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Safety and Efficacy of Venous Coil-Embolization of Type IIa Pelvic Arteriovenous Malformations

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Objective: To evaluate the safety and efficacy of coil embolization of venous segments in patients with Type IIa pelvic arteriovenous malformations (AVMs).

Materials and Methods: A retrospective study was performed on 13 patients (median age, 43 years, range 20–62 years, 7 males) who underwent transvenous coil embolization for Type IIa pelvic AVM (characterized by multiple arterioles shunting to focal venous segments of a single draining vein) without the use of additional liquid embolic agents from March 2017 to February 2023. Treatment outcomes were analyzed based on clinical evaluations, post angiography findings, and follow-up CT.

Results: Fourteen procedures were performed on 13 patients. Except in one patient, all treatments were completed in a single session. Transvenous access was employed in 10 procedures, whereas direct puncture was used in four sessions. The embolization procedures used an average of 55.7 ± 58.5 coils (range, 7–238) and lasted an average of 127.3 ± 39.5 minutes. The technical success rate was 92.9% (of 13/14). All patients reported symptom improvement. Follow-up CT scans showed complete occlusion of the AVM without recurrence in ten of the 13 patients. There was one minor adverse event: a small retroperitoneal hemorrhage, likely related to direct puncture, which resolved spontaneously. No other adverse events were observed.

Conclusion: Coil embolization of the draining vein segment, without the use of additional liquid embolic agents is a safe and effective method for managing Type IIa pelvic AVM.

Keywords: Arteriovenous malformations; Vascular malformations; Therapeutic embolization; Interventional radiology

INTRODUCTION

Arteriovenous malformation (AVM) is a rare vascular anomaly characterized by abnormal connections between arteries and veins [1]. AVMs can manifest in various locations, including the pelvic region. Pelvic AVMs may from asymptomatic presentations to causing pelvic discomfort, pelvic pain, dysuria, and in severe cases life-threatening bleeding, and high-output cardiac failure [2,3]. According to Ko's 2019 classification, AVMs are classified into six types based on their vascular structure: I, IIa, IIb, IIc, IIIa, and IIIb. The treatment approach varies depending on the specific type [4,5]. Research is ongoing to identify the most effective and feasible treatments for each cancer type [5].

Type IIa AVM are characterized by multiple arterioles shunting into a single enlarged draining vein. This type of treatment involves mechanical embolization of the draining vein using coils or plugs, along with liquid embolic material reflux into arterial feeders using ethanol, n-butyl cyanoacrylate, or an ethylene vinyl alcohol copolymer (EVOH) [4,6]. However, the use of liquid agents carries risk, including non-target embolization, such as skin necrosis, nerve injury, and systemic side effects [4,6,7]. This study aimed to assess the treatment outcomes and complications of coil embolization of the draining vein segment for Type IIa pelvic AVM without additional liquid embolic materials.

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MATERIALS AND METHODS

Patients

This study was approved by the Institutional Review Board, and the requirement for patient consent was waived owing to its retrospective nature. Patients who underwent coil embolization for Type IIa pelvic AVM without the use of additional liquid agents between March 2017 and February 2023 were evaluated. The institutional treatment criteria for pelvic AVM included symptomatic cases or asymptomatic cases requiring treatment to prevent long-term cardiac complications caused by arteriovenous shunting.

The patients' medical records and pretreatment imaging findings on CT or MRI were reviewed. The initial angiographic findings, access routes, number of embolic materials, procedure time, anesthesia type, and treatment sessions were analyzed.

