Diagn Interv Radiol 2009; 15:143–147

INTERVENTIONAL RADIOLOGY

ORIGINAL ARTICLE

# Transarterial embolization for renal arterial bleeding

Ertuğrul Mavili, Halil Dönmez, Nevzat Özcan, Murat Sipahioğlu, Abdullah Demirtaş

PURPOSE
To evaluate the effectiveness of percutaneous transarterial embolization for the treatment of renal arterial bleeding in patients with renovascular injury.

MATERIALS AND METHODS
The archives of our angiography suite were retrospectively reviewed, and 15 patients who had undergone renal embolization due to renal artery bleeding were included in the study. The site, number, and type of bleeding lesions, and the result of the embolization procedure were recorded. The technical and medical success, and technical and medical complications of the procedure were noted.

RESULTS
On renal digital subtraction angiography (DSA) 18 lesions were detected in 15 patients. In 13 cases bleeding was effectively controlled with embolization in a single session. In one case bleeding was controlled on the second attempt. One case underwent nephrectomy. Nontarget embolization was seen in two patients, one treated with polyvinyl alcohol (PVA), the other with n-butyl cyanoacrylate (NBCA) mixture. Iatrogenic dissection of the segmental branch was seen in one patient. Puncture-site bleeding, postembolization syndrome, perirenal abscess or renal abscess, and arterial hypertension were not detected in any of the patients.

CONCLUSION
Percutaneous transarterial embolization is an effective, minimally invasive, and a tissue preserving treatment method for renovascular injuries. Therefore, endovascular embolization should be the first preferred treatment modality.

*Key words: • kidney • renal arteries • therapeutic embolization • biopsy • injuries*

From the Departments of Radiology (E.M. ✉ *ertmavili@yahoo.com*, H.D., N.Ö.), Nephrology (M.S.), and Urology (A.D.), Erciyes University School of Medicine, Kayseri, Turkey.

Received 10 June 2008; revision requested 12 November 2008; revision received 12 November 2008; accepted 15 November 2008.

Renal vascular lesions may be secondary to blunt or penetrating trauma, iatrogenic injuries during a procedure or spontaneously with or without underlying pathology (1). In most cases renal injuries are self-limiting and do not need any intervention (2). Presence of massive hemorrhage or continuous hematuria may necessitate aggressive therapy. Control of bleeding can be achieved either by open surgical procedures or minimally invasive transarterial embolization (3). Transarterial renal embolization was introduced in 1964, and since that time the devices used in interventional radiology have evolved. It is now possible to perform superselective embolization with minimal tissue loss (4).

The aim of this study was to present the radiological and clinical results in patients with renal vascular lesions treated with endovascular embolization.

## Materials and methods

The archives of our angiography suite were retrospectively reviewed to identify patients who had undergone renal embolization for renal vascular lesions between 1998 and 2007. Fifteen patients were included in the study. All patients were examined and treated as a part of routine care and gave informed consent. The symptoms of the patients at the time of embolization, and type of injury and pre- and postembolization renal function tests and delayed onset of renal insufficiency or hypertension were obtained from the medical records. Pre- and postembolization angiographic findings were reviewed and the site, number, and type of lesions, and the result of the embolization procedure were recorded.

The indications for renal digital subtraction angiography (DSA) were gross renal hemorrhage persisting for more than 72 hours and necessitating blood transfusion in 13 patients, and perirenal hemorrhage and deterioration of renal function in 2 patients.

Eleven patients underwent DSA as the first imaging modality. Four patients underwent ultrasound (US) (2 patients) or computed tomography (CT) (2 patients) as the first imaging modality. Embolization was performed when free extravasation, aneurysm, pseudoaneurysm, arteriocalyceal fistula (ACF), or arteriovenous fistula (AVF) was detected.

