had persistent massive hematuria due to a closed contusion of the right kidney in a car accident. (A) Renal artery computed tomography angiography shows a pseudoaneurysm in the pelvis of the lower pole of the right kidney (white arrow). (B) Enhanced CT shows subcapsular effusion of the right kidney with an aneurysm-like enlargement of the right pelvis (white arrow). (C) Angiography with the Cobra catheter shows that the pseudoaneurysm in the lower pole of the right kidney is ruptured and bleeding (long black arrow), and there is contrast extravasation (short black arrow). An arteriovenous fistula has formed in the right kidney, and early opacification of the inferior vena cava is seen (white arrow). (D) Angiography with the Cobra catheter (after embolization with 2 MWCE35-3-3 coils and 1 gelatin sponge strip) shows complete occlusion of the bleeding artery. The pseudoaneurysm and renal arteriovenous fistula are not visible. The surrounding kidney tissues appear normal.

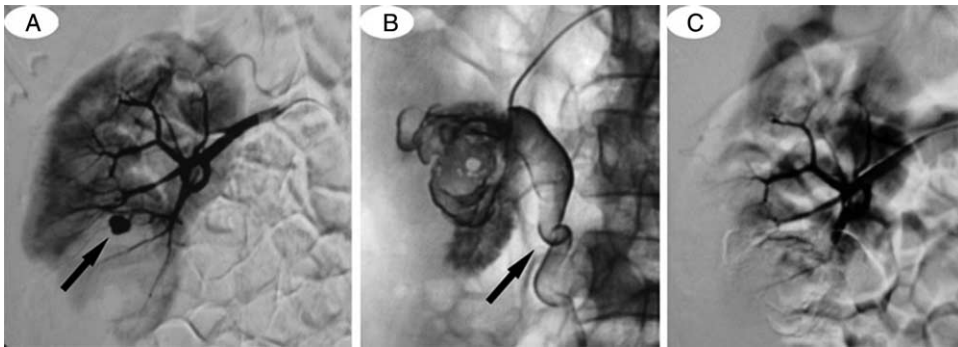


FIGURE 4. A 35-year-old woman presented with sustained hematuria after a right kidney biopsy. (A) Cobra angiography shows a pseudoaneurysm of the small branch of the posterior segment of the right renal artery (black arrow). (B) Superselective angiography reveals early opacification of the right renal pelvis and the ureter (black arrow) at the arterial phase (renal artery–renal pelvis fistula). (C) Repeat polyvinyl alcohol particles (500–710 μm) angiography after embolization shows that the bleeding artery is completely occluded with no sign of contrast extravasation. The surrounding kidney tissues appear normal.

Therefore, coils combined with gelatin sponge strips comprise the preferred option for those cases to prevent potential displacement of coils when used alone and reduce the risk of recurrence.

Early opacification of the renal veins and inferior vena cava can be seen on angiography at the arterial phase in patients with an arteriovenous fistula (Fig. 3). Large PVA particles are contraindicated for patients with an obvious renal arteriovenous fistula because they may travel back to the pulmonary artery through the fistula and lead to a serious pulmonary embolism.¹¹

Although acute renal hemorrhage due to a renal artery–renal pelvis fistula is rarely reported,¹⁷ 1 patient with pseudoaneurysm rupture complicated by a renal artery–renal pelvis fistula was seen in the present cohort. Angiographically, a large amount of contrast agent was seen to have flowed into the ureter through the renal pelvis (Fig. 4). Angiography of a bleeding artery associated with renal tumors shows that the feeding artery is thickened, the vessels within the tumor area are disorganized and twisted, and the surrounding vessels are feeding the mass. The accessory renal artery often supplies the tumor (Fig. 5). Embolization with PVA alone or in combination with gelatin