Embolization Procedure

Embolization was performed via either transvenous or direct puncture access (Fig. 1). A transvenous approach was preferred when the draining vein could be identified and traced using preprocedural imaging. After femoral arterial access was established, baseline selective angiography was performed to evaluate the AVM's angioarchitecture. Transvenous access was achieved via the right internal jugular vein or the contralateral common femoral vein using a 6 Fr, 75 cm angled Ansel sheath (Cook Medical, Bloomington, IN, USA) and a 4- or 5-Fr catheter. The target nidus, defined as the first identifiable, early, contrast-filling venous segment of the draining vein, was determined using digital subtraction angiography from multiple angles and approached using roadmap images from the transarterial catheter. Compact coil packing of the target venous segment was performed using 0.035-inch coils (MReye or Nester; Cook Medical, Boston Scientific, Marlborough, MA, USA). Detachable coils were preferred to prevent migration, and coils were oversized by 30%–50% to create a secure framework. For veins exceeding 3 cm in diameter, several large MReye coils (45 mm in diameter and 16 cm in length) were used to secure the framework (Fig. 2). If transvenous access was not feasible, the procedure was changed to a direct puncture approach under general anesthesia with the patient in the prone position. The transarterial catheter was replaced with a 6-Fr, 70-cm guiding sheath (Flexor® Ansel Guiding Sheath; Cook Medical), enabling arteriography during the procedure with the patient in the prone position. The target nidus was punctured under ultrasound, fluoroscopy, or cone-beam CT guidance using an 18- or 21-gauge Chiba needle (Cook Medical). A 4- or 5-Fr catheter was inserted following the puncture. If a 4- or 5-Fr catheter could not be placed into the target vein due to concerns about bleeding, a microcatheter system was introduced and coil packing was performed using 0.018-inch coils (Interlock detachable coil; Boston Scientific, or Concerto; Medtronic, Minneapolis, MN, USA) (Fig. 3). The embolization procedure concluded after confirming complete occlusion of the AVM and the absence of arteriovenous shunt on angiography. For deeply located AVMs, tract embolization of the direct puncture was performed to prevent bleeding from traversing the vessels using n-butyl cyanoacrylate (Histoacryl; B. Braun, Melsungen, Germany) and ethiodized oil (Lipiodol; Guerbet, Villepinte, France) mixed in a 1:2 ratio. The patient was discharged from the hospital one day after embolization.

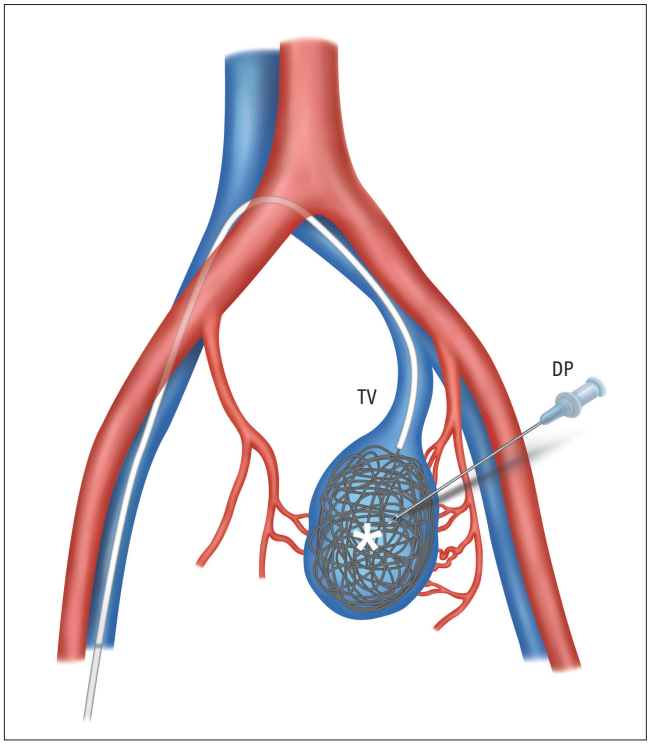

Fig. 1. Schematic representation of venous coil embolization via TV and DP for Type IIa pelvic arteriovenous malformations (*), characterized by multiple arterioles and a single draining vein into an internal iliac vein. TV = transvenous approach, DP = direct puncture