For the DSA procedure, the femoral artery was punctured and a 6F sheath was inserted. An abdominal aortography was obtained with a 5F omniflush or pigtail (AngioDynamics, Queensbury, New York, USA) and thereafter a selective renal DSA was performed with a 5F catheter. All catheter advances were performed over a 0.035-inch guidewire. For selective catheterization and embolization we used a 4F catheter (when the lesion was at or near a segmental branch) or a microcatheter system (when it was at a subsegmental branch). In 5 patients, embolization of the arterial lesion was feasible using a 4F catheter; while in the remaining 10 patients the distal location or the presence of vessel tortuosity necessitated the use of a coaxially placed microcatheter (Tracker, Boston Scientific, Natick, Massachusetts, USA). The catheters were inserted as near as possible to the lesion, and the embolizing agent inserted. Embolizing agents consisted VortX 18 and 35 vascular occlusion coils (Boston Scientific, Target vascular) (7 patients) (Fig. 1), polyvinyl alcohol particles (350–550 mμ) (PVA) (3 patients) (Fig. 2), a combination of coils and PVA particles (1 patient) or n-butyl cyanoacrylate (NBCA) (4 patients) (Braun, Melsungen, Germany) iodized oil (Lipiodol, Andre Guerbe Lab, France) (Figs. 3, 4) mixture. The NBCA-iodized oil mixture was prepared by hand. For rapid polymerization we choose a 66% mixture, which was obtained by mixing NBCA and iodized oil at a 1:2 ratio. For slow polymerization the mixture was obtained at a 1:4 ratio. The procedure was completed when total occlusion of the lesion and cessation of the hemorrhage on control angiogram was seen.

When the lesion was superselectively catheterized we used coils or NBCA-iodized oil mixture. When the lesion could not be superselectively catheterized, we used PVA particles or NBCA-iodized oil mixture.

The technical and medical success, and technical and medical complications of the procedure were extracted from the radiological records and patient charts. Complete cessation of renovascular bleeding after the embolization procedure was defined as technical success. Resolution of gross hematuria, absence of recurrent hematuria, no recurrent need for blood transfusion, no recurrent decrease of hemoglobin, and no need for angiographic reembolization or subsequent renal surgery were regarded as medical success. Nontarget embolization of vascular territories, iatrogenic vascular damage, and puncture-site bleeding were accepted as technical complications. Medical complications included postembolization syndrome (back pain and fever not otherwise accounted for), perirenal abscess or renal abscess, decrease in renal function, and arterial hypertension.

## Results

Table shows the distribution, type, performed intervention and results of the lesions. The lesions were secondary to iatrogenic trauma (5 biopsy, 3 operation, 4 percutaneous nephrolithotomy,

**Figure 1. a, b.** Pre- **(a)** and postembolization **(b)** DSA images of a 61-year-old woman who presented with bleeding after percutaneous nephrolithotomy. DSA revealed a pseudoaneurysm at the lower pole of left kidney **(a)**. After superselective catheterization with a microcatheter, the aneurysm *(short arrow)* and the tip of the microcatheter *(long arrow)* are seen **(a)**. A coil (*arrow,* **b)** was inserted, and on postembolization DSA, no filling of the pseudoaneurysm is seen **(b)**.

