CLINICAL STUDY

Embolization of Congenital Renal Arteriovenous Malformations Using Ethanol and Coil Depending on Angiographic Types

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ABSTRACT

Purpose: To evaluate effectiveness and safety of embolization of congenital renal arteriovenous malformations (AVMs) using ethanol and/or coil according to angiographic type.

Materials and Methods: Between August 2010 and October 2015, 11 patients (13 sessions; 10 women and 1 man; mean age, 50.8 y) with congenital renal AVMs were treated using ethanol and/or coils via 2 approaches (transarterial access or direct puncture). Demographics, clinical findings, diagnostic modalities, angiographic types, technical and clinical success rates, and complications were reviewed. Renal AVMs were classified into 3 angiographic types, and treatment was based on this classification.

Results: Technical success rate was 91% (10/11), and clinical success rate was 100% (11/11). Of patients, 7 had type III AVMs, 3 had type I AVMs, and 1 had type II AVM. Embolic agents were ethanol in 5 patients, coils with ethanol in 3 patients, and coils in 3 patients. Of the 8 patients treated with ethanol, 6 had infarcted renal areas of 3.5%–30% (mean, 14.6%). After a mean follow-up period of 16.3 months, there was no evidence of recurrent AVMs on imaging or laboratory studies.

Conclusions: Embolization of congenital renal AVMs via transarterial or direct percutaneous approaches using ethanol and/or coils based on a simple angiographic classification was safe and effective and elicited good outcomes. Most of the patients with congenital renal AVMs were women.

ABBREVIATIONS

AVM = arteriovenous malformation, NBCA = *N*-butyl cyanoacrylate, PVA = polyvinyl alcohol

Congenital renal arteriovenous malformations (AVMs) are rare congenital vascular disorders that involve abnormal fistulous communications between the renal artery and the renal vein via an enlarged, tortuous group of vessels called a nidus. The reported prevalence of renal AVMs is $< 0.04\%$ (1–6). Renal AVMs can manifest with hematuria, flank pain, hypertension, or high-output heart failure. Among these manifestations, gross hematuria is the most common that needs to be treated (2,4,6,7). The treatment for renal AVM has evolved from partial or total nephrectomy to minimally invasive transcatheter embolization; advances in microcatheter/microwire systems enable selective embolization of renal AVMs with fewer complications such as renal infarction and post-embolization syndrome (1,2). Numerous embolic agents have been used to treat renal AVMs, including gelatin sponge particles, polyvinyl alcohol (PVA), microcoils, ethanol, *N*-butyl cyanoacrylate (NBCA), and ethylene vinyl alcohol copolymer (Onyx; ev3 Inc Peripheral Vascular, Plymouth, Minnesota) (1–3,6).

Successful endovascular treatment of a renal AVM is targeted at complete and permanent obliteration of the nidus (7). Thus, establishing a treatment strategy requires accurate assessment of the angioarchitecture of the renal AVM. Traditionally, renal AVMs were classified as cirsoid or aneurysmal types (8). The cirsoid type has multiple arteriovenous interconnections, and

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the aneurysmal type has a single arteriovenous fistula. However, this classification is limited because there is no way to explain the case of multiple arterioles shunted into a single vein. Therefore, a more objective and practical classification system of renal AVMs is necessary to determine a treatment strategy. The purpose of the present study was to retrospectively evaluate the efficacy and safety of embolization of congenital renal AVMs performed according to a nontraditional classification based on angiographic architecture via 2 approaches (transarterial or direct puncture) using ethanol and/or coils.

MATERIALS AND METHODS

Patients

Between August 2010 and October 2015, 11 patients with congenital renal AVMs (10 women and 1 man; mean age, 50.8 y; age range, 38–74 y) underwent 13 embolization sessions. Exclusion criteria includes history of renal trauma, biopsy, or surgery, and presence of renal malignancy. Institutional review board approval was obtained for retrospective review of patients' medical records and radiologic images.