Outcome Analysis

Symptomatic changes and adverse events were evaluated during an outpatient visit four weeks after the procedure. Follow-up contrast-enhanced CT arteriography was performed

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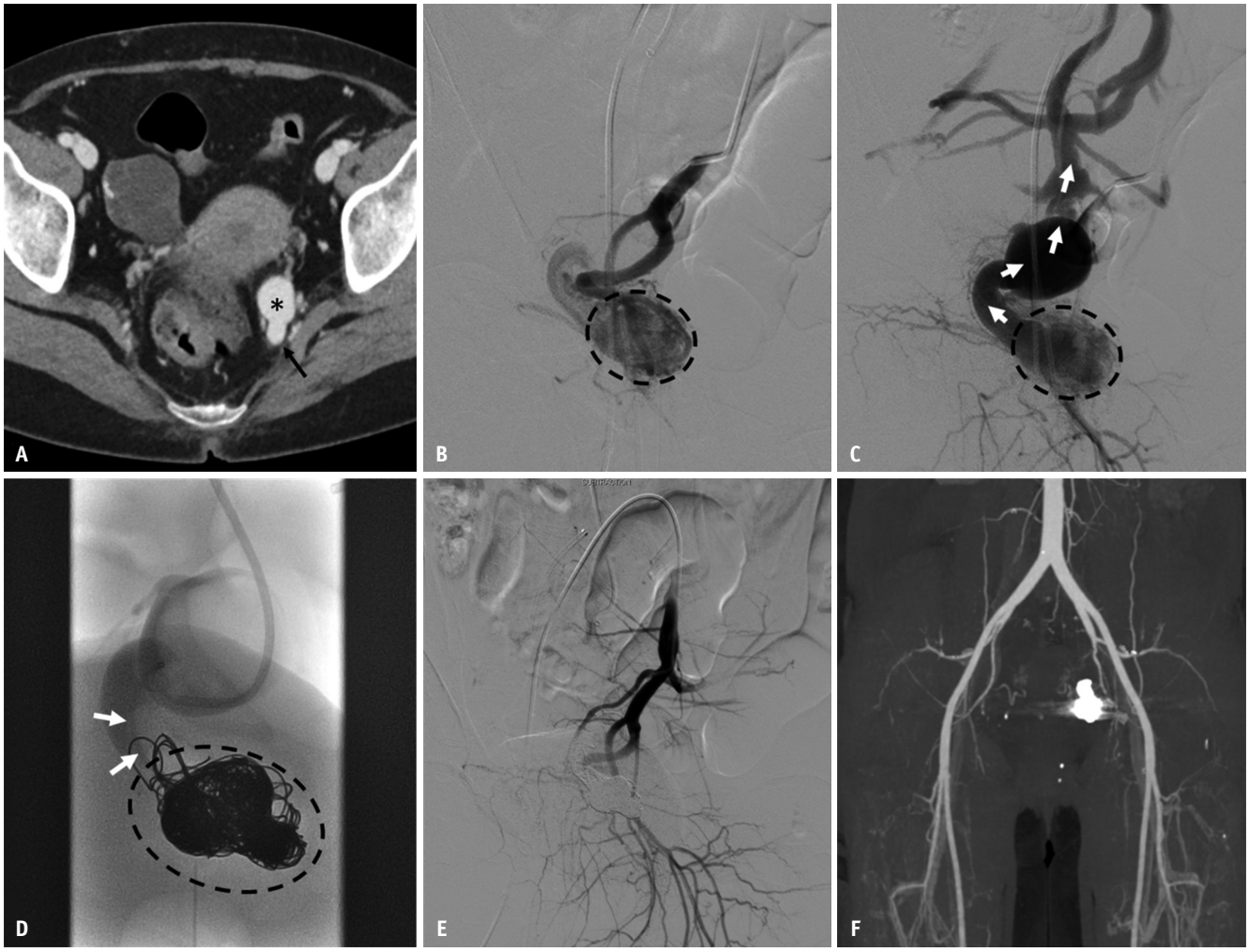