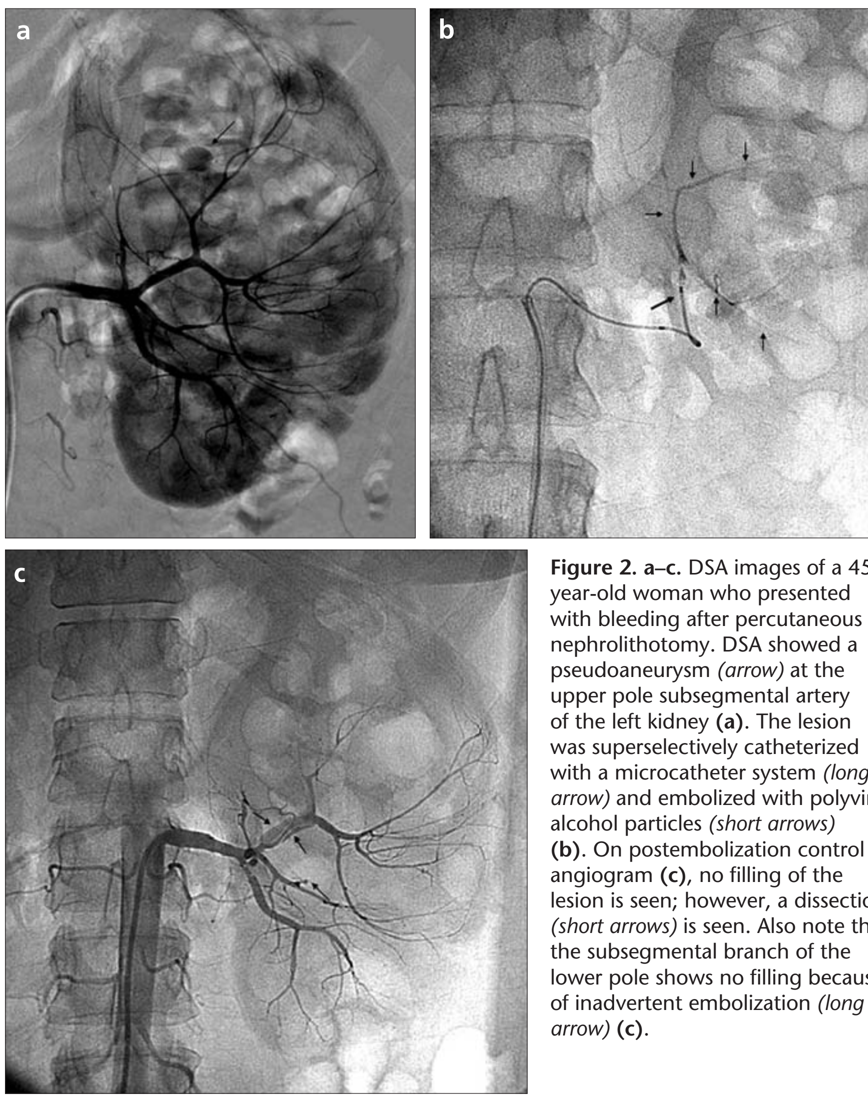

**Figure 2. a–c.** DSA images of a 45-year-old woman who presented with bleeding after percutaneous nephrolithotomy. DSA showed a pseudoaneurysm *(arrow)* at the upper pole subsegmental artery of the left kidney **(a)**. The lesion was superselectively catheterized with a microcatheter system *(long arrow)* and embolized with polyvinyl alcohol particles *(short arrows)* **(b)**. On postembolization control angiogram **(c)**, no filling of the lesion is seen; however, a dissection *(short arrows)* is seen. Also note that the subsegmental branch of the lower pole shows no filling because of inadvertent embolization *(long arrow)* **(c)**.

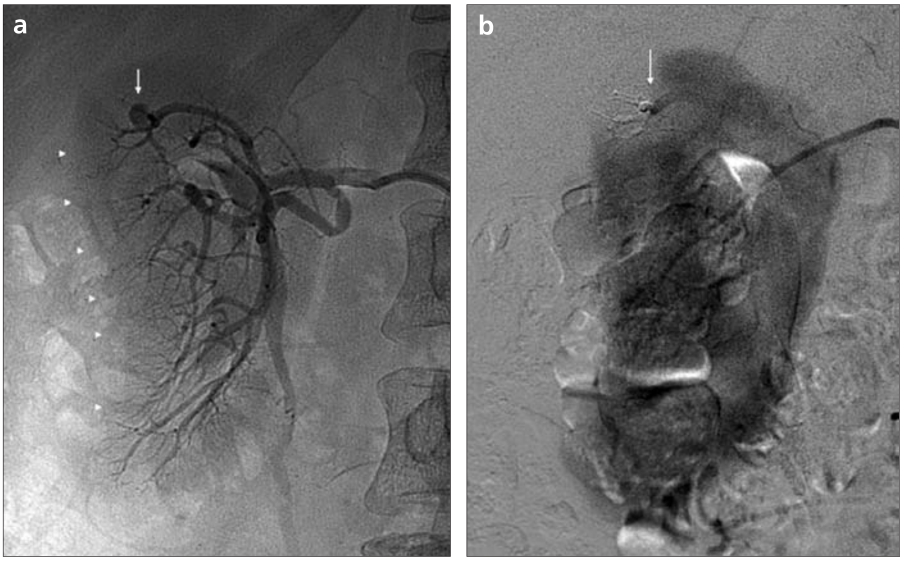

**Figure 3. a, b.** Pre- **(a)** and postembolization **(b)** DSA images of a 48-year-old man who presented with hypertension and deterioration of renal function. An aneurysm *(arrow)* at the upper pole subsegmental artery and extrinsic compression of the parenchyma *(arrowheads)* are seen on preembolization DSA **(a)**. The lesion was selectively catheterized with a microcatheter and embolized with n-butyl cyanoacrylate **(b)**. Minimal tissue loss is seen on control angiogram *(arrow)* **(b)**.