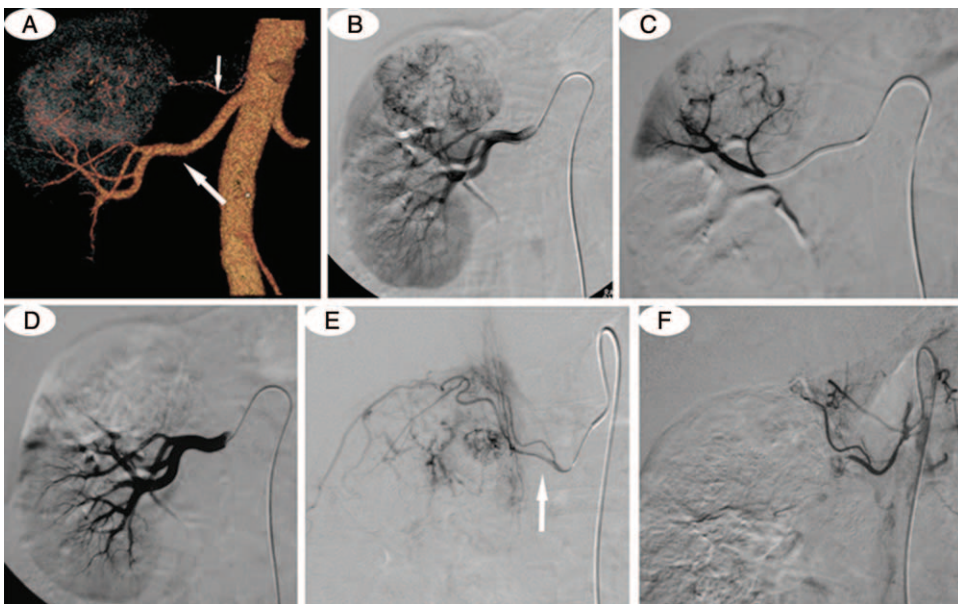


FIGURE 5. A 58-year-old man with a right renal tumor presented with persistent massive hematuria. (A) Renal artery computed tomography angiography reveals that the right renal artery (long white arrow) and the right accessory renal artery (short white arrow) are feeding the tumor. (B, C) Angiography with the Cobra catheter and microcatheter show an artery feeding the tumor in the upper pole of the right kidney. A superselective microcatheter is placed in the feeding artery for embolization. (D) Polyvinyl alcohol (PVA) particles (300–500 μm) angiography after embolization shows that the artery feeding the tumor in the upper pole of the right kidney is successfully occluded. Normal kidney tissues of the lower pole are visible. (E) Superselective microcatheter placement in the accessory renal artery (white arrow) shows the right tumor artery. (F) Microcatheter angiography following PVA particles (300–500 μm) embolization shows that the feeding artery is completely occluded. Hematuria disappeared after the surgery, and the removed tumor was pathologically confirmed as cell carcinoma of the right kidney.

sponge is recommended for managing tumor-related hemorrhage. Using the coaxial technique, a bolus injection of PVA particles can be performed through a 2.7-Fr microcatheter to embolize the end of the target artery, which avoids occluding normal renal vessels. When combined with gelatin sponge, the trunk of the feeding artery can be completely occluded. Identification and complete embolization of all arteries feeding the tumor are top priority during emergency embolization for acute renal hemorrhage associated with renal tumors. The omission of any feeding artery may result in persistent hematuria after the procedure or even life-threatening massive hemorrhage at the time of surgical removal.^{18–20} At present, CTA is useful for explicitly revealing the anatomical locations, distribution, and presence of collateral vessels of the feeding arteries.^{21–23} Using the preoperative renal artery CTA images for guidance, clinicians may have a general understanding of the nature of the renal tumor and the feeding arteries preoperatively. Thus, rapid, targeted embolization of the corresponding sites can be performed during the interventional procedure. Renal artery CTA can also significantly reduce the time required for the operation and the amount of intraoperative bleeding, thereby protecting the patient's renal function and minimizing radiation exposure of both physician and patient. During the procedure, 7 other small bleeding arteries were identified in addition to those found by CTA. They were not detected by preoperative renal artery CTA because of the significantly decreased quantity and pressure of contrast medium entering the small arteries compared with those during superselective angiography, which made it difficult for reconstruction using the postprocessing software. This is an issue with the current CTA technique that needs to be solved. Therefore, for patients with acute renal hemorrhage, interventional surgeons should make sure to identify any potential bleeding artery without relying solely on the CTA findings. A careful search can avoid incomplete hemostasis and other consequences due to an undiscovered lesion.

The persistent hematuria in 3 patients with severe renal trauma and the patient who underwent percutaneous nephrolithotomy may be explained by temporary occlusion of some bleeding arteries during the angiography, making them undetectable and untreatable via embolization. The 4 patients unresponsive to embolization therapy underwent surgical removal of the affected kidney after consultation with urologists and with the patients' consent.

Special attention should be given to the six aspects during emergency treatment of renal hemorrhage. First, emergency embolization should be performed as soon as the diagnosis is confirmed, with priority given to hemostasis, correction of hemorrhagic shock, and saving the patient's life. Second, in view of the variations of renal arteries, multiple feeding arteries may exist. Thus, whenever possible, renal artery CTA should be performed before the procedure to identify the nature of the lesions and the number and location of the bleeding arteries. Angiography of the abdominal aorta should be performed during the interventional procedure to avoid missing any feeding vessels that may compromise the treatment effect.¹² Third, superselective embolization should be used whenever applicable to occlude completely all bleeding vessels and preserve as much renal function as possible. Fourth, nonionic isotonic contrast agents (eg, Visipaque) should be used to reduce the amount of contrast medium, thereby reducing the related kidney damage. Fifth, embolic agents of the proper size should be used to avoid excessive or incomplete embolization. It

is not recommended that gelatin sponge be used alone as it mainly acts as a supporting agent. Sixth, for patients unresponsive to embolization, surgical removal of the ipsilateral kidney should be considered after consultation with urologists.

CONCLUSIONS

Emergency embolization is a safe, effective minimally invasive treatment for renal hemorrhage. In view of the diversified arteriographic presentation of acute renal hemorrhage, proper selection of the embolic agent and complete occlusion of all bleeding arteries are the keys to successful hemostasis. Preoperative renal CTA plays an important role in the diagnosis and localization of the bleeding artery.

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