Fig. 2. A 53-year-old female patient with pelvic AVM. **A:** Preprocedural axial CT scan shows dilated venous sacs (*) with early venous drainage into the left internal iliac vein (arrow). **B:** The right oblique view of the left internal iliac arteriography shows early visualized AVM nidus (dashed circle) and dilated draining vein. **C:** In the venous phase of the same angiography, venous flow direction from the nidus (dashed circle) to the internal iliac vein (arrows) is observed. **D:** Spot radiography shows transvenous coiling of the venous sac (nidus, dashed circle) using a microcatheter (arrows). **E:** Completion left internal iliac arteriography demonstrates no residual AVM. **F:** Follow-up CT angiography shows no residual early venous drainage in the left pelvic area. AVM = arteriovenous malformation

to assess residual or recurrent AVMs three–six months post-procedure. A metallic artifact reduction technique was used to reduce coil related artifacts. Technical success was defined as complete occlusion of the pelvic AVM based on completion angiography. Clinical success was defined as improvement in the patient's symptoms. Treatment response was assessed on follow-up CT scans using the criteria proposed by Cho et al. [8]. Complete occlusion was defined as the complete occlusion of the draining vein without arteriovenous shunt flow via the AVM. Partial occlusion was defined as partial thrombus formation in the draining vein with residual or recurrent lesions and shunt flow. Any adverse events were classified according to the Society of Interventional Radiology standards [9].

RESULTS

A total of 13 patients were included in the study (median age, 43 years, range 20–62 years, 7 males). Among them, seven complained of pain: five experienced pelvic pain, one had perineal pain during urination, and one reported radiating pain in the thigh. The remaining six patients were asymptomatic, but one showed an increase in the size of the draining vein on a one year of CT follow-up (from 2.7 to 3.1 cm). The average maximum diameter of the dilated draining vein was 3.7 cm (ranging from 2.3 to 5.9 cm) (Table 1).

Of the 13 patients, 12 underwent a single session of coil embolization: nine via transvenous access and three through direct puncture. In one patient, an initial transvenous