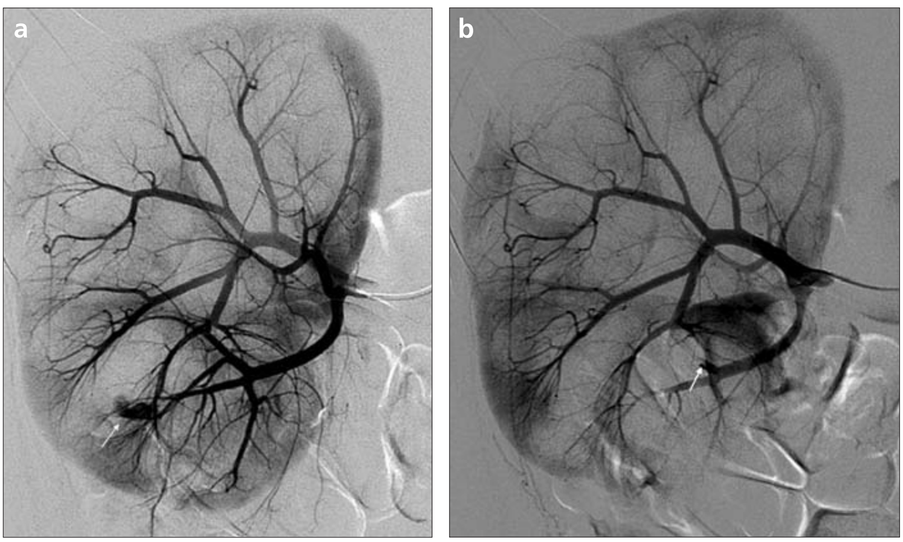

**Figure 4. a, b.** Pre- **(a)** and postembolization **(b)** DSA images of a 35-year-old man who presented with bleeding after percutaneous nephrolithotomy. Preembolization DSA shows a pseudoaneurysm *(arrow)* at the lower pole subsegmental artery of the right kidney **(a)**. The lesion was selectively catheterized and embolized with n-butyl cyanoacrylate (*arrow,* **b**). On postembolization control angiogram, there is no filling of the lesion **(b)**.

1 nephrostomy), penetrating trauma (one stabbing case) and spontaneous (one polyarteritis nodosa case). Four patients underwent US or CT examination prior to the embolization procedure. US was performed in two patients. It provided information about the lesion site and flow pattern of the lesion. CT, which also was performed in two patients, showed the location and type of the lesion. Both modalities showed the condition of both kidneys.

Eighteen lesions (13 pseudoaneurysms, 2 free extravasations, one AVF, one ACF, and one aneurysm) were detected in 15 patients. One patient had 3 pseudoaneurysms, and one had a pseudoaneurysm and free extravasation. In the patient with 3 pseudoaneurysms, they were filling from different subsegmental arteries; therefore, all the feeding arteries were selectively catheterized with a microcatheter system and occluded with coils. In the patient with a pseudoaneurysm and free extravasation, the lesions were filling from different subsegmental arteries; the feeding arteries were selectively catheterized with a microcatheter system, the pseudoaneurysm was occluded with a coil, and free extravasation was occluded with PVA particles. One patient with a transplant kidney had hematuria after percutaneous biopsy, which was successfully embolized with a 0.035-inch coil. But two months later, after ureteral catheter extraction procedure, a urinoma emerged; therefore, a nephrostomy catheter was inserted. But after the procedure, her renal function decreased, and an AVF was detected on Doppler US. This lesion was also successfully occluded with a 0.035-inch coil. All other lesions were solitary.

Technical success was achieved in all patients, and medical success was achieved in 13 (87%) patients. In one patient, a second bleeding site was detected and embolized. In the second patient, the bleeding ceased after embolization but subsequently recurred, and nephrectomy was performed.

Nontarget embolization of vascular territories was seen in two patients (13%), one treated with PVA, the other with NBCA mixture. Extensive renal branch embolization or extrarenal embolization was not detected. Iatrogenic dissection of the segmental branch was seen in one patient (7%). Puncture-site bleeding, postembolization syndrome, perirenal abscess or renal abscess, decrease in renal function, and arterial hypertension were not detected in any of the patients.