Diagnosis of renal AVM was established on screening ultrasonography (n = 3), conventional abdominopelvic contrast-enhanced computed tomography (CT) (n = 1), renal CT angiography (n = 4), or conventional angiography (n = 3). All lesions were unilateral. Seven patients presented with gross hematuria, and 4 patients were asymptomatic. Among the 4 asymptomatic patients, AVMs were discovered on screening ultrasonography in 3 patients, and the remaining patient had a renal AVM that was increased in size on 2-year follow-up contrast-enhanced CT after initial diagnosis.

Embolization Procedure

The embolization procedures were performed under general anesthesia in 4 patients (5 sessions). During each procedure, a Swan-Ganz catheter (Baxter Healthcare Corporation, Irvine, California) and radial arterial catheter were inserted to monitor pulmonary artery wedge pressure and arterial pressure, respectively. No adverse events were recorded (including pulmonary artery pressure increase) in the first 4 patients who were treated under general anesthesia with Swan-Ganz catheter monitoring. Moderate intravenous sedation (50 mg of pethidine hydrochloride; Hana Pharm Co, Ltd, Seoul, Korea) during procedure is applied in each of the following patients.

After achieving initial femoral arterial access, baseline selective and superselective angiography was performed. Superselective angiography of the branches of the renal artery feeding the AVM was performed using a microcatheter (MicroFerret; Cook, Inc, Bloomington, Indiana) and micro–guide wire (Fathom; Boston Scientific, West Valley, Utah). Angiographic types of renal AVMs were classified into the following 3 types according to the Houdart classification of intracranial AVMs (9): type I, arteriovenous fistula with up to 3 arteries draining into a single vein; type II, multiple arterioles shunted into a single vein; and type III, multiple shunts between the arterioles and venules. The treatment strategy was tailored for each angiographic type of renal AVM. An intraarterial approach was performed for type I and III AVMs, and an approach to the nidus via the transvenous route or direct puncture was attempted for type II AVMs.

For type I AVMs, under fluoroscopic guidance, a microcatheter was placed into the fistulas, and the fistulas were occluded with microcoils (MicroNester coil; Cook, Inc) that included Interlock-18 fibered interlocking detachable coils (Boston Scientific, Marlborough, Massachusetts). For type III AVMs, a microcatheter was placed as close as possible to the fistulas, and embolization was performed using ethanol with or without microcoils. Ethanol embolization was performed using absolute (99%) ethanol; maximum single bolus of ethanol did not exceed 0.05 mL/kg over 10 minutes. A test injection of contrast agent was performed with a 1-mL or 3-mL syringe to optimize the injection velocity of the ethanol, and the ethanol was injected manually under fluoroscopic control. A flow control technique placing a balloon catheter either in the feeding artery or the draining vein was not used. After 10 minutes, if the AVM was patent, the ethanol injection was repeated up to 4 times. The total dose of infused ethanol was limited to 0.5 mL/kg in patients with Swan-Ganz catheterization; < 0.4 mL/kg was infused in patients without Swan-Ganz catheterization. Unless the AVM was obliterated after the injection of ethanol, additional coils were deployed just proximal to the fistula. Even if residual AVM was noted on the final arteriogram, the procedure was suspended when the ethanol dose reached the maximum dose within a session.

In 1 case of type II renal AVM, a transvenous approach through the renal vein failed because of incomplete opacification of the nidus on renal venography. To achieve direct puncture access, with the patient in the prone position, the region of the puncture site was prepared and draped, and the starting point of the dominant outflow vein was punctured with an 5-cm long 18-gauge Chiba biopsy needle (Cook, Inc) under fluoroscopic guidance. Nester coils (Cook, Inc) were used for embolization of the draining vein. After coil embolization, 2 mL of ethanol was additionally injected through the needle. In all cases, angiograms were obtained before and after embolization to confirm complete obliteration of the nidus of the renal AVM.

CT Protocol and Imaging Analysis

Initial CT examinations were performed with a dual-source CT scanner (SOMATOM Definition Flash;