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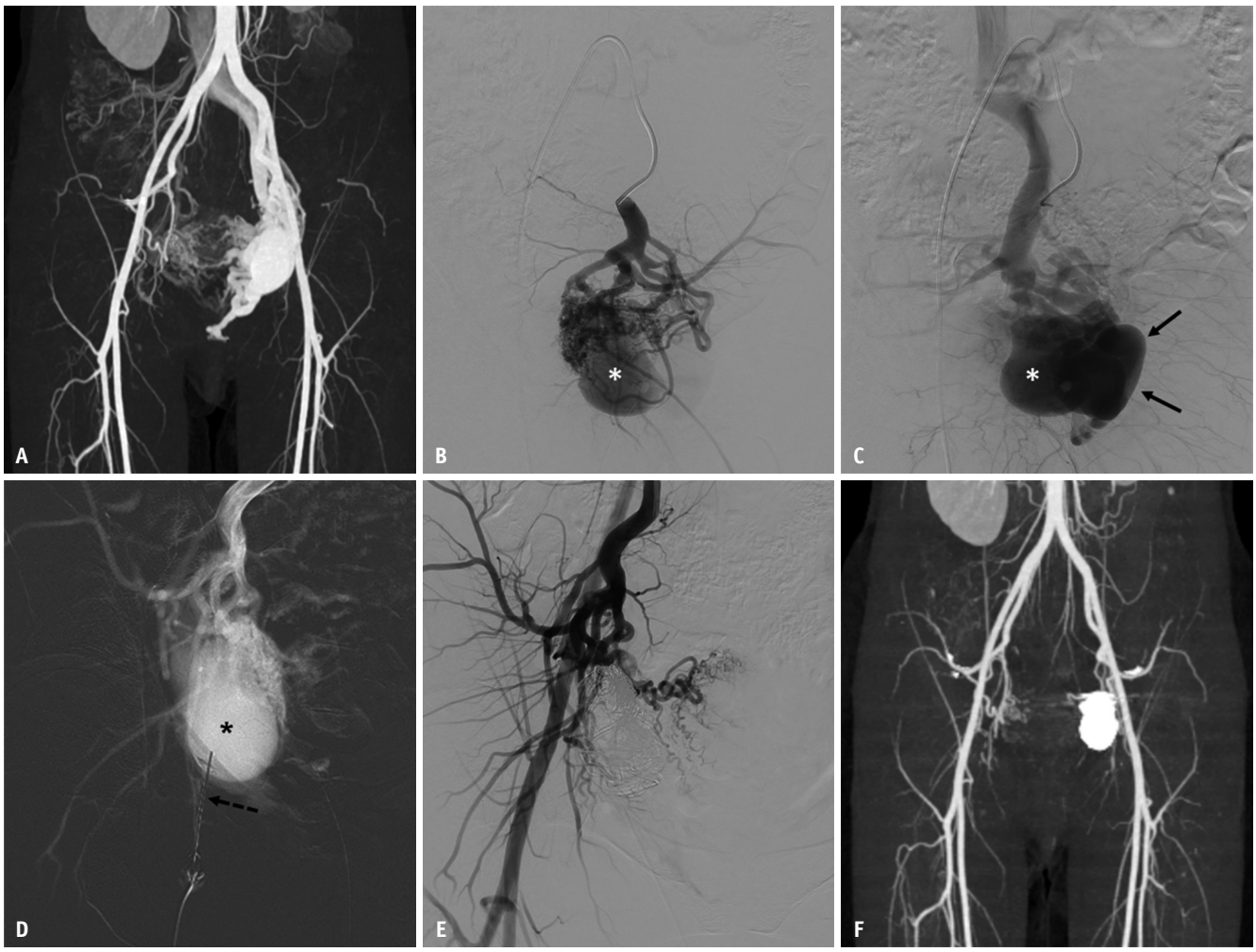

Fig. 3. A 45-year-old female patient with pelvic AVM. **A:** Preprocedural CT angiography depicts left pelvic AVM. **B, C:** Left internal iliac arteriography shows early visualization of the venous sac (*). Delayed phase angiography shows an enlarged dilated draining vein (arrows) originating from the AVM nidus (*) and draining into the internal iliac vein in a tortuous path. **D:** After failing to access the AVM nidus (*) using a transvenous approach due to the tortuous vein path, the patient was placed in the prone position and a direct puncture approach was performed using a 21 G needle (dashed arrow). **E, F:** Completion angiography **(E)** and CT angiography **(F)** show no residual AVM and disappearance of early vein drainage. AVM = arteriovenous malformation

approach failed, and successful embolization was performed in the second session with direct puncture. In total, 14 procedures were performed across 13 patients. Four direct puncture sessions and three of the ten transvenous sessions were conducted under general anesthesia, while the remaining seven transvenous sessions were performed under local anesthesia.

The procedure took an average of 127.3 ± 39.5 minutes with an average use of 55.7 ± 58.5 coils (range, 7–238). The technical success rate was 92.9% (13/14), and the transvenous approach failed in one patient. All symptomatic patients experienced symptom improvement (7/7), and all asymptomatic patients remained symptom-free, resulting in clinical success.

One patient (1/14, 7.1%) experienced retroperitoneal bleeding, a minor adverse event, after the procedure. Among the four patients who underwent direct puncture, two had tract embolization, and retroperitoneal bleeding occurred in one of these cases. Bleeding was suspected to result from leakage between the venous sac and catheter during the procedure. The bleeding spontaneously resolved without further management and disappeared on follow-up CT. No major complications were observed.