## Discussion

Iatrogenic injuries are the most common (>50%) cause of renal vascular lesions; they may present as AVF, ACF, pseudoaneurysm (PA), or perinephric hematoma (4, 5). Associated findings may include continuous abdominal bruit, palpable thrill, high output cardiac failure, thromboembolic phenomena, reduced renal function, severe hypertension, intermittent or persistent hematuria, urinary obstruction, and perirenal hemorrhage (6). In our study, 13 (87%) lesions were iatrogenic, and 5 of them (33%) were secondary to biopsy. Persistent hematuria, perirenal hemorrhage, and reduced renal function were the presenting findings.

An early and accurate diagnosis is the key to avoid unnecessary nephrectomy.

CT, US, and magnetic resonance angiography (MRA) may be helpful for the detection of vascular renal lesions, but angiography remains the diagnostic standard (7–10). It not only demonstrates the lesion but also provides the opportunity of endovascular treatment during the same imaging session (10). In this study, 4 patients underwent US or CT; all other patients were evaluated with DSA as the first imaging method because they needed emergent intervention. We think that the patients with ongoing hematuria should be transferred to the angiography unit as soon as possible. US and CT may provide important clues for the diagnosis in patients with renal deterioration, but the risk of drug-induced nephropathy in patients with decreased kidney function should be taken into account (11). It has been proposed that MRI is superior to CT in these patients, but the increasing number of cases of nephrogenic fibrosis in patients with decreased kidney function makes this suggestion doubtful (12).

Most vascular injuries heal spontaneously; therefore, most patients are followed up with conservative treatment. Surgical or percutaneous treatment of vascular lesions has been recommended when there is massive bleeding, renal hemorrhage persisting for more than 72 hours, or progressively deteriorating renal functions (13, 14). Percutaneous transarterial embolization may be used for all types of injury (even shattered or avulsed kidney) because the alternative treatment method is emergent nephrectomy or clamping of the renal artery which results in the loss of kidney (1, 3). All the patients in this study would have undergone surgery if embolization could not be performed. With the use of percutaneous techniques, nephrectomy was performed in only one patient.

The efficacy of percutaneous transcatheter embolization depends on the appropriate choice of the embolization material; the material should be chosen according to the site, size and the flow pattern of the vessels to be occluded, the availability of the material, and the knowledge of the radiologist who will perform the procedure. The speed and reliability of delivery, duration of occlusive effect, and preservation of normal tissue should also be considered (10, 15–18). Various embolic agents including gel-foam, coils, PVA, and NBCA are available for the percutaneous treatment of renal vascular lesions; coils are the most commonly used embolic agents. The use of coaxial technique with microcatheters and microcoils permits precise localization and catheterization of the bleeding arterial branches, which reduces tissue loss (19). Therefore, most of the tissue loss is limited to that caused by the original trauma itself (3). The main disadvantage of coils is that usually more than one coil is required for adequate occlusion which increases the cost and procedure time (10). We also used more then one coil when total occlusion could not be achieved, but the

**Table.** Distribution and types of lesions, interventions, and results

| Age/Sex | Lesion type/Number | Site | Cause | Catheter/Embolizing agent | Complication | Result |
|---|---|---|---|---|---|---|
| 63/M | Pseudoaneurysm + extravasations/2 | Right subsegmental artery | Biopsy | Microcatheter/Coil + PVA particles | None | Technical success, medical failure |
| 56/M | Pseudoaneurysm/1 | Right subsegmental artery | Biopsy | Microcatheter/PVA particles | None | Success |
| 44/M | Pseudoaneurysm/1 | Right subsegmental artery | Biopsy | 4F catheter/Coil | None | Success |
| 76/M | Pseudoaneurysm/1 | Left subsegmental artery | Biopsy | 4 F catheter/Coil | None | Success |
| 56/M | Extravasation/1 | Right segmental artery | Partial nephrectomy | Microcatheter/PVA | None | Success |
| 30/M | Pseudoaneurysm/1 | Left subsegmental artery | Partial nephrectomy | Microcatheter/Coil | None | Success |
| 61/F | Pseudoaneurysm/1 | Left subsegmental artery | PNL | Microcatheter/Coil | None | Success |
| 19/F | ACF/1 | Transplant renal segmental artery | Biopsy | 4F catheter/Coil | None | Success |
| 19/F | AVF/1 | Transplant renal segmental artery | Nephrostomy | 4F catheter/Coil | None | Success |
| 45/F | Pseudoaneurysm/1 | Left subsegmental artery | PNL | Microcatheter/PVA | Reflux Dissection | Success |
| 38/M | Pseudoaneurysm/3 | Right segmental and subsegmental arteries | Stab wound | 4F catheter/Coil | None | Medical failure, reintervention |
| 48/M | Aneurysm/1 | Right subsegmental artery | Spontaneous | Microcatheter/Glue | None | Success |
| 35/M | Pseudoaneurysm/1 | Right subsegmental artery | PNL | Microcatheter/Glue | Reflux | Success |
| 61/M | Pseudoaneurysm/1 | Left segmental | Partial nephrectomy | Microcatheter/Glue | None | Success |
| 78/M | Pseudoaneurysm/1 | Left subsegmental | PNL | Microcatheter/Glue | None | Success |

F, female; M, male; ACF, arteriocalyceal fistula; AVF, arteriovenous fistula; PNL, percutaneous nephrolithotomy; PVA, polyvinyl alcohol.

coil was the most effective tool, particularly in patients with small arteries, which make control of reflux difficult.

PVA is biocompatible and inert and provides fast occlusion of the arteries. Although previously accepted as a permanent embolic agent, according to histological examination, most large vessels containing PVA were incompletely occluded, with particles becoming embedded in the walls (20, 21). But the control of PVA during injection is difficult, and inadvertent embolization, as seen in one of our cases, may occur. Therefore we reserve this alternative for lesions that are difficult to reach and cannot be superselectively catheterized.

The use of NBCA in renal arteries has been reported by Yamakado et al. (17) and Parildar et al. (18). Cantasdemir et al (10) reported five cases and concluded that NBCA provides a permanent and accurate embolization in a cost-effective manner. We also used NBCA mixture successfully in 4 patients. We preferred NBCA because it offers the advantages of low viscosity for easy injection through small or tortuous catheters, and it provides quick and stable thrombosis (15). Although it was fast and cost-effective, inadvertent embolization, which is the major concern while using liquid embolic agents, occurred in one patient. Reflux may be caused by a volume of glue that is too large and/or an inappropriate speed of injection of the glue (this might be avoidable with information obtained from test injection). Gluing of NBCA to the catheter tip and causing inadvertent embolization during retrieval of the microcatheter may also occur. Adding iodized oil delays the polymerization time and gives radiopacity to the mixture, which enables observing the exact site of occlusion and thereby prevent nontarget embolization (22).

Complications related to interventional embolization procedures are rare (5, 23). Additional renal arterial trauma, such as dissection, which was seen in one of our patients, has been reported in a small percentage of patients (24). Inadvertent or nonselective embolization of the main renal artery or occlusion of more than one branch of the renal artery may lead to post-embolization syndrome, systemic hypertension, and functional impairment. Even when embolization is limited to the target branch, post-embolization syndrome may occur, particularly if it is a large branch and has to be occluded near its origin, and further, hypertension may also occur without main renal artery or multiple branch embolization. Partial recanalization of any occluded branch can also produce stenosis, leading to hypertension (5, 19, 23). These complications have not been noted in recent reports using superselective embolization. We did not encounter this complication, either. We, like others, think that this was related to the superselective technique, which preserved the functioning renal tissue (3, 5, 13, 23, 24). Therefore we prefer superselective catheterization whenever possible.

In conclusion, percutaneous transarterial embolization in renal vascular lesions is a reasonable and effective therapeutic technique. Selective catheterization is the most critical step for preserving maximum renal tissue, preventing additional renal trauma by minimizing the occlusion of additional proximal branches, and eliminating the potential risk of nephrectomy. PVA and NBCA mixtures are fast, cost-effective, and easy to use, but the potential risk of retrograde nontarget embolization, particularly for lesions with slow flow, should be taken into account.