Follow-up was conducted over a median duration of 13.0 months (range, 1.3–39.0 months), and follow-up imaging was obtained in ten out of 13 patients (77%). The interval between the procedure and follow-up imaging was a median interval of 13.5 months (range, 1.0–39.0 months). All

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Table 1. Demographic data and results of coil embolization of the venous segment for Type IIa pelvic AVM

Patients	Sex/age	Symptoms	Size of enlarged vein*, mm	Number of sessions	Access	Number of coils	Procedure time, min	Technical success	Clinical success	Compli-cation	Follow-up CT interval, mo	Recurrence
1	F/49	Pelvic pain	21 x 28 x 31	1	TV	54	175	Y	Y	N	10.5	N
2	F/30	Asymptomatic	21 x 30 x 26	2	TV (fail), DP	19	182	TV: N, DP: Y	Y	N	12.7	N
3	M/49	Pelvic pain	32 x 40 x 61	1	TV	59	67	Y	Y	Mild retroperitoneal bleeding†	NA	NA
4	M/62	Asymptomatic	25 x 50 x 26	1	TV	53	108	Y	Y	N	23.5	N
5	M/33	Asymptomatic, size increment‡	25 x 31 x 29	1	TV	27	100	Y	Y	N	NA	NA
6	F/43	Asymptomatic	28 x 36 x 45	1	DP	30	146	Y	Y	N	21.8	N
7	M/23	Perineal pain	13 x 38 x 17	1	DP	21	112	Y	Y	N	NA	NA
8	M/62	Pelvic pain	38 x 46 x 51	1	DP	238	201	Y	Y	N	9.1	N
9	M/42	Thigh radiating pain	18 x 17 x 28, 12 x 11 x 15§	1	TV	7	78	Y	Y	N	24.3	N
10	M/28	Asymptomatic	35 x 45 x 59	1	TV	74	121	Y	Y	N	39.0	N
11	F/54	Pelvic pain	27 x 25 x 26	1	TV	57	116	Y	Y	N	4.5	N
12	F/53	Asymptomatic	16 x 23 x 13	1	TV	23	132	Y	Y	N	14.2	N
13	F/20	Pelvic pain	25 x 16 x 38	1	TV	62	117	Y	Y	N	1.0	N

*Expressed as width times length times height, †During the procedure, mild venous bleeding into the retroperitoneal cavity was incidentally discovered, but hemostasis was achieved spontaneously without any further management, ‡During the follow-up, the maximal diameter of the enlarged draining vein increased from 27 to 31 mm, §Two connected enlarged veins in a dumbbell shape.
AVM = arteriovenous malformation, TV = transvenous, Y = yes, N = no, DP = direct puncture, NA = not applicable

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follow-up imaging revealed AVM occlusion without evidence of recurrence.

DISCUSSION

Complete packing of the early draining vein segments using only coils effectively induced complete occlusion of the Type IIa pelvic AVM. According to the angiographic classification of peripheral AVMs [4,5,8], venous-side embolization is crucial for the complete embolization of certain types. Type II AVMs are characterized by a single draining vein, whereas Type IIIb AVMs involve multiple dilated veins and feeding arteries, both of which require treatment targeting the early draining venous segment on angiography. Other AVM types require different approaches based on their distinct angiographic anatomies. Type I AVMs (a single arteriovenous fistula) are treated with arterial coil embolization at the fistula site, while Type IIIa AVMs (numerous tiny fistulae) are managed with selective transarterial ethanol embolization of the feeding arteries [5].

Park et al. [10] evaluated 84 patients with Type II AVM involving the body and extremities. These patients underwent coil embolization of the venous segment combined with ethanol injection, resulting in full recovery or significant improvement in 88.9% of cases. Wohlgemuth et al. [6] reported treatment outcomes in 11 patients with Type II peripheral AVM treated with plug embolization of the venous segment and additional EVOH injection using the push-through method, achieving complete devascularization in 91% of cases. In the present study, the clinical success and complete remission rates with coil-only embolization were 100%, comparable to those reported in previous studies.