#### References


1. Somani BK, Nabi G, Thorpe P, McClinton S. Endovascular control of haemorrhagic urological emergencies: an observational study. BMC Urol 2006; 6:27.
2. Brandes SB, McAninch JW. Urban free falls and patterns of renal injury: a 20-year experience with 396 cases. J Trauma 1999; 47:643–649.
3. Dinkel HP, Danuser H, Triller J. Blunt renal trauma: minimally invasive management with microcatheter embolization experience in nine patients. Radiology 2002; 223:723–730.
4. Poulakis V, Ferakis N, Becht E, Deliveliotis C, Duex M. Treatment of renal-vascular injury by transcatheter embolization: immediate and long-term effects on renal function. J Endourol 2006; 20:405–409.
5. Fischer RG, Ben-Menachem Y, Whigham C. Stab wounds of the renal artery branches: angiographic diagnosis and treatment by embolization. AJR Am J Roentgenol 1989; 152:1231–1235.
6. Maleux G, Messiaen T, Stockx L, Vanrenterghem Y, Wilms G. Transcatheter embolization of biopsy-related vascular injuries in renal allografts. Long-term technical, clinical and biochemical results. Acta Radiol 2003; 44:13–17.
7. Sullivan RR, Johnson MB, Lee KP, Ralls PW. Color Doppler sonographic findings in renal vascular lesions. J Ultrasound Med 1991; 10:161–165.
8. Chazen MD, Miller KS. Intrarenal pseudoaneurysm presenting 15 years after penetrating renal injury. Urology 1997; 49:774–776.
9. Dong Q, Schoenberg SO, Carlos RC, et al., Diagnosis of renal vascular disease with MR angiography. Radiographics 1999; 19:1535–1554.
10. Cantasdemir M, Adaletli I, Cebi D, Kantarci F, Selcuk ND, Numan F. Emergency endovascular embolization of traumatic intrarenal arterial pseudoaneurysms with N-butyl cyanoacrylate. Clin Radiol 2003;58: 560–565.
11. Lameier NH. Contrast-induced nephropathy--prevention and risk reduction. Nephrol Dial Transplant 2006; 21:11–23.
12. Sadowski EA, Bennett LK, Chan MR, et al. Nephrogenic systemic fibrosis: risk factors and incidence estimation. Radiology 2007; 243:148–157.
13. Dorffner R, Thurnher S, Prokesch R, et al. Embolization of iatrogenic vascular injuries of renal transplants: immediate and follow-up results. Cardiovasc Intervent Radiol 1998; 21:129–134.
14. Huppert PE, Duda SH, Erley CM, et al. Embolization of renal vascular lesions: clinical experience with microcoils and tracker catheters. Cardiovasc Intervent Radiol 1993; 16:361–367.
15. Kish JW, Katz MD, Marx MV, Harrell DS, Hanks SE. N-butyl cyanoacrylate embolization for control of acute arterial hemorrhage. J Vasc Interv Radiol 2004; 15:689–695.
16. Schoder M, Cejna M, Langle F, Hittmaier K, Lammer J. Glue embolization of a ruptured celiac trunk pseudoaneurysm via the gastroduodenal artery. Eur Radiol 2000; 10:1335–1337.
17. Yamakado K, Nakatsuka A, Tanaka N, Takano K, Matsumara K, Takeda K. Transcatheter arterial embolization of ruptured pseudoaneurysms with coils and n-butyl cyanoacrylate. J Vasc Interv Radiol 2000; 11:66–72.
18. Parildar M, Oran I, Memis A. Embolization of visceral pseudoaneurysms with platinum coils and N-butyl cyanoacrylate. Abdom Imaging 2003; 28:36–40.
19. Heye S, Maleux G, Van Poppel H, Oyen R, Wilms G. Hemorrhagic complications after nephron-sparing surgery: angiographic diagnosis and management by transcatheter embolization. AJR Am J Roentgenol 2005; 184:1661–1664.
20. White RI, Strandberg JV, Gross GS, Barth KH. Therapeutic embolization with long-term occluding agents and their effects on embolized tissues. Radiology 1977; 125:677–687.
21. Davidson GS, Terbrugge KG. Histologic long-term follow-up after embolization with polyvinyl alcohol particles. AJNR Am J Neuroradiol 1995; 16:843–846.
22. Pollak JS, White RI Jr. The use of cyanoacrylate adhesives in peripheral embolization. J Vasc Interv Radiol 2001; 12:907–913.
23. Sofocleous CT, Hinrichs C, Hubbi B, et al. Angiographic findings and embolotherapy in renal arterial trauma. Cardiovasc Intervent Radiol 2005; 28:39–47.
24. Corr P, Hacking G. Embolization in traumatic intrarenal vascular injuries. Clin Radiol 1991; 43:262–264.