Regarding safety, Bae et al. [11] reported that ethanol embolotherapy for pelvic AVMs via the transarterial approach resulted in major complications in 25% of cases, including bladder necrosis and ovarian insufficiency. Similarly, Mallios et al. [3] observed a 28.5% complication rate, including pulmonary embolism and femoral paresis, in cases treated with liquid embolic agents such as cyanoacrylate and Ethibloc. Park et al. [10] analyzed the factors influencing complications in peripheral AVM embolization and identified the transarterial approach as the riskiest with the direct puncture method being the safest. Absolute ethanol concentration has also been highlighted as a significant factor. Large total doses or single boluses of ethanol entering the systemic circulation can cause severe complications such as pulmonary vasospasm and cardiovascular collapse, as well as local issues such as skin necrosis and nerve injury [12]. Over 20 years of experience in AVM treatment at our institution has resulted in reduced ethanol use, and consequently, increased reliance on venous coils. This study demonstrated that in Type IIa AVMs, complete embolization can be achieved without ethanol, provided the venous sac is adequately packed with coils to eliminate early venous drainage.

Our study reported one minor complication (7.1%) of retroperitoneal hemorrhage that resolved spontaneously without intervention. Since the direct puncture method was first described in 1983, it has become a well-established approach to treat various types of AVMs [5,13]. However, this technique inherently carries the risk of intraprocedural bleeding during catheter manipulation. Several strategies can be employed to minimize complications. Frequent angiography is essential to confirm catheter tip placement and identify residual venous cavities for coiling. If catheter dislodgement occurs, consider an additional direct puncture of the target nidus followed by prompt embolization. Utilizing a 4–5 Fr catheter for 0.035-inch coils or along with a microcatheter for microcoils enables effective coil placement without requiring larger vascular sheaths. Additionally, tract embolization with liquid embolic agents such as glue can reduce the risk of complications.

This study included asymptomatic patients, a group for whom treatment indications remain controversial. AVMs tend to grow due to the continuous transmission of high arterial pressure to lower-pressure veins through shunts. Among the six asymptomatic patients in this study, one showed an increase in size over one-year follow-up. Early treatment before further enlargement can minimize procedure-related complications and reduce the number of sessions and coils required. Treating patients before symptoms arise also helps prevent high-output cardiac failure nd systemic organ failure, which are potential complications of pelvic AVMs.

Despite favorable outcomes, this study has several limitations. First, the small sample size may limit the generalizability of the results. Second, follow-up CT angiography has limitations in evaluating residual lesions due to metallic artifacts from the coils. However, advanced artifact reduction techniques can mitigate this issue, and the absence of an early venous return may indirectly indicate effective shunt flow occlusion. Alternatively, time-resolved MR may minimize metal artifacts and provide useful hemodynamic information. Lastly, coil-only embolization

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necessitates more coils, potentially increasing procedure time and financial burden to patients compared with ethanol and coil embolosclerotherapy.

In conclusion, this study suggests that coil embolization of the venous segment without the additional use of liquid embolic agents is a safe and effective method for managing Type IIa pelvic AVM.

Availability of Data and Material

The datasets generated or analyzed during the study are included in this published article and its supplement.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: Young Soo Do. Data curation: Sang Yub Lee, Young Soo Do, Kwang Bo Park. Investigation: Jun Gon Kim, Shin-Seok Yang. Methodology: Sang Yub Lee. Resources: Shin-Seok Yang, Dong-Ik Kim. Supervision: Young Soo Do. Visualization: Lyo Min Kwon. Writing—original draft: Lyo Min Kwon. Writing—review & editing: all authors.

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